Chapter Five

An Analysis of Scientific Literacy Levels of Traditional Science Curriculum Students

5.1. Orientation to the Chapter

This chapter will examine critical question two, i.e. what were the levels of scientific literacy in the selected cohort of undergraduate science students? As mentioned in chapter one, the second critical question is included to determine the effects of the traditional science curriculum on scientific literacy levels of the students. This critical question presents science 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 scientific literacy levels. This alignment to C2005 represents a new dimension in the measurement of scientific literacy levels. The principal focus of this chapter is on the analysis of the results of the scientific literacy test completed by the selected students. This analysis is preceded by two precursor components. First, a preview to the data analysis component to highlight factors that will inform the analysis of scientific literacy scores. Second, a tests and plots component to establish whether the scientific literacy scores of the selected students are normally distributed.

5.2. Preview to Data Analysis

This component of the chapter orients the reader to the analysis of scientific literacy data by briefly addressing two foundational issues. First, a discussion on the nature of the scientific literacy questions. Second, the rationale for testing the scientific literacy data for normality, and subsequent tests and frequency plots to test for normality of the data.

The source of data pertaining to the scientific literacy levels of the students, as mentioned in chapter three (see sub-section 3.4.1.2. pp.49-53), were twenty multiple-choice questions that were linked to four science themes (Earth & Beyond, Matter & Materials, Life and Living, and Energy and Change) from the Natural Science learning area of C2005. The twenty questions were part of the all-inclusive questionnaire that was administered to the students. The twenty questions were not confined to conceptual knowledge exclusively as they included a distinct element of extrapolation and application of the science concepts to real life situations. Thus, the questions lent themselves largely to the

"comprehension and application levels" in Bloom's taxonomy of educational objectives: cognitive domain, (Ornstein & Hunkins 1998:280). Comprehension and application are the second and third levels in Bloom's hierarchy of educational objectives: cognitive domain. There were also questions that were more suited to Bloom's first level of educational objectives, namely: knowledge. Bloom's fourth, fifth and sixth levels of educational objectives (analysis, synthesis, and evaluation respectively) did not feature in the classification of the twenty questions on scientific literacy. It must be emphasized that the use of Bloom's taxonomy is purely for the convenience of reviewing the data on scientific literacy, and Bloom's behaviourist principles have in no way been extended to this study. The variables, themes, concepts, and Bloom's levels of educational objectives: cognitive domain, which were linked to the twenty questions on scientific literacy, are listed in Table 5.1. below:

Variable	Theme	Concept/s	Bloom's Taxonomy Level
2	Earth & Beyond	Greenhouse effect	Knowledge
3	Earth & Beyond	Acid Rain	Comprehension
4	Earth & Beyond	Ozone depletion	Knowledge
5	Earth & Beyond	Seasons	Comprehension
6	Earth & Beyond	Force of Gravity	Application
7	Matter & Materials	Density	Application
8	Matter & Materials	Inertia	Application/Knowledge
9	Matter & Materials	Action- Reaction	Application/Comprehension
10	Matter & Materials	Momentum	Application/ Comprehension
11	Matter & Materials	Boiling Point	Comprehension
12	Life and Living	Cellular respiration	Knowledge
13	Life and Living	DNA	Comprehension
14	Life and Living	pH	Comprehension
15	Life and Living	Enzymes	Comprehension
16	Life and Living	HIV/AIDS	Comprehension
17	Energy and Change	Electricity	Knowledge
18	Energy and Change	Energy Changes	Application
19	Energy and Change	Conduction	Knowledge
20	Energy and Change	Colour	Comprehension
21	Energy and Change	Friction	Application

Table 5.1. The Classification of Scientific Literacy Questions according to theme, concepts, and Bloom's levels of educational objectives: cognitive domain

Now that the nature of the questions on scientific literacy has been visited, the second foundational issue of this sub-section can be explored, namely normality of the scientific literacy data. As mentioned above, the testing of the scientific literacy data for normality was necessary as the variable on the scientific literacy represented a dependent variable in this study. Scientific literacy was dependent on a variety of factors including the first language of a student. 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 nature of the tests and frequency plots conducted included the Shapiro-Wilk statistical test, and stem-and-leaf plots, box plots, and probability plots. The Shapiro-Wilk statistical test was administered to establish whether the data related to scientific literacy were normally distributed. Thereafter, stem-and-leaf plots, box plots, and probability plots were completed to illustrate the distribution of the scientific literacy data (see Figure 5.1. p.116). These plots are presented alongside one another below for each data set to illustrate the distribution of the same data in three different ways. The results of the Shapiro-Wilk statistical test and frequency plots are discussed below.

5.3. Tests and Plots for Normality of Scientific Literacy Scores

The Shapiro-Wilk test statistic value of 0.978239 ($p = 0.0087$) 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 scientific literacy test scores of the students is displayed more prominently in each of the frequency plot illustrations that follow:

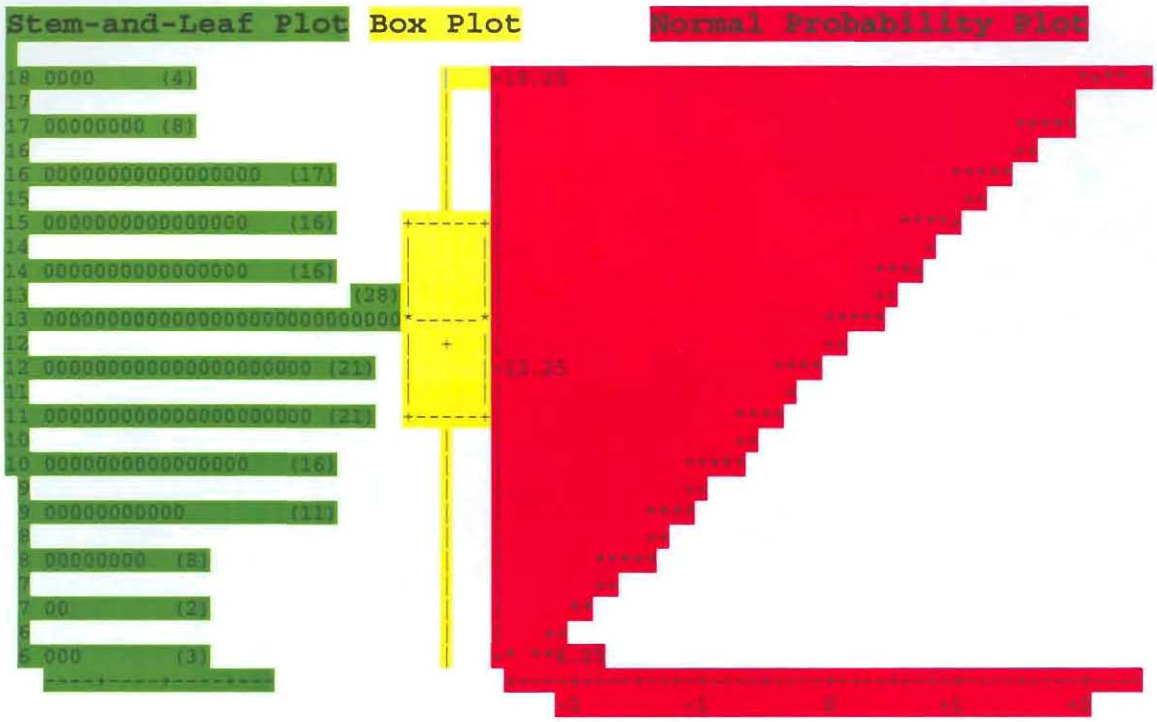

Figure 5.1. Frequency Plots of Scientific Literacy Scores

The stem-and leaf plot corresponds closely with a bell shaped distribution of the data on scientific literacy scores, hence a near normal distribution can be assumed. The mode and the peak are at a score of 13, with a frequency of 28. The bell shape extends over a range of scores from 16 through to 10, and the base of the bell becomes asymptotic with the limited number of low frequency scores of 17 to 18 on one side, and 6 to 9 on the other side.

The Box plot confirms the near normal distribution of the data on scientific literacy scores with a clustering of scores between 11 and 15 and a symmetrical distribution on either side. The median of the box plot is indicated by the central horizontal line, and the central + sign indicates the mean. The box plot is slightly negatively skewed because the mean is less than the median. The near normal distribution is expressed by the closeness of the median and mean in the box plot.

The Normal Probability plot yielded almost a straight line indicating a near normal distribution of the data on scientific literacy levels of the students.

Thus, the three frequency plots are in sync and the deviation from normality of the scientific literacy scores can be considered minimal.

Further analysis of the frequency plots yielded the following observations:

LOWEST SCORE		HIGHEST SCORE		MEAN	MEDIAN	MODE
Value	Frequency	Value	Frequency			
6	3	18	4	12	13	13

Table 5.2. Statistical Overview of Scientific Literacy Levels of the Students

According to Table 5.2, the lowest score was 6 with three students achieving this score, and the highest score was 18 with four students achieving this score. As mentioned above, the mean and median differ slightly and this is illustrated in Table 5.2. with a differential of just one between the mean and median of 12 and 13 respectively.

The above tests for normality, frequency plots and analysis of extreme observations related to the data on scientific literacy levels of the students all helped to provide an understanding of the parameters and patterns of the scientific literacy levels of the students. It also helped to contribute to an objective assessment and acceptance of the normal distribution of the scientific literacy data. Thus, parametric statistical tests can be used to analyze the data on scientific literacy.

Now that both the nature of the questions and the distribution of the data have been discussed, the focus of this chapter will now shift to the analysis of scientific literacy levels.

5.4. Analysis of Scientific Literacy Levels of the Selected Cohort of Science Students

This component of the chapter will address critical question two, namely, what were the levels of scientific literacy in the selected cohort of undergraduate science students?

To determine the levels of scientific literacy of the students, the following method was employed:

The variables V2 through to V21 related to the test for scientific literacy, i.e. questions that related to the conceptual knowledge of science as well the application of that knowledge in life were provided to students (see sub-section 3.4.1.2. pp.49-53, and Appendix 1).

The correct responses to these questions are listed in Table 5.3. below:

Variable	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Correct Response	4	2	4	3	4	3	4	1	1	4	3	3	4	4	4	4	3	2	2	2

Table 5.3. Correct Responses to Scientific Literacy Questions

It was originally intended to classify students as follows:

<8/20 = Scientifically Illiterate
9 to 12 = Mediocre Scientific Literacy
12 to15 = Good Scientific Literacy
16 to 20 = Excellent Scientific Literacy

A cluster analysis was then performed using the Centroid method and the clusters reflected above were adjusted for consistency with the statistically generated clusters. Therefore, the group referred to as scientifically illiterate had to be those with scores that were less than or equal to 8, and the mediocre scientifically literate students became those with scores of 9 to 11 out of 20. The last two groups, good and excellent scientific literacy remained unchanged. The statistical classification using the Centroid method therefore led to boundary changes for two of the original groups.

The distribution of students' scores for scientific literacy were as follows:

Ranges of Scores out of 20	**Category**	**Number of Students**	**Percent**
Less than or equal to 8	Scientifically Illiterate	13	7,6
9 to 11	Mediocre Scientific Literacy	48	28,1
12 to 15	Good Scientific Literacy	81	47,3
16 to 20	Excellent Scientific Literacy	29	17,0
		N =171	100

Table 5.4. The General Distribution of Students' Scores for Scientific Literacy

It can be discerned from Table 5.4. that most of the scores for scientific literacy were clustered between 9 and 16 with some of the scores being distributed on the extremes. Thus, the majority (approximately 75,4 %) of the students were of mediocre or good scientific literacy, and a limited number (7,6 %) of students were scientifically illiterate, and a reasonable number (17 %) of the students had an excellent scientific literacy.

The detailed distribution of scientific literacy scores reveals a range from 6 through to 18. Table 5.5. below illustrates the detailed distribution of students' scores for scientific literacy. The acronym TOTS is used to abbreviate the total score for scientific literacy. The FREQ Procedure data were used to generate Table 5.5.

Scientific Literacy or TOTS	Frequency	Percent
6	3	1.8
7	2	1.2
8	8	4.7
9	11	6.4
10	16	9.4
11	21	12.3
12	21	12.3
13	28	16.4
14	16	9.4
15	16	9.4
16	17	9.9
17	8	4.7
18	4	2.3

Table 5.5. The Detailed Distribution of Students' Scores for Scientific Literacy

The original categorization of students according to their levels of scientific literacy intended to classify students with scores of less than 8 into a scientifically illiterate category. However, from Table 5.5, it is obvious that this would have meant that only 5 students would feature in this category, i.e. those with scientific literacy scores of 6 and 7 out of 20. Therefore, as mentioned in section 5.4, when the Centroid method of cluster analysis was applied, the boundaries of this

scientifically illiterate category were redefined to include a score of 8, thereby making the data more statistically viable. Hence, the category of scientifically illiterate was comprised of 13 students.

Table 5.5. also reveals that there were no absolute scores for scientific literacy, i.e. none of the students achieved a score of 20 out of 20. Also, none of the students scored 0 to 5 which means that those in the scientifically illiterate range (0 to 8 out of 20) were clustered on upper end of the scientifically illiterate continuum. Additionally, Table 5.5. shows that the most frequent score for scientific literacy was 13 out of 20 with 28 students or 16,4 % recording that score. This finding was also discussed in the Stem-and-Leaf frequency plot analysis of scientific literacy data above (see sub-section 5.3. pp.115-117).

These detailed scientific literacy scores are accentuated in the Figure 5.2. below.

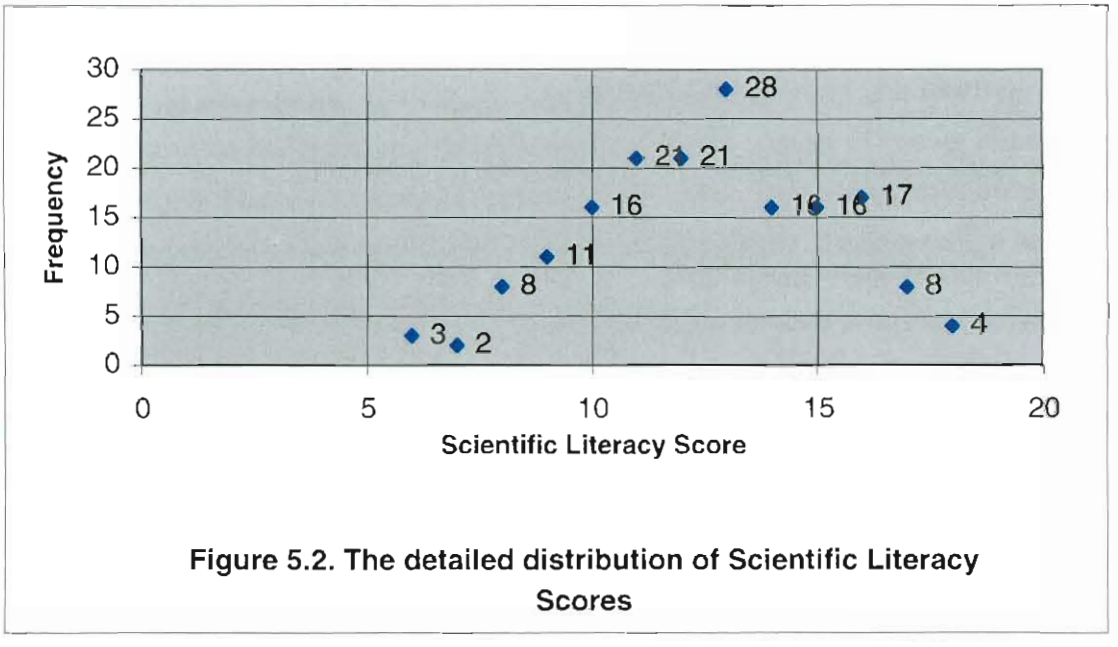

Figure 5.2. The detailed distribution of Scientific Literacy Scores

The above scores for scientific literacy were then examined to determine which questions were answered correctly in each of the categories of scientifically literate students. Such an analysis revealed patterns with regard to the nature of questions correctly answered by each of the groups. This is a new dimension in the analysis of the scientific literacy levels of the students. The analysis entails an examination of the questions with the most, moderate and least number of correct responses by concept, theme, discipline, and an explanation of the patterns that emerge. The analysis of the scores for scientific literacy of each group of students (Scientifically Illiterate, Mediocre Scientific Literacy, Good Scientific Literacy, Excellent Scientific Literacy) is presented below.

5.4.1. Analysis of Scientific Literacy Scores of Scientifically Illiterate Students

The first group of students analyzed were the ones with total scores of less than or equal to 8 out of 20 for the test on scientific literacy. They were thus classified as scientifically illiterate, and the total number of students that were in this category was 13. Figure 5.7. below depicts the frequency of correct responses against the variables linked to the questions on scientific literacy.

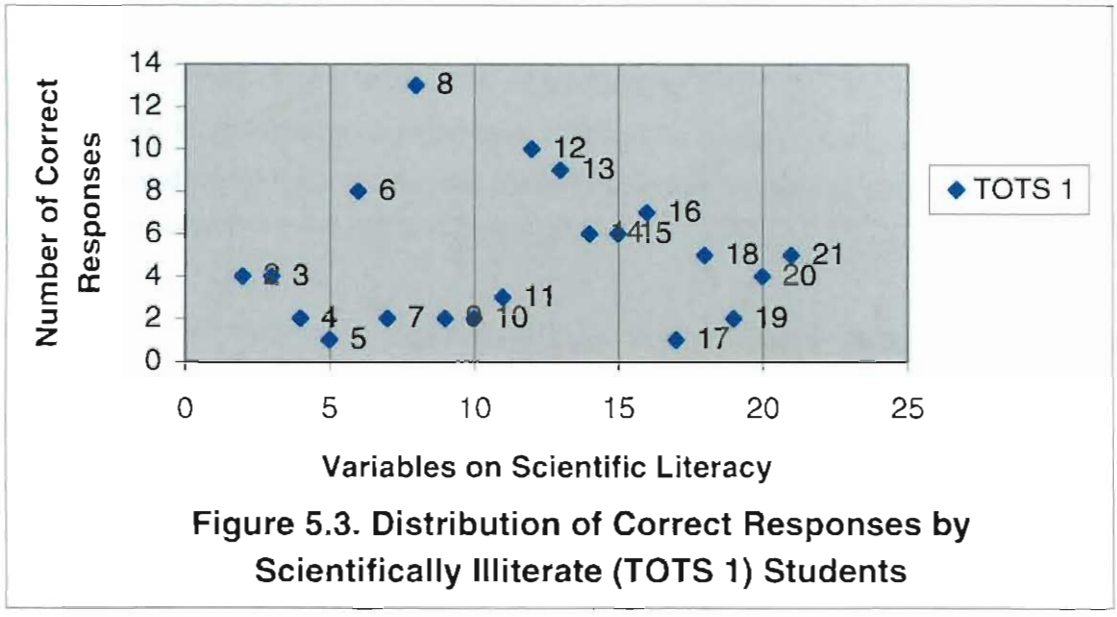

Figure 5.3. Distribution of Correct Responses by Scientifically Illiterate (TOTS 1) Students

According to Figure 5.3. the scientifically illiterate students provided the most number of correct responses for variables 8 (100 %), 12 (77 %) and 13 (69 %). Variable 8 related to inertia, variable 12 to cellular respiration, and variable 13 to genetics. Upon closer examination of variables 8, 12 and 13, it is apparent that there is a bias amongst the scientifically illiterate students towards the Life Sciences. This bias is attributed to two (12 and 13) of these three variables being directly related to the theme of Life and Living, which is central to the discipline of the Life Sciences. Also, the question with the most number of correct responses, the inertia question, was relatively simple, and this could have been the cause of a disproportionately higher number of correct responses to this question. Variable 8 has a dual status of application/knowledge (Bloom's taxonomic levels) in Table 5.1. which relegates it to a low cognitive level question. It is simply the restatement of Newton's first law of motion and is a daily experience.

The moderately scored variables (6, 14, 15, and 16) reflect a balance between the Life and Physical sciences as popular disciplines for the scientifically illiterate group. Variables 6 (acceleration due to gravity), 14 (pH), 15 (enzymatic action), and 16 (AIDS) represent a combination of the Life and Physical Sciences.

As for the Earth Sciences, the performance of these students was unsatisfactory because the associated variables 2, 3, 4, and 5 were scored poorly. The Earth Science variables concerned global warming, weathering, ultra violet rays and seasonal change respectively. The performance of the scientifically illiterate students on Earth Science variables 2, 3, 4, and 5 were scored as follows: 4 out of 13 (31 %), 4 out of 13 (31 %), 2 out of 13 (15 %) and 1 out of 13 (8 %) respectively. The average score for the Earth Sciences questions was therefore 21 %.

Variables 5 and 17 had the least number of correct responses for the scientifically illiterate students. There was just one correct response each for variables 5 and 17. Variable 5 related to seasonal change and variable 17 related to the kilowatt-hour (kWh), the unit in which electricity is bought. The question on seasonal change is a concept integral to the theme Earth and Beyond, and was one of the most difficult questions that featured in the test on scientific literacy. The difficulty in the seasonal change question lay in it being a comprehension (Bloom's taxonomy) type question but with an extrapolation of knowledge about planets at an abstract level. The question that related to the kWh required some knowledge of how units can be manipulated, as it is a disguised form of the unit joule, which is the conventional Systems Internationale (SI) unit for energy. However, on electricity bills energy is measured in kWh not joules, and to apply scientific knowledge responsibly requires an understanding of the different forms that the same information can take in different contexts.

Overall, the students who were classified as scientifically illiterate displayed the following tendencies: the questions with the most frequent number of correct answers suggests a popularity of the Life Sciences; those with a moderately number of correct answers reflects a balance between the Life and Physical Sciences; and the questions with the least number of correct answer pertained to the Earth and Physical Sciences. Additionally, the Earth Science questions were poorly answered. Therefore, one can infer that the order of popularity of disciplines for the scientifically illiterate students decreases in the following sequence: Life Sciences, Physical Sciences, and Earth Sciences.

The same pattern of analysis as above will follow for each of the remaining three groups of students with different scientific literacy levels to establish any similarities and differences in the kinds of questions answered most frequently by each of the groups of students.

5.4.2. Analysis of Scientific Literacy Scores of Students with Mediocre Scientific Literacy

The second group of students analyzed were those with total scores of 9 to 11 out of 20 for the test on scientific literacy. They were thus classified as being students with a mediocre scientific literacy, and the total number of students that were in this category was 48. Figure 5.4. below depicts the frequency of correct responses against the variables linked to the questions on scientific literacy for students of mediocre scientific literacy.

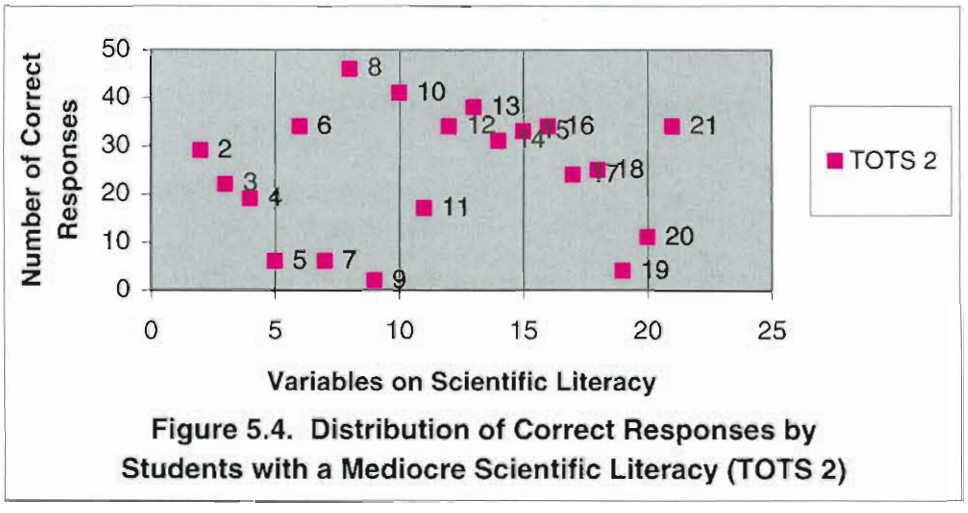

Figure 5.4. Distribution of Correct Responses by Students with a Mediocre Scientific Literacy (TOTS 2)

As was the case with the scientifically illiterate students, variable 8 had the most number of correct responses. A total of 46 (96 %) of students with a mediocre scientific literacy selected the correct response to this question. As mentioned above this question related to inertia, the tendency of a body to resist changes in its state of motion, and was the easiest of all the questions thus giving it a disproportionately high scoring. Considering that variable 8 on inertia was a relatively simple question, it can be ignored when determining the most popular disciplines of the students with a mediocre scientific literacy.

Other variables with a large number of correct responses include variable 10 (85 %) and 13 (79 %). Variable 10 related to the concept momentum, which is part of the theme Energy and Change, a core component of the Physical Science syllabus in Grade 12. The high frequency of correct responses to the relatively difficult variable 10 is a manifestation of the higher order thinking skills of this group compared to the scientifically illiterate students who scored only 2 correct responses (15 %) for this same question. Variable 10 is classified as an application/comprehension question (Bloom's taxonomic levels) in Table 5.1.

Variable 13 related to genetics and was also popular amongst the students with mediocre scientific literacy as it was with the students who were scientifically illiterate. Genetics is a core topic in the Life Sciences syllabus. Therefore, it can be inferred from these two variables (10 and 13) with the most number of correct responses that the students with a mediocre scientific literacy have an affinity for both the Life and Physical Sciences.

Upon closer examination of Figure 5.4. the clustering of a moderately high number of correct responses to variables 6 (acceleration due to gravity), 12 (cellular respiration), 14 (pH), 15 (enzymatic activity), 16 (HIV/AIDS), and 21 (frictional force), confirms a balance between the Life and Physical Sciences for students with mediocre scientific literacy. Acceleration due to gravity and frictional force are clearly Physical Science concepts, cellular respiration and HIV/AIDS are within the Life Sciences realm and the remaining two concepts are cross cutting.

According to Figure 5.4. the least popular questions for this group of students with a mediocre scientific literacy were linked to variables 9 (vector sum of forces) and 19 (conduction). Variable 9 was indeed a very challenging question as students had to compare the two options of pushing and pulling an object with vector diagrams and then determine whether pushing or pulling is easier by comparing the resultant force exerted by the ground on the object being pulled. Variable 19 was also a tricky question, as it is commonly known that Copper is used as a conductor in most electrical connections. However, the General Science curriculum at schools emphasizes that the conduction properties of Silver are superior to that of Copper. The only reason why Copper is used more extensively is because it is relatively inexpensive compared to using Silver. Thus, the two questions which students of mediocre scientific literacy found most challenging related to the Physical Sciences. This finding related to the least popular questions therefore reduces the popularity of the Physical Sciences amongst students of mediocre scientific literacy. Overall, the Life Sciences has emerged as the most popular discipline amongst these students of mediocre scientific literacy.

Additionally, the Earth Sciences were not as popular as the Life Sciences (see Figure 5.4. p.123). The performance of the students on the questions related to the Earth Sciences (variables 2, 3, 4 and 5) was not as impressive as the questions on the Life Sciences. The Earth Science questions concerned global warming, weathering, ultra violet rays and seasonal change. The actual number of correct responses for students with mediocre scientific literacy on variables 2, 3, 4 and 5 were 29 (60 %), 22 (46 %), 19 (40 %) and 6 (13 %) respectively out of a possible maximum of 48. The average score for the Earth Science questions was therefore 40 %.

The trend thus far is a bias towards questions on the Life Sciences. It would be interesting to see how this trend changes as the levels of literacy improve. These changes are discussed below with the examination of the last two groups of students, namely those with good and excellent scientific literacy.

5.4.3. Analysis of Scientific Literacy Scores of Students with Good Scientific Literacy

The third group of students analyzed were those with total scores of 12 to 15 out of 20 for the test on scientific literacy. They were thus classified as being students with a good scientific literacy, and the total number of students that were in this category was 81. Figure 5.5. below depicts the frequency of correct responses against the variables linked to the questions on scientific literacy for students of good scientific literacy.

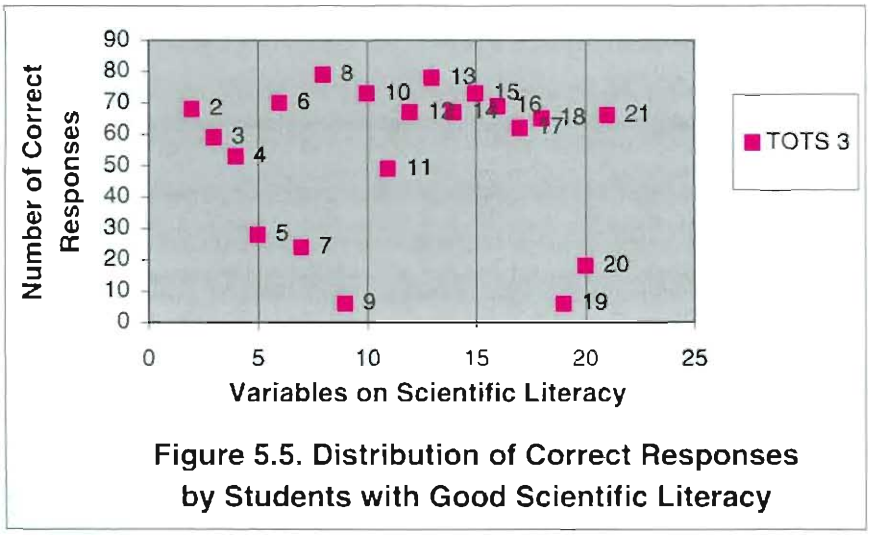

Figure 5.5. Distribution of Correct Responses by Students with Good Scientific Literacy

Once again, the most number of correct responses went to variable number 8 that related to the concept inertia. According to Figure 5.5, the total number of correct responses for variable 8 was 79 (98 %) out of a total of 81 students in the category good scientific literacy. As mentioned above, the high frequency of correct responses for variable 8 can be attributed to this being the simplest of questions as it was simply a restatement of Newton's first law of motion.

There are several glaring differences between the distribution of correct responses by these students with a good scientific literacy compared with those who were scientifically illiterate or those with a mediocre scientific literacy. For example, the performance of these students on the Earth Sciences questions is considerably better than that of the former two groups. According to Figure 5.5, the number of correct responses to the Earth Science variables 2, 3, 4, and 5 were 68 (84 %), 59 (73 %), 53 (65 %), and 28 (35 %) out of a maximum score of 81. Thus, the average score for the Earth Science questions for the students with good scientific literacy was 64 %. This figure is considerably higher than the average scores for the scientifically illiterate students and those with mediocre scientific literacy who scored 21 % and 40 % averages respectively. Furthermore, the population size of the students with a good scientific literacy is far greater than those in the first two groups of students. Sometimes percentages can be misleading; however, in this case the performance of students is better both in percentage and actual number.

Another glaring difference of these students with a good scientific literacy is a distinct separation of the high scoring variables from the low scoring variables as illustrated in Figure 5.5. In the distribution of correct responses for the scientifically illiterate and those with mediocre scientific literacy, there is a circular scattering of the high and low scores. This distinct separation of scores for students with a good scientific literacy is reflective of the majority of the students in this group having the same abilities and understanding of scientific phenomena.

The lowest scoring variables for students with a good scientific literacy were 9 (vector sum of forces) and 19 (conduction). Interestingly, these questions were also the lowest scoring ones for students with a mediocre scientific literacy.

With regard to the type of questions that were most popular amongst these students with a good scientific literacy, one could assume, based on an analysis of Figure 5.5. that there is no preference as there is almost a similar kind of scoring for Earth Sciences, Physical Sciences and Life Sciences. This equivalence is suggested by the almost linear distribution of high scores across a combination of

disciplines. However, with the low scoring variables 5 (seasonal change), 7 (density), 9 (vector sum of forces), 19 (conduction) and 20 (colour of light), there an overall weakness related to the Physical Sciences. Variables 7, 9, 19, and 20 were part of the Physical sciences, and the variable 7 part of the Earth Sciences. Therefore, one can conclude that the students with a good scientific literacy were more favourably disposed to questions on the Life and the Earth Sciences. Interestingly, there is a distinct shift from the first two groups (scientifically illiterate and those with mediocre scientific literacy) who were more favourably disposed to the Life Sciences. This analysis creates an interesting backdrop for the analysis of scores for the students with excellent scientific literacy as it would be interesting to discover whether the preferred type of questions are similar or different and how the distribution of scores varies. The analysis of the scores for students with excellent scientific literacy follows.

5.4.4. Analysis of Scientific Literacy Scores of Students with Excellent Scientific Literacy

The fourth group of students analyzed were those with total scores of 17 to 20 out of 20 for the test on scientific literacy. They were thus classified as being students with excellent scientific literacy, and the total number of students that were in this category was 29. Figure 5.7. below depicts the frequency of correct responses against the variables linked to the questions on scientific literacy for students of good scientific literacy.

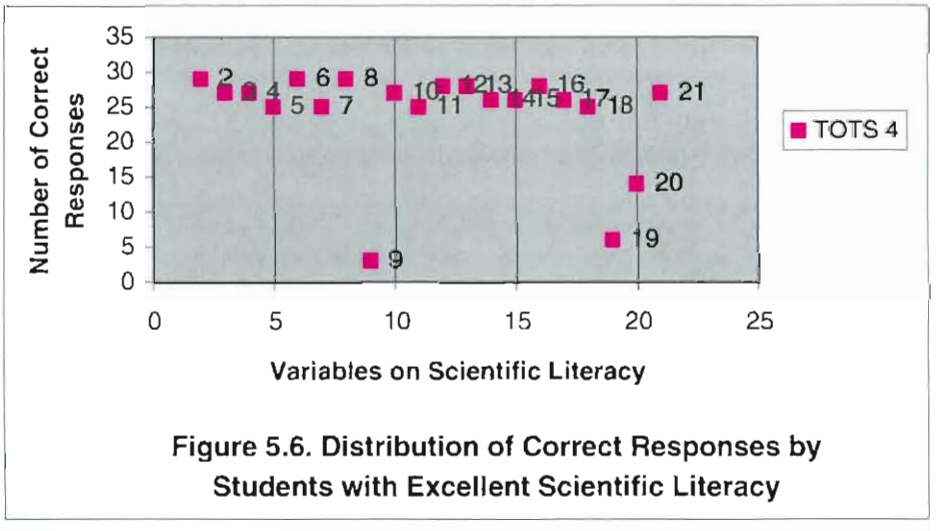

Figure 5.6. Distribution of Correct Responses by Students with Excellent Scientific Literacy

According to Figure 5.6, there is a greater consistency in the separation of high and low scoring variables for students with excellent scientific literacy as compared to those with a good scientific

literacy. As mentioned above, the students with mediocre scientific literacy, as well as those considered scientifically illiterate, had a circular scattering of the high and low scores.

The consistency in the distribution of correct responses, as expressed in the almost linear distribution of scores in Figure 5.6. is suggestive of a uniform understanding of science concepts, and the application thereof, across the domain of science, i.e. these students have almost equal abilities and understandings in the Natural, Physical, and Earth Sciences. This equivalence in knowledge is manifested by equivalence in scores in Figure 5.6. above. Figures 5.3, 5.4, and 5.5 all had variable 8 as the one with the most number of correct responses. However, in Figure 5.6, variable 8 is not clearly distinguishable as the highest scoring variable. In the linear spread of variables with the most number of correct responses in Figure 5.6, variable 8 is just one of the highest scoring correct responses. In fact, variable 8 tied with variable 2 (greenhouse effect) and with variable 4 (acceleration due to gravity) as the variables with the most number of correct responses. All three of these top-scoring variables had absolute (100 %) scores of 29 out of 29. As the top scoring variables related to inertia, global warming and acceleration due to gravity, one could infer that there is a bias in these students with excellent scientific literacy for the Physical and Earth Sciences and not the Life Sciences. However, the closeness with which all the questions were scored correctly suggests equivalence in the abilities and understandings of these students across all three disciplines. The nearness in the scores is accentuated in the range of scores across the linear distribution of scores in Figure 5.6. i.e. there were 25 to 29 correct responses to most of the questions.

The lowest scoring variables for students with excellent scientific literacy were 9 (vector sum of forces) and 19 (conduction), with an average performance on variable 20 (colour of light). Coincidentally, variables 9 and 19 were the most poorly answered by the students with a good scientific literacy as well as the group of students with a mediocre scientific literacy. The students who were considered scientifically illiterate had the least number of correct responses to variables 5 (seasonal change) and 17 (kWh). As variables 9 and 19 are essentially Physical Science questions, one is inclined to believe that there is a weakness in this group of students in the Physical Sciences. However, their almost perfect scoring for other Physical Science questions, as expressed in the linear distribution of correct responses in Figure 5.6, eclipses their poor performance on these two questions. Thus, the core distillation from the above analysis of the students with excellent scientific literacy is that there is equivalence in the abilities and understandings of these students in all three disciplines, namely, the Physical, Life and Earth Sciences.

5.4.5. Summary of Most Popular Science Disciplines for Students with Different Scientific Literacy Levels

The preferences of the four groups of students are summarized in Table 5.6. below.

Scientific Literacy Level	Most Popular Discipline in Sciences
Scientifically Illiterate	Life Sciences
Mediocre Scientific Literacy	Life Sciences
Good Scientific Literacy	Life and Earth Sciences
Excellent Scientific Literacy	Life, Earth and Physical Sciences

Table 5.6. Most Popular Science Disciplines for Students with Different Scientific Literacy Levels

Table 5.6. is suggestive of an evolution of the students' abilities and understandings of science concepts and application thereof. Essentially, scientifically illiterate students and students with mediocre scientific literacy have a grasp of simple Life science concepts, students with good scientific literacy have evolved to a higher level with a good grasp of both the simple Life Sciences and the more challenging Earth Sciences, and students with excellent scientific literacy having reached the ultimate level with an equivalence in understandings across all three disciplines.

5.5. Conclusion

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

The lowest scientific literacy score was 6 with three students achieving this score, and the highest score was 18 with four students achieving this score. Most of the scores for scientific literacy were clustered between 9 and 16 with some of the scores being distributed on the extremes. Thus, the majority (approximately 75,4 %) of the students were of mediocre or good scientific literacy, and a limited number (7,6 %) of students were scientifically illiterate, and a reasonable number (17 %) of the students had an excellent scientific literacy.

The above scores for scientific literacy were then examined to determine which questions were answered correctly in each of the categories of scientifically literate students. Such an analysis revealed patterns with regard to the nature of questions correctly answered by each of the groups. This was a new dimension in the analysis of the scientific literacy levels of the students. The analysis entailed an examination of the questions with the most, moderate and least number of correct responses by concept, theme, discipline, and an explanation of the patterns, which emerged.

The core findings of this analysis of scientific literacy levels revealed that the order of popularity of disciplines for the scientifically illiterate students decreased in the following sequence: Life Sciences, Physical Sciences, and Earth Sciences. The Life Sciences also emerged as the most popular discipline amongst these students of mediocre scientific literacy. However, students with a good scientific literacy were more favourably disposed to questions on the Life and the Earth Sciences. Moreover, the students with excellent scientific literacy had equivalence in their abilities and understandings in all three disciplines, namely, the Physical, Life and Earth Sciences.

In the graphical distribution of correct responses for the scientifically illiterate and those with mediocre scientific literacy, there was a circular scattering of the high and low scores. This scattering of scores indicated that students in the scientifically illiterate and mediocre scientific literacy groups had different abilities and understandings across the three disciplines and within the same discipline as well. The distinct separation of high and low scores for students with a good scientific literacy reflected that the majority of the students in this group have the same abilities and understanding of scientific phenomena. There was a greater consistency in the separation of high and low scoring variables for students with excellent scientific literacy as compared to those with a good scientific literacy. Therefore, there was even greater uniformity in the abilities and understanding of scientific phenomena of students with excellent scientific literacy.

What is clearly discernible from the above analysis of scientific literacy levels of a cohort of students is that there will always be an assortment of abilities and understandings of scientific phenomena within any cohort of students. That assortment in abilities and understandings may be due to variations in teaching, to curriculum content, to student interests, or to a host of other reasons. In the above analysis, it is fairly obvious that the variety is due, in part, to preference or popularity of different disciplines in the Natural Sciences. This differentiation of students by discipline and level of scientific literacy could influence pedagogy and curriculum content in an attempt to improve the scientific abilities and understanding of the selected cohort of students.