SELF AND PEER ASSESSMENT

How can I use assessment to improve learning?

Introduction

“... self-assessment by students, far from being a luxury, is in fact an essential component of formative assessment. Where anyone is trying to learn, feedback about their efforts has three elements—the desired goal, the evidence about their present position, and some understanding of a way to close the gap between the two. All three must to a degree be understood by anyone before they can take action to improve their learning.” (Black & Wiliam, 1998)

This is particularly true when the focus of the assessment is on the processes involved in IBL. Many students do not understand their nature and importance in mathematics. If a student’s goal is only to get ‘the right answer’, then she will not attend to the deeper purposes of the lesson.

This module encourages discussion of the following issues:

- How can we help students to become more aware of IBL processes, and their importance in problem solving?
- How can we encourage students to take more responsibility for their own learning of IBL processes?
- How can students be encouraged to assess and improve each other’s work?

Activities

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Acknowledgement:

In preparing this material, we acknowledge the permissions given by the Bowland Charitable Trust to adapt the professional development resources, Bowland Maths, that they had previously funded us to produce for the UK. This includes many of the handouts and video extracts. Additional resources were also adapted from Improving Learning in Mathematics, a government funded program in the UK. The original sources are:


**ACTIVITY A: EXPLORE HOW STUDENTS MAY BE MADE AWARE OF IBL PROCESSES**

*Time needed: 20 minutes.*

Inquiry-based learning (IBL), as has been said in earlier modules, is about engaging students' curiosity in the world and the ideas that surround them. During Mathematics and Science lessons, we want students to move from being passive receivers of factual knowledge to active engagement in using inquiry-based learning processes. This means using their conceptual knowledge to tackle new, unfamiliar problems, in similar ways to those used by scientists and mathematicians. Students will begin to observe and pose questions about the world around them. When these questions are too complex, they will engage in a modeling process: simplify and represent the situation; analyze data; interpret and evaluate findings, communicate findings with others (See figure) and reflect on the outcomes. For many students, these are new and unfamiliar learning goals and will require a shift in the way students approach their learning.

This activity begins to consider some ways in which students may be helped to appreciate these new learning goals and thus begin to consider their value and importance.

Handout 1 presents a number of suggestions made by teachers that could help students become more aware of IBL processes.

- Discuss the advantages and disadvantages of each suggestion.
- Can you think of any other ways of making students more aware of these processes?

This module considers some of these suggestions in more depth.
Handout 1: Helping students to become aware of IBL learning goals

1. Using a poster or handout
Make a poster showing the generic list of processes and display this on the classroom wall. Refer to this habitually, while students work on unstructured problems, so that they become more aware that your goals for the lesson are for them to become more able to simplify and represent, analyse and solve, interpret and evaluate, communicate and reflect.

2. Creating task-specific hints
Before the lesson, prepare some task-specific hints that apply IBL processes to the particular problem in hand. When students are stuck, give them the appropriate hint either on paper or orally. For example, you could ask: Can you use a table or graph to organise this data?; What is fixed and what can you change in this problem?; What patterns can you see in this data?.

3. Asking students to assess provided samples of work
After students have worked on a task, present them with some prepared, sample responses from other students. These solutions provide alternative strategies students may not have considered and may also contain errors. Ask students to pretend they are examiners. The students rank order these solutions, along with their own response, giving explanations as to why they think one response is better than another.

4. Using prepared ‘progression steps’
Students evaluate sample responses as in (3) above, but this time you also provide them with prepared progression steps that highlight the IBL processes. Students use these to evaluate the work. End the lesson by sharing what has been learned from this process.

5. Asking students to assess each other’s work.
After tackling a task in pairs, students exchange their work. Each pair of students is given the work of another pair. Students make suggestions for ways of improving each solution and stick these on the work using “sticky” notes. These comments are passed back to the originators, who must then produce a final, improved version based on the comments received. This is a more challenging strategy for the teacher than (3), as the issues that arise will be less predictable.

6. Students interview each other about the processes they have used.
When students have finished working on a task, ask them to get into pairs. Each member of a pair interviews his or her partner about their approach and the processes they have used while working on the task. The teacher may provide some pre-prepared questions to assist in this. After noting down the replies, students change roles. Suitable questions might be:

- What approach did you take?
- Which processes did you use (from a provided list)?
- How could this work be improved?
- What could you have done differently?
- Is there still something you are confused by?
ACTIVITY B: CONSIDER HOW STUDENTS CAN LEARN FROM SAMPLE WORK

Time needed: 30 minutes

One powerful strategy for enabling students to appreciate different learning goals is to ask them to assess the work of others. This role shift has several learning advantages:

- **It encourages students to consider alternative methods.** In many Mathematics and Science lessons, students are only presented with one method for doing each task. They do not therefore come to appreciate the strengths and weaknesses of alternative approaches.
- **It encourages students to consider methods that they would have not have normally chosen.** When solving mathematical problems, for example, research shows us that many students do not choose to use algebra or graphical methods.
- **It enables students to see the purpose of IBL tasks more clearly.** Many students just consider the purpose of the lesson as to ‘get the right answer’. In assessing work, particularly against provided criteria, students are encouraged to appreciate the relative qualities of different methods.

This activity involves watching a video clip of a lesson in which secondary students assess student work that has been provided by the teacher. This work was chosen to represent five different approaches to the problem *Text Messaging*, on Handout 2. Before the lesson, the students had been asked to attempt the problem individually, without help. In this follow-up lesson, students first try to comprehend the sample work then they evaluate it.

Before watching the video clip, do the task *Text Messaging* yourself, and consider the sample work with a group of colleagues, if possible.

- What IBL processes are evident in the sample work?
- Anticipate the issues that will arise when this sample work is assessed by students.

Now watch students as they assess the sample work, and then go on to improve their own work.

- What do aspects of the provided work do students attend to?
- What criteria do students use as they assess the sample work?
- What are students learning from the sample work?

Teachers sometimes comment that some students attend more to the neatness of the sample work than to the quality and communication of the reasoning employed. Other teachers are concerned that students will uncritically 'copy' sample work.

- How do you respond to these concerns?
- What criteria would you use for choosing sample work to use with students?
Handout 2:  An assessment task and student responses

Text Messaging

1. How many text messages are sent if four people all send messages to each other?
2. How many text messages are sent with different numbers of people?
3. Approximately how many text messages would travel in cyberspace if everyone in your school took part?
4. Can you think of other situations that would give rise to the same mathematical relationship?
ACTIVITY C: DISCUSS HOW STUDENTS CAN LEARN FROM ASSESSING THEIR OWN WORK.

Time needed: 30 minutes

Often when students have finished a piece of work, they want to move on. They don’t want to re-examine it, polish it, or present it so that other people can understand and follow their reasoning.

On the video, two teachers, Emma and Shane, ask their students to assess and improve each other’s work. To help them do this, they provide some structured frameworks.

Emma uses the Golden Rectangles task and has collated a selection of her own students' work on this task into a poster. She has also simplified the assessment framework on Handout 3 for use with her students. In the lesson, she asks groups of students to assess the work on the poster using the simplified framework. The headings on her framework are: “Represent”, “Analyze”, “Interpret”, “Communicate”. These correspond to the phases in the modeling diagram (shown in Activity A). On the video, students may be heard referring to a "traffic lights" scheme that Emma uses in her Mathematics lessons. Here, 'Green' means that students understand, while 'Red' means that they do not. ‘Amber’ lies in between.

Shane used the Counting Trees task and has prepared a less structured sheet to help his students assess each other's work. This sheet contains the questions: Did they choose a good method?; Was their reasoning correct?; Are their workings accurate?; Are their conclusions sensible?; Was their reasoning easy to follow?; What did you like about their work?; What would you like to see next time?

- Familiarize yourself with the tasks.
  - Watch the video extracts of Shane’s and Emma’s lessons.
  - What observations do students make about each other’s work?
  - How might this help them to improve their own work?

- Compare Emma’s simplified progression steps with Shane’s less structured sheet.
  - What are the advantages and disadvantages of each method for helping students to reflect on and improve their work?

- Compare the use of work from within the students' own class to the use of the sample responses used in Activity B.
  - What are the advantages and disadvantages of each method?

The assessment frameworks may help students to develop an awareness of how IBL processes relate to particular tasks, and recognize how they can improve their responses. For the steps to be used in this way the language will need to be adapted to the class and specific ‘answers' will need to be removed.

Teachers have commented that students are more able to be critical of sample responses that are taken from sources outside the classroom, when they cannot be identified. When giving feedback to members of their own class, personal relationships come into play. Students do not feel so able to criticize the work of friends. Classroom cultures may need to be developed where ideas and work may be criticized without individuals feeling threatened and exposed.
Handout 3: Two assessment tasks with assessment frameworks

Golden rectangles

In the 19th century, many adventurers travelled to North America to search for gold. A man named Dan Jackson owned some land where gold had been found. Instead of digging for the gold himself, he rented plots of land to the adventurers.

1. Assuming each adventurer would like to have the biggest plot, how should he place his stakes?
   Explain your answer.

2. Investigate whether the proposition is true for two adventurers working together, still using four stakes.

3. Is the proposition true for more than two people?
   Explain your answer.

Counting Trees

This diagram shows some trees in a plantation.

The circles show old trees and the triangles show young trees.

Tom wants to know how many trees there are of each type, but says it would take too long counting them all, one-by-one.

1. What method could he use to estimate the number of trees of each type?
   Explain your method fully.

2. On your worksheet, use your method to estimate the number of:

(a) Old trees
(b) Young trees

Assessment framework for Golden rectangles

<table>
<thead>
<tr>
<th>Representing</th>
<th>Analyzing</th>
<th>Interpreting and evaluating</th>
<th>Communicating and reflecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student draws one or two rectangles with a perimeter of 100s.</td>
<td>The student works out the areas of their rectangles correctly.</td>
<td>The method draws several rectangles but not all squares and the rectangles are incorrectly or omitted.</td>
<td>The work is communicated inadequately, but those findings can be generalized.</td>
</tr>
<tr>
<td>Draws several rectangles.</td>
<td>Calculates the areas of their rectangles and finds some generalization.</td>
<td>Realizes that different shapes have different areas.</td>
<td>The work is communicated clearly and reasoning may be followed.</td>
</tr>
<tr>
<td>Draws several, correct rectangles for an adventurer working alone and for 2 working together. May draw far too many rectangles.</td>
<td>Calculates the areas correctly and finds that a square is best for 1 adventurer and that 2 working together do better than alone.</td>
<td>Attempts to give some explanation for their findings.</td>
<td>The work is communicated clearly and the reasoning may be easily followed.</td>
</tr>
<tr>
<td>Draws an appropriate number of rectangles and collects the data in an organized way.</td>
<td>Calculates the correct areas, finds that a square is best for 1 adventurer and that 2 working together do better than alone. Finds a rule or pattern in their results.</td>
<td>Gave reasonable explanations for their findings.</td>
<td>Explains work clearly and may consider other shapes.</td>
</tr>
</tbody>
</table>

Assessment Framework for Counting Trees

<table>
<thead>
<tr>
<th>Representing</th>
<th>Analyzing</th>
<th>Interpreting and evaluating</th>
<th>Communicating and reflecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chooses a method, but this may not involve sampling.</td>
<td>Fails to choose method, possibly making errors.</td>
<td>Estimates number of old and new trees, but answer given is unreasonable due mainly to method and errors.</td>
<td>Communicates work adequately but with omissions.</td>
</tr>
<tr>
<td>E.g. Counts all trees or multiplies the number of trees in a row by the number in a column.</td>
<td>E.g. Does not account for different numbers of old and new trees or that there are gaps.</td>
<td>E.g. May not account for all of the trees counted in the method.</td>
<td>Communicates reasoning and results adequately, but with omissions.</td>
</tr>
<tr>
<td>Chooses a sampling method but this is unrepresentative or too small.</td>
<td>Fails to choose method, mostly accurately.</td>
<td>Estimates number of new and old trees, but answer given is unreasonable due mainly to the method.</td>
<td>Communicates work adequately but with omissions.</td>
</tr>
<tr>
<td>E.g. Learns the rules to count the number of new trees in the row and multiplies by the number of rows.</td>
<td>E.g. May not account for special numbers of old and new trees, or that there are gaps.</td>
<td>E.g. Learns a different counting method.</td>
<td>Communicates reasoning and results adequately, but with omissions.</td>
</tr>
<tr>
<td>Chooses a reasonable sampling technique.</td>
<td>Fails to choose method, mostly accurately.</td>
<td>Estimates number of old and new trees in the plantation.</td>
<td>Explains what they are doing but explanation may lack detail.</td>
</tr>
<tr>
<td>Chooses an appropriate sampling technique.</td>
<td>Uses a proportional argument correctly.</td>
<td>The reasoning of the estimate is checked. E.g. repeating with a different sample.</td>
<td>Communicates reasoning clearly and fully.</td>
</tr>
</tbody>
</table>

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ACTIVITY D: PLAN TO USE PEER AND SELF-ASSESSMENT STRATEGIES

Minimum time needed:  
30 minutes before the lesson  
20 minutes for the pre-lesson assessment  
30 minutes to prepare feedback  
60 minutes for the lesson  
15 minutes for reporting back

In this activity, participants plan and carry out a lesson in which students become assessors of their own work (Track A), or assessors of work that we provide for them (Track B). It is helpful if some participants choose to do each track and then they can be compared. A sample lesson plan for each track is provided on Handout 4.

• Plan when you will allow students time to tackle an IBL task, individually or in pairs, without your guidance.

• Plan a lesson in which students revisit the task and assess other students’ work - either work from their classmates or from some sample responses that you will provide. Make sure students have an opportunity to discuss the importance of the IBL Processes, and sufficient time to revise their own work in the light of the comments.

If you are working on this module with a group, it is helpful if each participant chooses the same assessment task, as this will facilitate the follow-up discussion.

After the lesson meet together to feed back on what happened.

Take it in turns to describe your experiences of using self and peer assessment.

• How did your students perform on the task, unaided?
• How did students assess the provided responses and the work of their peers? What aspects did they attend to?
• How did students make use of the assessment frameworks? Did these help students to understand IBL processes?
• How well did students react to and use the evidence to improve their own work?
• What are the implications of this lesson for your future lessons?
Handout 4: A lesson plan in which students are assessors

The following suggestions describe one possible approach to self- and peer-assessment. Students are given a chance to tackle a problem unaided, to begin with. This gives you a chance to assess their thinking and to identify students that need help. This is followed by formative lesson in which they collaborate, reflect on their work and try to improve it.

Before the lesson 20 minutes

Before the lesson, perhaps at the end of a previous lesson, ask students to attempt one of the assessment tasks, Text messages, Golden rectangles or Counting Trees, on their own. Students will need calculators, pencils, rulers, and squared paper.

The aim is to see how able you are to tackle a problem without my help. There are many ways to tackle the problem - you choose. There may be more than one ‘right answer’. Don’t worry if you cannot understand or do everything because I am planning to teach a lesson on this next in the next few days.

Collect in students’ work and review a sample of it. Look carefully at the range of methods students use and the quality of the reasoning. Try to identify particular students who have struggled and who may need support. Also look out for students that have been successful. These may need an extension activity to challenge them further.

Re-introduce the problem to the class 5 minutes

Begin the lesson by briefly reintroducing the problem:

Do you remember the problem I asked you to have a go at last time? To

At this point, choose between the Track A or Track B. Either decide to let students assess and improve their own work, or offer them the provided samples of work to assess. There won’t be time for both!

Track A: Students assess their own work

Track A: Students assess and improve their own work 15 minutes

Ask students to work in pairs or threes and give each group a large sheet of card and a felt-tipped pen. Give each group back their initial attempts at the problem.

I want you to look again at you answers but this time, work as a group. Take it in turns to describe your attempt to the rest of the group. After each suggestion, the others in the group should say what they like about your method and also where they think it can be improved.

After you have all done this, I want you to work together to produce a better answer than you did separately.

Make a poster showing your best ideas. It doesn’t have to be beautiful, but it should show you thinking.

Go round the room, listening, assessing their thinking and making appropriate interventions. Listen specifically to students that struggled with the task when they worked alone, and offer them support. If students have succeeded and their work is correct, provide one of the planned extensions.

Track A: Students exchange and comment on each other’s work 15 minutes

Ask students to exchange their posters with another pair and issue each group with a copy of the ‘progression-steps’ framework for the task – one that is written in student-friendly language.

On a separate sheet of paper, write comments on:

• Representing: Did they choose a good method?
• Analysing: Is the reasoning correct – are the calculations accurate?
• Interpreting: Are the conclusions sensible?
• Communication: Was the reasoning easy to understand and follow?

As they do this, go round encouraging students to read the work carefully and comment on the points mentioned. You may need to help them understand what the ‘progression steps’ mean. When students have commented on the work, one person from the group should take the poster to the group that produced it, and explain what needs to be done for the work to be improved.

Track A: Students improve their own work 5 minutes

Give groups a little time to absorb the comments and time to further improve their ideas.

Track B: Students assess provided sample work

Track B: Students assess provided sample work 15 minutes

Give out the sample student work.

These samples of work were taken from another class. I want you to imagine that you are their teacher. This work may give you ideas you haven’t thought of. It is also full of mistakes!

I want you to comment on each of the following themes:

• Representing: Did they choose a good method?
• Analysing: Is the reasoning correct – are the calculations accurate?
• Interpreting: Are the conclusions sensible?
• Communication: Was the reasoning easy to understand and follow?

In this way, students will become more aware of what is valued in their work – the Key Processes of representing, analysing, interpreting and communicating.

Listen to their discussions and encourage them to think more deeply. Encourage students to say what they like and dislike about each response and ask them to explain their reasons.

Track B: Students assess sample work using “progression steps” 10 minutes

After students have had time to respond freely, issue each group with a copy of the “progression steps” framework for the task – one that is written in student-friendly language.

This framework may give you further ideas.

Where would you put the work on the framework?

Track B: Plenary discussion of the sample work 15 minutes

Project each piece of sample student work on the board and ask students to comment on it:

What can we say about this piece of work?
Share some of the comments you wrote.
What did you think of the methods they chose?
Which method did you like best? Why was this?
Did you find any mistakes in their work?
Do you agree with their conclusions?

Track B: Working in pairs: Students improve their own work 10 minutes

Now using what they have learned, ask students to work together to improve their own solutions. As they do this, ask students to explain their thinking.

Max. tell me what you have done to improve your own solution.
**ACTIVITY E: DISCUSS STRATEGIES FOR DIFFERENTIATION**

*Time needed: 20 minutes*

Reflect on your normal teaching practices. When you assess classes, you begin to realize the considerable individual differences in students and they have very different learning needs. Some students need more support, while others need a greater challenge.

- How do you normally deal with range of different learning needs of your students?
- Discuss the advantages and disadvantages of the four strategies shown on Handout 5.
- Compare your views with the comments given on Handout 6.

### Handouts 5 and 6: Meeting the needs of all students

| Assessment needs that all students have different learning needs. How do you respond to this in your normal lesson? |
| Discuss and note down the advantages and disadvantages of each approach. Add your own ideas underneath. |
| **Differentiate by quantity?** When students appear successful, you provide them with a new problem to do. |
| **Differentiate by task?** You try to give each student a problem that is matched to their capability. |
| **Differentiate by outcome?** You use open problems that encourage a variety of possible outcomes. |
| **Differentiate by level of support?** You give all the students the same problem, but then offer different levels of support, depending on the needs that become apparent. |

The strategies suggested on Handout 5 are:

- **Differentiate by quantity?** When students appear successful, you provide them with a new problem to do.
- **Differentiate by task?** You try to give each student a problem matched to her capability.
- **Differentiate by outcome?** You use open problems that have a variety of possible outcomes.
- **Differentiate by level of support?** You give all students the same problem, but offer different levels of support, depending on the needs that become apparent.

The first two of these approaches are unhelpful, particularly when developing IBL processes, for the reasons identified in Handout 6. IBL tasks are ‘open’ in the sense that they encourage a variety of approaches. Their difficulty is not merely related to their apparent ‘content’, but is also related to the familiarity of the context, the complexity of information within the problem, the connections that need to be made, the length of the chains of reasoning required, and so on.
Helping students that struggle

As well as finding the tasks challenging, students may find the whole idea of self and peer assessment difficult. They are being asked to reflect on the methods and processes that they and others have used. Think again about your lessons using the IBL tasks.

• How might you help those who struggle with the task?
• How can you help those who struggle with the whole idea of peer assessment?

Teachers have found that when students get stuck with a task, then they may be considerably helped by:
• discussing their difficulty with a partner (not necessarily their neighbour);
• looking at examples of other students' work (however rough) - these will suggests new ways to access and approach the task.

As soon as the teacher gives detailed guidance on what to do, the students are unable to make strategic decisions for themselves. Such guidance should therefore only be given as a last resort, after students have been allowed to struggle and help each other.

We have found that most students enjoy and value self and peer assessment. Some however, may be unused to revisiting tasks and reflecting on earlier work and may not therefore appreciate the value of discussing different solution methods in depth. "When I know the answer, what point is there in discussing the problem further and looking at other people's work?" Such students prefer to 'get on' and tackle new tasks. We have found that it is important to carefully explain the purpose of peer assessment to students meeting it for the first time.

Stretching students that succeed

Some students may have done very well at the problems, even at the very beginning. Others may have worked well and finished quickly. It is a good idea to plan for such eventualities.

Think back to your own lesson.
• When students succeeded, how did you extend their thinking?
• What alternative approaches to the task did you, or could you suggest?
• What extensions to the task did you, or can you suggest?

Even if students succeed in the problems, they can still learn a great deal by revisiting them. Students may be encouraged to:
• find alternative or more elegant ways of representing and tackling the task;
• make up their own variants or extensions to tasks
• devise their own "progression steps", to develop their understanding of Key Processes.

You may be like to suggest your own possible extensions to the tasks. For example:
• Text Messaging: How long would it take to spread a piece of news around the school if each person sends a text message to four other people?
• Counting Trees: What method would you use if you were asked to estimate the number of beans in a jar?
• Golden rectangles: Suppose the adventurers were only given three stakes each? (The task would need to be renamed: Golden triangles).
SUGGESTED FURTHER READING


This short booklet offers a summary of the extensive research literature into formative assessment. It shows that there is clear evidence that improving formative assessment raises standards, and offers evidence showing how formative assessment may be improved. This booklet is essential reading for all teachers.


In this booklet, the authors describe a project with teachers in which they studied practical ways of implementing formative assessment strategies and the effect this had on learning. The section on peer-assessment and self-assessment (pages 10-12) are particularly relevant to this module.


This book gives a fuller account of the earlier booklets *Inside the black box* and *Working inside the black box*. It discusses four types of action: questioning, feedback by marking, peer- and self-assessment and the formative use of summative tests. The section on peer and self-assessment (pp 49-53) is particularly relevant to this module.


This booklet applies the above findings specifically to Mathematics. It considers some principles for Mathematics learning, choice of activities that promote challenge and dialogue, questioning and listening, peer discussion, feedback and marking, and self and peer assessment. This booklet is essential reading for all mathematics teachers. Pages 9-10 are particularly relevant to this module.