Chapter 5

Data analysis and findings

Exploring the experiences of students

5.1 Introduction

Chapter 4 presented the data analysis and findings related to the first research question, namely, *what conjectures and principles are associated with an intervention that uses computer technology as an expert system shell to develop higher-order thinking skills in Foundation English Communications students at TUT?* The second part of the research was aimed at exploring how students experienced the learning environment to which the conjectures and principles outlined in Chapter 4 are applicable. Exploring the students' experiences of the learning environment allows for a better apprehension of the value and validity of the conjectures that informed or gave substance to the design of the learning environment. This exploration may also provide insight into the extent to which the conjectures are substantiated by practical experience. In addition, this exploration may give direction to potential modifications and improvements to the environment.

5.2 How will foundation students experience a learning intervention that uses technology in the form of an expert system shell in order to develop higher-order thinking skills?

What follows is a description of the findings that have resulted from a grounded theory analysis of transcripts of focus group interviews (see Addendum G) conducted with these students.

5.2.1 Setting the scene

In order to address the second research question, two groups of Foundation English Communications Skills students were exposed to the learning environment described in 4.3. This intervention took place over an eight-week period and consisted of 12 contact sessions, half of which were held in a computer laboratory. Four focus group sessions (two per group) were held with these two groups; one set of interviews was conducted two weeks into the intervention and another at the end of it. Transcriptions of these interviews were used as the basis for the grounded theory analysis. Open, axial and selective coding were used to analyse these transcriptions.

5.2.2 Fragmenting the data into labels and formulating categories

Sentences and fragments were labelled using the application Atlas.ti and through a process of constant comparison these labels were organised into more abstract categories or higher level codes. These categories together with the applicable codes are listed in table 5.9.

Table 5.9 Categories and their related codes formulated from analysis of focus group interviews held with students

Higher-level code or category	Code
Extend thinking	Apply learning Reflection More difficult than expected Logical thinking Think outside the box Out of comfort zone Flow-diagram Difficult for the designer Giving advice when still learning Understand the problem Learning by developing Apply understanding to development Own ideas Broadened understanding Broader mind Compare understanding Consider the end user Disagreement encourages thinking

Table 5.9 Categories and their related codes formulated from analysis of focus group interviews held with students (continued)

Higher-level code or category	Code
Extend thinking (continued)	Expanded awareness Improve understanding Learning by struggling Open-mind Posing questions Think like experts Transfer learning to different settings
Challenging learning environment (Demanding greater cognitive engagement)	Don't know where to start Complicated Challenge for non-IT students Cognitive challenge Consider the end user Difficult for the designer Easier to listen to lecture Flow-diagram Learning to use the software Using the software More difficult than expected More practice Time Working in groups
Collaborating in groups	Compare understanding Consult with group members Convince group members Different ideas Disagreement encourages thinking Feel used by group members Group agreement Group debate Group decision-making Group disagreement Group members' lack of contribution Group members not learning
Disagreement among group members	Convince group members Disagreement encourages thinking Disagreement leads to better end results Group decision-making Different ideas Group disagreement
Positive attitude	Attitude Enjoyable Exciting Interesting
Learning through development	Applying learning to development Linking technology to learning Paper-based Planning Posing questions Practical application Using knowledge gained to develop expert system
The representation of understanding	Apply understanding to development

Table 5.9 Categories and their related codes formulated from analysis of focus group interviews held with students (continued)

The representation of understanding (continued)	Individual representation of understanding Options Posing questions Using knowledge gained to develop a functional expert system

5.2.3 Exploring the relationships in the data

A thorough analysis was performed of each category identified during the open coding phase of the data analysis. A coding paradigm was used as a guide during this process. 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 looked at during this phase of coding. Table 5.10 outlines the results of this analysis.

Table 5.10 Axial coding – Student group

Phenomena	Causal conditions	Attributes of context	Other intervening conditions	Action / interaction strategies	Consequences of the action / interaction strategies

Extend thinking (Encouraging extended thinking)
Properties:
• Transferability
• Level of difficulty
• New ways of thinking
• Retention
• Types of thinking:
  ○ Logical
  ○ Critical
	Application of learning
	
	Reflection
	
	More difficult than expected (exposure to a learning environment that was more demanding than expected).
	
	Difficult for the designer (the challenges inherent in designing the expert system as opposed to just using it).
	
	Giving advice while still learning.
	
	Learning by developing.
	
	Consider the end user. Disagreement encourages thinking.
	
	Learning by struggling.
	
	Posing questions.
		Group discussion
		
		Group assignment
		
		Computer laboratory sessions
		
		Non-laboratory contact sessions
				Logical thinking
				
				Move out of comfort zone.
				
				Applying understanding to development.
				
				Compare understanding.
				
				Think like experts (to develop the ES).
				
				Transfer learning to different settings.
					Think outside the box (thinking in new ways, seeing things from unfamiliar perspectives).
					
					Deeper understanding of the problem
					
					Own ideas
					
					Broadened understanding
					
					Broader mind
					
					Expanded awareness
					
					Improved understanding
					
					Open mind

Table 5.10 Axial coding – Student Group (continued)

Phenomena	Causal conditions	Attributes of context	Other intervening conditions	Action/interaction strategies	Consequences of the action / interaction strategies
Demanding (*greater)* cognitive engagement Challenging learning environment Challenges presented by the learning environment. Properties: • Learning task (assignment) • Using the software • Level of experience • Level of guidance • Time	Don't know where to start (not knowing where to start or being left alone to figure out where to start contributes to the phenomenon occurring). Complicated (complex) Challenge for non-IT student (Computer programming experience/knowledge). Difficult for the designer (more difficult to create than to use). Easier to listen to lecture (just looking is easier than having to create, less of a challenge). Flow-diagram (having to draft a flow diagram presented challenges). Presentation of the programming syntax (was not presented in such a way that the students could easily	Group discussion Group assignment Computer laboratory sessions Non-laboratory contact sessions	Learning how to use the software. Using the software (there were challenges inherent in learning and using the software but this needed to be done before something new could be created, before the cognitive challenge really began). More practice More practice exercises	Cognitive challenge (learn something new, challenge ourselves, creating is challenging. In response to the phenomena the students challenged themselves, created something new.) Considering the end user (be aware or consider the end product, see things from another perspective). Broader thinking applied. Move out of comfort zone. Think beyond school days. Reflection	More difficult than expected (the learning environment facilitated the challenges and the cognitive challenges were more difficult than expected; creating something is hard). Expanded awareness Think like experts. Transfer learning to different settings.

Table 5.10 Axial coding – Student Group (continued)

Phenomena	Causal conditions	Attributes of context	Other intervening conditions	Action/interaction strategies	Consequences of the action / interaction strategies
	see IF THEN statements clearly). Time (pressure of getting things done within a limited amount of time). Working in groups (cooperation a problem).				
Phenomena	**Causal conditions**	**Attributes of context**	**Other intervening conditions**	**Action/interaction strategies**	**Consequences of the action / interaction strategies**
Collaborating in groups Working together in groups	Group assignment Different levels of understanding	Group assignment Computer laboratory sessions Non-laboratory contact sessions The practical development of an expert system in and out of a computer laboratory	Disagreement encourages thinking Feel used by group members Group disagreement Group members' lack of contribution	Compare understanding. Consult with group members. Group decision-making	Different ideas Group agreement Group members not learning

Table 5.10 Axial coding – Student Group (continued)

Phenomena	Causal conditions	Attributes of context	Other intervening conditions	Action / interaction strategies	Consequences of the action / interaction strategies
Disagreement among group members	Group assignment Different ideas See things differently Working with different people Group disagreement	Group assignment Computer laboratory sessions Non-laboratory contact sessions The practical development of an expert system in and out of a computer laboratory		Convince group members Group decision-making	Disagreement encourages thinking. Disagreement leads to better end results. Not getting the job done.
Phenomena	**Causal conditions**	**Attributes of context**	**Other intervening conditions**	**Action / interaction strategies**	**Consequences of the action / interaction strategies**
Positive attitude Properties: • Enjoyment • Excitement • Interest Challenging	Novelty Developing something Interesting Provides a challenge Linking technology to learning Learning through development Combine knowledge	Development of an expert system Laboratory sessions Group assignment			

Table 5.10 Axial coding – Student Group (continued)

Phenomena	Causal conditions	Attributes of context	Other intervening conditions	Action / interaction strategies	Consequences of the action / interaction strategies
Representing understanding Properties: • Expert system • Flow-diagrams • Questions • Options	Apply understanding to development of an expert system. Using knowledge gained to develop an expert system. Using software (CourseLab)	Development of an expert system Planning Laboratory sessions Group assignment Flow-diagrams		Posing questions Designing options	Development of a communication guideline (the expert system) Thinking about various options/contexts
Phenomena	**Causal conditions**	**Attributes of the context**	**Other intervening conditions**	**Action / interaction strategies**	**Consequences of the action / interaction strategies**
Collaborating in groups Working in groups Properties: • Level of cooperation (working together – no contribution) • Decision-making • Level of agreement	Group assignment	The practical development of an expert system in a laboratory and outside laboratory time. Group activity Group assignment Computer laboratory sessions Non-laboratory contact sessions	Group members' lack of contribution Group members not learning	Consult with group members Attempt to convince group members Group decision-making (vote)	Different ideas Group disagreement Disagreement encourages thinking Disagreement leads to better end results

5.2.4 Developing an analytical story – how did the students experience the learning environment?

The main idea that emerged during the 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 the way in which students experienced the learning environment was outlined. The relationship between categories at a dimensional level as well as the way in which they relate to the core category or concept was then outlined. These relationships were validated against the data by extracting salient quotes from transcripts of the focus group interviews held with the student group and incorporating them in a descriptive passage. These steps were not regarded as distinct from one another but together allowed for the development of an analytic story. This analytic story was outlined in a descriptive passage. Table 5.11 outlines the results of this process.

Table 5.11 Selective coding

Selective coding steps	Central idea: Working in a learning environment that uses technology as a cognitive tool
Explicating the story line.	The central idea that runs through the coding of the transcripts is the students' experiences of working in a learning environment that uses technology as a cognitive tool. Working within the learning environment provided students with the opportunity to link the learning of communication with technology. This learning environment comprised activities both in computer laboratories and out of computer laboratories. The activities that were not conducted in computer laboratories were used as planning sessions. During these sessions students worked in groups to outline the structure of their expert systems in the form of flow-diagrams and by writing down questions and answers. The drafting of the flow-diagram often encouraged students to think logically about the structure of their proposed expert systems. This was often considered to be the more difficult part of the process and the one that required the greatest amount of thinking. Some students considered the drafting of the flow-diagram to be the most time-consuming part because it involved formulating ideas and the articulation of various options. Other students considered the implementation of the ideas to be more difficult and time-consuming. The non-laboratory contact sessions also provided students with an opportunity to reflect on the development that took place during

Table 5.11 Selective coding (continued)

	laboratory sessions. The flow-diagrams and questions formulated during the planning sessions were used during the laboratory sessions to develop the expert system that represented their understanding of various Communications concepts. Both the planning and development processes required students to collaborate in groups. Students considered the group work to allow for the combining of knowledge and ideas. The group activities also facilitated discussion. A group assignment that consisted of an ill structured problem in the form of a conceptual brief was given to the students. The discussions that resulted from the group assignment led to the generation of different ideas concerning the development of an expert system. These differing ideas were often compared with one another in order to determine the most appropriate option. Sometimes modifications to ideas were made as a result of the process of comparison. The group discussions often led to disagreement among group members. Often group members had to be convinced by others in the group that a certain course of action should be taken. Sometimes a vote was taken when it was necessary for the group to make a decision. The students generally regarded group disagreement in a positive light and were of the opinion that it encouraged deeper thinking and often led to better end results. The discussions that resulted from group disagreement often made students aware of different ways of approaching a problem and of achieving a solution. These discussions also seemed to highlight the need to have a clear understanding of the problem that needed to be solved. It also resulted in a deeper exploration of the individual student's own ideas. The articulation of solutions and ideas highlighted the need to think logically about the subject domain. Disagreement among group members often seemed to lead to a process of reflection and the exploration of alternative ideas. Students, however, sometimes found the various group members' lack of contribution to be frustrating and were concerned that many in the various groups were not really learning anything. Group activities and the resulting disagreements that occurred at times were thought to slow down the development process. Students often considered the linking of technology to the learning of Communications concepts to be a novel approach to learning and as a result found it to be enjoyable, exciting and interesting. They also considered it to be a practical and hands-on approach to learning; this also contributed to it being an enjoyable and interesting experience. Most students found learning by developing something to be an effective way to engage cognitively with the subject. Some students regarded the fact that it provided them with a challenge to be enjoyable and interesting. Linking technology to the learning of a subject such as Communications also seemed to make the subject more relevant to the students as they considered themselves to be part of a project that exposed them to an authentic real world situation. The group activities also made the learning experience enjoyable for most of the students as they gave them an opportunity to combine knowledge and compare understanding. The development of the expert system required students to apply their understanding of various Communications concepts that they learnt about from their lecturers. This often made them realise that they did not know the subject content as well as they thought they did and encouraged them to consider Communications in a broader context. They often considered themselves to be moving outside of their comfort zones during this

Table 5.11 Selective coding (continued)

	process and considered it to be a step above what had been required of them when they were at school. Some students were of the opinion that the task of completing the group assignment forced them to think at a different level and place themselves in a real world context, solving real world communication problems. They admitted that they now see Communications in a far broader light and would now be in a better position to apply the concepts taught during the contact sessions. They generally thought that their communication behaviour would change as a result of working within the learning environment. They indicated that they would now be in a better position to identify communication errors and be able to communicate more effectively in a variety of situations. Many students saw the development of an expert system to result in a guide to inexpert communicators and considered themselves to be in a better position to guide these users themselves. The learning environment seemed to encourage the students to expand their thinking. This environment proved to be more demanding than they expected it to be and presented them with various challenges that they were unaccustomed to. They were not used to representing their knowledge actively and considered a typical lecture to be less demanding. They often found it challenging to assume the role of the designer of an expert system that provided expertise to a non-expert user. The planning and development process prompted the students to consider the perspective of the end user. They felt that it was necessary to anticipate questions and problems that the user was likely to have and to provide answers and solutions to these. This forced them to reflect on their own understanding and encouraged them to see the domain in the way a human expert might see it. This often allowed the students to consider the application of earning in authentic settings and gave them a deeper understanding of how learning could be applied. The students were prompted to think logically in order to develop their expert systems. The planning of the expert systems using a flow-diagram illustrated the flow of logic applicable to the expert system and prompted the students to adapt their thinking according to this. The generation of ideas through group discussion and disagreement prompted students to consider their own ideas as well as those of others in the group critically. The learning environment encouraged the students to think in new ways about a subject that they had previously considered mundane and insubstantial. The learning environment demanded greater cognitive engagement from the students than they were used to and they often felt lost and bewildered in it. The open-ended nature of the group assignment frequently made them feel disorientated and many of them did not know where to start or how to approach it. Some of the students found the software challenging to use while most of them thought it was easy in comparison to other 'programming' languages that they had been exposed to. Their exposure to other programming environments, however, led them to expect the CourseLab development environment to contain certain features and to present programming syntax in specific ways. Because CourseLab is not really a programming environment but rather a course development environment, programming is facilitated by means of a series of dialogue boxes. The end result of this is that the complete flow of the script or program cannot be read easily on one page. The students sometimes found this to be a little disorientating and would have preferred to be able to trace the programming logic (i.e. the IF, THEN statements and the METHODS) in one view. They thought that it might be especially challenging for people who do not have much information technology (IT) or programming experience. There was a sense that they considered themselves to be a select group because they

Table 5.11 Selective coding (continued)

	had had exposure to programming before. The software, nevertheless, did add to the learning load in the learning environment. Many of the students found articulating the logic of an expert system in the form of a flow-diagram to be challenging. Many students considered the lack of available time to be a considerable difficulty. They often seemed to feel pressured to achieve an outcome in an environment that demanded a great deal from them. They would have preferred having more time to tackle practice exercises and to get to know the 'programming' environment better. The students did, however, find the cognitive challenge presented by these difficulties to be enjoyable and rewarding. The group activities became a problem when insufficient cooperation was obtained from some of the group members. Some of the members of the various groups made little contribution to the planning and development of the expert system and proved to be a source of frustration to the others who felt used.
Relating categories at the dimensional level.	All students were required to work in groups during both the planning and development stages. These group planning and development activities seemed to be both a source of frustration and a vehicle that generated ideas and facilitated deeper thinking. Group disagreement emerged as a significant theme and was regarded in both a positive and negative light. The need to justify and substantiate points of view required students to contemplate their ideas more carefully and often resulted in the realisation that there may be more than one solution to a problem. These group disagreements also frustrated some students as they considered them to be an obstacle to the development process. The group activities also seemed to allow some students to hide behind the work of others. The learning environment resulted in students thinking at a different level. Some students were encouraged to think outside their comfort zones while others remarked that they had to apply a greater degree of logical thinking. The group debates and disagreements resulted in students evaluating their own and other members' ideas more critically. They evaluated these ideas in terms of their usefulness and in relation to the utility of other ideas. The students also considered the learning to have real world relevance and considered themselves to be in a better position to identify errors in communication and apply what they had learnt. Learners considered themselves now to be able to think like experts. There was also a sense that they would be able to transfer their insights and understanding to different settings. During the course of the planning and development process the students represented their understanding of various Communications concepts in the form of flow-diagrams, lists of questions and answers, and functional expert systems developed in the CourseLab environment. One of the biggest challenges expressed by the students was the fact that there was insufficient time to complete the task comfortably.
Relating all categories around the core category.	The development activities that took place in the learning environment involved students collaborating with one another in groups using technology to develop an expert system. This facilitated the linking of technology to the learning of communication and provided the students with a novel learning experience. It resulted in a generally positive and enthusiastic attitude toward the learning although some members found the group dynamics frustrating at times. The articulation of the expert system on paper as well as the eventual development of the expert system constituted a representation of their understanding of the content that they were taught. The group collaboration that formed part of the

Table 5.11 Selective coding (continued)

	learning environment resulted in discussion and the generation of divergent and often conflicting ideas. These, together with the hands-on development, often resulted in students thinking at a higher level and in ways that they were unaccustomed to. They indicated that they would be in a better position to apply their learning to different settings as they had obtained a broader insight into the domain. Through this process they seemed to become aware of a higher form of thinking as well as of the complex nature of communication.
Validating those relationships against the data.	Students stated that the environment gave them a “chance to link communication to technology” (FG 4.7.36) and allowed for the incorporation of “technology into your everyday life” (FG 4.1.37) and as a result the learning experience became “enjoyable” (FG 3.3.35), (FG 3.3.36), (FG 4.6.35), “interesting” (FG 4.6.35), (FG 4.1.38), (FG 3.4.4) and even “exciting” (FG 3.4.4), (FG 3.1.11). They also felt that they enjoyed the learning experience because “it was something” (FG 3.1.11) new. A student suggested that it was “interesting because it gives us a challenge” (FG 3.1.5). The students also found the learning method enjoyable and interesting because they felt as though they were gaining "more experience" (FG 2.2.25) to tackle a task that had an authentic feel to it. The focus group interviews revealed that the students felt as though the learning environment gave them a broader, more comprehensive insight into the subject domain. The following quotes indicate an awareness of the "real world" application of communication principles: FG 1.4.5: *Like we learn what our managers out there in the business world expect from us.* FG 3.1.8: *I learnt how to use communication in different situations.* FG 3.1.38: *It is preparing us for our future in workplaces.* The following quotes indicate an awareness of the broad nature of the subject domain: FG 1.8.34: *I can say that I realise that communication is very broad.* FG 1.8.44: *Because communication is broad it is all about understanding and I think all of us we … I mean we found out the other things that we didn’t know.* There was also a sense that the students were encouraged to think about the subject domain in different ways: FG 2.2.17: *It forces you to think outside the box.*

Table 5.11 Selective coding (continued)

	FG 3.1.5: *I find it interesting because it gives me a challenge as a person to think outside the box, not inside.* FG 4.3.3: *I think it helps you think outside the box because you have to think beyond your school days. You have to take your communication level into the workplace.* FG 1.7.9: *I have to think; if it's fine for me; it will be OK or understandable for others.* It was suggested that the students preferred to apply their knowledge by "doing it practically" (FG 2.3.33) as this led to "better understanding" (FG 4.4.19) and that learning became "easier" (FG 4.7.24) when it was "practical" (FG 4.7.24). Some students suggested that it was "easier to remember something that you have done practically" (FG 2.7.34). One student suggested that "even though it [the expert system] does not work at the end of the day" (FG 4.2.14), "the process of creating it", or attempting to create a functional expert system results in learning. There was also a sense among the students that listening to a lecture seems to suggest that the subject domain is reasonably simple, but this is often not the case. The following quotes support this interpretation: FG 4.3.16: *When it is being lectured it becomes easier because we are just looking what you are saying, what you are telling us, we are not applying it. When you start applying it that's where it becomes a problem because we have to do exactly what you have just told us.* FG 4.3.17: *We think its simple but when it comes to applying it, the knowledge, it becomes a problem.* FG 4.4.19: *I think I get a better understanding while practising something, not reading it actually from the book."* Some students suggested that the real thinking took place during the development of the flow-diagram: FG 2.3.21: *I think the only thing that takes time is developing that flow-diagram. Creating the actual expert system doesn't take time."* FG 2.3.21: *But then drawing up that flow-diagram … having to come up with the options and the topic, that's challenging for us."*

Table 5.11 Selective coding (continued)

	FG 2.2.22: *Plotting it down is the problem … when you have to … link.* Many students, however, realised that the development of the functional expert system based on their flow-diagram design was not only time-consuming but also often revealed a breakdown in the logic of their expert system design: FG 4.4.4: *As for us, creating it is more challenging.* FG 4.5.6: *It is difficult because when you draft it on a page it is easier but when it comes to doing it practically it's very difficult because you have to have time and implement all the ideas that you have.* FG 4.7.30: *When you get into a lab, yes, we enjoy it but when we come out we've got to think about what we did and just when we think about what we are doing at the lab we gather the fact that it needs more time like we have to sacrifice some of the time, some of our time. We come into lab late, we do the work and then … yes, but when we get into a lab, its nice and then when you come out we have got to think about what we did there, eish, there we went wrong, there we were right.* The students indicated that the learning experience was often more challenging than they expected it to be: FG 4.1.1: *At first we thought that it would be just something simple, we get into a lab, we do everything, we get done within one hour but as time passed we found it more difficult because it needs more time where a group has to sit down to analyse everything just to get the work done properly.* Students seemed to find the open-ended nature of the assignment disorientating at times: FG 2.2.3: *Communications is really broad; it's like a broad subject, so most of us don't really know where to start.* FG 2.2.2: *The examples you gave us were easy, about the dog or whatever but now we have to create something that has to tell people what to do, which is hard.* FG 4.1.9: *We were trying to do something which talks about Communications whereas we are also learning how to*

Table 5.11 Selective coding (continued)

	communicate. A student suggested that the "struggling" within the learning environment was a positive experience: FG 2.2.32: *I think in the end you will remember this, after all the battling and the crying, you will remember it better than if a lecturer just stands in front of you and actually tells you what to do.* Designing and developing the functional expert system encouraged students to extend their thinking and think at a higher level. One student suggested that “the more you struggle the more you ask questions” (FG 1.3.16). Another student indicated that the learning tasks teach "you to understand the problem before solving it” (FG 4.3.10). It was also suggested that the learning environment encouraged logical thinking: FG 4.6.23: *It makes me become a logical thinker, to think out of the box.* FG 4.2.2: *It needs more logical thinking because when you are doing the program sometimes it becomes more confusing.* FG 2.5.10: *We know the steps and procedures to follow in order to have successful communication.* The discussions and disagreements “make you think more to get like the better idea” (FG 3.5.29) and prompts the student to “come up with different ideas” (FG 3.8.33). This is especially true when there is disagreement within the group and group members need to be “convinced” (FG 3.7.32). Sometimes the disagreements were regarded in a negative light as they "take us back" (FG 3.2.28) and the students "end up arguing" (FG 3.2.28) and "not getting the job done" (FG 3.2.28). There was also concern among various group members that some students were not contributing anything, "not contributing towards the programming" (FG 3.4.21) and "not coming up with any ideas" (FG 3.4.21), and as a result not learning. The group activities also enabled students to combine ideas and "knowledge and compare which one is better" (FG 3.5.36). This often led to a process of discussion where the group "will get the solution that will cover all of them" (FG 3.7.32). The group discussions together with the other planning and development activities allowed the students to gain insight into the broad and complex nature of communication as they were given a "broader mind in understanding what communication is and how to use it" (FG 3.4.4). These activities also enabled students to gain some understanding of how to apply their knowledge and also allowed them to appreciate the complexity of communicating in real world settings as the learning environment takes your "communication level into the workplace" (FG 4.3.3) and encourages you to "think beyond your school days" (FG 4.3.3) and "think outside the box" (FG 4.3.3), (FG 1.6.8), (FG 2.2.17), (FG 3.1.5).

Table 5.11 Selective coding (continued)

Filling in categories (translating them into an analytic story).	Students collaborated in groups to plan and develop an expert system that resulted in a representation of their understanding of certain communication concepts that were introduced to them during the contact sessions. The process of articulating their understanding in this way made them realise that they did not fully comprehend the complex nature of the subject and exposed them to a higher, more comprehensive and sophisticated form of thinking. The flow-diagrams that were drafted on paper and eventually developed into functional expert systems required them to think about communication in broader terms as a variety of possible situations needed to be explored when these activities were undertaken. Students had to consider the value of their expert system to a non-expert user and accordingly were encouraged to contemplate the subject domain from this non-expert user's perspective. The flow-diagrams were mainly in the form of algorithms that required students to trace the logic of the conclusions that were reached when a certain combination of options was selected. This challenged the students to expand their thinking to include logical thinking. The students were motivated to undertake the task of drafting a logical flow-diagram due to the fact that these decision structures were eventually going to be converted into functional expert systems. If there were a breakdown in logic during the paper-based planning stage then this would be carried over to the development stage. The breakdown of logic during the development stage prompted the students to reflect on the logic of their flow-diagrams during subsequent non-computer laboratory contact sessions. This process of reflection facilitated an exploration of the domain that resulted in deeper and broader understanding. The exploration and articulation of various options (contexts, etc.) and the linking of these options to appropriate solutions gave the students insight into the functional aspects of communication as well as to its multi-faceted nature. The group collaboration resulted in vigorous discussion and the generation of differing ideas concerning various aspects of the development. This not only exposed students to different points of view but also encouraged them to defend their own point of view in an attempt to persuade the other group members to adopt a certain course of action. This also seemed to serve as a form of reflection as many of the individual ideas needed to be revisited and modified during this process. These group activities also allowed students to combine and share knowledge, experience and expertise. Comparing ideas, combining knowledge and defending positions encouraged a form of critical thinking. The learning environment proved to be more challenging for the students than they expected it to be. They were more accustomed to attending lectures that were supplemented by conventional study material than being tested on this content. Because this learning environment presented the student with an open-ended assignment that required them to create something original and innovative, students often felt disorientated and out of their depth. They did, however, feel that this feeling of disorientation was mitigated by the group collaboration where students could combine understanding and knowledge, compare ideas and discuss possible solutions to problems. Students were frustrated at times because they felt that they were required to perform a task they did not have the prerequisite knowledge for. They had to think like experts and advise non-experts in a domain that they were not completely familiar with. This prompted them to venture out of their comfort zones and think beyond what they were accustomed to.

Table 5.11 Selective coding (continued)

	The feelings of frustration were aggravated by time constraints. Although they generally considered the software to be easy to use they felt that more practice was required in order to become familiar with the expert system concept and the process of creating one using CourseLab. Some of the limitations of CourseLab as a development environment were exposed due to the students' exposure to other development environments such as Visual Basic. They often felt that it would have been more helpful if they could trace the logic of their expert system by looking at the programming syntax in one view. This is difficult to achieve in CourseLab, which is mainly course development software, as the scripting is done by means of dialogue boxes that hide some of the programming logic from the user.

5.3 Chapter summary

This chapter has presented the findings related to how the students experienced the learning environment based on the conjectures and principles formulated during this research. This presentation involved listing the categories and codes put together through a grounded theory analysis of relevant data. A table outlining the relationships in the data was then presented. This table consists of the following headings:

- Phenomena
- Causal conditions
- Attributes of context
- Other intervening conditions
- Action / interaction strategies
- Consequences of the action / interaction strategies

The central concept or main idea that emerged from the open and axial coding phases of this exploration was then presented and the way in which all other categories relate to this central concept was described. This was done by means of a table that was divided into the following sections:

- Explicating the story line
- Relating categories at the dimensional level
- Relating these categories around the core category

- Validating those relationships against the data
- Filling in categories (translating them into an analytic story)

The following chapter presents a discussion of the findings applicable to this research and an attempt is made to link these findings to the relevant literature.