Assessing Learning in a Student-Centred Classroom Environment

Gary Simpson
Woodleigh School, Victoria, Australia
simpg@woodleigh.vic.edu.au

Abstract

The author describes the manner in which student learning outcomes can be successfully measured, in a student-centred classroom environment, using both formative and summative approaches. He argues that by carefully planning units of work and/or individual activities in negotiation with students, it is possible to ascertain what they already know and understand about a subject and what skills and interests they may bring to the study of it. It is then possible to assess the growth of students' knowledge, understanding, and skill during, and at the end of, an activity or unit of study and report on this personal growth.

Introduction

How do we assess learning? I am sure we all regularly use a combination of formative and summative approaches to measure our students' progress. These are still valid approaches in student-centred classroom environments and guided discovery lessons. However, the devil is in the detail. It remains important to plan how student learning outcomes can be assessed, and to be prepared to negotiate this with the class.

This paper commenced life as a response to the following question asked by the Editor of this journal: "How can one assess a guided discovery lesson?" In it, I write more broadly of assessing learning in classroom environments that are characterized as being centred on the activity of students as they construct knowledge. This may not directly answer the question asked, but should help inform readers concerned with assessment and reporting in student-centred, and also guided-discovery, environments.

Prior Planning

As described by Figure 1, the planning process for a single activity or a unit of study is quite complex. A teacher wishing to work in a student-centred manner needs to know what their students already know about a topic, and what their skills and interests in relation to that topic may be. She should also know who they are as learners, and what the students would like to know about the topic. However, there are constraints. What is the school policy in relation to this topic? What are the faculty's agreed aims and objectives for this topic? What facilities do the faculty, school, or community offer to support the students' investigations? What are the externally mandated aims and objectives for students of this age studying your subject? (i.e., does the local education bureaucracy require certain material to be taught to your class?) What do your students' parents want for their students? How much do you--the teacher--know about this topic and its real world applications? What skills and interests do you bring?

All these questions need to be considered as the activity is prepared, before one becomes concerned with how the activity will be assessed and the students' outcomes reported. Often, teachers become excited by the prospects of the task and forget to plan the manner in which they will assess student outcomes. It is also important to remember to consider where, or how, the activity fits into the broader scope and sequence of the school's science program. If this can be built into the planning process, then the assessment of all tasks can be rigorous.

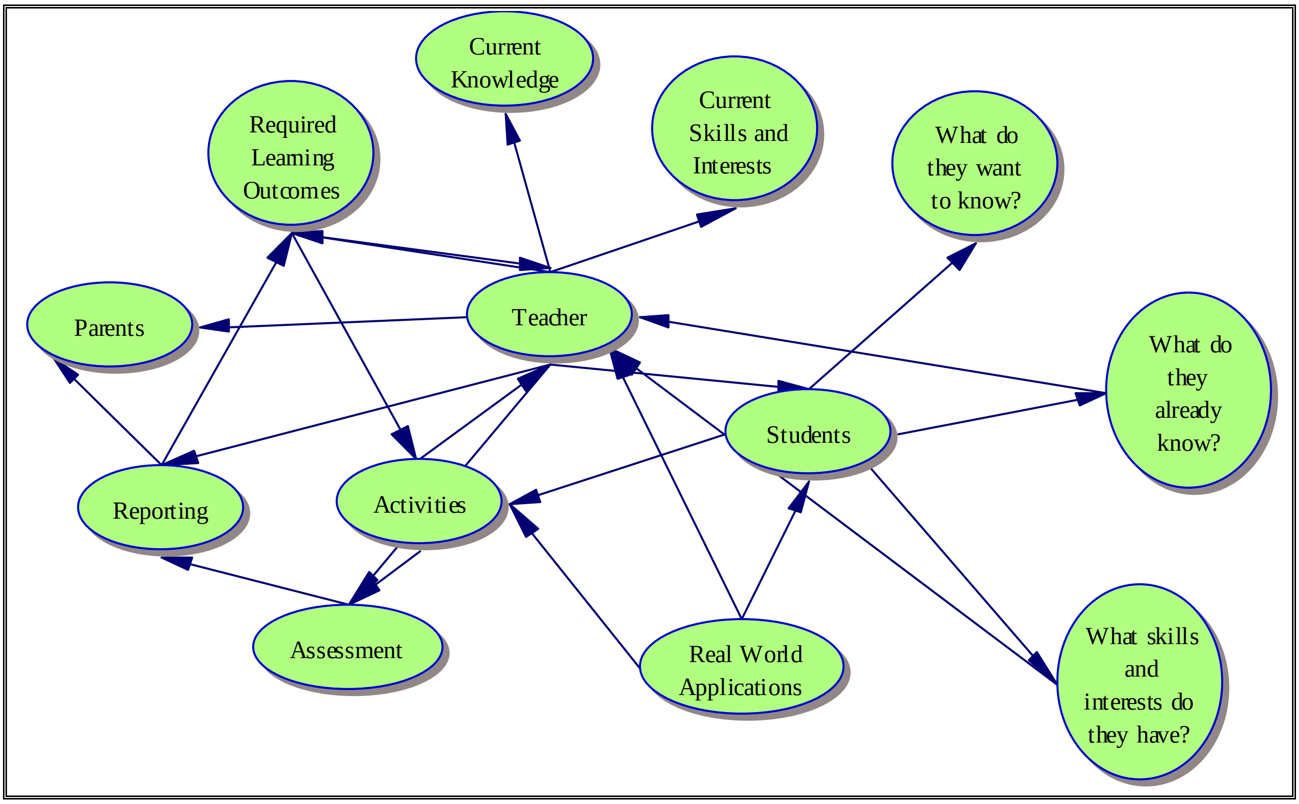

Figure 1. The planning process (after Semple, 2001).

Measurement of Prior Knowledge and Understanding

The first task is to know our students. This requires the development of a relationship, between the teacher and each individual student, that permits students to voice their opinions about what should happen in their class. We can also measure many of the attributes of our students.

Student knowledge and understanding of a topic can be measured directly by paper-and-pencil tests. However, there are many other activities that can also be used for this purpose:

- Class discussion, with or without prepared questions, to stimulate discussion and subjectively gauge understanding.
- Brainstorming (whole class, small groups, or individual).
- Concept mapping (whole class, small groups, or individual).
- Collecting the classroom wisdom. I start this process by writing the first line of a set of notes on the board and then, by asking probing questions, invite students to supply information. Their responses are recorded on the board, and gaps in their knowledge listed. The gaps become our starting points for investigation.
- Matching key ideas with their definitions from a jumbled collection (worksheets, on the overhead projector, or on the board, with students working as individuals, in pairs, small groups, or as a whole class).
- Responding to audio and/or visual stimuli (worksheets, on the overhead, TV, computer screen, or on the board, as individuals, pairs, larger groups, or whole class).

- A TWL activity. What do you ***T***hink you know about this topic? What do you ***W***onder about? And eventually, what did you ***L***earn about this topic?

We can also measure many of the learning attributes of our students. The purpose of this testing is not to diagnose conditions, but rather to inform the teacher of the diverse nature of his students and their different needs. We can measure students' preferred intelligence/s (many test instruments applying Howard Gardner's work on multiple intelligences, such as McGrath and Noble [1995], are available for different age levels) and their preferred learning style/s (again, many test instruments, such as Underwood [2002a,b], can be obtained), and it is possible to administer simple tests to give an indication of learning ability. However, one does need to be very careful with the use of such data. While diagnosing difficulties requires extensive testing by trained professionals, I stress that a simple test achieves nothing more than informing the teaching of potential difficulties. Stewart Sykes (1997) has completed much work in this area. Appendix A provides a table that Sykes uses as a checklist of learning disability characteristics. Appendix B contains a sample test that I have successfully used with my students to evaluate these characteristics, although it is also possible to do so by using a series of shorter activities over a number of lessons.

Opportunities for Taking Social Action

Whilst the example I explore in the next section does not offer an opportunity for students to take action, it is possible to encourage students to take action and demonstrate not just learning of concepts and skills, but incorporation of the knowledge and understanding gained into their deeper cognitive structures. Can my students contextualize the learning experience?

Both James Gallagher (2000) and Tony Townsend (2004), with their Mercedes Model (Figure 2) and Relational Learning Model (Figure 3), respectively, suggest that this is a critically important aspect of education in the new millennium. It is not enough to know facts in isolation, "facts for forgetting," as Townsend described them. It has become critically important that our students are able to engage with the material they are studying, be able to make value judgments related to that information, and apply the knowledge, understanding, and skills gained in the classroom in real world situations that have meaning for them. In this way, the activity of the classroom is linked to the lived experience of the students and the educational outcomes are deeply enriched.

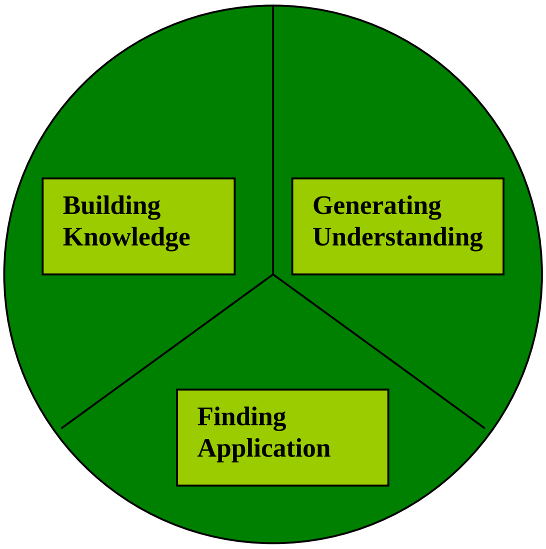

Figure 2. Gallagher's Mercedes Model for teaching and learning.

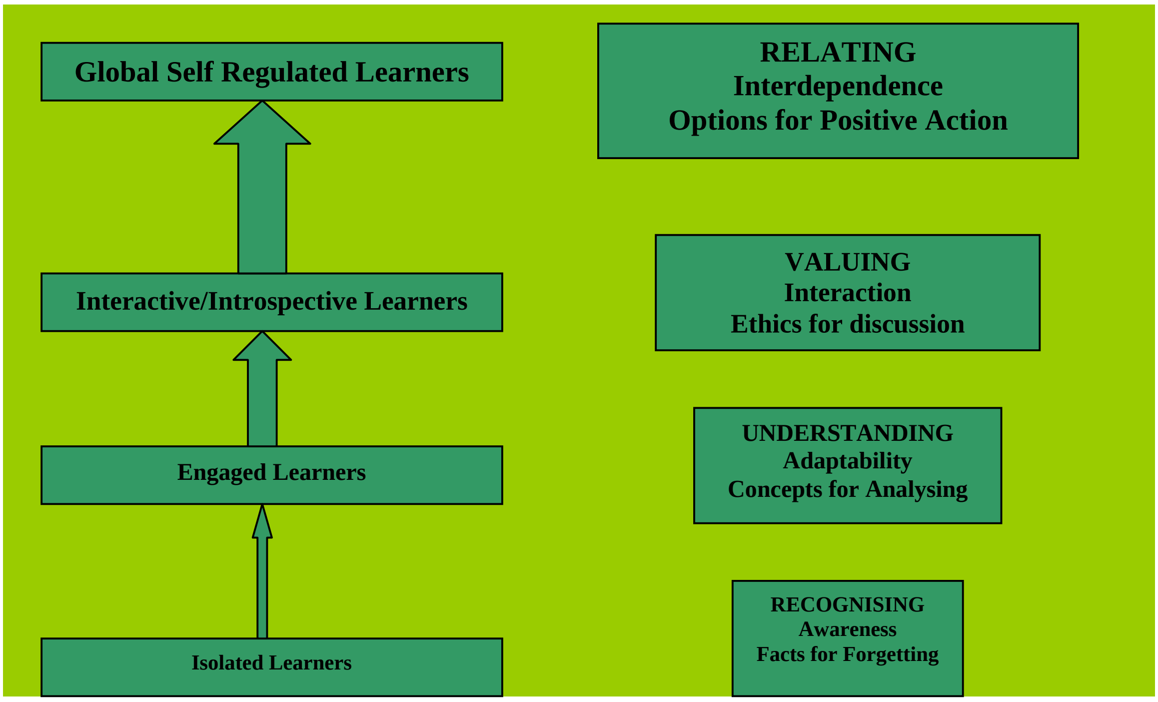

Figure 3. Townsend's Relational Learning Model.

Assessment and Reporting

Teaching in a manner that is influenced by a student-centred philosophy allows one to make regular formative assessments of students' progress. As one negotiates many aspects of a task with students, and guides the design, implementation, and performance of tasks with ongoing conversations, it is possible to give one's students regular feedback and make regular notes about their growth.

Having set criteria for the task based on the aims of the unit of study, it is then possible to require students to assess their own performance, and the performance of peers, against those criteria. In Figures 4-6, and Appendices C-E, I have attempted to provide an example of how this works for one task in one of my classes. This is a Year 11 (16-year-old post-compulsory education) Biology class studying an externally mandated course. The Victorian Curriculum and Assessment Authority (VCAA) in Australia requires that teachers are able to report the achievement of particular learning outcomes for each student (VCAA, 1999). I have used the task of Figure 4, which students receive prior to commencing the activity, to assess the following learning outcomes:

- Experimental methods used to investigate requirements for life.
- Design and carry out practical activities that investigate the requirements of an organism.
- Record, analyse, and evaluate data from practical work designed to investigate the requirements of plants and animals.
- Use controls in biological experimentation.
- Work cooperatively in the design, planning, and conduct of practical activities.
- Prepare reports on practical activities that reflect what has been gained from the activity.

Requirements for Life

In groups of 2 or 3, you are to design and carry out an experiment that investigates questions you have about the various requirements for life of organisms. Experiments on plants are preferred because they are often easier, quicker to achieve, and lack the ethical implications of experiments on animals. Experiments with animals will be considered by a student ethics committee and ratified by the teacher. Students can use school facilities for plant experiments, but this may not be possible for animal experiments.

Each group report needs to include the following:

A **hypothesis**, and background information that has informed the hypothesis. What were your original questions? Why did you have those questions? What research did you do to help answer those questions?

An **aim** (or aims) that will test the hypothesis. How will you test your idea?

A list of **apparatus** required for the experiment. If you require my help with obtaining resources, I will need a list of materials for your experiment. If another scientist is to test the accuracy of your work, that person will need to know what equipment you have used.

A clear, concise, easy to follow **methodology** that clearly fulfils the aims. This is a list of everything you did, step by step. Again, if your work is to be checked for accuracy, then someone else has to be able to repeat exactly what you did and get the same results.

A collection of **results** and **observations**, preferably in table form. Results are things you can measure. Things like the weight of the chickens? How long are the stems? How many leaves? These can be put into tables and then graphed. Observations are things like a description of the condition of the feathers on your chicken, or the condition of the leaves. These are also logged in tables, but are best shown by pictures or diagrams that compare different organisms.

A **discussion** and **conclusion** that describe things like: Any changes to the experiment that were required. What were the sources of experimental error? How did you attempt to control error? In light of your hypothesis and aim(s), how do you explain the results and observations you collected? This is where you should including graphs and other analytical methods. What suggestions can you make for improvements for future experiments? You should also finish with a concluding statement about how well you think your aims were achieved.

Your group is to present your findings to the class, detailing what questions you started with, how you designed your experiment, and what results you obtained. The class will be encouraged to question you about your experiment.

Figure 4. Sample group self-design experiment.

Students are also made fully aware of the criteria that will be used to assess their work (see Figure 5). The process of establishing working groups, negotiating the dimensions of their task, and deciding whether the activity is ethical and should proceed can take a number of weeks. This class receives five, 80-minute lessons per fortnight over a 16-week semester. Because the activity assesses their understanding of the concepts studied, it occurs late in the teaching sequence. It receives considerable time at school, with an expectation that considerable time also be spent at home. When talking with students, I make many notes regarding these criteria and how the students are developing in relation to them.

I use the guiding questions of Figure 6 to question students about the planning and implementation of their experiments. During these discussions, I am able to quite quickly identify those students who have a firm grasp of experimental technique and the concepts to be studied, and those who do not. I am also able to monitor individual growth. The students' ability to answer these questions generally improves, and instead of me questioning them, they tend to come to me with ideas they wish to discuss and test.

Assessment Criteria

For satisfactory completion of the work requirement, the following criteria must be addressed. These criteria will also be used to assess your level of achievement (A+ to E, or UG [ungraded] for work that does not meet the criteria).

Written Report

1. Hypothesis/background
   a) Clear statement of hypothesis.
   b) Concise background statement to support hypothesis.

2. Aim
   a) Clear link to hypothesis.
   b) Concisely stated.

3. Apparatus
   a) Complete and detailed list including brands, size, and quantity.

4. Methodology
   a) Clearly relates to aims.
   b) Attempts made to control error.
   c) Achievable.

5. Results/observations
   a) Clear set of tables, etc. to display collected data.

6. Discussion/conclusion
   a) Graphs and other forms of analysed data.
   b) Discusses errors made, sources of error, and attempts to control error.
   c) Relates findings to aims and hypothesis.
   d) Discusses problems experienced and suggests improvements for the future.

7. Presentation
   a) Logical format.
   b) Neat, clear presentation.
   c) References correctly cited and listed.

8. Participation
   a) Clear evidence that all members of the group have participated equally in the experiment.

Classroom Presentation

1. Should include all the features listed above.

2. Should inform the students about the topic.

3. Should involve the students in a meaningful way (e.g., video with questions, short practical session, worksheet, crossword--but not a WordFind).

Figure 5. Assessment criteria.

Students are then asked to make a short presentation to the rest of the class, explaining what they did, why they did it, how they carried out the experiment, and what they learnt about experimental design and the concepts they were studying. I ask them to evaluate how well they think they have done (see the self-assessment matrix in Appendix C), and I ask the rest of the class to provide feedback to each presentation (Appendix D). I also complete a similar assessment (Appendix E). I therefore have many notes (formative), and my final assessment (summative), upon which to base my assessment of the students' progress.

What were your original questions? Why did you have those questions? What research did you do to help answer those questions?
How will you test your idea?
If you require my help with getting resources, I will need a list of materials for your experiment. If another scientist is to check the accuracy of your work by trying to repeat it, that person will need to know what equipment you used and what you did. This is a list of everything you did, step by step. So, think carefully. What do you need?
Results are things you can measure. Things like the weight of the chickens, the length of the stems, or the number of leaves. These can be put into tables and then graphed. What will you measure?
Observations are things like a description of the condition of the feathers on your chicken, or the condition of the leaves. These are also logged in tables, but are best shown in pictures or diagrams that compare different organisms. What will you observe?
What changes were required to your experiment? What were the sources of experimental error? How did you attempt to control error?
How do you explain the results and observations you collected, in light of your hypothesis and aim(s)? This is where you should including graphs and other analytical methods.
What suggestions can you make for improvements for future experiments?
How well do you think your experiment tested your aim(s)?
What do your results tell you about your hypothesis?

Figure 6. Guiding questions used to probe students' understanding of their experiments.

It is then possible to write meaningful reports to school authorities, external authorities (not that they require them in Victoria at this year level), students, and their parents that indicate that you know the student, understand what they have gained from a learning experience in your classroom, and how they have grown as a young scientist.

Final Reflection

Teaching in a guided discovery, or student-centred, manner still requires student learning outcomes to be assessed. However, because of the nature of the relationships established between teacher and students, the criteria for assessment form an integral part of the planning process and are shared with the student. In this way, I believe that assessment can be more detailed and comprehensive in terms of the depth of knowledge and understanding that students achieve. This can be further assessed, where appropriate, by requiring the students to take some sort of related social action in either the school or local community. This allows students to display the way in which they have contextualized the concepts studied and included them in their cognitive structures. The reporting will also reflect this more intimate knowledge of the student as learner, displaying what they knew before, what they know now, what strengths they have displayed, and where further improvement can be made.

References

Gallagher, J. J. (2000). *Implementing needed reforms in science education: Research and development to enhance understanding and application of knowledge*. Keynote address presented at the Second International Conference on Science, Mathematics and Technology Education, National Taiwan Normal University, Taipei.

McGrath, H., & Noble, T. (1995a). *Seven ways at once, Book One: Classroom strategies based on the seven intelligences*. Melbourne: Longman.

McGrath, H., & Noble, T. (1995b). *Seven ways at once, Book Two: Practical work units based on the seven intelligences*. Melbourne: Longman.

Semple, A. (2001). *ACER professional standards in science professional development*. Melbourne: Australian Council for Educational Research (ACER).

Sykes, S. (1997, April). *Learning disabilities: A thorn by any other name*. Address to the staff of Beaconhills Christian College, Victoria, Australia.

Townsend, T. (2004, March). *Maximising learning in Third Millenium classrooms*. Address to the Victorian State Conference of the Australian Council for Educational Leaders (ACEL), Moorabbin, Australia.

Underwood, M. (2002a). Catering for individual student needs: Learning styles (Part 1). *The Science Education Review*, *1*, 58-64.

Underwood, M. (2002b). Catering for individual student needs: Learning styles (Part 2). *The Science Education Review*, *1*, 92-99.

Victorian Curriculum and Assessment Authority (VCAA). (1999). *Victorian certificate of education biology study design*. Melbourne: VCAA.

Appendix A

Checklist of Learning Disability Characteristics (Sykes, 1997)

Characteristic	Nil	Mild	Moderate	Severe
1. Severe and prolonged directional uncertainty and confusion (e.g., reversal of letters and numerals, left-right confusions, difficulties interpreting maps or street directories, spatial and temporal confusions, problems telling the time).				
2. Short-term sequential retention difficulties (e.g., retention of basic number facts, difficulties memorising series of digits).				
3. Serial learning problems (e.g., difficulty learning series of information, days and weeks, months in the year, seasons, etc.).				
4. Reading problems (e.g., word recognition, comprehension, rate).				
5. Spelling problems (e.g., phonetic spelling and misspelling of frequently used words).				
6. Written expression problems (e.g., telegraphic and disjointed sentences and paragraphs, frequent spelling errors [particularly of commonly used words]).				
7. Handwriting problems (e.g., awkward style and slow rate).				
8. Mathematics problems (e.g., limited knowledge of basic number facts, difficulty with basic algorithms and fractions).				
9. Oral expression problems (e.g., communication lacks clarity and sequence).				
10. Problems studying and organising learning.				
11. Concentration and attention problems.				
12. Interpersonal and social difficulties.				

As a guide to the positive identification of learning disabilities, it would be expected that a student would exhibit ratings of moderate or severe on at least 8 of these 12 characteristics.

Appendix B

Learning Ability Test

The following activities were designed to allow the teacher to make judgements on 8 of the 12 characteristics from Sykes' (1997) Checklist of Learning Disabilities. They are meant only to alert the teacher to the possibility of difficulties, and cannot be assumed to correctly and accurately assess the learning ability of a student. Where a concern becomes apparent, the student should be referred for formal assessment. With the exception of Item 5, the tests were read out to students.

1. Dictation: Words

The solar system has nine known planets. From the Sun outward, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto (although from about 1978 to 1999, and as a result of Pluto's irregular orbit, Pluto was closer to the Sun than Neptune). The solar system also has an asteroid belt, a somewhat orderly collection of small to kilometres-wide rocky objects, most of which lie between the orbits of Mars and Jupiter.

2. Dictation: Numbers

12	123	1236	67891
34	456	4589	76543
51	104	8417	39684
76	408	3968	15739
98	987	9876	70809

3. Sequential Patterns

a) List all the days of the week, in reverse order, starting with Friday.
b) List all the months of the year, in correct order, starting from April.
c) Name the four seasons, in order, from the start of the calendar year.

4. Number Function

Addition	Subtraction	Multiplication	Division	Fractions to decimals	Decimals to fractions
2 + 5	7 – 6	2 x 2	12 / 4	½	0.333
13 + 8	8 – 5	3 x 4	3 / 3	1/3	0.67
-8 + 9	19 – 9	5 x 6	6 / 3	1/5	0.4
22 + 34	11 – 15	10 x 8	18 / 6	1/8	0.25
-20 + 12	17 – 29	12 x 7	21 / 7	¼	0.125

5. Comprehension

(The following information, including the questions at the end, was displayed on the overhead projector.)

Comets are small objects made of rock, ice, and gases that orbit the Sun. Short-term comets complete their elliptical orbits in 6 to 200 years (although some orbits are parabolic and the comet is never seen again); long-term comets take thousands of years to complete their orbit or may never return at all.

Most comets are composed of frozen water, carbon dioxide, methane, ammonia and non-icy materials such as silicates and organic compounds. They were once described as "dirty snowballs" mixed with small amounts of rocks, debris, dust and organics. But more recent studies suggest that comets are more like "mud balls," with rocky debris accounting for more than half the volume.

Comets have three main parts:

> Nucleus - the centre of which is made up of rock and ice.
> Coma - consists of gases and dust and surrounds the nucleus.
> Tail - made up of gases and dust that spread out from the nucleus and coma.

a) What are comets?
b) What are comets composed of?
c) How long does it take for a comet to return?
d) Why do some comets never return?
e) What is the nucleus of a comet?
f) What is the tail of a comet?

6. Written Expression

In 100 words or less, describe what you like most about studying science.

Appendix C

Self-Assessment Matrix: Student-Designed Experiment

Criteria	Details	Comments
Questions	What were the original questions? Why did you have those questions? What research did you do to help answer those questions? How did you test your idea?	
Designing	Did the list of equipment required include everything you needed? Did the list of things you did include everything you did? How did you control variables? Does this method test your aim?	
Data	Did you measure everything you needed to answer your original question? Did you observe everything you needed to answer your original question? Do your tables and graphs clearly show what you discovered?	
Evaluation	What changes were required to your experiment? What were the sources of experimental error? How did you attempt to control error? Were you successful? How do you explain the results and observations you collected in light of your hypothesis and aims? What suggestions can you make for improvements for future experiments? How well do you think your experiment tested your aims? What do your results tell you about your hypothesis?	
Communication	Has your group clearly explained your original question? Have you clearly explained your investigation? Are your conclusions correct? What other things could you have done to improve this investigation?	

Appendix D

Peer-Assessment Matrix: Student-Designed Experiment

Criteria	Details	Comments
Questions	Are the original questions clearly spelt out? Was any research completed to help answer those questions?	
Designing	Did the list of equipment required include everything needed? Did the list of things done include everything the students needed to do? Were variables controlled? Does this method test their aim?	
Data	Did they measure everything they needed to answer the original question? Did they observe everything they needed to answer their original question? Do the tables and graphs clearly show what was discovered?	
Evaluation	Did the group highlight the changes required to the experiment? Have they explained their attempts to control error? Were the results and observations collected explained in light of the original hypothesis and aims? Are suggestions made for improvements for future experiments? How well did the experiment test the aims?	
Communication	Did the group manage to clearly explain their original question? Did they clearly explain their investigation? Do you believe that the conclusions they drew are correct? What other things could they have done to improve this investigation?	

Appendix E

Teacher Assessment Matrix: Student-Designed Experiment

Criteria	Details	Comments
Questions	Are the original questions clearly spelt out? Was any research completed to help answer those questions?	
Designing	Did the list of equipment required include everything needed? Did the list of things done include everything the students needed to do? Were variables controlled? Does this method test their aim?	
Data	Did they measure everything they needed to answer the original question? Did they observe everything they needed to answer their original question? Do the tables and graphs clearly show what was discovered?	
Evaluation	Did the group highlight the changes required to the experiment? Have they explained their attempts to control error? Were the results and observations collected explained in light of the original hypothesis and aims? Are suggestions made for improvements for future experiments? How well did the experiment test the aims?	
Communication	Did the group manage to clearly explain their original question? Did they clearly explain their investigation? Do you believe that the conclusions they drew are correct? What other things could they have done to improve this investigation?	