Assessment, Learning and Teaching: A Symbiotic Relationship

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CHAPTER EIGHT

ASSESSMENT, LEARNING AND TEACHING – A SYMBIOTIC RELATIONSHIP

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GOALS

The goals for this chapter are to support you to:

- Explain the central role of assessment to learning and teaching
- Distinguish between different types and purposes of assessment
- Recognise how different tasks and strategies can be used to monitor students' progress depending on the purpose of assessment
- Describe the key components around quality assessment processes
- Recognise how increasing accountability can influence teacher assessment practices

Australian Professional Standards for Teachers – Graduate level

- Standard 1: Know students and how they learn (Focus areas 1.3, 1.5)
- Standard 2: Know the content and how to teach it (Focus areas 2.3)
- Standard 5: Assess, provide feedback and report on student learning (Focus areas 5.1, 5.2, 5.3)

Introduction

Assessment generally refers to the gathering and interpreting of information about students' learning (Resnick & Schantz, 2017). In science, 'student learning' includes scientific understandings, processes, skills, attitudes and values – so is much more that just measuring the content that students acquire. Unfortunately though, knowledge acquisition often remains a focus in secondary science, which limits the types of tasks used by teachers to assess their students (e.g., tests and scientific reports). Ultimately, this can lead to skewed perspectives about *what students know, understand* and *can actually do* in science (Panizzon & Pegg, 2008).

The link between student learning and assessment is fairly straight-forward but less so is the critical role of assessment in guiding teacher practice. As explained by Cross (1998, p. 6):

Classroom assessment informs teachers how effectively they are teaching and students how effectively they are learning. Through classroom assessment, teachers get continual feedback on whether and how well students are learning what teachers hope they are teaching. And students are required, through a variety of classroom assessment exercises, to monitor their learning, to reflect on it, and to take corrective action while there is still time left

In order to put the spotlight on this complex interplay between assessment, learning and teaching, the metaphor of *symbiosis* is used in the title of this chapter. It is a biological term that refers to a mutually beneficial relationship between different organisms, people or groups living in close proximity. Thinking of assessment in this manner moves it from being viewed as a task that occurs at the end of some kind of teaching sequence to an ongoing process that monitors student learning and progress in science. The pivotal role of assessment to teaching and learning is visualised in Figure 8.1. As demonstrated here, assessment provides important feedback to the teacher in an ongoing manner to inform future learning opportunities for students (1). It also enables monitoring of student progress against the intended learning outcomes, which is beneficial for both students and teachers (2).

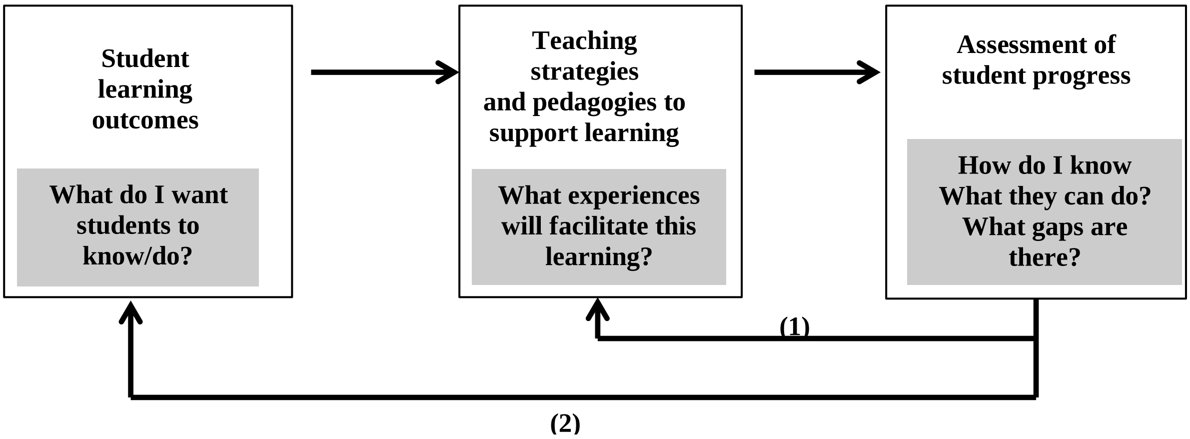


Figure 8.1. Symbiotic relationship between assessment, learning and teaching

What this relationship looks like and how it might be achieved in the science classroom to ensure equity for students are the foci of this chapter. Initially, the various types of assessment and their purposes in education are described. Following this, possible tasks and activities for assessing students' learning in science are presented. Ways of ensuring quality and equitable practices are then discussed in the context of building teacher professional judgement. Finally, some of the pressures impacting teachers as they juggle classroom assessment practices with the increasing demands exerted by high-stakes testing are also explored. This chapter deliberately sets out to inform and importantly to challenge your current views of assessment and its role in learning and teaching.

Different types of assessment - 'fit for purpose'

Traditionally, assessment has been categorized as diagnostic, formative, summative or evaluative depending upon its intended purpose. In the late 1990s different categories emerged from the work of Black and Wiliam (1998) who preferred *assessment for learning*, *assessment of learning* and *assessment as learning*. The alignment between these categories and their purposes are summarised in Table 8.1.

Table 8.1. Assessment types and purposes

Types *Traditional*	*Black & Wiliam*	**Purposes**
Diagnostic	*Assessment for learning*	Identify the preconceptions held by students at the beginning of a teaching sequence so that activities and opportunities can be planned to build on the current conceptions of students. Activities, such as concept cartoons and two-tier multiple-choice items that explore the alternative conceptions of students are widely available.
Formative	*Assessment for learning*	Provide informal and ongoing feedback to students about their learning progress in science. A critical component of this is to provide positive encouragement but also guidance as to how students might improve their work. The other focus of Black and Wiliam is the way that teachers use the insights gained from assessment to guide their own practice to support and encourage student learning.
Summative	*Assessment of learning*	Collection of evidence using different tasks to assess students formally against outcomes/achievement standards. Marks are allocated and recorded to determine grades that are reported to the student and parents/guardians. This is the most commonly known type of assessment, which is done solely for the purpose of marks.
	Assessment as learning	Encourage students to reflect and/or evaluate their own learning. What are their strengths and weaknesses? This is extremely powerful because it helps students become metacognitive and knowledgeable about how they learn.
Evaluative		Not of direct relevance to the classroom teacher of science but about the measurement and assessment of student learning generally. It involves tracking and monitoring cohorts of students over time and analysing changes in the patterns or trends in the data. This type of assessment is solely for accountability measures so that systems and schools can be measured against specified standards.

While there is clearly an overlap between the more traditional terms used for assessment and those emerging from the work of Black and Wiliam (1998), there are three critical points of difference.

1. An emphasis on assessment as being integrated with not only student learning but also to the actual process of teaching. For Black and Wiliam, assessment informs teachers

about what students can do but also highlights gaps in learning, which then provides advice about where to target subsequent teaching.

2. Recognition that *assessment for learning* is pivotal in supporting student learning because ongoing feedback provides valuable advice that helps students know where to focus attention to enhance their own learning.
3. Emergence of *assessment as learning* acknowledges that students too have responsibility for their learning. Once they are introduced to strategies that encourage thinking about how they learn, students become metacognitive and self-regulated with their own learning, which is extremely powerful.

In this chapter, the terms used by Black and Wiliam (1998) are applied.

Diversity of assessment tasks and strategies

Many teaching strategies are also effective ways of assessing the progress of our students. Critically, the types of activities, tasks or strategies selected should depend on the purpose of assessment, the year level of your students, and the intended learning outcomes. For example, student presentations to the class could be used as *assessment for learning* with teachers and other students providing constructive feedback resulting in further development of the work. Alternatively, this same task could be used as *assessment of learning* with marks allocated by the teacher and recorded for reporting purposes. This is an important point to grasp because once in schools there are often prevailing cultures about the types of tasks used for assessment. In the case of secondary science, teachers often revert to tests, examinations and scientific reports for *assessment of student's learning* even though this does not have to be the case. We know from research that student presentations, digital products (i.e., videos), and portfolios are extremely useful in providing evidence about what secondary students know and can do in science (Fensham & Rennie, 2013). Ultimately, it is the classroom teacher who makes these types of professional decisions regarding the most appropriate tasks for assessing their students as part of their professional judgement.

In acknowledging teacher judgement, little attempt is made in this section to specifically align assessment tasks to a particular type of assessment. This is because there are no rules or specifications about what tasks teachers should use when *assessing of* or *for learning*. The only exception to this is with senior secondary science students where curricula might direct teachers to use particular types of assessment, such as scientific reports or examinations.

Assessing students' initial ideas – concept maps

The purpose of assessment activities used at the beginning of a teaching sequence is to ascertain students' existing understandings so that teaching can be designed to stimulate students to continue building and restructuring their existing scientific understanding (i.e., teaching based on the theory of constructivism – see Chapter 2). For example, visual displays, such as concept maps encourage students to demonstrate links and connections between different concepts (see Figure 8.2). By developing maps at the beginning of a teaching sequence in one colour and then reviewing these at the end using another colour, students can compare and contrast the maps identifying, additions, changes and improved depth in their own understanding. For example, the map below might be expected initially but should become more complex as students learn about energy transformations. It encourages them to reflect on their own learning.

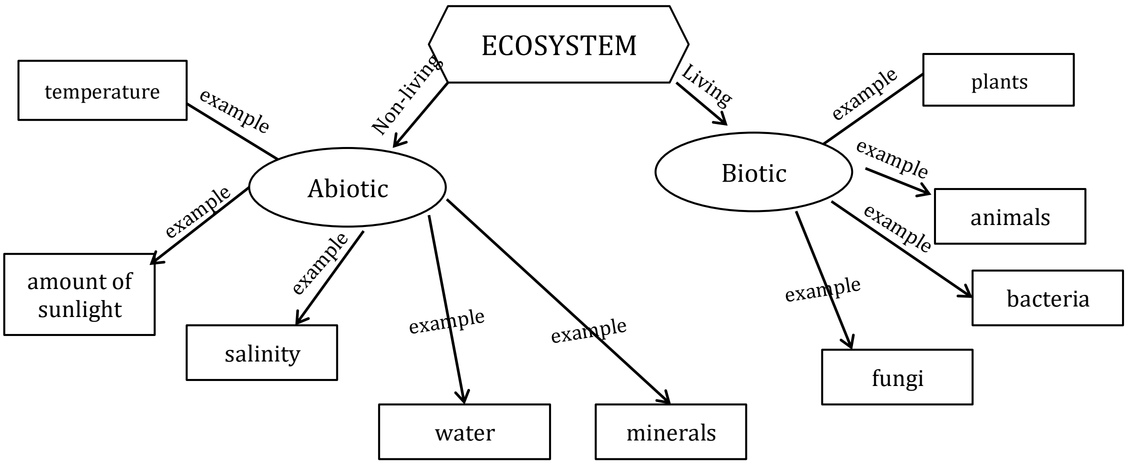


Figure 8.2. Example of a concept map – Ecosystems

Observations and conversations with students

Teachers make observations of what is happening in their classrooms all of the time. However, by focusing on individual students it is possible to gain a sense of progress through their engagement with written tasks, in their development of scientific skills (i.e., measuring, collecting data), or with their scientific communication. Time spent asking students' questions and carefully listening to their answers immediately highlights areas of difficulty, hence an opportunity for the teacher to provide constructive feedback to enhance learning.

Student voice – oral or written

Oral and written assessment tasks require students to internalise what is being asked and produce a considered response. This work should be less about regurgitation of facts or information and more about students demonstrating their ability to apply, critique, synthsize and challenge the topic being explored as part of their assessment. While termed, *assignments* they can be quite diverse in nature.

- *Research a topic*: Teachers identify a particular area for exploration. In junior secondary science it could be about famous scientific discoveries and their impact on humanity. In preparing to assess students, the teacher must think carefully about the learning outcomes targeted so that appropriate points to be addressed or questions to be answered are posed for students. Without this type of direction or scaffolding, many students are left to their own devices with little idea about what is actually required.

- *Reflective journals*: Encourage students to move beyond a diary entry of what is completed during a lesson to thinking back over what they have actually learnt, noticing how their understandings change and evolve. This type of task encourages students to become metacognitive and aware of how they learn in science. With students less experienced with reflective journals, it is useful to stimulate their thinking using questions that build the skills necessary for reflection of their work.

- *Portfolio*: Represents a selection of student work completed over a period of time, which is used to demonstrate the growth and development of students' scientific understandings and skills. There is a degree of ownership for the student who chooses the work that best illustrates their achievement. For secondary students, a reflective journal might also be undertaken with the student reflecting on their own progress as represented by the work they have included in the portfolio. Collectively, these become very powerful metacognitive tools for the student while allowing the teacher to assess one or both.

Investigative activities

Investigative activities enhance scientific skills and processes while reinforcing students' understandings of scientific concepts. Importantly, they do not have to be based on the collection of first-hand data with analysis of secondary data also appropriate.

- *Investigations and/or controlled experiments (i.e., fair testing):* Practical work can involve students completing a specified protocol (i.e., controlled experiment) through to more open-ended investigations where students develop an inquiry question to explore. In terms of assessment there are two aspects to consider: (i) assessing the actual scientific skills of observing, measuring, recording data; and (ii) assessing the analysis, synthesis and interpretations of these data. Teachers need to think carefully about how to assess each so that it is appropriate. For example, assessing the preparation of a wet mount for a microscope must be done by observing individual students. Alternatively, laboratory reports demonstrate the extent to which students can communicate the results and draw conclusions about the findings in relation to the aim, hypothesis or question being investigated.

- *Investigative activity*: Instead of a formal practical activity, it might be useful to focus on particular scientific inquiry skills. Predict-Observe-Explain (POE) tasks (see Chapter 3) can be conducted either as a whole class or in small groups. Responses might be shared to stimulate discussion within the class about the scientific concept being explored (i.e., *assessment for learning*) or written up and submitted as *assessment of learning*.

- *Online interactive simulations*: Access to digital scenarios and tools allow students to manipulate, isolate and alter individual variables so they can explore and better understand their impact on the concept or system being studied. Students can repeat the process a number of times generating more complex data sets for analysis. These types of tools are equally appropriate to use as *assessment for* or *assessment of learning* depending on the purpose of the work.

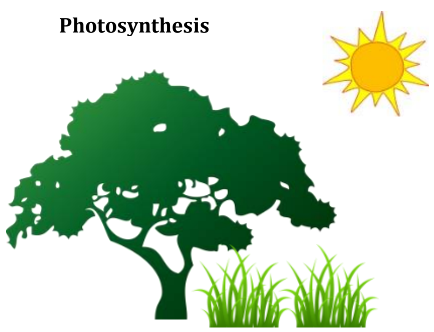
Student productions

There are a number of different types of student productions that can be used for assessment.

- *Presentations*: Posters, PowerPoints, Prezis and iMovies are relevant ways to assess students. By setting parameters, such as specifying the time allowed or number of slides to be used, ensures that students are not only synthesizing knowledge but also extracting the key points to address the question or topic.

- *Building models/dioramas*: Construction of 3-D models encourages students to demonstrate their scientific understandings through physical representations i.e., model of a cell with students justifying the use of objects to represented organelles.
- *Slowmation*: Refers to a particular type of iMovie. Slowmation involves students taking digital still photos and combining them to produce an animation around a particular scientific concept or theme. Snapshot 8.1 explores slowmations as assessment tasks.

SNAPSHOT 8.1. An example of using slowmation for assessment



Access the slowmation gallery at https://slowmation.uow.edu.au.gallery/. View the photosynthesis animation. The value of these animations is that students have to:

- Unpack their own understanding of the scientific concept/process and how best to represent it;
- Deconstruct the concept/process into separate components checking their own understanding; and,
- Reconstruct the components of the concept into a sequence that can be understood by others.

The design and development of well-constructed slowmations take considerable time. As such, they should be used for *assessment of learning* with marks allocated for the planning and preparation of the animation.

Quiz – tests – examinations

Tests, quizzes and examinations are used commonly with secondary science students for *assessment of learning* but should be used more frequently diagnostically or as *assessment for learning*. They usually comprise a set of multiple-choice and extended response questions. A quiz (i.e., very short test) could be used at the beginning of a topic to identify students' prior learning or at the beginning of a lesson to gauge how much students understand from the previous lesson. Tests and examinations, on the other hand, tend to assess a sequence of work covering an extended period of time.

Tests and examinations can be effective and highly appropriate mechanisms for assessing what students know, understand and can do in particular areas of science *if* used appropriately (Darling-Hammond & Rustique-Forrester, 2005). What is pivotal when tests are used as *assessment of learning* is the *quality of the items* and the way in which marks are allocated. For example, items that gauge the ability of students to memorize and regurgitate facts simply reinforce the notion that science is about learning *stuff*. The items used should explore the ability of students to explain and apply their conceptual understandings of science; demonstrate their scientific skills and knowledge of the processes of science; and, the ways in which science helps them to interpret their world. An example of how to achieve this is provided in Snapshot 8.2.

SNAPSHOT 8.2. Quality test items

Multiple-choice items are used in tests and examinations. However, many students are able to recognize words in the items with work covered in class so are able to select the correct answer. Consider the following item used by the American Association for the Advancement of Science ([AAAS], 2007, p. 5) in a study with high school students.

Which of the following is an example of a chemical reaction?

A. A piece of metal hammered into a tree
B. A pot of water being heated and the water evaporation rates
C. A spoonful of salt dissolving in a glass of water
D. An iron railing developing an orange, powdery surface after standing in air

Approximately 18% of students selected B, 24% chose C, while 57% opted for D. When the students who selected D were interviewed, only five could explain that a new substance had been formed. Most students admitted selecting D because they recognized the example of rusting, which was used in class. To overcome this issue, a further question might be added: "Explain why you selected this answer". Students with limited scientific understanding will not be able to answer this part of the question. By allocating one mark for D but two marks for the explanation, students who understand the chemical process will be rewarded appropriately.

Teacher questioning

Questioning, whether closed or open, is one of the most powerful strategies for assessing the progress of students on a daily basis. In a nutshell, questions should elicit "*evidence of understanding*" in relation to student learning in science (Millar, 2013, p. 58). While teaching, the type of responses provided by students along with the number of students prepared to respond gives the teacher immediate feedback about which students are struggling with particular aspects of the lesson (i.e., *assessment for learning*). But equally important is that questioning underpins most of the assessment tasks discussed in this section because without carefully constructed questions targeting particular learning outcomes, teachers can severely limit and hinder students from demonstrating their actual level of achievement in science (Panizzon & Pegg, 2008). The art of constructing and posing questions is addressed in detail in Chapter 6.

Using professional judgement to ensure quality and equitable assessment practices

Regardless of which of the above tasks are used for assessment, they must be fair and equitable for all students. Items should provide opportunities for students to explain, demonstrate and communicate their learning in science – *not what they do not know*. Key to this is making certain that students are clear about the expectations and the learning outcomes being targeted, especially with *assessment of learning*. For example, distributing the criteria to be used to assess work from the outset of a teaching sequence provides direction to students about where to focus their learning and reduces anxiety. Some teachers have difficulty with the idea of distributing assessment criteria early in a teaching sequence because they feel that if students know the criteria they will all achieve highly. Actually, this is not the case because students respond using their constructed knowledge, which cannot be prompted by knowing the assessment criteria unless the item is merely gauging the student's ability to memorize facts and figures.

Rubrics

An excellent way to communicate assessment expectations to students is to develop and share *rubrics*. In brief, rubrics help make explicit the outcomes to be achieved along with the steps involved in the learning. A rubric is designed for a specific assessment task and helps to align the assessment criteria to the learning outcomes and the curriculum achievement standards.

Each criterion is broken down to identify how marks will be allocated to higher level through to lower level responses (see Snapshot 8.3).

SNAPSHOT 8.3. Assessment rubric for data handling skills

Data handling skills	Grade		
	C	B	A
Measurement	• Measures when required and uses standard units of measure e.g., cm, kg.	• In addition to C. + • Repeats measurements or uses replicates.	• In addition to B. + • Reassesses the measuring procedure to enhance accuracy including selection of most appropriate apparatus e.g., uses appropriate size measuring cylinder.
Recording	• Data are recorded in a suitable format e.g., table, drawing, list.	• In addition to C. + • Each data trial is recorded separately.	• In addition to B + • Recording of data is done using appropriate conventions e.g., tables have titles, columns and headings.
Graphing	• Constructs bar graphs.	• In addition to C. + • Graphs selected depending on the type of data i.e., line graphs for continuous variables.	• In addition to B. + • Graphs plotting using convention of the dependent variable on the vertical axis and independent on horizontal; appropriate scale used to reduce vertical exaggeration.

It is the allocation of marks to a criterion that sends the clearest message to students about what is actually valued by their teacher. For example, if more marks are allocated to the type of output used by the student (i.e., an iMovie) rather than the degree to which students can articulate their scientific understandings, students learn quickly that presentation matters most. This is clearly not ideal and will focus students on superficial approaches to their classwork.

While rubrics are helpful in ensuring consistency and equity in the marking of assessment tasks, developing clear and consistent rubrics requires considerable practice. Asking a colleague to check a rubric prior to implementation is a wise step especially for graduate teachers.

Feedback

With student work assessed, there is still one more crucial step. Much research indicates that a key factor in raising student achievement, regardless of their age, is teacher feedback (Hattie & Timperley, 2007). Snapshot 8.4 discusses levels of teacher feedback.

SNAPSHOT 8.4. Quality feedback

Hattie and Timperley (2007) identified four non-hierarchical levels of teacher feedback:

Level 1: A focus on how well *the task* is completed (e.g., correct or incorrect) with the teacher providing directions about acquiring more, different or correct information, e.g., "*You need to include more in your description about the importance of plants*".

Level 2: A focus on *the process* required to finish a task or create a product (i.e., model). Feedback targets the processing of information or learning processes required to complete the work, e.g., "This model will make more sense if you discuss the structures explored during the last practical".

Level 3: A focus on developing *self-regulation* to enhance confidence and the ability of the student to self-assess, e.g., "You already know the structure of an atom. Check to see how you have incorporated these ideas into your discussion of results!" This feedback builds student self-efficacy because it provides clarity and guidance about how students can improve their own learning.

Level 4: A focus on the *personal* or *self*, which is frequently unrelated to the performance on a given task, e.g., "*That's great response, well done!"*

Reflecting on these levels, which do you think are most frequently used by teachers? You probably guessed correctly, Levels 1 and 4. However, it is 2 and 4 that maximize student achievement because they *empower students to become more effective learners*.

Dealing with increasing external accountability around school assessment

Within this chapter the focus is on classroom teachers and their use of professional judgement to select appropriate types of assessment to inform students about their progress in science and their own practice. In the current educational environment, assessment is often being used for different purposes by governments and other stakeholders who have competing agendas. This has resulted in increasing educational and political accountability over the last two decades and is a complex and controversial issue (Klenowski & Wyatt-Smith, 2012).

An obvious example of this is with Year 12 students and their Australian Tertiary Admission Rank (ATAR), which is partially determined using an externally set and marked examination in all states and territories in Australia. The increasing accountability around the ATAR puts teachers under pressure to intensively prepare their students in ways that will maximize their scores. As a result, many teachers resort to direct instruction and a focus on assessments that help students to practice for the examination items and conditions (e.g., use of frequent tests for class assessment).

Other examples include the National Assessment Program-Numeracy and Literacy (NAPLAN) test with the data often used by the media and government authorities to undermine the community perception of the quality of jurisdictions, schools and individual teachers. The same occurs with international tests, such as Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). These high-stakes tests are implemented for evaluative purposes (see Table 8.1) yet the results are sometimes used to make assumptions about the overall achievement of students in specific classrooms across Australia. This is interesting given that both PISA and TIMSS involve only a sample of Australian students - not the total population. Similarly, NAPLAN is actually not mandatory as parents and schools are able to exclude their children from involvement in the test.

These accountability pressures impact teachers in their classroom practices. One of the most immediate outcomes has been a *teaching-to-the-test* mentality in countries like Australia, the UK and the USA (Klenowski & Wyatt-Smith, 2012). In Australia, so strong is this growing culture that teachers are being reprimanded, even dismissed, for coaching their students during NAPLAN tests or for actually altering test results. This demonstrates the increasing demands being placed on teachers to attain high results for their students on these large-scale, highly accountable tests where teachers' foci should be on the day-to-day progress of their students.

SUMMARY OF KEY POINTS

Assessment is intrinsically linked to learning and teaching – it is not something that happens at the end of a teaching sequence. Assessment is important for not only informing students about what they know and can do in science but also their teachers who use this information to plan future lessons. Understanding the different types of assessment and their purposes is pivotal for teachers who must use their professional judgement to select the most appropriate ways of assessing their students in relation to the targeted learning outcomes. Collecting evidence around student achievement in science requires quality items that are fair and equitable and give all students the chance to achieve in science.

DISCUSSION QUESTIONS

1. Explain why it is important to use a range of different tasks when assessing students in science. Who chooses which tasks to use and why should this be the case?
2. How does assessment impact teaching? Refer to your own teaching experiences in discussing this question.
3. Fair and equitable assessment is critical. Explain what this statement means in relation to classroom teaching. How can this be achieved by classroom teachers?

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