Project report: Academic literacy and communicating assessment to students on L1 Science Modules

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Executive summary and key findings

This project aimed to understand assessment and how it is communicated to students in Level 1 Science with application across STEM subjects. The project specifically examined *S104 Exploring science* assessment, its language and assessment task types and surveyed students (pre- and post-module; n= 53 & 41) for their views on assessment and the use of key terms in assessment tasks. Additionally, a set of high-achieving and low-achieving students' TMAs (n=48 assignments) were linguistically analysed to examine lexical density, reading complexity, academic vocabulary use and the use of metadiscourse. Based on these findings, a number of recommendations for improving assessment and academic literacy support have been made to module teams.

The findings showed that the module contains assignments that assess students' gradual progression in the module by designing assignments which move from easy to a more sophisticated one. The assignment instructions on the length of the expected response text was vague because the instruction indicated no word limit in a number of cases but only suggested either 'a sentence' or vague word counts. This was reflected in the substantially varied length of the student written responses to the same TMA question. The assignment briefs employ a number of process words and key words in each question. Among them, it was found that two process words were challenging to students as revealed by both the assignment analysis and the student survey: *discuss* and *reflect*. The main reason appears to be that the module does not teach how to write a 'discussion' text and a reflection text in science. As these text types are difficult to write and require a sophisticated level of using language to communicate about scientific topics, it is not fair to expect Level 1 students to come prepared with this ability. It is not sufficient to simply explain to students what the word means. They need to see the process of writing a discussion and reflection and their examples.

The survey results indicated that most students found problem-solving, experimental report, long written answer questions, single answer or multiple choice questions and tasks involving maths or numeracy as the most useful assessment tasks. The students also indicated that that they found assignments marked by both their tutor and a computer useful. In the pre-module survey, the students demonstrated a varying level of their understanding of the process words frequently used in the TMAs. This could have serious implications for how they respond to the assignment questions.

The linguistic analysis of eight students' assignments showed that their language proficiency level is sufficient for the module. However, their expertise in the use of academic and scientific language varied significantly which was reflected in their grades. It appears that those students who already had the ability to make appropriate choice of language to make meanings in science continued to excel while those with a lower ability in doing so were disadvantaged due to the lack of support for developing their scientific literacy during the study. This is something the new Level 1 modules such as S111 and S112 should consider in order to support struggling students. Research shows that carefully designed embedded academic literacy activities help students not only succeed in the module (Shrestha & Parry, 2019) but also enable them to transfer their academic literacy expertise to other modules as seen in business studies (Shrestha, 2017).

1. Introduction

This project aimed to understand assessment and how it is communicated to students in Level 1 Science with application across STEM subjects. The project specifically examined *S104 Exploring science* assessment, its language and assessment task types and surveyed students for their views on assessment and the use of key terms in assessment tasks. Additionally, a set of high-achieving and low-achieving students' TMAs were linguistically analysed to examine lexical density, reading complexity, academic vocabulary use and the use of metadiscourse. Based on these findings, a number of recommendations for improving assessment and academic literacy support have been made to module teams.

2. Project background

2.1 Academic language and STEM (literature)

Academic literacy or academic language is widely considered as central to academic knowledge building and success (Snow, 2010). Evidence also indicates that academic language may pose challenges to many students who are at risk of underachievement (Cummins, 2014). Given the disciplinary variation and associated academic language practices (Haneda, 2014), academic literacy in science is distinct from other disciplines. Some studies have shown that students with lower academic literacy skills are unlikely to succeed in science (Kirby & Dempster, 2015), thus affecting overall student retention and progression in STEM subjects. This has implications for how assessment is designed and communicated to students which seems to be under-researched.

As any other discipline, science has its own distinct way of communicating knowledge in the field. This means students need to learn this unique language of science to demonstrate their scientific literacy which is considered to be complex by science educators (e.g., see Blown & Bryce, 2017). However, using the language of science may not be natural, like academic language, for many students who come from non-traditional background as in the Open University. Additionally, there tends to be a lack of recognition of science literacies and the role of academic language in science education (Feez & Quinn, 2017). This situation puts those students from non-traditional academic backgrounds at risk of not succeeding in science. Another challenge to such students is the dominant form of assessment being writing in higher education including the science discipline. Particularly, being able to use scientific written discourse means having an ability to use decontextualized language, for example, to analyse, report, synthesise, hypothesise, evaluate, and classify a scientific phenomenon (Lemke, 1990). Therefore, it is important to consider how science teaching materials are designed for learners in regards to communicating scientific knowledge to them and how that knowledge is assessed. This project is concerned with the latter in which we examined students' assessment literacy in science and their written performance in assignments in S104.

2.2 The context of research: *S104 Exploring science*

S104 Exploring science is a 60-point Level 1 key science module offered as by the Faculty of STEM at The Open University. It introduces students to physics, earth science, chemistry and biology in addition to developing students' mathematical, communicative and practical skills. The module started its first presentation in 2008 and had dual presentations each year with the student number 1,500 – 2,000. The module was presented until 2016 when it was replaced by S111.

The module has 6 Tutor Marked Assignments (TMAs), eight interactive computer marked assignments and one end of module assignment. Student completion and pass rates for the module has been constantly low. For example, the students completion rates were 64% (2014J), 63% (2015J) and 64% (2016J) which were below the faculty average. Likewise, the student pass rates were 53%, 53% and 48% for the same years despite high overall student satisfaction rate (over 90%). This meant that the module had challenges in supporting students who may have been disadvantaged or belonged to the widening participation category.

Within the STEM faculty, attempts have been made to prepare mature adult learners for studying science in distance education. For example, it has an access module Y033 Science, Technology and Maths Access module. A recent study argues that this module has prepared students well for studying an undergraduate science degree at The Open University (Butcher, Clarke, Wood, McPherson, & Fowle, 2018). Please note that this access module embeds academic literacy in the module material as Prithvi Shrestha contributed to the module as an academic literacy advisor during the production of the module. The impact of this access module needs to be seen in relation to the new Level 1 science module like *S111 Questions in science.* When we consider the completion and pass rates for S111, the figures have gone up (over 65%) for both. However, S111 does not sustain the embedded academic literacy support as in Y033 which was found effective (ibid.).

2.3 Research questions

The research questions in this study were driven by a desire to understand how students of S104 understood assessment practices in science and whether students' assessment literacy and academic literacy play a role in their success in the module. A review of the relevant literature (see section 2.1) also helped to derive the research questions. The following research questions guided this study:

1. How is assessment in Level 1 science communicated to students?
2. What are S104 students' perceptions of and attitudes towards assessment practices in science?
3. Does academic literacy play a role in high and low achieving students' assessment performance?

3. Methodology

This project adopted a mixed methods research design (Creswell & Plano Clark, 2007) to investigate the research questions. A mix of both qualitative and quantitative data collection methods were employed in order to gain a better understanding of the issues identified in

Section 2.2. These included assessment documents, student surveys and linguistic analysis of student assignments. Additionally, we had planned to interview a selected number of students to collect in-depth student views. However, due to the time lapse (6-7 months) between the last assignment they submitted and our availability to interview them, we decided to drop this instrument because we though that the students' memory of their assessment experience would not have been immediate and the data, therefore, would not be valid and reliable. Each research instrument is explained in detail below.

3.1 Research instruments

3.1.1 Assessment documents

This study focused on how assessment is communicated to students in science. The obvious place to look for this communication was assessment documents made available to students. These assessment documents also provided the context of assessment which is essential to understand the purpose and the audience of the assessment that was designed for. Therefore, learning outcomes, assignment tasks, and assignment guidelines were collected to address the first research question. In total, six assignments in S104 with these three elements were collected.

3.1.2 Pre- and post-module surveys

Exploring Science (S104) is a 60 credit Level 1 UG module. 500 students studying the 2016B presentation of S104 were invited to complete a **pre-module** questionnaire survey in December 2015. 53 students completed the survey. 535 students were invited to complete a **post-module** survey in October 2016. 41 students completed the survey. The survey consisted of questions relating to students perceptions of the purpose and usefulness of different methods of assessment and assessment question types. Additionally, there were questions that required students to show their understanding of key concepts in science. The survey also contained questions relating to student demographics. Please see the survey questions in the Appendices.

3.1.3 Student TMAs

In order to gain a better understanding of how students interpret and respond to assessment tasks, it is necessary to examine students' written performance in assessment. Given the range of backgrounds science students come from, it is inevitable that their academic literacy level and scientific literacy would be varied. Therefore, we decided to collect assignments from both high and low achieving students in S104. The purpose was to address the third research question which investigates the potential role of academic literacy in student achievements. In total, 48 assignments were randomly collected from eight S104 students of the 2015B presentation. Six assignments from each student were collected. Among them, four students were high achievers and the other four were low achievers. In this study, a student was considered a high achiever if they secured 70% or above on a TMA and if they secured below this score, they were categorised as a low achiever.

3.2 Data analysis

3.2.1 Assessment documents

The assessment documents were analysed by examining assignment questions and the associated guidelines. In particular, we considered the process words (instruction words) used in the assignment tasks and what text types students were expected to produce when they wrote their assignments. The latter was examined by analysing the assignment guidelines and the process words.

3.2.2 Survey data

Some of the questions used a Likert scale with possible responses from 1-5 (1= not at all useful to 5= extremely useful) The quantitative responses were grouped together and plotted as bar charts. The students were also asked some open-ended questions and their qualitative responses were analysed.

3.2.3 Student TMAs

The student TMAs for this study were statistically analysed. The analysis was carried out by using a corpus analysis tool called Textinspector. All student assignments were put through this tool to examine lexical density, reading complexity, academic vocabulary use and the use of metadiscourse. Additionally, basic statistical features such as the number of sentences and words, and the ratio between the words and the type of words were also considered to understand the language level of the student's TMA.

4. Results and discussion

4.1 Nature of assessment in Level 1

An analysis of the TMA tasks and the guidelines suggests that the assessment in S104 varied across the TMAs as expected. A summary of the TMA length and text types found in the six assignments is presented in Table 1 below.

Table 1: A summary of process words, length and text types in S104 TMAs

TMAs	Process words	Length (words)	Possible task type
TMA01	Define and explain Outline, describe, identify, compare, state, calculate	Under 500	Definitions and explanations Short answers

TMA02	Explain, describe, acknowledge, reflect	About 700	Explanation Personal reflection Short answer
TMA03	Complete, list, summarise, explain, describe, plot, draw, calculate, show, convert, reflect	About 1,000	List, summary, explanation, reflection Short answer
TMA04	State, describe, solve, decide, check, summarise, calculate, complete, rearrange, determine, explain, quantify, find, show working, rate, identify	Abut 2,500	Description, report Short & long answers
TMA05	Complete, identify, explain, write formula, discuss, calculate, show, state, sketch, label, draw, estimate, reflect, comment	About 1,600	Explanation, calculation, reflection Short answers Long answer
TMA06	Identify, explain, discuss, indicate, name, state, draw, assign, suggest, calculate, consider, cite, reference, describe, include, write an account, predict	About 2,700	Explanation, discussion, recommendation, account of a topic Short and long answers

As the table shows, the TMA lengths ranged from about 500 words to 2,700 words. However, it should be noted that the word length was not clearly mentioned for some of the questions. Instead, students were advised to write 'one or two sentences' as illustrated by the TMA questions below.

Extract 1

TMA01 Question 1

For each term:

(i) Quote the correct definition as given in the S104 Glossary.

(ii) Clearly state the difference (or differences) that distinguish the correct definition from the incorrect one. (Guideline: one sentence for each definition)

TMA03 Question 1

There are two specimens of sedimentary rocks in your Practical Kit – Specimens 2 and 3. Complete a copy of Table 1 by listing four characteristics that differ between these rock specimens (ignoring the fact that one has been polished). You should also summarise your

observations of these characteristics for each rock and then explain how each of the differences you have observed relates to the geological processes that formed the rocks. (Guideline: Your entries in the 'Observations' column should be just a few words, but entries in the 'Explanation of difference' column should be one or two sentences long.)

When students are advised only how many sentences to write, there is a possibility of students writing long and short sentences, thereby resulting in some answers quite short and others long as a sentence can be as long as it can be so far it is grammatically correct. Furthermore, students may be unsure about how long they need to write to answer the question fully.

In addition to the length, the nature of each assessment task was analysed by examining the process words and the key words. As Table 1 shows, a wide range of process words were used to design the questions. Some of the process words were repeated in several TMA tasks. For example, the most common process words were *describe, explain, state* and *identify*. The first three process words here are common in assignment questions in other disciplines too. The other process words such as *calculate* and *draw* may be specific to the STEM subjects. These process words are explained in the guidelines for each question as shown below (Extract 2). This explanation may have been helpful to students when writing their assignments. We, nevertheless, do not know how student translated these process words in their writing. The word *explain* is significant in science because scientific knowledge is socially constructed using cause and effect relationships of objects and phenomena to make meanings (Braaten & Windschitl, 2011; Driver, Asoko, Leach, Scott, & Mortimer, 1994). It is, therefore, important for science students to have a clear understanding of the words like it.

Extract 2

TMA02 Advice on answering Question 2

New process words used in this question are:

'compare', which means to look for and show any similarities and differences between two or more items

'calculate', which means work out and show your working

Question 2 also asks you to 'estimate', which means to judge or roughly

calculate the number, value or quantity of an item.

A notable feature of the process words was the process word *reflect* used in three TMAs (TMA02, 03 and 05) where students were asked to reflect on their progress on developing skills, knowledge and learning strategies in the module. Reflective writing is often found to be challenging among university students even when they are taught how to write it (se Survey results too). Therefore, this task in the TMA may have been a challenging one to S104 students too especially because this skill is not taught explicitly in the module and the guidelines appear to be only responding to a set of questions. This level of support might not have been sufficient.

The key words were chosen from the topic areas covered relevant to each TMA. The assignment clearly stated which topics were covered by the questions (e.g., global warming in TMA02, energy and light in TMA04). For each question, a set of learning outcomes were provided at the beginning of the question. For example, Extract 3 shows the learning outcomes and the key words from the field of global warming. The key words are mentioned in the guidelines although there is no further information as to where students could find them in the module material. This is crucial especially for those students who may be finding these key concepts challenging.

Extract 3

TMA02 Question 1

This question carries 16 marks. It will be assessed according to how well you demonstrate, in your answer, the following learning outcomes:
Kn1 knowledge and understanding of greenhouse gases and the Earth's energy balance
Ky3 communicate scientific topics clearly and concisely, using methods and scientific language appropriate to your purpose and audience

Using only information from Book 1 and referring to appropriate diagrams from that book, explain how the burning of coal to generate electricity can contribute to global warming. Your answer should describe the production and properties of the principal greenhouse gas in this scenario and explain how those properties can alter the energy balance at the Earth's surface.

Your answer should be written in your own words and style. You should acknowledge any figures you used from Book 1 using the format (Book 1, Figure X.X, p. xx) at the appropriate places within your answer.

(Word limit: up to 180 words including in-text acknowledgements.)

Table 1 also presents the type of texts students are expected to write. The type of texts is determined by the process words used in the assignment task and any guidance given to the student. As shown in the table, students were expected to produce a variety of text types in each assignment although increasingly in later TMAs these text types become wide-ranging than in the first two TMAs. This seems pedagogically sound because students may find the TMA tasks extremely daunting if they have to produce many varieties of text type from the first assignment. Additionally, the text type could be either a short answer or a long answer one depending on the question. TMA01, for instance, has the following questions:

Extract 4

TMA01

Question 1

Given below are incorrect definitions of four key terms introduced in Book 1. Although wrong, each incorrect definition is written in the style used in the S104 Glossary. Read the incorrect definitions and then answer the questions that follow.

Mean

The maximum value of a series of measurements (or numbers) divided by the number of those measurements.

Scientific notation

A notation that represents any number by expressing it as a whole number between 1 and 10 multiplied by a simple power of ten, using a positive or negative index. Thus $2 \times 10_3$ is in scientific notation (because 2 is between 1 and 10), but $0.130 \times 10_4$ and $13.0 \times 10_2$ are not.

Significant figures

The number of digits you quote when you write down the value of a quantity that has been measured with a degree of uncertainty. For example, 10.2 cm is quoted to 3 significant figures and this means there may be some uncertainty in the final digit, but the other digits are certain. The smaller the number of significant figures quoted for a value, the smaller the uncertainty in that value.

Random uncertainty

A type of uncertainty derived from a measured quantity that is consistently higher or lower than a mean value i.e. many measurements being scattered all above or all below their mean value. The larger the random uncertainty associated with a measurement, the larger the scatter. Compare with experimental uncertainty, systematic uncertainty.

For each term:

(i) Quote the *correct* definition as given in the S104 Glossary.

(ii) Clearly state the difference (or differences) that distinguish the correct definition from the incorrect one. (Guideline: one sentence for each definition)

[…]

Question 3

Using Book 1 Figure 4.15, identify the contributions to the energy balance at the Earth's surface. Then state the conditions under which the GMST (i) would be in a steady state and (ii) would rise. (Guideline: up to 160 words.)

TMA01 required students to write one sentence for each defined term in response to Question 1. On the other hand, Question 3 asked students to answer the question within 160 words. Yet, both the answers are meant to be quite short. The text types may be a mixture of definitions and explanations in the answer to Question 1. The answer to Question 3 may be mainly an explanation to the different states of the GMST.

The questions from TMA06 may be contrasted with the previous example in terms of what students are expected to write for their assignment. The first obvious difference is the increasing number of questions in the later TMA as shown in Extract 5 below.

Extract 5

TMA06

Question 1

(a) From the full structural formulas in Figure 1, labelled with the letters (A)–(F), identify the three molecules that are isomeric. In your answer briefly discuss your selection and explain why you discounted the other three molecules.

Figure 1

(b) Compound A, shown in Figure 2, is a biologically important molecule that is produced naturally by many plants and animals. It is also used as a treatment for Parkinson's disease. This molecule contains a chiral carbon atom.

Figure 2

(i) Explain what the terms chiral atom and chiral molecule mean. (Guideline: two or three sentences.)

(ii) Indicate the chiral carbon atom present in Compound A by marking and labelling it on this copy of Figure 2.

(c) Compound B, shown in Figure 3, is produced in the body from Compound A. Compound B works on several receptors in the brain.

Figure 3

Identify two different types of intermolecular interaction which could be involved in binding Compound B to a target receptor in the brain. State which functional group(s) on Compound B could exhibit each of these interactions and describe the properties of each interaction. In your answer make it clear which complementary functional group would need to be present in the receptor for the interaction to occur. (Guideline: up to 170 words.)

Question 2

[...]

(c) Biodiversity is explored in Chapter 3 of Book 5 and the summary of the chapter states: "The loss of biodiversity matters for ethical, aesthetic, biological and economic reasons" (Butler et al., 2008).

State two biological reasons why you consider that the loss of biodiversity matters. Give a specific example to illustrate each of the reasons you have given. One of your examples can be from the module materials or from the article given below, but your other example should be one that you have researched yourself on-line. Both of the sources you use must be appropriately cited and referenced in your answer using the OU Harvard style of citation and referencing. (Guideline: up to 300 words.)

[...]

Question 5

At the molecular level respiration is the process that releases the energy stored in organic molecules and enzymes act as biological catalysts allowing cells to carry out chemical transformations at moderate temperatures. In the absence of oxygen (anaerobic conditions), yeast respires by breaking down sugars producing alcohol and the gas carbon dioxide. This process is known as fermentation.

Five experiments were set up to see how much carbon dioxide was given out by yeast in 30 minutes, under different starting conditions (Table 2). The temperature was kept constant at 20 °C. A graph showing the results of the five experiments, A–E, is given in Figure 8.

(a)

(i) Explain the purpose of experiment A with no carbohydrate in the bottle. (Guideline: one or two sentences.)

(ii) For each of the experiments B–E, briefly describe the results represented graphically in Figure 8. Explain why differences in the volume of gas collected over the 30 minute period occurred, taking into consideration the type of carbohydrate (glucose, sucrose or starch) used in each experiment. (Guideline: up to 240 words.)

(b) The investigation could be extended to see how temperature affects the way the yeast respires. Predict the effect on the results of experiment B (5 cm$_3$ yeast suspension + 1 cm$_3$ glucose solution) if it was repeated (i) at 4 °C and (ii) at 60 °C and give an explanation for each of your predictions. (Guideline: up to 150 words for parts (i) and (ii)

combined.)

(Hint: In addition to material from Sections 5.5 and 5.6 from Book 5

you will find it helpful to review Sections 10.2 and 10.3 from Book 4.)

In addition to the increasing number of questions, the process words used are wide-ranging. This suggests that students are expected to demonstrate a high level of academic and scientific literacy so that they can write responses that integrate different text types deploying appropriate academic language and style. For example, Question 1 alone contains eight process words: *identify, briefly discuss, explain, indicate, mark, label, state* and *describe*. This definitely requires students to be able to write an answer that uses the language that reflects these process words. For example, while *identify* requires the use of something like 'X is Y', *discuss* requires explaining 'why X is chosen over Y or X is better than Y' and using 'claim and support' language.

4.2 Student perceptions: Pre- and post-module survey results

Student perceptions were examined through the use of pre-and post-module surveys. A number of aspects of assessment were included in the survey. The students were asked to rank (on a Likert scale from 1 to 5, 1=not at all useful to 5= extremely useful) their perceived usefulness of eight different assessment type questions used in S104:
- long written answers
- practical activity
- short written answers
- single word or multiple choice answers
- problem solving
- tasks involving numeracy/maths
- experimental reports
- group/co-operative work

Examples of the different assessment type questions used in S104 were included in the survey to ensure that the students were sure of the assessment type question that they were being asked about. For example, '*Using information from Figure 1a only, estimate the proportions of emissions from (i) gas, (ii)oil and (iii) coal sources relative to total carbon emissions in 1975. (Guideline: one sentence for each source.)*' was the example given for a

short written answer type question, while *'Describe how the higher order structure of the two classes of proteins, globular and fibrous, depends on the primary structure and relate higher order structure to function, giving two examples for each class of protein. (Guideline: up to 420 words)'* was the example given for a long written answer type question.

The responses for the **pre**-module survey are shown in Figure 1 and the responses for the **post**-module survey are shown in Figure 2. The problem-solving assessment question type was rated as most useful by both the students who had completed the pre-module survey and the students who had completed the post-module survey (54% and 58% of respondents rating this assessment question type as extremely useful respectively). Interestingly, 51% of the pre-module survey respondents rated the practical activity assessment question type as extremely useful, where as only 33% of the post-module survey respondents rated this assessment type as extremely useful. This change may have been due to the students' experience in the module.
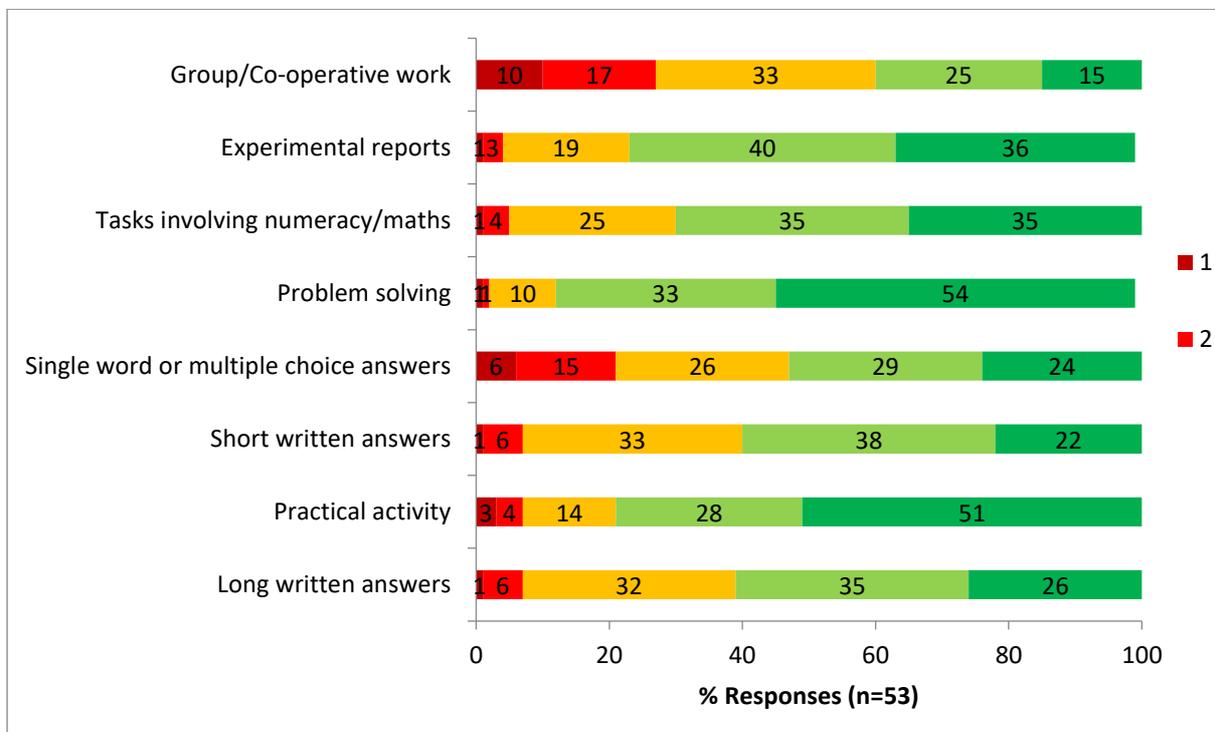
Figure 1: Student **pre**-module survey responses on their perceived usefulness of different assessment type questions used in S104. Response options ranged from 1= not at all useful (dark red) to 5=extremely useful (dark green)
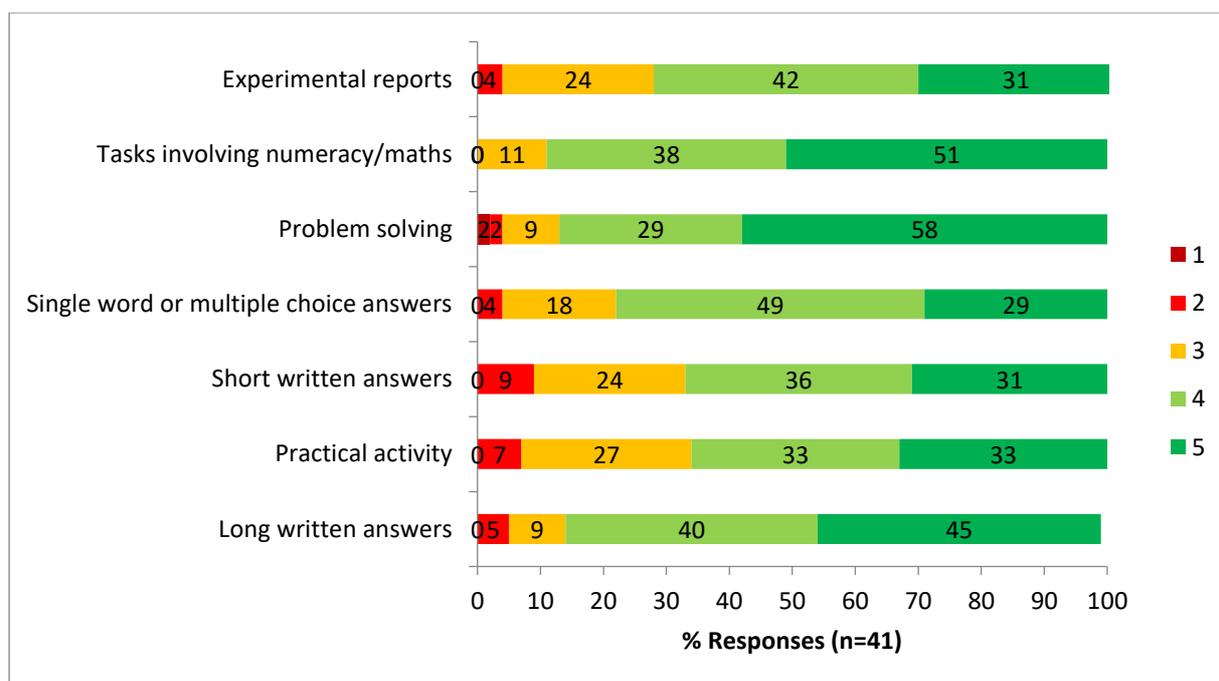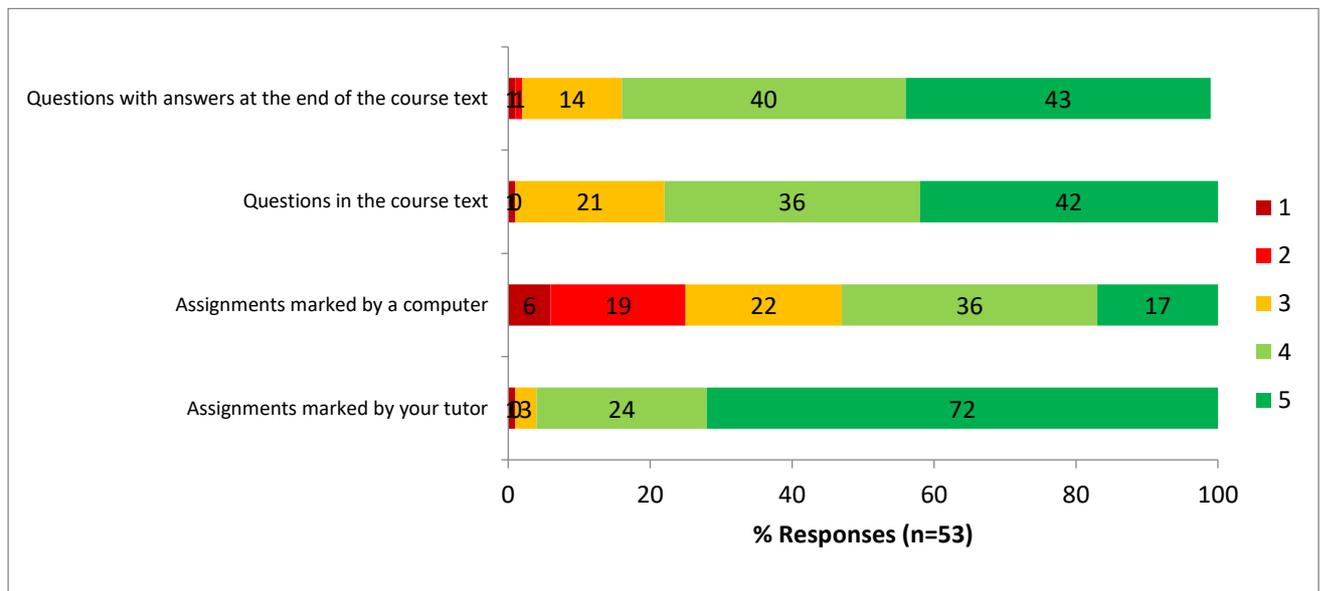
Figure 2: Student **post**-module survey responses on their perceived usefulness of different assessment type questions used in S104. Response options ranged from 1= not at all useful (dark red) to 5=extremely useful (dark green). Note that the Group/Co-operative work assessment type question was not surveyed in the post-module survey.

The mean response ratings given by the students for each of the assessment type questions for the pre- and post-module surveys were calculated and are shown in Table 2. Interestingly, the post-module survey respondents perceived long written answer type questions, single word or multiple choice answer type questions and tasks involving numeracy/maths as more useful than the pre-module survey respondents. The mean perception of usefulness scores for these assessment type questions increased by 15.1%, 11.3% and 10.3% respectively in the post-module survey.

Table 2: Mean response ratings for student confidence with the different assessment type questions on S104 for the pre- and post-module surveys. The percentage change in mean response ratings are shown in the final column (positive in green and negative in red)

Assessment type question	Pre-module survey (December 2015)	Post-module survey (October 2016)	% Change
Long written answers	3.79	4.22	+11.3
Practical activity	4.2	3.92	-6.7
Short written answers	3.74	3.89	+3.9
Single word or multiple choice answers	3.5	4.03	+15.1
Problem solving	4.35	4.39	+0.9
Tasks involving numeracy/maths	3.99	4.4	+10.3
Experimental reports	4.04	4.03	-0.2
Group/co-operative	3.18	Not surveyed	N/A

work			

The students were also asked to rank their perceived usefulness of different methods of assessment employed on S104:

- questions with answers at the end of the course text
- questions within the course text
- assignments marked by a computer
- assignments marked by your tutor

Again, the students were asked to rate them on a Likert scale from 1 to 5 (1: not at all useful, 5= extremely useful) and the responses for the pre-module survey are shown in Figure 3. The mean response ratings given by the students for each of the assessment methods were calculated and are shown in Table 3.

Figure 3: Student **pre**-module survey responses on their perceived usefulness of different methods of assessment used in S104. Response options ranged from 1= not at all useful (dark red) to 5=extremely useful (dark green)

Table 3: Mean response ratings for student confidence with the different assessment type questions on S104 for the pre- and post-module surveys. The percentage change in mean response ratings are shown in the final column (positive in green and negative in red)

Assessment method	Pre-module survey (December 2015)	Post-module survey (October 2016)	% Change
Questions with answers at the end of the text	4.2	Not surveyed	N/A
Questions within the course text	4.18	Not surveyed	N/A
Assignments marked by a computer	3.39	3.9	+13.1
Assignments marked by	4.66	4.74	+1.7

your tutor			

The students perceived the assignments marked by their tutor as most useful. 72% of pre-module survey respondents and 78% of post-module survey respondents ranked this assessment type as extremely useful and the mean rating scores for their perceived usefulness of this assessment type were 4.66 and 4.74 respectively. The questions with answers at the end of the text and questions within the course text were also rated highly by the students with mean rating scores of 4.2 and 4.18 on the pre-module survey. Interestingly, there was a 13.1% increase in the mean rating for the perceived usefulness of assignments marked by a computer in the post-module survey.

In the **pre**-module survey, the students were asked about their understanding of different process words and terms used in S104 assessment questions. They were asked about 8 terms:

(i) Define
(ii) Describe
(iii) Explain
(iv) Summarise
(v) Compare
(vi) Discuss
(vii) State
(viii) Contrast

Again, examples of S104 assessment questions using these terms were included in the survey. For example, here are two questions about 'Explain' and 'Describe' respectively:
'*Using only information from Book 1, and referring to appropriate diagrams from that book, explain how the burning of coal to generate electricity can contribute to global warming.*'
'*Using information from Book 2, describe four observations that indicate the Earth's interior is made of materials that differ from the types of rock found at, or just below, the Earth's surface.*' They were both taken from the S104 assignments.

Interestingly, sometimes the students would use other question or process words as part of their explanation of the terms. For example, some students used 'Explain', 'Describe' and 'State' as part of their explanation for the term 'Define'. Sometimes they would also give an answer to the example question as part of their explanation. Some students also compared the different question or process words as part of their explanations such as:
'*Describe is more detailed than define.*'

Many students used similar explanations for 'Compare' and 'Contrast':

'*Contrast means, and bears similarity to Compare, to identify likes and unlikes within a sample and consider their similarity or difference*'

'*Contrast is similar to compare showing differences or unlikeness between two things*'

(i) Here are a few of the students' explanations for the term 'Define':

'To give a description of the meaning of the word'

'Say exactly what something is'

'To give a brief explanation of what something is, but not to go into specific detail'

(ii) For 'Describe', here are a few of the students' explanations:

'To detail the attributes and qualities of an item'

'To give detailed account of'

'To provide information about the subject'

(iii) Here are a few of the students' explanations for the term 'Explain':

'To make something understandable'

'Say why as well as what'
'Give an account off something in detail and talking through how the process takes place including facts and figures'

(iv) For 'Summarise', here are a few of the students' explanations:

'Taking all the information provided and condensing it down to the most useful/applicable to the question'

'Provide a short description of the main message, including the main conclusions made but without detailed reasoning and analysis'

'To give a short but accurate account of the material'

(v) Here are a few of the students' explanations for the term 'Compare':

'Cross-referencing two or more sources of information, running through the pros and cons of each method and reaching verdict for which would be the most useful'

'Take 2 ways (one positive, one negative / one for, one against) and see the most suitable'

'To describe negative and positive points of each approach and then use these points to decide which is the best approach'

(vi) For 'Discuss', here are a few of the students' explanations:

'A group appraisal of a topic in other to define the differences or similarities of an object or issue, highlighting different views and opinions with an objective of a balanced information or views'

'To consider/confer other opinions'

'Identify and describe different viewpoints on the statement, with evidence to support or negate them'

(vii) Here are a few of the students' explanations for the term 'State':

'A simple low mark question asking for a fact or a figure. No explanation necessary'

'Write down, say, or otherwise communicate the exact values recorded. I would expect the answer to be a set of numerical values, probably in a table'

'Provide the results'

(viii) For 'Contrast', here are a few of the students' explanations:

'Showing how two sides of an argument differ from each other'

'Detail the similarities and differences between two items, concentrate discussion on the differences between them'

'Say how the different theories are similar and how they DIFFER from each other'

Following this, the students were asked about which of these terms/process words they found most challenging. A few students answered that they found none of the terms challenging and they were satisfied with their meaning. 35% of the student responses (n= 43) selected 'Contrast' as the most challenging term. 'Discuss', 'Define' and 'Explain' were also selected to be challenging terms by the students (16%, 14% and 12% respectively). The results are shown in Figure 4.
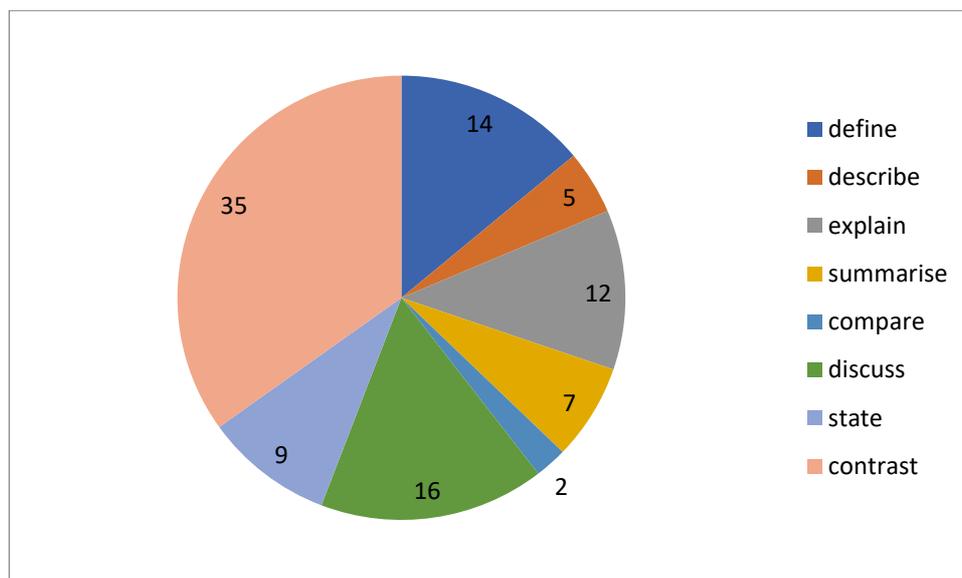
Figure 4: Student **pre**-module survey responses to question asking which of the 8 terms do you find most challenging. % of response options selected shown (n=43).

One of the popular reasons why 'Contrast' was selected to be the most challenging term was, as discussed earlier, because of its similarity to 'Compare':

'In standardised examination vocabulary 'and contrast' is unnecessary in 'compare' questions as it does not change/add any meaning to the question'

'Contrast as I feel this means the same as compare'

'Contrast as it would seem to have no added value over compare'

However, additional reasons were given by some students:

'Never really used Contrast as a term in my everyday goings on'

'Contrast - as it requires you to fully understand, digest and interpret an area'

'Contrast is ambiguous in an open ended question that can be answered in multiple ways and is asking for an opinion to be given on the validity of the different theories by comparing their differences'

In the **post**-module survey, the students were also asked about how clear they found the different words and terms used in S104 assessment questions. They were asked about 11 terms/process words- 5 of the 8 terms from the pre-module survey ('Define', 'Compare' and 'Contrast' were omitted) plus 6 other terms: 'Estimate', 'Calculate', 'Identify', 'Reflect', 'Determine' and 'Predict':

      (i) Describe
      (ii) Explain
      (iii) Summarise
      (iv) Discuss
      (v) State
      (vi) Estimate
      (vii) Calculate
      (viii) Identify
      (ix) Reflect
      (x) Determine
      (xi) Predict

The students were asked to rate each term/process word according to how clear it was to them using a Likert scale with possible responses from 1-5 (1= completely unclear to 5= very clear). The percentage of Responses (n=52) for each of the 11 terms is shown in Figure 5.
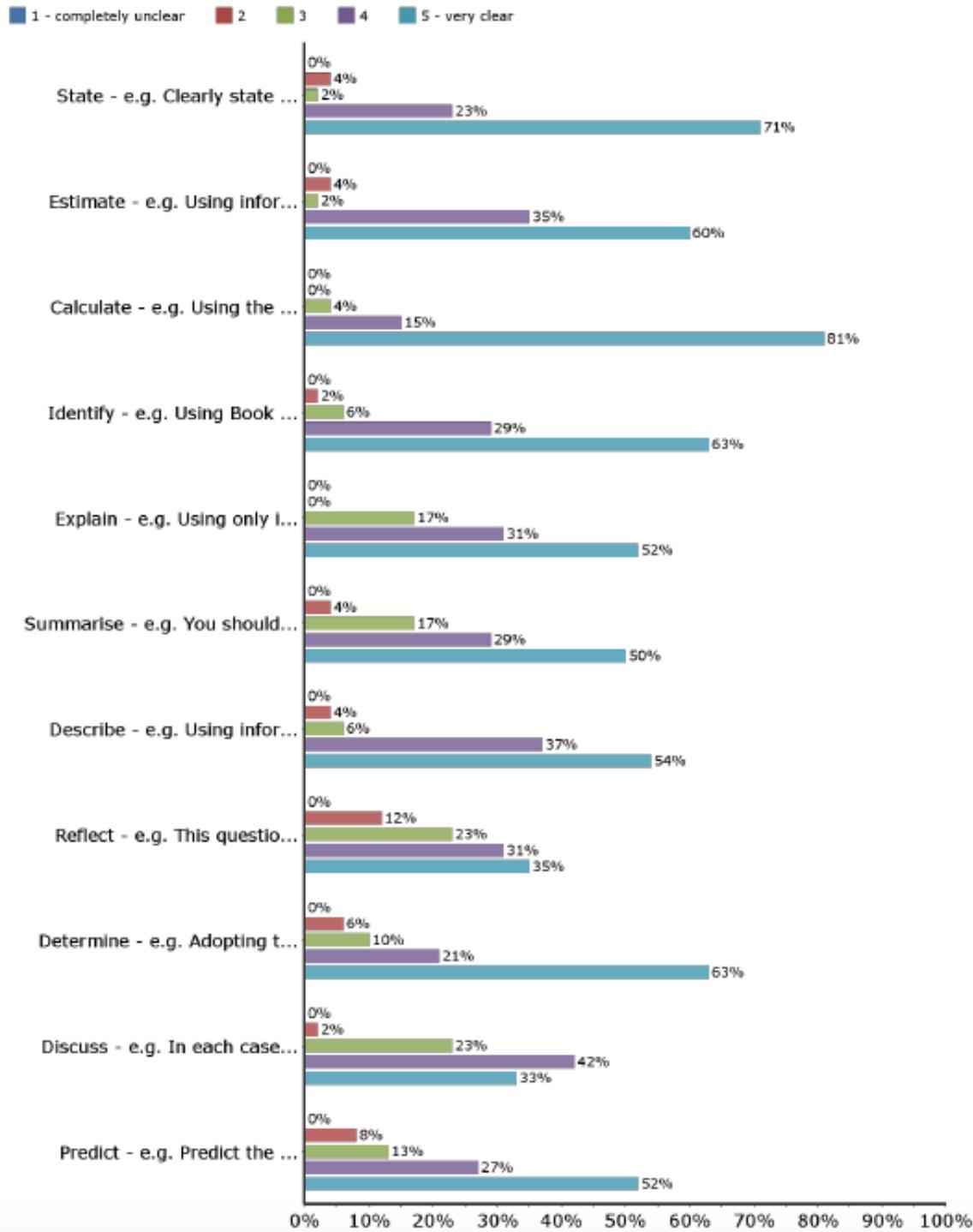
Figure 5: Student **post**-module survey responses to question asking how clear the 11 terms/process words taken from S104 assignments were to them. Possible response options ranged from 1= completely unclear (dark blue) to 5=very clear (light blue). % of response options (n=52).

The mean response ratings given by the students for the clarity of each of the 11 terms/process words were calculated and are shown in Table 3.

Table 3: Mean response ratings given by students (n=52) for the clarity of 11 process words or terms used in S104 assignments for the **post**-module survey. The 5 terms that were also surveyed in the **pre**-module survey are shown in bold.

Process word/term	Post-module survey (October 2016)
State	4.62
Estimate	4.50
Calculate	4.77
Identify	4.54
Explain	4.35
Summarise	4.25
Describe	4.40
Reflect	3.88
Determine	4.42
Discuss	4.06
Predict	4.23

The students rated the clarity of all 11 process words/terms very highly (the overall mean rating score given was 4.37) and none of the process words/terms were rated as 'completely unclear' by the students. Of the 11 process words/terms, the students were least confident with 'Reflect'(mean rating score of 3.88) and most confident with 'Calculate' (mean rating score of 4.77). This may be because 'Calculate' may be scientific and technical while 'Reflect' is more abstract and requires students to evaluate the learning process which is generally found to be complex and challenging to students (Ryan, 2011). Of the 5 terms/process words surveyed in both the pre- and post module surveys, 'Discuss' had the lowest mean rating score (4.06) in the post-module survey and this correlates with the pre-module survey results, where students rated it as the most challenging of these 5 terms (16% of responses in Figure 5).

Finally, the students were asked some open-ended survey questions about the purpose of the formative and summative assessments employed in S104. Some of the responses included:

'The assessment for the module motivated my engagement and learning'

'The formative assessments helped me consolidate material as I learnt it and helped me with revision later on in the course'

'I found the formative assessments useful for practising maths-based skills- it was good to be able to practice answering questions and finding out where I had gone wrong without the pressure of the work being assessed.'

'The formative assessments were useful in helping me learn and in giving me confidence that I had understood each subject.'

'The summative assessments test knowledge and application.'

'The assessments motivated me by giving me a series of targets to work towards.'

'The continuous assessments helped me prepare for similar style questions in the exam.'

'The formative assessments are useful as you can analyse your progress and receive feedback from your tutor.'

'The formative assessments are very useful as they provide clarity on how well I am doing and where my weaknesses are.'

'The continuous assessments helped me focus on key parts of the module materials.'

4.3 High and low-achieving students' academic literacy skills

In this section, we report on the results of a statistical analysis of the language used in the 48 assignments collected from eight students. As noted in 3.2.3, the linguistic analysis focused on lexical density, reading complexity, academic vocabulary use and the use of metadiscourse.

4.3.1 Language proficiency

All 48 assignments were analysed for their level of language proficiency in relation to the Common European Framework of Reference (CEFR) for languages. It divides language proficiency into six levels: A1 (most basic user), A2, B1, B2, C1 and C2 (most advanced user, native like proficiency). A summary of the eight students' linguistic proficiency in English is presented in the table below.

Table 4: Students' Linguistic proficiency as shown by their six assignments

	TMA01	TMA02	TMA03	TMA04	TMA05	TMA06
Student 1 (High score)	C2	C2	C2	C2	C2	C2+
Student 2 (High score)	C1+	C2	C2	C1+	C1+	C2+
Student 3 (High score)	C1+	C2	C2	C1+	C2	C2+
Student 4 (Low score)	C1	C1+	C2	C2	C1+	C1+
Student 5 (Low score)	C1+	C2	C1+	C2	C1	C2+

Student 6 (Low score)	C2	C2	C2	C2+	C2	C2+
Student 7 (Low score)	C2	C2	C2+	==C1+==	==C1+==	C2
Student 8 (High score)	C2	C2	-	C2	C2	C2+

It appears that two of the high scoring students' English language proficiency is below C2 in 2-3 TMAs while three of the low scoring students had below C2 in 2 – 4 TMAs. However, one low achieving student had C2 or higher in all assignments. This probably shows only a slight difference among these students regarding the language proficiency. This means there are other factors which differentiate their written performance. The other factors below may indicate any differences in their writing.

4.3.2 Lexical complexity

Lexical complexity refers to the complexity of words used in a text. Related to this notion is lexical diversity which means the range of words employed by a writer in a text, thus the more diverse the words, the more complex and difficult or advanced the text is. For the purpose of this report, lexical diversity is measured by using a program called *voccd* which measures lexical diversity of a text by calculating through a series of type-token (i.e., kind of word and words representing that kind) ratio samplings and curve fittings. Tables 5 present the length of each assignment and their lexical diversity respectively.

Table 5: Length of each assignment

	TMA01	TMA02	TMA03	TMA04	TMA05	TMA06
Student 1 (High score)	684	734	==1149==	2485	2718	2561
Student 2 (High score)	601	780	783	==1659==	==1152==	1996
Student 3 (High score)	746	972	771	==2525==	2921	2554

Student 4 (Low score)	646	672	846	1502	1614	1105
Student 5 (Low score)	713	493	629	1280	829	1493
Student 6 (Low score)	1007	556	1008	2656	1396	2236
Student 7 (Low score)	943	969	1093	2224	1730	4251
Student 8 (High score)	955	1582	-	2378	1588	2360

As can be seen in the table, the length of the text varied across the eight students for a single TMA. For example, the length of TMA02 ranged from 493 words (Student 5) to 1582 words (Student 8). This variation in length may have been due to the instruction on the length of the response to each question as remarked earlier that it is not clear how much needs to be written as an answer for many questions. It appears that low achieving students write either over-length or under-length responses to the question although this assertion needs to be taken cautiously.

Table 6: Measure of textual lexical diversity (MTLD) in assignments

	TMA01	TMA02	TMA03	TMA04	TMA05	TMA06
Student 1 (High score)	76.13	95.49	100.44	81.33	93.05	93.85
Student 2 (High score)	72.02	97.6	108.3	83.46	90.65	93.42
Student 3 (High score)	81.88	89.61	157.85	105.13	99.83	112

Student 4 (Low score)	74.59	81.27	110.06	109.2	135.54	85.33
Student 5 (Low score)	70.63	99.95	108.81	99.92	122.29	91.3
Student 6 (Low score)	75.15	91.35	97.14	91.82	85.38	106.96
Student 7 (Low score)	85.68	89.43	101.62	93.86	155.98	114.27
Student 8 (High score)	92.1	110.73	-	102.51	124.76	125.64

vocd indicators show how complex a text is. That means the higher the indicator is the more complex and diverse the text may be; the lower the indicator is the less complex and diverse it may be. It is assumed that a proficient academic writer's text will have a measure of 80 or over (Durán, Malvern, Richards, & Chipere, 2004). On this basis, it appears that most students, including the high achievers, have a *vocd* indicator of 80 for TMA01. It may be that TMA01 is much simpler than the rest and so the student responses are less sophisticated. It is interesting to note that two low achieving students, Student 4 and Student 7, have a higher *vocd* indicator than the high achievers in TMA04 (109.2) and TMA05 (155.98) respectively. It is also worth noting the low *vocd* in Student 1's TMA04. A detailed analysis might reveal these differences further.

4.3.3 Metadiscourse markers

Metadiscourse markers refer to words or phrases such as *firstly* and *in contrast* used to organise a text or indicate the writer's stance or position in the text. These words or phrases range from those that connect ideas (logical connectors) to citing sources (evidentials). The Textinspector analysis drew on Hyland's (2004) categories of metadiscourse markers. Metadiscourse markers are commonly employed in established academic writers which is expected in student assignments. Table 6 summarises the use of metadiscourse markers in each student's TMAs.

Table 6: Use of metadiscourse markers in assignments (% of total words in each assignment)

	TMA01	TMA02	TMA03	TMA04	TMA05	TMA06
Student 1 (High	7.81	9.38	6.29	4.18	5.18	6.6

score)						
Student 2 (High score)	6.55	11.05	10.81	6.58	8.26	7.55
Student 3 (High score)	5.13	12.64	8.32	7.63	5.66	8.02
Student 4 (Low score)	8.66	14.74	12.24	9.63	10.08	11.67
Student 5 (Low score)	6.52	10.04	7.09	5.94	4.95	8.69
Student 6 (Low score)	7.72	10.02	10.81	6.11	6.6	8.03
Student 7 (Low score)	6.65	10.02	9.29	7.07	6.37	6.3
Student 8 (High score)	5.94	6.47		5.87	6.98	7.94

The table shows that each student made use of the metadiscourse markers in each assignment although the amount of their use varied across the TMAs and the students. One noticeable result is that Student 4 has the highest number of metadiscourse markers across all six TMAs as highlighted above. It is interesting that it is the same student who wrote shorter assignments than most of the other students (see Table 5 above). A closer look at the types of metadiscourse markers indicate that all these students used the following types of discourse markers the most, logical connectives with the highest and relational marker with the lowest instances among the four types with a high frequency:

- *Logical connective* (express semantic relationship between sentences and paragraphs), e.g., in addition, thus, however, etc.
- *Person marker* (explicit reference to the author), e.g., I, we, my, mine, our etc.
- *Hedge* (withhold writer's full commitment to claims), e.g., might, perhaps, possibly, etc.
- *Relational marker* (explicitly refer to or build relationship with the reader), e.g., frankly, note that, you can see, etc.

It is worth noting that *person markers* were widely used by all eight students while the low achieving students tended to use them the most. This may suggest that science as a discipline which focuses on facts and objective information, the use of such a high percentage of *personal markers* may have been valued less by the science tutors, possibly influencing their marking of the low achieving students.

4.3.4 Reading complexity

Textinspector, the software that analysed student assignments, uses three measures to assess a text's readability (how easy or difficult a text is). For the purpose of this report, only the results from the two widely used measures are presented: Flesch-Kincaid Grade and Gunning Fog index. Flesch-Kincaid Grade considers the length of words, syllables and sentences using a formula and the result is a US schooling grade. Like Flesch-Kincaid Grade, Gunning Fog index calculates readability by measuring the average number of words in a sentence and the number of complex words. The result is a US schooling grade. In both tests, a higher grade means a difficult text. A summary of the readability tests of the eight students' assignment texts is presented in Table 7.

Table 7: Readability test scores of each assignment (Flesch-Kincaid Grade & Gunning Fog Index respectively for each TMA)

	TMA01		TMA02		TMA03		TMA04		TMA05		TMA06	
Student 1 (High score)	12.45	15.8	11.19	14.6	10.84	14.66	10.54	14.22	10.54	13.77	11.55	15.29
Student 2 (High score)	11.01	14.2	9.83	12.62	8.59	11.94	8.28	11.81	8.19	11.03	10.51	13.76
Student 3 (High score)	11.5	15.05	9.12	12.4	7.44	11.14	7.45	11.06	11.29	14.74	10.09	13.45
Student 4 (Low score)	17.31	21.72	13.07	16.21	10.87	13.89	11.35	14.79	11.14	14.38	9.88	13.37
Student 5 (Low score)	10.98	14.01	10.58	13.69	7.81	10.76	9.77	13.32	8.04	10.84	11.75	15.19
Student 6 (Low score)	11.25	14.46	11.5	14.99	9.05	12.69	10.11	13.71	10.67	14.11	13.29	16.45
Student 7 (Low score)	10.62	13.72	13.67	16.19	11.02	14.75	8.57	11.79	9.56	12.8	12.76	15.3
Student 8 (High score)	11.42	14.53	11.47	14.79	-	-	10.64	14.37	15.25	18.35	13.07	16.33

The table shows that the readability score for each student on the TMAs was wide-ranging with regard to both the tests. The scores for Flesch-Kincaid Grade ranged from 7.45 (8th US grade) to 17.31 (US college graduate) and the scores for Gunning Fog Index were from 10.46 (10th US grade) to 21.72 (beyond US college graduate). So while some of the TMA texts were quite simple (e.g., Student 3's TMA 04) and many others were very complex (e.g., Student 4's TMA 01). A notable result of this test was Student 4's scores for three TMAs (TMA1, 2 and 4) which were the highest among the eight students. It may be that the student did not communicate the information well to the tutor by writing complex texts (including the use of technical terms inappropriately) which resulted in low scores. It appears from the results that the high achieving students' assignment text scores were mostly between 11 and 14 which is a suitable reading level for a first year undergraduate student. Although a careful analysis of the assignments may reveal further, it can be argued that reading complexity of the assignment text may have played a role in its success or failure.

5. Conclusion, recommendations and implications

This study examined The Open University's Level 1 science module (S104) assessment materials, student perceptions about assessment practices in science (pre-module and post-module) and student written assignments in S104 across six TMAs. All this was conducted in relation to how assessment is communicated to students in STEM, how students respond to assignment questions and the role of academic literacy or academic language.

The analysis showed that the module contains assignments that assess students' gradual progression in the module by designing assignments which move from easy to a more sophisticated one. The assignment instructions on the length of the expected response text was vague because the instruction indicated no word limit in a number of cases but only suggested either 'a sentence' or vague word counts. This was reflected in the substantially varied length of the student written responses to the same TMA question. The assignment briefs employ a number of process words and key words in each question. Among them, it was found that two process words were challenging to students as revealed by both the assignment analysis and the student survey: *discuss* and *reflect*. The main reason appears to be that the module does not teach how to write a 'discussion' text and a reflection text in science. As these text types are difficult to write and require a sophisticated level of using language to communicate about scientific topics, it is not fair to expect Level 1 students to come prepared with this ability. It is not sufficient to simply explain to students what the word means. They need to see the process of writing a discussion and reflection and their examples.

The survey results indicated that most students found problem-solving, experimental report, long written answer questions, single answer or multiple choice questions and tasks involving maths or numeracy as the most useful assessment tasks. The students also indicated that that they found assignments marked by both their tutor and a computer useful. In the pre-module survey, the students demonstrated a varying level of their understanding of the process words frequently used in the TMAs. This could have serious implications for how they respond to the assignment questions.

The linguistic analysis of eight students' assignments showed that their language proficiency level is sufficient for the module. However, their expertise in the use of academic and scientific language varied significantly which was reflected in their grades. It appears that those students who already had the ability to make appropriate choice of language to make meanings in science continued to excel while those with a lower ability in doing so were disadvantaged due to the lack of support for developing their scientific literacy during the study. This is something the new Level 1 modules such as S111 and S112 should consider in order to support struggling students. Research shows that carefully designed embedded academic literacy activities help students not only succeed in the module (Shrestha & Parry, 2019) but also enable them to transfer their academic literacy expertise to other modules as seen in business studies (Shrestha, 2017).

We make the following recommendations based on the findings of this study:

- Continue with the good practice of keeping assignments simple to begin with and gradually make them more sophisticated
- Provide clearly the word limit for each question

- Develop and embed academic literacy and/ or scientific literacy materials in Level 1 and possibly Level 2 for students on how to write explanation, discussion and reflection texts in science and if possible build on what has been done in Y033 (this may include providing good examples of these text types in the short term)
- Conduct student needs analysis in terms of their scientific literacy and academic literacy regularly via module surveys
- Conduct more scholarship work or research on widening participation students in science modules with regard to their academic and scientific literacy to inform future module designs.

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