Chapter Six

An Analysis of Technological Literacy Levels of Traditional Science Curriculum Students

6.1. Orientation to the Chapter

This chapter will examine critical question 3, i.e. what were the levels of technological literacy in the selected cohort of undergraduate science students? As mentioned in chapter one, the third critical question is included to determine the effects of the traditional science curriculum on technological literacy levels of the students. This critical question presents technology in real life situations and will therefore expose the extent to which students use the information learned at school in their everyday lives. Moreover, this question embraces innovative, C2005 aligned approaches to measure technological literacy levels. This alignment to C2005 represents a new dimension in the measurement of technological literacy levels. The principal focus of this chapter is on the qualitative analysis of the results of the technological literacy test completed by the selected students. This analysis is preceded by two largely quantitative precursor components. First, a preview to the data analysis component to highlight factors that will inform the analysis of technological literacy scores. Second, a tests and plots component to establish whether the technological literacy scores of the selected students are normally distributed.

6.2. Preview to Data Analysis

This component of the chapter orients the reader to the analysis of technological literacy data by briefly addressing two foundational issues. First, a brief review of the nature of the technological literacy questions, with a brief description of the differences between the analysis of technological literacy scores as compared to scientific literacy scores. Second, the rationale for testing the technological literacy data for normality, and subsequent tests and frequency plots to test for normality of the data.

The methodology that was embraced to test the technology literacy levels of the students was described in chapter three (see sub-section 3.4.1.2. pp.49-53 and sub-section 3.6.3. pp.71-72). Six open-ended questions, which corresponded to seven specifie outcomes for technology, were developed and administered as part of the all inclusive questionnaire. Each of the six questions

corresponded with a specific outcome for technology except for the last question that addressed both specific outcomes one and two. The classification of responses to each technology question was based on the SOLO Taxonomy (see sub-section 3.4.1.2. pp.49-53). Each response corresponded with a score from 1 to 5 as outlined below in Table 6.1.

SOLO Taxonomy Classification	Score
Prestructural	1
Unistructural	2
Multi-structural	3
Relational	4
Extended abstract	5

Table 6.1. The SOLO Taxonomy for Classification of Technology Scores

The variable on the technological literacy represented a dependent variable in this study because it is influenced by a variety of factors like academic performance in Grade 12 (matric). This dependent variable was first tested for normality to determine whether parametric or non-parametric statistical tests can be used when analyzing the related data. Parametric tests are based on the distributional assumption of normality, while non-parametric tests are based on the distributional assumption of abnormality.

The Shapiro-Wilk statistical test was administered to establish whether the data related to technological literacy were normally distributed. Thereafter, a stem-and-leaf plot, a box plot, and a normal probability plot were completed to illustrate the distribution of the technological literacy data (see Figure 6.1. above). These plots are presented alongside one another for each data set to illustrate the distribution of the same data in three different ways.

Before the results of the Shapiro-Wilk statistical test and frequency plots are discussed, a brief discussion of the differences between the analysis of technological literacy scores as compared to seientific literacy scores is presented.

First, the range of scores for scientific literacy was from 6 through to 18 out of a maximum of 20. The range of scores for technological literacy scores was from 1.18 through to 3.45 out of a maximum of 5. Second, the technological literacy scores were not whole or natural numbers as they represented the mean score for eleven sub-questions on technological literacy. (Note: Although there were six questions on technological literacy. Some of these questions consisted of multiple parts. Hence, there were eleven sub-questions on technological literacy.) The overview of technological literacy scores is presented in Table 6.2. below. Third, the corresponding mean, median and mode for technological literacy are lower, and not natural numbers as illustrated in Table 6.2. below.

LOWEST		HIGHEST		MEAN	MEDIAN	MODE
Value	Frequency	Value	Frequency			
1.18	7	3.45	2	2.13	2.09	2.18

Table 6.2. Statistical Overview of Technological Literacy Levels of the Students

The above overview of differences between the scientific and technological literacy scores paves the way for a discussion of the normality tests and frequency plots applied to the technological literacy data, which follows.

6.3. Tests and Plots for Normality of Technological Literacy Scores

The Shapiro-Wilk test statistic value of 0.984131 ($p = 0.0487$) was obtained which is significant at a five percent level. Therefore, the null hypothesis of normality was rejected, and the data is not normally distributed. However, the stem-and-leaf plot, the box plot and the normal probability plot reveal that the deviation from normality is not great. The near normal distribution of technological literacy test scores of the students is displayed more prominently in each of the frequency plot illustrations that follow:

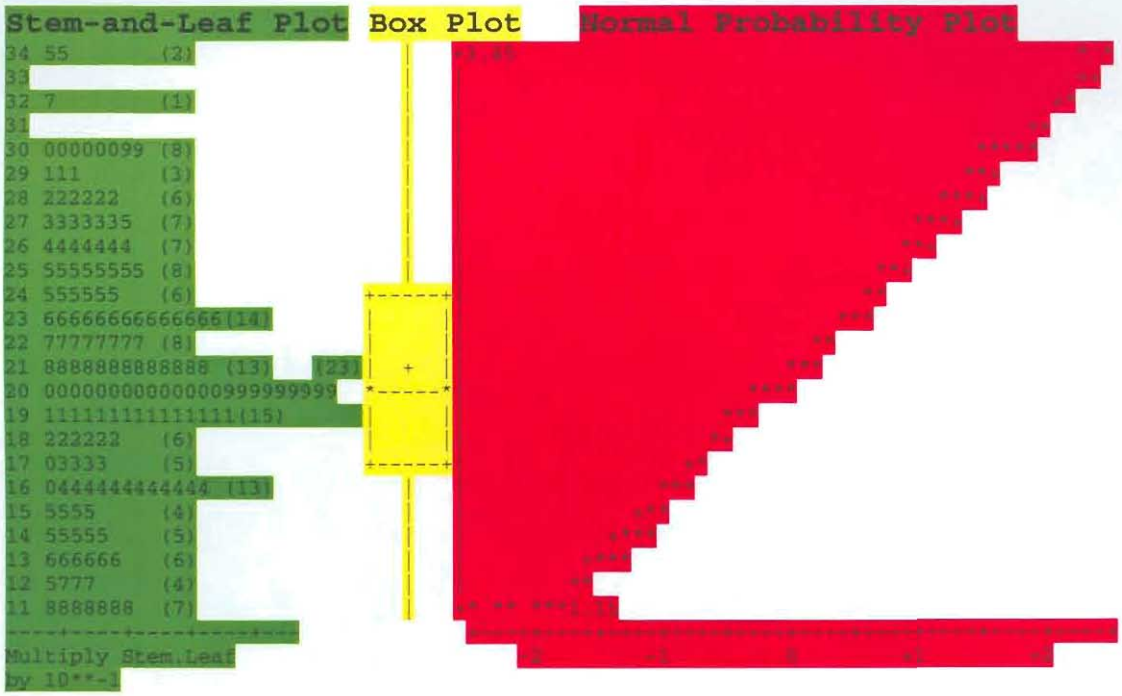

Figure 6.1. Frequency Plots of Technological Literacy Scores

The stem-and-leaf plot can be interpreted as a bell shaped curve which is positively skewed, thus showing that the data is not perfectly normally distributed. The mode and the main peak of the curve are at a score of 2.09, with a frequency of 23. The main or central peak extends over a range of scores from 1.8 through to 2.4, and there are two smaller peaks on either side of the central peak base at scores of 1.6 and 3.0. Although the Stem Leaf is not perfectly shaped for a normal distribution, the shape does tend towards a near normal distribution.

The box plot also suggests an imperfect distribution of the data of technological literacy scores, as the box is not equidistant between its two extremities. The box plot is positively skewed, as the mean is greater than the median.

The normal probability plot yielded almost a straight line indicating a near normal distribution of the data on technological literacy levels of the students. Therefore, although the data might be slightly skewed to the right (bottom in Figure 6.2.) as expressed in the stem-and-leaf and the box plot, it is evident that the skewedness is not extreme and the data on technological literacy levels of the students can be considered to be normally distributed. Of course, the data will not be perfectly distributed but the shape of the curve in the normal probability plot does approximate to normality.

The above analysis of frequency plots contributed to an objective assessment and acceptance of the near normal distribution of the data. Thus, parametric tests can be applied to the data. The analysis of technological literacy levels of the cohort of students that experienced traditional science curricula at school follows.

6.4. Analysis of Technological Literacy Levels of the Selected Cohort of Science Students

This section of the chapter will address critical question three, namely, what were the levels of technological literacy in the selected cohort of undergraduate science students?

To determine the levels of technological literacy of the students, the following method was employed: There were six questions on technological literacy. Some of these questions consisted of multiple parts. Hence, there were eleven sub-questions on technological literacy, which corresponded to eleven variables (V23, V25, V27, V29, V31, V33, V38, V43, V48, V53, & V55). Each student scored between 1 and 5 points for each of the eleven variables. For each student, the mean of these 11 scores was calculated, and the students were classified as follows:

X	=	1	Technologically Illiterate or Prestructural
X	=	2	Unistructural Technological Literacy
X	=	3	Multistructural Technological Literacy
X	=	4	Relational Technological Literacy
X	=	5	Extended Abstract Technological Literacy

(X represents the mean of the scores for the 11 variables, and each of the above classifications is consistent with the SOLO Taxonomy as described in chapter three. The range of scores here was between 1,18 and 3,45. Thus there were no students in the X = 4 or 5 category.)

As mentioned above, the scores for technological literacy were not whole or natural numbers and the range of scores were from 1,18 through to 3.45. Each of the technological literacy test scores was then converted to a whole number, and the acronym RTOTT is the rounded technological literacy test score. The distribution of students' rounded scores for technological literacy were as follows:

Technological Literacy or RTOTT	Frequency	Percent
1	22	12.9
2	107	62.6
3	42	24.5

Table 6.3. The General Distribution of Students' Scores for Technological Literacy

Table 6.3. shows that the most frequent rounded technological literacy score was 2. Almost 63 % of the students scored a rounded technological literacy score of 2. These students were at the unistructural level of the SOLO Taxonomy.

A small percentage of the students (almost 13 %) scored a rounded technological literacy score of 1. These students were at the prestructural level of the SOLO Taxonomy.

A mediocre number of students (almost 25 %) scored a rounded technological literacy score of 3. These students were at the multistructural level of the SOLO Taxonomy.

Note that although a student may have a rounded technological literacy score of 1, 2, or 3, it does not imply that all the responses provided by the student to all the technological literacy variables were the same. For example, a student may have a rounded score of 2 but have some responses at higher or lower levels of the SOLO taxonomy. There were even some students who scored 4 or 5 on some of the eleven sub-questions related to technological literacy but their mean scores were 3. A discussion on the detailed distribution of technological literacy scores follows.

Table 6.4. below illustrates the detailed distribution of students' scores for technological literacy. The acronym TOTT is used to abbreviate the true (not rounded) scores for scientific literacy. The FREQ Procedure data were used to generate Table 6.4.

Technological Literacy Score or TOTT	Frequency	Percent
1.18	7	4.1
1.25	1	0.6
1.27	3	1.8
1.36	6	3.5
1.45	5	2.9
1.55	4	2.3
1.6	1	0.6
1.64	12	7.0
1.7	1	0.6
1.73	4	2.3
1.82	6	3.5
1.91	15	8.8
2	14	8.2
2.09	9	5.3
2.18	13	7.6
2.27	8	4.7
2.36	14	8.2
2.45	6	3.5
2.55	8	4.7
2.64	7	4.1
2.73	6	3.5
2.75	1	0.6
2.82	6	3.5
2.91	3	1.8
3	6	3.5
3.09	2	1.2
3.27	1	0.6
3.45	2	1.2

Table 6.4. The Detailed Distribution of Students' Scores for Technological Literacy

As revealed in Table 6.3. the technological literacy scores of the students were confined to the prestructural, unistructural and multistructural levels with rounded scores of 1, 2 and 3 respectively out of a total of 5. None of the students were able to score at the relational or extended abstract level which required mean scores of 4 and 5 respectively out of a total of 5. Table 6.4. magnifies the distribution of prestructural, unistructural and multistructural scores, i.e. in the prestructural range the scores were between 1.182 and 1.455, in the unistructural range the scores were between 1.545 and 2.455, and in the multistructural range the scores were between 2.545 and 3.455.

Thus, for each of the demonstrated levels of technological literacy, there was a spread of the scores across a continuum. So, a rounded technological literacy score of 2 should not be narrowly interpreted as such, but could lie anywhere between 1.545 and 2.455. Simply stated, the rounded technological literacy scores are used for convenience and that should always be borne in mind.

The categorization of students using prestructural, unistructural, and multistructural labels led to the identification of the students in each of these groups. The three groups of students' scores were compared with their scientific literacy scores to establish if there were similarities in the two sets of scores. Table 6.5. shows the overlap of the students with corresponding scientific and technological literacy levels.

Category	Scientific Literacy Level	Technological Literacy Level	Number of Students
1	Illiterate	Prestructural	5
2	Mediocre	Unistructural	32
3	Good	Multistructural	20
4	Excellent	Multistructural	14
			N =71

Table 6.5. Combined Scientific and Technology Literacy Levels of Students

A total of 71 students (42 %) of the students had corresponding scientific and technological literacy scores. Note that ideally an excellent scientific literacy score would correspond with a Relational SOLO taxonomy status for technology. However, because there were no rounded technological literacy scores of 4 (relational type), students with excellent scientific literacy and multistructural level of technological literacy were combined for convenience.

The categories that featured in Table 6.5. above formed the basis of identifying selected students who were interviewed to corroborate claims made in the questionnaire and for the qualitative analysis of responses to the six questions on technological literacy which follows.

The qualitative analysis of the six questions on technological literacy provides a portrait of the patterns and qualitative differences in the responses of different categories of students. This is a new dimension in the analysis of the technological literacy levels of the students. One feature of the data that is of paramount importance in the analysis of technological literacy data is to understand that if a student falls within any category, e.g. category 2, there could be a mixture of pre-, uni- and multi-structural responses in any of the categories. The analysis that follows will therefore engage the categories as such. The reader is encouraged to review the questionnaire (Appendix 1) in tandem with the analysis which follows, where necessary.

6.4.1. Analysis of Responses to Technological Literacy Question One

The first question on technology addressed specific outcome three (SO3) in the technology learning area, namely: access, process and use data for technological purposes.

The corresponding task was:

The graph below (see Appendix 1 for figure of graph) reflects electricity consumption for a family of four in a standard three-bedroom home in Gauteng for a three-month period. Sketch changes to the shape of the graph for the period December to February. Provide reasons for changes to the shape of the graph:

The graph reflected a consumption of 1000 to 1300 units per month for the three-month period. The solution to the problem required an explanation of the impact of seasonal change (winter to summer) on electricity consumption. This rationale could then be translated into sketching a new graph for the period December through to February at a lower level of electricity consumption and explaining its shape.

6.4.1.1. Category One Students' Responses to Technological Literacy Question One

Contradictions and confusion characterized the category 1 students' responses. The responses also exhibited the prestructural characteristics predicted by Biggs & Tefler (1987), as the outcomes were inadequate or simply incorrect.

Simply incorrect responses, for example, ignored seasonal changes as a cause of the lower consumption of electricity, but linked people going on vacation exclusively to lower electricity consumption. The same student (2002380) went on to contradict this claim of lower consumption by reflecting an increased consumption of electricity in the period December through to February. One student (2008802) in category 1 even went as far as saying that consumption of electricity is lower in winter. This student went on to contradict this incorrect claim by showing equivalence in the electricity consumption between the winter and the summer months.

Another student (9927847) had no clue about how to interpret graphs: "...from jun to jul (sic) the graph decreases..." This student went on to reflect the electricity consumption for the Summer months as higher than the Winter months, and at a constant level in each of the Summer months. Yet another student (2012758) was very confused about seasonal times: "The electricity consumption would be higher in December (to) February than in May (to) July; because it's Winter (December (to) February) and things like heaters etc be used; which would increase the electricity consumption." This student went on to reflect higher electricity consumption in the summer months. A different student in category 1 (2028748) avoided answering the question by stating the relationship between the shape of the graph and the consumption of electricity. This was interesting as it raised expectations about the shape of the graph that would be drawn by the student. However, the student showed equivalence between the electricity consumption in the two periods.

The above analysis of category 1 responses shows that the access, process and use of data for technological purposes by these students is poor. It would be interesting to see the qualitative differences in the nature of responses by students in categories 2, 3 and 4. A discussion of responses from these categories follows.

6.4.1.2 Category Two Students' Responses to Technological Literacy Question One

One would expect a distinct shift in category 2 students to a general higher order of thinking; however, that is not necessarily the case. There is a distinct combination of responses in this category of students, some lower order responses and some higher order responses.

Lower order responses were of four types. First, some students sketched a near equivalence between the consumption of electricity in Winter and Summer, and corroborated their misunderstanding with statements like "...the electricity will automatically go higher, the same as May, June and July" (2006050). Second, some students (2000972) attributed the lower consumption of electricity in the period December through to February exclusively to the family going on vacation for three months. Third, some students were on the opposite extreme and predicted an increase consumption of electricity because of people staying at home during the holidays: "In December the electric (sic) consumption is too high because December is a school holiday month and so the kids might spend the rest of the day in the house using electric equipment..." (9927681). Fourth, some students contradicted themselves by reflecting a high consumption of electricity on the graph for the period December but arguing convincingly in the narrative that the consumption is lower in the period December through to February. Across these four types of lower order responses were many instances where there was a distinct silence on seasonal differences.

There were three conspicuous features of the higher order responses in category two. First, there was a greater degree of correspondence between the narrative and the graphical representations that were made. Second, some students emphasized that the use of heating appliances for warmth, and additional lighting for longer nights, results in greater electrical consumption in winter. This scenario was then contrasted with that in summer, and a lower consumption of electricity was justified. For example, "During the summer seasons the day is very long and the night is short then the lights won't be in much use. During winter the night is very long with short time of the day then electric lights will be in more use and the heaters will be lit for warmth. Then there will bc much consumption of electricity" (2021062). Third, there was a rationale for the differentiation of the electricity consumption levels in December, January and February. For example, "December – Electricity used will be less than other (two) months, because most people go on holiday and then only the lights are burning. January – It will increase but only from the middel (sic) January because that is only when the people are back. February – Will increase rapidly because students/children stay up later to study

etc" (2012596). In general, the responses of category 2 students were more coherent than those of category 1 students. The discussion of category 3 responses follows.

6.4.1.3. Category Three Students' Responses to Technological Literacy Question One

In the introduction to the analysis of technological literacy levels of students it was mentioned that if a student falls within any category, e.g. category 2, it implied that the mean score for that student was 2, and not that all the scores were 2. So, there could be a mixture of pre-, uni- and multi-structural responses in any of the categories. This has been the case for the foregoing two categories but not necessarily with category 3. A greater consistency prevails in category 3 with most of the students being at the multistructural level. However, there were a few students with prestructural and some with relational understandings.

This preamble to the analysis of category 3 has highlighted the first conspicuous feature of category 3, namely: a greater consistency in the responses. There are other noticeable features of this category 3 as well. These features are elaborated below.

First, the students in category 3 responded immediately with a justification of the graph based on seasonal differences. For example: "Since the months December, January and February are in summer, less electricity is being used. In May, June and July it was autumn and winter season so the use of electricity increased due to the extensive use heaters, kettles and such. It would therefore be logical for the use of electricity to be lower during summer" (2009582).

Second, almost all of the students in category 3 are able to sketch changes to the graph correctly, and justify their sketches in the narrative. Therefore, contradictory statements were uncommon.

Third, there is also a greater level of coherence in their narrative descriptions, almost to the extent that the narratives a relational status of the SOLO taxonomy where the learner now integrates the parts with each other so that the whole has a coherent structure and meaning. For example: "December – February is summer. Lights are turned on for shorter periods of time. The only appliance that uses much electricity in this time is the refridgerator (sic). No great need for warm water or food" (2015226).

Finally, as with category two, some students felt the need to differentiate between energy consumption in each of the months from February through to December and explain the changes in consumption. The rationale differentiation and explanations are similar to those in category 2 students.

The category 3 students thus far represent the highest level in the quality of responses to the question on accessing, using and processing data. It would be interesting to see how category 4 students' responses differ in substance, and quality, from category 3, if at all.

6.4.1.4. Category Four Students' Responses to Technological Literacy Question One

Just a reminder to the reader that category four students include those with excellent scientific literacy and multistructural technological literacy as indicated in Table 6.5. Category 4 students provided terse but coherent responses. The terse nature comes through with short statements and the use of mathematical signs: "consumption reaches low point during December (warmest time of the year = less heating of water, more daylight = less use of lighting" (2014398). The coherence is illustrated in: "Electricity consumption is less because its summer and less energy is required for the heating of the home and the nights are shorter, so less energy is needed to light the home" (9915905).

Almost all the students in category 4 sketched changes to the shape of the graph for summer correctly. Additionally, category 4 students provided a greater level of detail in their narrative: "Consumption will be at its lowest in February because it is the hottest month of the year..." (9928559). Moreover, there was also a greater depth to the responses in category 4: "In the winter people use more electricity when... (they) turn up the thermostat of the geyser so that the water is warmer" (2003356).

6.4.1.5. Summary of Responses to Technological Literacy Question One

Thus, the responses to the question on access, process and use of data has evolved from category 1 with simply incorrect or inadequate responses with high levels of contradiction, to category 2 with a combination of lower and higher order responses and some contradiction, to category 3 with a greater consistency and coherence in the responses, to category 4 with short statements and the use of mathematical signs in developing coherent arguments. The same type of analysis follows for the second question on technological literacy.

6.4.2. Analysis of Responses to Technological Literacy Question Two

The second question of technological literacy related to specific outcome 4 (SO4) in the technology learning area, namely: select and evaluate products and systems.

The corresponding task was:

Briefly describe the technological factors that you would take into consideration before purchasing a cell phone, and justify your selection of factors?

The above task probed the technological savvy of the students to understand the technological factors that informed their decision-making process when purchasing a product of technology, i.e. a cell phone. The correct responses to this question would entail not simply a list of technological features but the linking of these factors into a coherent whole. There was; however, some variety in the nature of the responses as outlined below. Once again the responses are grouped by category.

6.4.2.1. Category One Students' Responses to Technological Literacy Question Two

Category 1 students were either incorrect, avoided answering the questions, or focused on irrelevant information. A typical example of focusing on irrelevant information was a set of definitions on waves, conductors, 'senders', and cell phones. Category 1 students responses were also inadequate with a focus on commercial factors like: "Determine if you want a pay-as-you-go or a contract..." (2012758). The same student also focused on irrelevant information, i.e. outlined the merits of cell phones as communication devices which do not require wires: "...wires don't have to be connected to your cell phone in other (sic) to use it".

There was also incoherence in the responses provided by category 1 students. For example, some responses restated the question as in: "Look at the technological method of the cell phone" (9927847). This same student went on to state: "...It will help me in difficult situation (sic)" thus being ambiguous rather than outlining the fact that cell phones have free access to emergency services. There was also a hint of some knowledge of technological features of the phone from the same student who stated: "This is access to the Internet or any other place like over the water," suggesting that cell phones allow us to access to the information and communication.

6.4.2.2. Category Two Students' Responses to Technological Literacy Question Two

Category 2 students' responses were a combination of mediocre and poor types.

Mediocre responses included a list of technological factors like good reception and network coverage but did not attempt to integrate the list of factors and bring any coherence to the response. Good reception, for example, was intimated in statements like: "That its frequency wouldn't affect or be affected by the environment..." (2028176). There was, however, no attempt to link this feature of good reception to other technological factors like network coverage.

The slew of technological factors listed by category 2 students included battery quality, size and weight of the phone, and features like calculators and alarm clocks (2025350). Other technological features that were prominently featured amongst the mediocre responses were text messages, caller identity, and network coverage (9917181), picture messaging (2013886), durability (2021062), battery life (2001546), memory function to save phone numbers, games (2016474), and fax information, mail box functions (2006806). There was just one response in category 2 with some depth: "They have a lot of disturbance to electronic things like radios, TVs, etc," thus alluding to the concept of interference (2013986).

Poor responses were commercial in nature and included: "The amount charged for getting connected" (2000972). Other responses in this category contained irrelevant information like: "...there must be a need for a phone" (9811761). Some students provided no response at all (9828433).

6.4.2.3. Category Three Students' Responses to Technological Literacy Question Two

Category 3 offered more refined responses than their counterparts in categories 1 and 2. There was still a list of technological factors [durability (2001832), picture messaging (2015226), level of radiation (2004006), memory and phonebook facilities (2007470)] presented without integrating the response into a coherent whole. Nonetheless, the factors were enhanced with use of labels such as ergonomics (2003744), stand-by time (2003088), talk-time, re-charge time (2009582), security features (2006448), and a vibrating ring (2020082). Unequivocally, these students in category 3 were at a higher conceptual level of understanding than their counterparts in categories 1 and 2. This higher conceptual knowledge manifests itself in the superior list of technological features of cell phones provided by students in category 3.

Moreover, there were technological features that surfaced from category 3 students that were not mentioned by students in the first two categories. For example, "WAP (wireless application protocol) web access ... to access the Internet using a cell phone, not a personal computer" (2020082)/(2021378). Greater depth of understanding also featured in comments by students in category 3 that pertained to dual and tribands, as well as to "data modems and international roaming" (2013456). Apparently, "a dual band can operate on both GSM frequencies - 900/1800" (2022118), and a "tri-band cell phone can be used in Europe and America as well as in South Africa" (2007790). Students in this category also talked about using a cell phone for data transfer to a personal computer (2015226), and "using a Lithium-Iron battery that does not lose its battery (sic)" (2021378).

Other new features that surfaced in category 3 included students questioning the availability of "hands-free options, car kits" (2010060). This same student then went on to question whether the cell phone properties could be extended to a normal phone.

6.4.2.4. Category Four Students' Responses to Technological Literacy Question Two

Category 4 students' responses were similar to those in category 3 in that a list of technological factors was presented without being linked in a coherent fashion. As with category 3 students, this list was improved with labels that demonstrated an understanding of technological features of a cell phone. For example, dual networking capabilities for better reception (2011896), and the routine features of battery life span, memory size, stand-by time, fax, email and internet facilities, SMS, and good reception. Additionally, like category 3 students, category 4 students also elaborated on "WAP enabled, Dual Band 900/1800 (features)" (2011612) and followed through with explanations of these kind of features. The new (not mentioned in the previous three categories) technological features of a cell phone that surfaced in category 4 students included voice recognition (2014074), as well as protection against radiation and a discharge function to protect the battery.

6.4.2.5. Summary of Responses to Technological Literacy Question Two

Thus, the responses to the question on selecting and evaluating products and systems, by describing the technological features of a cell phone, were varied. The responses progressed from category 1 students who were either incorrect, avoided answering the questions, focused on irrelevant information, or incoherent, to category 2 students' responses which were a combination of mediocre and poor types. Mediocre responses included a list of technological factors like good reception and network coverage but did not attempt to integrate the list of factors and bring any coherence to the response. Lower order responses were commercial in nature or contained irrelevant information. Category 3 offered more refined responses than their counterparts in categories 1 and 2. Category 3 students still provided a list of technological factors but enhanced the list with the use of labels like ergonomics. Category 4 students' responses were similar to those of category 3 students. The same type of analysis follows for the third question on technological literacy.

6.4.3. Analysis of Responses to Technological Literacy Question Three

The third question on technological literacy related to specific outcome 6 (SO6) in the technology learning area, namely: demonstrate an understanding of the impact of technology.

The corresponding task was: *Discuss the impact of the Internet on society:*

This particular task was challenging in that it focused on impact, which is very different from interpreting data (task 1) or describing technological features (task 2). In fact, this task required an understanding of how a technological device has influenced our daily lives. Once again, the idea was simply not to elicit a variety of impacts but to test whether the information presented could be integrated and linked into a coherent whole. The analysis follows below.

6.4.3.1. Category One Students' Responses to Technological Literacy Question Three

Category 1 students' responses were, with the exception of one student who simply restated the question focus (2002380), generally better than for this task as compared to tasks 1 and 2. The responses of category 1 students were generally correct and adequate. Category 1 students listed a variety of impacts of the Internet on society.

Some of the impacts listed by category 1 students were simple like access to information: "...our generation will get to know about other countries..." (9927847), or "there is no need to go to the library to get information for a task you can just type in a topic and pages of information appears (sic) on the screen" (2008802). Others in category 1 listed expeditious communication as an impact: "They will be able to communicate with people...to send e-mails without the waste of time of posting it" (2028748). Some students in category 1 focused on commercial and practical benefits like shopping from home instead of "getting in the car and drive to do the shopping (sic)" (2012758), or banking and payment of accounts on the Internet.

One student went beyond the simple impacts of access to information, expeditious communication, and commercial and practical benefits, to talk about the social evil of the internet in that it is a cause of unemployment: "With the internet many people don't have work anymore" (2008802). Therefore, inasmuch as the Internet is seen as a benefit to society, it is also has demerits like threatening job security.

6.4.3.2. Category Two Students' Responses to Technological Literacy Question Three

Category 2 students' responses amplified the educational merits, the undesirable content, and the risks associated with the Internet, as discussed below. They also listed the routine merits of the Internet as outlined by students in category 1. These routine features of the Internet included: access to information, expeditious communication, and commercial features like banking and shopping or business transactions. One new feature of the Internet that surfaced amongst category 2 students was the advertising potential of the net: "it's a cheaper way of trying to sell your product" (2014878).

The education merits of the internet, as outlined by category 2 students, included its positive impact on "research and projects..." (9915173), "it enhances research capabilities for a wide range of people" (2016474). Additionally, the Internet was seen to enhance computer literacy as it "forces people to get to know how to use computer and Internet" (2002410). Moreover, one category 2 student believed that the Internet has "made distance learning far easier" (9917181).

The undesirable content of the Internet included pornography and instructions on how to develop destructive devices. For example, students felt that the Internet introduces "...ponography (sic) to those (whom) it is not eligible to, like children" (2008020). The same student went on to elaborate on the destructive nature of the internet content by citing the free access to drug formulas that can be

harmful to students if experimented with. The instructions for developing destructive devices was echoed in the statement: "...it now enables kids to get instructions to bombs..." (2011966).

There are various risks associated with using the Internet. Some of the students believed that "...people spend more time on the net and less time with their families" (2017578), or that "it (internet) has turned children into zombies, they do nothing but 'surf the web' the whole day" (2013886). Yet another risk includes: "...children communicate with people they don't know and they give them the home addresses and those people can come and steal from or make arrangements with kids and when they meet they kidnap them for money" (9927681). The latter scenario is not a figment of the student's imagination. According to the student, it is a fact that was lifted from a reputable television talk show that discussed the Internet.

6.4.3.3. Category Three Students' Responses to Technological Literacy Question Three

Category 3 students' responses were generally very similar to those in category 2. In fact, unlike other tasks, it was difficult to establish the higher level of thinking associated with this group of students for tasks 1 and 2. There were, however, a sprinkling of well-informed responses which elevated category 3 responses to those in categories 1 and 2, e.g. "The internet has led to a decentralization of business as people can now work from home" (2010060). Moreover, the superiority of some of the responses in category 3 students manifested itself in the use of labels like e-commerce, virtual libraries, chat rooms, on-line game playing, improved global awareness, as well as "fraud and computer hacking (which are) now abundant on the internet" (2027440).

Of course, common responses, as listed in category 2, were plentiful in category 3. These common responses included, amongst others, descriptions of the Internet as: a powerful and faster means of communication, readily accessible information, banking facilities, shopping. Some of the ideas of category 2 students were reiterated like improved research as a result of access to literature on the net. Also, the negative social impact of the internet like exposure to pornography and the construction of explosive devices like bombs (2009940) were emphasized by some students in category 3. The students did however, expand on this latter concept of pornography and talk about child porn or paedophilia (2003744) as a disgusting feature of the net. Social degradation also featured as a negative impact of the Internet amongst category 3 students: "Although it (Internet) has brought people together via conversation, personel (sic) interaction is still sorely missed and may lead to a disfunction (sic)" (2010060).

6.4.3.4. Category Four Students' Responses to Technological Literacy Question Three

Category 4 students' responses were not impressive, as they did not provide the elaborate understandings anticipated of them. Rather, the nature of category 4 responses was similar to those of category 3 students. In fact, had it not been for the use of interesting descriptors like "globalized the marketplace" (9928559), category 4 responses could have been relegated to category 2 status. The responses in category 4 were also suffused with the regular descriptions on the impact of the internet like it being a limitless source of information, ease of communication, facilitation of business especially for small business, and serving as a reference library. Students in category 4 also alluded to the social impact of the Internet as "pollution of innocent minds" (2015468), and the Internet being the cause of "new kinds of crime and new opportunities for fraud" (2014398). The only new feature of this set of responses from category 4 was the displacement of the television by Internet: "(The Internet has) taken over the number 1 role for passive entertainment from the TV" (9915905).

6.4.3.5. Summary of Responses to Technological Literacy Question Three

Thus, the responses to the question on SO6 in the technology learning area, namely: demonstrate an understanding of the impact of technology, using the question related to the impact of the internet on society were not as varied as was the case with the two previous tasks. Category 1 students listed impacts, which were simple like access to information, expeditious communication, and commercial and practical benefits. There was also a focus on social ramifications of the Internet like being a cause of unemployment. Category 2 students' responses amplified the educational merits, the undesirable content, and the risks associated with the Internet. They also listed the routine merits of the Internet as outlined by students in category 1. Category 3 students' responses were generally very similar to those in category 2. There were, however, a sprinkling of well-informed responses, like the use of e-commerce features of the Internet that elevated category 3 responses above those in categories 1 and 2. Category 4 students' responses were similar to those of category 3 students. A similar analysis will now unfold for the fourth question related to technological literacy.

6.4.4. Analysis of Responses to Technological Literacy Question Four

The fourth question on technological literacy related to specific outcome 7 (SO7) in the technology learning area, namely: demonstrate an understanding of how technology might reflect different biases, and create responsible and ethical strategies to address them.

The corresponding task was: *Should the drug AZT be made available to pregnant women in South Africa ?*

To provide a response to this question required an understanding of the high incidence of transmission of the HIV/AIDS virus from mother to infant, and the corresponding solutions to this form of transmission of the virus. AZT was one of the popular drugs in 1999 and 2000 used for the purpose of preventing the transmission of the virus from mother to offspring. Recently, the new drug, Nevirapine, has proved to have the same effect with greater success. Despite the evidence about reduced transmission rates while using either drug, the South African Government remained adamant that it would not support the provision of the drugs, even if they were made available at low cost to the government. The difficulty in answering this question lay in the fact that it was not taught in the Life Sciences syllabus and required that one extend beyond the school curriculum into real life challenges.

6.4.4.1. Category One Students' Responses to Technological Literacy Question Four

Category 1 students' responses were inadequate. The students either did not respond (2012758, 2028748) or admitted having no understanding of the drug AZT (2008802). One student (2002380) intimated no understanding of the drug by rejecting the drug and stating: "it would be a bad influence on the child and also the mother..." Another student recommended trialing the drug before providing it to pregnant women in the interests of safety, but did not show any understanding of the impact of the drug on the foetus.

6.4.4.2. Category Two Students' Responses to Technological Literacy Question Four

Category 2 students' responses were of three types: 1) a combination of informed answers which reflected some understanding of the drug and its use; 2) responses which were purely speculative or in which students admitted having no clue about what the drug; and 3) responses which defended the government's standpoint on not making the drug available to pregnant women.

The informed responses were terse and clearly demonstrated an understanding of the use of the drug. For example, "Yes, it should be made (available) to reduce the risk of unborn child for HIV/AIDS (sic)" (9828433). One student (2016474) justified why the drug should not be provided to pregnant women by stating that "...AZT cells, good or bad, it does not select just the infected cells, but kills good ones as well and in the end might affect the child." Another student (2028176) supported the use of the drug and implicitly demonstrated an understanding of the use of the drug by stating that the drug would prevent children from dying. This student also mentioned the subsidization of the drug by foreign countries like America, which would make the drug more cost-effective. Others supported the use of the drug for scientific reasons, e.g. "Yes, because the scientist had tested it and found that it protect the infant from being infected by virus (sic)" (2011728). Some of the answers went beyond the prevention of HIV/AIDS to focus on care of the child. For example, one student (2001546) knew that the child would survive and not the mother and questioned whether bringing a child up without a mother is desirable. The same student proposed that the money should be used to help educate people avoid contracting the disease.

Those students who speculated incorrectly made claims that AZT was used for abortions (2017528, 2013986, 2014878). Other speculative responses pertained to claims by students that drugs could have a bad influence on pregnant women (2006050), others stated that the drug can affect the baby (9828451) but did not elaborate, another group mentioned that it would help to save the mother's life at the expense of losing the child (2011966). Some students just felt that it was a matter of choice. Some students did not have clue about what the drug was capable of, and openly admitted this (9917181, 9915173).

Those students who supported the government's standpoint on not making the drug available to pregnant women, justified the approach for various reasons including high costs (9811761), or "because the department of health dismissed it because they seem that it is harmful to the person, so they don't want to make other people's life in danger" (9922393).

6.4.4.3. Category Three Students' Responses to Technological Literacy Question Four

Category 3 students' responses were generally coherent on whether AZT should be made available to pregnant women. Some students went beyond transmission issues to discuss impacts of the drug on society. A small number of students just speculated on why the drug should be made available and yet others were incorrect because they provided yes/no answers without a justification.

Many of the students were able to describe the effect of the drug AZT as a method of preventing the transmission of the HIV/AIDS virus from mother to child. The understanding of this concept by the students was either explicit or implicit. Explicit responses included: "Yes, ...it should be given to pregnant women to reduce the risk of transmission of HIV from mother to child" (2015226), or "Yes, it will theoretically decrease the amount of HIV-positive people in the country" (2016252). The implicit understanding of transmission came through in statements like "the kid should be given a chance in life. Not die painfully. Aids (sic) is a serious issue" (2003088), or "Yes, the child is not responsible for the mother mistakes" (2004006).

The students in category 3 went beyond transmission issues to discuss impacts of the drug on society. This focus was also a feature of category 2 students' responses but was more amplified in category 3 students' responses. Students raised issues like "...if we prevent the spread from parent to child...when the child becomes a parent, the cycle will not be carried down the generations." (2011748). Another student (2022118) was concerned about side-effects of the drug: "No, the side effects may have been tested over two or a maximum of 5 years, but no one really knows what AZT will do to those children when they are perhaps twenty, or their children." Yet another student (2000222), was concerned that we the earth is approaching its carrying capacity of humans and that HIV/AIDS might be away of natural selection to reduce the population of mankind: "No,...AIDS is a way that nature will use to try prevent a problem with to (sic) many people,...if people died is big, then the population will grow less." Other students were concerned about the challenges associated with caring for orphans: "If the drug is administered to pregnant women, then their babies are born free of AIDS but the fact that the mothers of these children will soon die is often forgotten. These children end up as a burden to a family member or in an orphanage" (2009582).

There were also some speculative answers to the question on whether AZT should be made available to pregnant women. For example, "If this would prevent AIDS victims from transmitting the virus to their children, then yes" (2021378). Other purely speculative responses from students included

justifications for providing the drug based on personal choice (2003744) or provided that additional research is undertaken (2013456).

6.4.4.4. Category Four Students' Responses to Technological Literacy Question Four

Category 4 students' responses were also a combination of well-informed responses, responses that justified why the drug should not be freely available, and simply speculative responses.

Well-informed responses were fairly explicit, showing good understanding of the potential of the drug AZT inhibiting mother-to-child transmission of HIV/AIDS. This knowledgeable set of responses included responses like: "Yes, if AZT is made available to (a) pregnant woman it would prevent the unborn baby to get the HIV" (2014074), or "...It (AZT) decreases the chances of the baby having aids/HIV (sic) very much (2011612), or "...by giving it to all people with aids (sic). The baby could have a better chance of surviving" (9909683).

As mentioned above, there were also responses, which justified why the drug should not be freely available. Some good responses as to why AZT should not be provided pregnant women included: "It could encourage more people to live recklessly" (9916081), or "No, studies has shown that AZT can be a dangerous drug by 'killing' you from inside-out. In fact, AZT was not developed for use for HIV-infected people" (2007642), or AZT should not be available because its side effects are still unknown (2011896).

Responses which were speculative in nature included: "As long as sufficient research has been done on the drug..." (9914891), or "Yes. After all, it's their choice" (9915905), or "If it could save lives yes, but not if it kills" (2003356)

6.4.4.5. Summary of Responses to Technological Literacy Question Four

Thus, the responses to the question on SO7 in the technology learning area, namely: demonstrate an understanding of how technology might reflect different biases, and create responsible and ethical strategies to address them, using the question related to making the drug AZT available to pregnant women, had a spread of responses from inadequate to superior. Category 1 students' responses were inadequate with students either not responding or admitting to having no understanding of the drug AZT. Category 2 students' responses were of three types: 1) a combination of informed answers

which reflected some understanding of the drug and its use; 2) responses which were purely speculative or in which students admitted having no clue about what the drug; and 3) responses which defended the government's standpoint on not making the drug available to pregnant women. Category 3 students were generally able to provide coherent responses to the question on whether AZT should be made available to pregnant women. Some students went beyond transmission issues to discuss impacts of the drug on society. A small number of students just speculated on why the drug should be made available and yet others were incorrect because they provided yes and no answers without a justification. Category 4 students' responses were also a combination of well-informed responses, responses that justified why the drug should not be freely available, and simply speculative responses. The same kind of analysis now follows for the fifth question on technological literacy.

6.4.5. Analysis of Responses to Technological Literacy Question Five

The fifth question on technological literacy related to specific outcome 5 (SO5) in the technology learning area, namely: demonstrate an understanding of how different societies create and adapt technological solutions to problems.

The corresponding task was: *Provide an illustrated example of an indigenous (home grown) form of technology that you have experienced in South Africa.*

This task required the students to think about an example of homegrown technology that they have encountered in their daily lives in South Africa. The idea was not to elicit from them information about some high-tech invention but to get them to think about how have seen technology in action in their daily lives.

6.4.5.1. Category One Students' Responses to Technological Literacy Question Five

Category 1 responses were disappointing in that some students could not extend themselves to even list an example. Those students who did attempt to provide a response listed irrelevant information like the availability of water, electricity, televisions and computers today as opposed to the 'old days' (2002380) when these facilities or appliances were not available. Clearly this is a typical prestructural response because despite the fact that the task was engaged, the students were distracted

or misled by an irrelevant aspect. Yet another response echoing this kind of preoccupation with irrelevance was: "TV is the best technology in our life, the screen of the TV, the sound" (9927847).

6.4.5.2. Category Two Students' Responses to Technological Literacy Question Five

Category 2 students' responses demonstrate that students' perceptions of technology are fashioned by products that are developed outside of their immediate environments. Indeed, the responses to the questions provided by category 2 students were irrelevant, largely inadequate or simply incorrect. The technological devices listed most commonly included recent technological appliances or devices (cell phones, generators, radios, satellite dishes, and sensors), recent advances in technology (local web-sites, computer programmes), or existing technological tools (trip switches, lights, windmills). Only one of the students in category 2 was able to provide an illustrated example of an indigenous (homegrown) form of technology that they have experienced in South Africa. The student provided the example of "the use of natural resources e.g. grass, mud, clay, dung to create insulated dwellings that have a large degree of permanence" (2011966).

6.4.5.3. Category Three Students' Responses to Technological Literacy Question Five

Category 3 students' responses were more elaborate than those offered by category 2 students. Nonetheless, the examples that were provided were generally not part of the daily experiences of the students. They had experiences at air shows or had read about or seen techno-gadgets that impressed them, and talked about them in their responses to this question.

Some of the examples provided category 3 students included: digital video broadcasting (DVB) which "allowed for digital compression and transmission of video" (2021378), the Infra-Red Mobile Lab (IRML) which detects heat sources by means of electronic equipment (2022118), the Rooivalk which is an "attack helicopter with its lazer guided machine gun" (2010060, 2011748), and a calculator that has been transformed into a device used by bushmen to track live game (20018320).

One of the real life examples provided was a "(water) wheel barrow" (actually it is a cylinderical drum) which is used to transport water and heat the water as well. Can be left in the sun to purify and then it is safer to drink" (2015226). This is actually an innovation from an African country but it has relevance in a rural context in South Africa. These kinds of innovations with technology are simple and yet practical. The merits of this device are amazing, particularly with the cholera virus spreading

in parts of South Africa. By heating the water in the sun for 24 hours the cholera virus and other disease spreading organisms are eliminated.

Three students also mentioned the wind-up radio as a technological device, which they have had, experiences with. This device uses mechanical energy provided during winding to supply electrical current to the radio, a device which could bring educational programs and entertainment to areas where there is no electricity.

Some of the responses in category 3 were inadequate or just listed irrelevant information. Some of the inadequate responses included illustrations of a mini-bus or discussion of the first successful heart transplant in the world, which took place in South Africa.

6.4.5.4. Category Four Students' Responses to Technological Literacy Question Five

Category 4 students' responses were similar to those of category 3 students, with the exception of some ingenious responses. Of course, there were also some responses, which were simply inadequate. The routine examples, which were not part of their everyday experiences, included the Rooivalk helicopter, G6 and G5 cannons, recent computer programmes, and radar and avionic systems. Also, the examples that have significance in a rural context, were reiterated: the water barrow and the wind-up radio.

The ingenious responses included the making of a rotisserie braai driven by a tape deck of an old radio motor (20104074), and the prevention of coastal erosion by developing a buffer between land and sea with a substance called "dollosse" (2014398).

6.4.5.5. Summary of Responses to Technological Literacy Question Five

Thus, the responses to the question on SO5 in the technology learning area, namely: demonstrate an understanding of how different societies create and adapt technological solutions to problems, were interesting and included fairly simple responses like the wind-up radio to more complex examples of the Rooivalk. Category 1 responses were disappointing in that some students could not extend themselves to even list an example. Those students who did attempt to provide a response listed irrelevant information. Category 2 students' responses were irrelevant, largely inadequate or simply incorrect. Category 3 students' responses were more elaborate than those offered by category 2

students. Nonetheless, the examples that were provided were generally not part of the daily experiences of the students. Category 4 students' responses were similar to those of category 3 students, with the exception of some ingenious responses. Of course, there were also some responses that were simply inadequate.

6.4.6. Analysis of Responses to Technological Literacy Question Six

The sixth and final question on technological literacy related to specific outcomes 1 and 2 (SO1 and SO2) in the technology learning area, i.e.:

SO1. Understand and apply the technological process to solve problems and satisfy needs and wants.

SO2. Apply a range of technological knowledge and skills ethically and responsibly.

The corresponding task was:

Suppose that the University of Pretoria decided to embark on an active campaign of community service and enlisted the support of its students. You have been requested to assist with resolving sanitation problems at an informal settlement for a population of 100 residents. You have the daunting task of applying your knowledge and understanding of sanitation issues to develop a system that is cost effective and convince the local community that the system that you develop is in their best interest. Prepare a detailed description of how you would approach this challenge. Your response should be restricted to a page and include details on:

Investigations Pursued:
Design and Planning:
Modifying Systems to Suit Contexts:
Sensitivity to the Issues and Choices in the Community of Informal Settlers:
Final Recommendation:

This question required a careful analysis of the state of sanitation at the settlement, and the subsequent development of an intervention to resolve the challenges in accordance with the steps identified above. The sequence of steps was derived from the suggested sequence in the Technology learning area as outlined in the Discussion Document of C2005 (DOE 1997a).

6.4.6.1. Category One Students' Responses to Technological Literacy Question Six

Category 1 students demonstrated an eagerness to answer the first two components of this question, namely investigations pursued, and design and planning. Thereafter their interest waned and they provided irrelevant or no responses. Some of the responses to the first two components were also either irrelevant or simply a repetition of the information in the question. For example, "I'll plan and design very well for it is a big task" (2008802). However, other responses to the first two components were impressive. Some students (2002380) started investigations very positively stating that they would first identify the worst spots in the area. Others (2028748) focused on aspects like population size, coping strategies, solutions provided by the community. The design and planning sessions recommendations included setting up a poster, and calling a meeting of the residents to let the informal settlers know that other residents are concerned about them (2002380). Another student (2012758) suggested that fines should be issued to enforce cleanliness, and that more people must be engaged to keep the bathrooms clean. One student (2028748) wanted to schedule visits and use a group approach to solve problems.

As mentioned above, the remaining three components of this question: modifying systems to suit contexts; sensitivity to the issues and choices in the community of informal settlers; and the final recommendation, had mostly no responses, or the occasional irrelevant answer or a repetition of information from the question. The only sensible answer to the sensitivity component was a response which emphasized that one should "let the community decide what to do" (2002380), thus showing an appreciation for the way the locals feel about solutions.

6.4.6.2. Category Two Students' Responses to Technological Literacy Question Six

Generally, category 2 students' responses were more refined than category 1 students' responses. Some students exhibited the general pattern of category 1 students because they answered the first two components of the question and simply ignored the remaining three components. The responses of category 2 students to all the components of question six will be discussed below.

In the component on investigations pursued, there was a combination of responses on a continuum from inadequate through to impressive. Inadequate responses included those with irrelevant detail or simply inadequate responses e.g. the exploration of a "high HIV rate" (2028176), which has no relevance to this situation of poor sanitation. Better responses entailed conducting a reconnaissance

in a variety of ways. Some students proposed to "approach the experienced individual(s) for their guide" (2012418), others wanted to observe the settlement to examine, what kind of rubbish is present the most and what are the possible causes of these problems, the sources of water, number of waste disposal sites, and how many toilets need to be built, and the kind of facilities that would be suitable.

Some of the impressive methods of investigation included: "Is the cause of the problem lack of access to facilities or negligence" (2010106), "no toilets, no running water, no refuse removal, identify each one and see the seriousness of the impact on the population" (2016474). Another student (2011966) explored "potential diseases, costs of improving facilities, examination of existing drainage sewers and pipelines." Many of the students focused on the cost effectiveness of proposed solutions. The solutions offered to cost related challenges included the identification of sponsor companies

In the component on design and planning, cost-effectiveness was a pervasive component. Many of the students in category 2 were in favour of getting the community involved and wanted "to enlist support of people to clean up, insert facilities and running water, and get refuse removal" (2016474). The responses can be labelled as inadequate, routine, innovative and impressive. Inadequate responses included those that persisted with irrelevant detail like the "HIV focus" (2028176) or simply provided a restatement of the question. Routine responses entailed plans to "build new structures near sewers and drainage, ample supply of water, taps and basins" (2011966), or provide a sufficient number of trashcans and a refuse collection service. Other students wanted a proper bath and toilet facility for everyone or a good piping layout. Yet another student (2000972) proposed: "I would put portable sanitary toilets everywhere they are needed."

Innovative responses included an advocacy campaign with posters and pamphlets. One student (2013936) encouraged a partnership between private companies and the local community to integrate solutions offered into one plan. Another innovation proposed that the community should, "build toilets higher than ground level to prevent overflow of the toilets" (2014878).

Impressive design entailed assumptions like if there are 4 people per family then 100 residents would require 25 toilets. The students also proposed that the toilets should be positioned according to household locations and appropriate sewerage pipes. Other impressive responses focused on quality and aesthetics. The emphasis on quality was qualified as a need for good plumbing and fitting facilities. Others were keen on the need for "durable" toilets and good sewerage facilities. With

regard to aesthetics, one student (2002488) stated categorically that: "The result must be aesthetically pleasing, daily cleaning must take place, maintenance must be ongoing."

The component on modifying systems to suit contexts was generally poorly answered by category 2 students with the exception of the odd, meaningful response. By and large, students in category 2 either provided irrelevant or inadequate responses. Some of the students even repeated the questions as a response. The few meaningful contributions included the "introduction of running water and toilets" (2008020), the development of an "underground pipeline to a sewerage farm, all water levels are lower than the facilities, therefore no overflowing" (2014878), and a concern about durability in that "facilities must be built to last e.g. tough and practical ablutions" (2011966). One student even suggested the establishment of a dumping site for the community.

Students in category 2 also provided poor answers to the component on sensitivity to the issues and choices in the community of informal settlers. Just under half of the students either did not answer or provided irrelevant answers, e.g. "order should be there" (2013986). Some of the students were also very instructive towards the community: "tell them exactly what is happening" (2001546).

Most of the remaining students were keen on engaging the community by listening to their complaints, opinions, views and beliefs. Two of the students emphasized that the solution must be convenient or appropriate for the community. Students were also sensitive to the limitations of the community and this was expressed in statements like: "They don't really have the money to buy..." (2017578). One student appreciated the involvement of the community but emphasized the need to remain within the budget.

The final recommendation component of the question was also poorly answered with more than half the students providing no response and irrelevant or inadequate responses. The remaining students provided a few average, and a variety of satisfactory, final recommendations.

The average or standard responses were pertained to the installation of taps every 5km, and building about 10 toilets close to the living area of the community. Many of the satisfactory final recommendations involved community participation. The community involvement entailed the education of the community to assume responsibility and address the sanitation challenges. These challenges included the community helping to construct sanitary facilities, spreading awareness of sanitation, or raising funds to build sanitary facilities. One student (2013886) also proposed that the

community pay a minimum cost to use the system. Some other satisfactory responses included enlisting support of various organizations to solve the problems and starting a fund-raising campaign for the community. Two of the final recommendations related to the development of cost effective solutions.

This concludes the analysis of category 2 responses to the sixth question on technological literacy. The analysis of category 3 students' responses follows below.

6.4.6.3. Category Three Students' Responses to Technological Literacy Question Six

Category 3 students' responses had a greater depth than category 1 and 2 students' responses. This depth was revealed in some highly technical responses as illustrated below. Further, unlike the previous two categories of students, a silent or irrelevant or inadequate response to components of question six was rare.

In the component on investigations pursued to resolve the challenges of poor sanitation, the category 3 students presented very intriguing approaches to their investigations. For example, some students wanted to explore the replication of solutions that were applied in similar situations elsewhere. Others were more enterprising in their approach in that they wanted to pursue a combination of geological (soil type and ground stability) and meteorological (weather conditions) surveys together with urban planning strategies to ensure that the system is scalable and adaptable. Cost effectiveness and community participation were pervasive issues.

Many of the investigations included a focus on cost effectiveness, e.g. who would finance the project, can the community afford to pay for a viable sanitation system, and what would be the cost to erect public sanitation structures for communal use.

Community involvement was also a key factor for many of these students. They were interested to know whether the community was willing to assist, and whether they would be able to maintain the system. The knowledge of the settlers about sanitation was also questioned, and most importantly, "what are the needs of the people?"

There were also routine responses, and the most common approach was to determine what facilities were available, what needs to be improved. Others areas of category 3 students' interest included the

community's access to and sources of water, the geographical layout of the settlement including the water-table level; available space to erect water facilities; garbage removal; risks of disease; and the impact of a new sanitary system on the community.

The design and planning component provided category 3 students with an opportunity to demonstrate their creative flair and technical insights into the resolution of the problem of poor sanitation in an informal settlement. There were some very informed solutions that proposed laying out the settlement in a grid pattern as is common for residential areas; or that water towers should be placed on high-lying land, and purification plants must be placed away from the settlements. Therefore, the quality of responses in category 3 was superior to those in categories 1 and 2.

The key categories of the remaining responses pertained to the centralization of sanitation facilities, creative strategies of dealing with high costs, community involvement, kinds of sanitation systems, and geological considerations.

In an attempt to centralize the facilities that would be made available to the community, category 3 students proposed "communal sanitization areas." These communal areas consisted of one bathroom/shower/toilet combination for every 5 people, or an ablution block per row of houses. One student insisted that the communal facilities ensure privacy.

The cost challenges were also addressed very creatively through corporate sponsorships, or through government subsidies. Some category 3 students wanted the community to raise their own funds through collecting paper, plastic, glass and soft drink cans for recycling purposes. Other students wanted the people to pay for water and electricity. The cost saving devices were impressive as well, e.g. the use of showers that do not run for more than 10 minutes, and toilets with half flushes for urination and full flushes for defaecation.

Community involvement was another pervasive theme in the design and planning component. The category 3 students were keen to engage the community in the construction of plumbing facilities, maintenance, pick-up and clean-up operations, and in advocacy. With regard to advocacy, the idea was to first raise awareness of hygiene and sanitation issues by making a presentation to the people, using posters, or getting health officials to explain effects of unhygienic living. The establishment of facilities would result in the creation of jobs if the community were willing to be engaged as described above. An important consideration, which did not feature in the categories 1 and 2, was to

consider the impact of population growth when designing facilities. The proposed design operated on a fixed ratio of residents to new facilities.

The systems that the students in category 3 proposed included features like easy accessible piping for maintenance, placement of septic tanks, rental portable toilets, and use of water channels. The students were keen to use existing designs for the layout of an efficient sewerage processing plant, also install as many fresh water points as possible. The students also wanted to make sure that regular removal of garbage took place.

The geological focus of the category 3 students came through in responses that suggested an examination of the location of the settlement to establish whether it is in a hole or on a mountain. Other students wanted to create detailed maps of the area, including stand numbers as well as any services already in place.

In the modifying systems to suit contexts component there were some interesting answers which suggested the water purification systems may have to be adapted for low-cost operation, or link the system to the municipal plant. Some students reiterated their design and planning ideas like "construct sewers and plumbing facilities to provide plumbing to every house or construct facilities at every block, similar to the system used at hotels" (2002290) or develop a centrally located water resource. The less interesting responses pertained to establishing portable toilets or pit latrines, and some students offered cautionary advice like do not overstrain the existing system. There were also quite a few inadequate responses and even some restatements of the question.

The sensitivity to the issues of the community component had a mixed set of responses from category 3 students. By and large, students were keen to get the community involved or reach a compromise between the community's and students' views. The few students who were insensitive made some indifferent comments like, "They would just have to accept what is given to them" or encouraged the students just to raise awareness of sanitation system and not to consult with the community. Some of the students offered interesting approaches to solve the win the favour of the community by suggesting that students be persuasive, or that they offer an incentive for the community to implement the new system.

The final recommendations component was essentially a reiteration of some of the key ideas that featured in the four components of question six that preceded this component. Some of the

reiterations included portable toilets, durable structures, regular refuse removal, supply of antiseptics for toilets, a central water resource or bathroom/shower/toilet, and low maintenance, low-tech filtration and water management systems. Many of the final recommendations emphasized the critical role of the community to ensure the success of the system as in: "Empower the community to sustain the system by providing them with the "necessary start and skills..." (2015226). Other students focused on cost-effective solutions. Inadequate or no responses were rare.

6.4.6.4. Category Four Students' Responses to Technological Literacy Question Six

Category 4 students' were expected to be as impressive as category 3 students, if not better. They shared the same technological literacy level of 3, but category 4 students had a higher scientific literacy level. However, category 4 students' responses, although similar to those of category 3 students, was not as impressive in technical detail. Surprisingly, there were several inadequate or silent responses.

In the investigations pursued component of question six, category 4 students provided a combination of routine and some impressive responses. The two persistent foci of the investigations pursued component included cost analysis and the involvement of the community. Cost analysis entailed exploring the use of local and inexpensive materials like underwater piping, and identifying available funds for the project. Community involvement entailed eliciting the views of the community and incorporating them into plans. Students also wanted to know if the communities were responsible for any of the problems.

The routine responses included, amongst others, consultations and on-site inspections to identify the existing sources of water and associated health risks, the kind of facilities that already exist, the waste removal systems that exist, the exact number of residents and their requirements of the community. Some students also focused on geological factors like the location of the settlement, the type of soil, and explored piping layout to avoid disturbing houses.

The impressive features presented by category 4 students included the installation of boreholes, tapping into neighbouring water systems, and the concept of septic tanks was elaborated with illustrations. Another interesting feature, which did feature in other categories, was to research solutions proposed in other countries and adapt them accordingly in South Africa.

The design and planning component of question six provided some good insights into sanitation issues. For example, as boreholes were being recommended the possibility of contamination by seepage from toilets did exist, and students therefore recommended that the new toilets or pit latrines be situated approximately 100m away from the water sources and the community. Additionally, the use of septic tanks was emphasized for purification.

Students also offered centralized and decentralized design and planning options to the community. The centralized option necessitated a shared ablution block for every six houses or a cluster living pattern to facilitate use of the common ablution facility. The decentralized option was, of course, the installation of a bathroom and toilet facility in each residence. Students suggested that 20 such facilities be installed for the 100 residents, which translates into a maximum of 5 people per facility. As an interim measure, it was also suggested that temporary sanitation facilities be installed. Other proactive measures entailed exploring the cost of extending the existing sanitation, and checking for the possibility of establishing boreholes.

The community was also involved in the designing and planning, as they were to provide the required labour to establish and maintain the system. For example, when the pit latrines were full, new ones had to be developed by the community. Other community responsibilities entailed refuse removal, laying of pipes for sewers, daily removal of sewerage when applicable and purifying borehole water before using it. The usual cost considerations were mentioned, as in cost-effective underwater piping being installed. More elaborate design and planning measures included the use of architects or engineers to design a suitable system.

The modifying systems to suit contexts component of questions six was unsatisfactorily answered, and had an unusually high number of inadequate or silent responses. There was also a fair amount of repetition with students recommending that the new system be designed to cope with contamination of water due to seepage. Also, the regular removal of sewerage and use of septic tanks was reiterated. The only reasonable responses pertained to supply pipe diameter being smaller at the point of supply and consideration of future upgrades when installing facilities.

The sensitivity to issues and choices of the community of informal settlers component of question six elicited positive feedback from category 4 students. Students were very sympathetic to the community's needs and respected their views. They explored several options to solicit ideas from the community. For example, meetings with the community were proposed, negotiating with the

residents to determine the location of the facilities, eliciting feedback from community about their relocation, and seeking final approval from the community about facilities that will be established. Category 4 students also understood that some members of the community might not be familiar with the causes of disease and other effects of poor sanitation and they offered to educate the community.

In the final recommendation component of question six, category 4 students' responses related largely to community endorsement before a final submission to the contractor to the develop system. Many of the students just reiterated some of the ideas that emerged in the previous components of the question. Their terse responses included: an ablution block for every six people, septic tanks for toilets, regular refuse removal, establish bore holes and pit latrines, and the development of cost-effective but efficient systems with educated residents to maintain systems.

6.4.6.5. Summary of Responses to Technological Literacy Question Six

Thus, the responses to the question on SO1 and SO2 in the technology learning area varied considerably across the different categories of students. The completeness and the quality of the responses increased proportionately as we progressed from categories 1 to 3 and category 4 students were satisfactory but not impressive. A brief summary of the responses of each category of students follows.

Category 1 students demonstrated an eagerness to answer the first two components of this question, namely investigations pursued, and design and planning. Thereafter, their interest waned and they provided irrelevant or no responses.

Category 2 students' responses were more refined than category 1 students' responses. Some students exhibited the general pattern of category 1 students because they answered the first two components of the question and simply ignored the remaining three components. In the component on investigations pursued, there was a combination of responses on a continuum from inadequate through to impressive. In the component on design and planning, cost-effectiveness was a pervasive component, and the responses were inadequate, routine, innovative and impressive. The component on modifying systems to suit contexts was generally poorly answered by category 2 students with the exception of the odd, meaningful response. Students in category 2 also poorly answered the component related to sensitivity to the issues and choices in the community of informal settlers. Just under half of the students either did not answer or provided irrelevant answers. The final

recommendation component of the question was also poorly answered with more than half the students providing no response and irrelevant or inadequate responses. The remaining students provided a few average and a variety of satisfactory final recommendations.

Category 3 students' responses had a greater depth than category 1 and 2 students' responses. This depth was revealed in some highly technical responses. Further, unlike the previous two categories of students, a silent or irrelevant or inadequate response to components of question six was rare.

In the component on investigations pursued to resolve the challenges of poor sanitation, the category 3 students presented very intriguing approaches to their investigations. Others were more enterprising in their approach in that they wanted to pursue a combination of geological (soil type and ground stability) and meteorological (weather conditions) surveys together with urban planning strategies to ensure that the system is scalable and adaptable. Cost effectiveness and community participation were pervasive issues.

In the design and planning component, there were some very informed solutions. The key categories of the remaining responses pertained to the centralization of sanitation facilities, creative strategies of dealing with high costs, community involvement, kinds of sanitation systems, and geological considerations.

In the modifying systems to suit contexts component there were some interesting answers, but some students reiterated their design and planning ideas, and some less interesting responses like portable toilets. There were also quite a few inadequate responses and even some restatements of the question.

The sensitivity to the issues of the community component had a mixed set of responses from category 3 students. By and large, students were keen to get the community involved or reach a compromise between community's and students' views. The few students who were insensitive made some indifferent comments. Persuasion and the use of incentives were encouraged.

The final recommendations component of category 3 students was essentially a reiteration of some of the key ideas that featured in the four components of question six that preceded this component.

Category 4 students' responses, although similar to those of category 3 students, were not as impressive in technical detail. There were also several inadequate or silent responses. In the

investigations pursued component of question six, category 4 students provided a combination of routine and some impressive responses. The two persistent foci of the investigations pursued component included cost analysis and the involvement of the community. The design and planning component of question six provided some good insights into sanitation issues. Students also offered centralized and decentralized design and planning options to the community. The modifying systems to suit contexts component of questions six was unsatisfactorily answered, and had an unusually high number of inadequate or silent responses. There was also a fair amount of repetition. The sensitivity to issues and choices of the community of informal settlers' component of question six elicited positive feedback from category 4 students. Students were very sympathetic to the community's needs and respected their views. They explored several options to solicit ideas from the community. In the final recommendation component of question six, category 4 students' responses related largely to community endorsement before a final submission to the contractor to the develop system. Many of the students just reiterated some of the ideas that emerged in the previous components of the question.

6.5. Conclusion

This chapter examined critical question 3, i.e. what were the levels of technological literacy in the selected cohort of undergraduate science students? The principal focus of this chapter was on the qualitative analysis of the results of the technological literacy test completed by the selected students. This qualitative analysis was preceded by two quantitative precursor components.

After providing, amongst others, a brief review of the linkages between the technological literacy outcomes of C2005 and the six technology related questions that featured in the questionnaire; and confirming the near normal distribution of the data, the true qualitative analysis commenced. The results of the analysis revealed that, as predicted in chapter one, that one way to demonstrate an outcome in technology, is to use open-ended, yet focused, questions. However, an assessment system, which quantifies the responses to these open-ended questions, is not yet in place in South Africa. One of the options, which South Africa may choose from in assessing the qualitative outcomes outlined in C2005, is the SOLO Taxonomy as described in chapter three.

In using the SOLO taxonomy to analyze the six technology related questions, there were two distinct phases. First, assigning a SOLO taxonomy status and number to a response like pre- (1), uni- (2) or multistructural (3), relational (4), or extended abstract (5). The technological literacy scores of the

students were confined to the prestructural, unistructural, and multistructural levels with rounded scores of 1, 2 and 3 respectively out of a total of 5. None of the students were able to score at the relational or extended abstract level, which required scores of 4 and 5 respectively out of a total of 5. It is important to note that the technological literacy score of a student in this study represented the ***mean*** score for 11 sub-questions. Therefore, if a student were classified as unistructural, it did not preclude the possibility of that student having some uni- and multistructural responses as well. The technological literacy levels of the students were then combined with their scientific literacy levels and there was considerable overlap. The combined categories (see Table 6.5. p.138) were used to analyze the responses qualitatively.

The qualitative analysis revealed that for each of the six technology related questions, there was a generally a spread of responses from inadequate to superior, and the quality of the responses were generally aligned to the categories of students. For example, the responses to the question on selecting and evaluating products and systems (i.e. describing the technological features of a cell phone) started with category 1 students who were either incorrect, avoided answering the questions, focused on irrelevant information, or provided incoherent responses. Category 2 students' responses were a combination of mediocre and poor responses. Category 3 students offered more refined responses than their counterparts in categories 1 and 2. Category 3 students still provided a list of technological factors but enhanced the list with the use of labels like ergonomics. Category 4 students' responses were similar to those of category 3 students.

One can conclude from this illustrated analysis of the question related to a cell phone, that in order to successfully demonstrate the associated outcome of selecting and evaluating products and systems, there are different levels through which learners must progress. Sure, some learners may be able to automatically qualify at the SOLO taxonomy level of multistructural or even extended abstract level. However, there are other students who will be confined to pre- and unistructural levels when they first encounter the challenges presented in demonstrating an outcome. These students will have to be guided through processes that will elevate their understandings to reach higher SOLO taxonomic levels.

The sad reality is that many educators, education officials and academics are proceeding with the implementation of C2005 without this understanding of how to quantify essentially qualitative outcomes. While Chisholm et al (2000) made several recommendations on the proposed changes to the structure of the curriculum, there was a distinct silence on simplifying the assessment of outcomes as illustrated with the SOLO Taxonomy above. Killen (2000) argues that in order to provide more useful feedback to learners, we need a systematic way of describing how we arrived at our qualitative judgements and he proposes the SOLO taxonomy as one system to achieve this outcome. The foregoing analysis confirms that the SOLO taxonomy is a feasible option to pursue when assessing qualitative answers.