Supporting problem classes

What are Problem Classes

Problem Classes are frequently held in quantitative and mathematically related disciplines (e.g. Physics, Engineering, Economics, Pharmacy etc). Students are given a set of questions or problems, which they work through each week. These classes are designed to give the students the opportunity to learn by applying their knowledge and hone their problem solving skills by practising the different techniques and methods that they have learnt about during the course.

There are two common class arrangements –

A. Students work on the set of problems, in their own time, before class and then go through their solutions in class time

B. Students work on their own, or in small working groups, to address and solve problems in class time.

The students are usually given a worksheet that contains problems that have increasing levels of difficulty – covering the basic application of the essential material that has been taught that week in Lectures etc. through to more demanding, advanced questions that may challenge the students to work at the limits of their knowledge and skill.

The role of the demonstrator varies a little depending on the class arrangement. In type **A.** classes, the demonstrator may be called on to demonstrate the working of the correct solution to the problems, often on the whiteboard or visualiser. In type **B**. classes the Demonstrator moves around the class supporting the students as they hit difficulties or have questions about the problems they are tackling.

Additional practical responsibilities that you may have in the class

- Keeping a register of attendance (for some modules a minimum level of attendance is expected and may even attract a small % of the marks for the module).
- Signing off the work of students completed before or during the class.
- Providing ‘correct’ or model answers for the problem sheet.
- Grading performance in the class.

Types of 'Problems'

At the heart of many mathematical and quantitative disciplines is the broad skill of 'problem solving' – sometimes these problems are 'staged' by the educator to take the learner through a set of 'taught' processes or methods (probably explained in the lectures). These constructed problems often include all the necessary information needed to work out the right answer and require the students to follow a series of logical steps towards the single solution. Such problems require 'convergent reasoning'. The set problems are usually very 'tidy' with few, if any, unnecessary facts presented and they include several clues that point the learners towards the 'right' methods and protocols to use.

Real life problems are more likely to be 'messy' in the way they present and the learner needs to first work out what are the important facts and features that are known about the problem. It may also be necessary to 'estimate' when some details are not yet known. They are likely to require the 'solver' to undertake an initial period of 'divergent thinking', to explore a range of possible solutions, before deciding which is the best way of tackling this particular problem.

A standard tactic for educators and course designers is to build a ladder of problems for students to work through. This continuum of problems increase in difficulty in a number of different ways and through a range of dimensions –

Range of Dimensions to increase the difficulty of Problems

Straightforward ⟶ **Difficult**

Well structured problem	Moderately structured	Poorly structured problem
Requires a step by step solution protocol	Requires choosing the right approach from a limited range	Unconstrained choice of possible solution strategies
Clearly defined endpoint and goal	More than one endpoint and goal	Multiple perspectives and no agreed-upon goal
All starting information provided	Most of the starting information provided	Some of the starting information provided
No estimation required	A little estimation required	Significant estimation

		required
Seen a very similar problem before	Seen something a little similar before	Not seen anything similar before

Thinking about the problems your students will be facing in the Problems Class how would you classify the difficulty of the problems they will be tackling.

Learning how to solve problems

As more experienced learners we use many different strategies to try and solve unfamiliar problems. We try and tease the problem apart and break it down into smaller, more manageable chunks; we try and relate it to things we have seen or tried before in similar situations and we use the methods and techniques that we have been taught. If working collectively we will also combine our knowledge and share our impressions and thoughts, we will brainstorm our ideas and challenge each other's assumptions and estimations. When we are supporting problem classes we are trying to help less experienced problem solvers develop these tactics.

Take a moment to think about the tactics you use to tackle new problems in your own research – write down five things you do to address a new problem. Now think about how you could share these tactics with a student.

When it comes to learning how to solve problems – current research suggests that setting authentic problems in realistic contexts is important and that students should be encouraged to solve lots of these problems – because only after having done so will they see the similarities of problem solving approaches across a range of different contexts.

Problem Solving Models

Early researchers looking at problem solving assumed that people could learn a set of abstract problem solving skills and transfer these to any setting.

One early general approach to problem solving – Bransford's IDEAL model

a. An early Problem Solving Model

1) **I**dentify the problem

2) **D**efine the problem through thinking about it and sorting out the relevant information

3) **E**xplore solutions through looking at alternatives, brainstorming, and checking out different points of view

4) **A**ct on the strategies

5) **L**ook back and evaluate the effects of your activity

Bransford & Stein, 1984.

Today, researchers' views are further informed by cognitive theories of learning and are underpinned by the view that problem solving is based on a complex interaction of cognitive, behavioral and cognitive elements.

b. An updated Problem Solving Model

1) **Represent the problem** –call up the relevant context knowledge, identify the goal and the relevant starting conditions for the problem.

2) **Search for a Solution** – refine the goal and develop a plan to reach the goal.

3) **Implement the Solution** - execute the plan of and evaluate the results.

Gick, 1986.

Note – it is very possible to jump straight from 1) to 3) if the problem solver recognises parts of the problem – if the solver has solved a similar problem before they can remember how it was solved last time and simply do the same thing again.

This is why – the more problems you have solved in the past – the better your problem solving skills become – you have just seen more solved problems to compare the new problem to!

Funkhouser and Dennis, 1992

However, this is also the basis of a big challenge for teachers – remembering that learners may not be able to make the jump, having seen far fewer problems solved. Many new teachers realise that they are using short-cuts in the way they solve problems that are not yet available to their learners. Learning how to

support students in moving more systematically through the stages of the process is important for a novice problem solver.

Expert versus Novice problem solvers

There are a number of differences in how an expert problem solver tackles a new problems when compared with a novice.

- Experts are able to draw upon a bigger pool of past experiences and know more about the different problem contexts – they have more 'similar experiences' to draw upon in recognising patterns and useful strategies.

- Experts create rich and dynamic 'mental models' of the problem context and system – they organise and structure their existing knowledge in light of this context and they don't jump to the first conclusion or first good idea they have.

- Experts believe they can solve the problem – they have confidence in their abilities so they keep trying different solutions if they first don't succeed. Novices can feel that 'they can't do it' and build a mental barrier that encourages them to give up easily.

Thinking about these three differences between Expert and Novice problem solvers – suggest ways in which you can help a novice problem solver move towards great expertise in the problem classes you will be supporting.

Teaching Approaches for Problem Classes

Working through solutions at the board

- **A general Approach**

Before jumping into the detail of a particular question, it can be helpful to introduce or remind the students about the 'problem solving' model and then for you to go on and use the model in your board demonstration.

It can also be very helpful to remind the students about the context or the relevance of the problem – to set the scene.

Reading the whole question or problem out loud – emphasising important elements and key information with verbal emphasis and pauses – to act as a role model of how the students should read questions.

"So what does the problem tell us.." - Organise the information that has been given, including appropriate units

You can also think about representing the problem in a different format – sketch it out using a diagram or a graph, represent it as a model to illustrate the problem (rather than jumping straight in to working through the mathematical equation). Or to pull out of the problem presented in words, the known and the unknown data that the problem includes – to re-state and clarify the question and to focus on what exactly is being asked.

Using the 'Think out loud' tactic - verbalise what you are doing and why. Explain how you make the choices that you making, e.g. How did you choose the method that you will use?

Encourage the participation and involvement of the students – e.g. Get the students to suggest what you should do next or what the next line in the equation might be.

Point out common errors and likely mistakes.

Stand back from what you have done and ask them to evaluate it – does the solution look reasonable, is it in line with expectations? Spell out what the resulting numbers, or the lines on the graph, mean in words and the initial question that was asked.

If you have time - explore some of the alternative methods and solutions and demonstrate why they were not your preferred ones.

Working through solutions at the board

- **The difficulty**

Writing on a board and maintaining good (eye) contact with the students is a real challenge for any teacher. It is so easy to end up only conversing with the board and/or losing track of what you are saying and making mistakes on the board. One helpful rule is:

Only try to do one thing at once

Either write on the board **or** talk, not both. Although the silence as you write will seem to be very long, it won't be feeling that way to the students. They will be trying to follow what you are writing and perhaps trying to make a copy for themselves. However, do conscientiously break up the time you spend writing, by turning fully back to the students, making good eye contact and commenting on what you have just written up. It is important to re-connect with the students if you have had you back to them for a few

moments as you wrote. An alternative is to have one of the students write up their solutions on the board leaving you free to explain what they are doing and answering any questions about it.

- **Planning your use of board space**

It can also be worth planning the use of your board space before you jump into giving your explanations. Think about what board space you will need for each solution and partition your board into working 'pages' so you don't need to erase partial solutions to make room to finish the working out. Are there parts of the explanation that will be referred to several times during the class (e.g. a glossary of terms, an index or key) – if you are right handed, write these up in the top right hand corner, so that you can point to them without obscuring them whilst you are mid-flow solving a later problems.

- **Student board work**

Many teaching texts recommend getting your students to share their own solutions and presenting them to their peers. The benefits being that they get to improve their presentation skills and get immediate feedback on their solutions (you also get to see how they are doing in this regard) – however, this does need to be handled with care, as many students will feel quite intimidated having to come out to the front of the class to present their work.

Pause to think –

What can you do to reduce the anxiety of the presenting student and how will you respond if they make a mistake whilst writing their solution on the board?

- Choose one student at random to present their solution (be prepared to help them if they are a weaker student).
- A safer option is to ask for a volunteer (but you may also get the same person volunteering every time!).
- Set the expectation that each student will be expected to do this over a class or a couple of classes (keep a note of who has presented so that you can implement this fairly).
- Ask another student to contribute to, or comment on what the student is writing.
- Add your own commentary and explanation as necessary.
- Give plenty of praise and encouragement.
- If the student makes a mistake, try to give a prompt or ask a question to help them to diagnose the error for themselves.

Being a Facilitator
Guide, Prompt, Supporter, Encourager,

In both demonstrating and problem class facilitator roles – the 'teacher' is acting to support the experiential learning of the students. The students are actively experimenting and reflecting on this action.

There is a set of recognisable 'common difficulties' for students in these classes –

- The student who is anxious and afraid to 'have a go'.
- The student who doesn't plan or prepare but jumps into the 'doing'.
- The student who is not careful enough and is slapdash when doing practical things or is not accurate in working out.
- The student who is keen to do the experiment but then doesn't reflect on what has been learnt by doing it.

Think about your personal response to these challenging student behaviours and work out a plan of action to help the student to improve.

Some possible responses –

- The student who is anxious and afraid to 'have a go'

Ask them what is it that holds them back and minimise the 'risks' for them. Break down the start into a smaller number of manageable steps and set them a time frame in which to have concluded certain elements.

When they have been successful – don't forget to praise them and encourage them onto the next step.

- The student who doesn't plan or prepare but jumps into the 'doing'

Once you are aware that a student does this – go and speak to them straight away at the beginning of the class and prompt them to think about the stages of the work they will be doing. Ask them questions that force them into thinking ahead. Then monitor this and keep checking in with them to see if they are keeping on thinking ahead to the next stage in the work.

- The student who is not careful enough and is slapdash when doing practical things or is not accurate in working out.

This is a difficult challenge – the aim is to get the student to 'self-check' and to learn how to work more precisely. However, in the short term it is likely that you will need to prompt them to do this or even point out errors to them. Take care that you don't fall into the trap of doing the work for them – it can be a little frustrating to have to keep pointing out their errors but there are no short cuts with this problem.

- The student who is keen to do the experiment but then doesn't reflect on what has been learnt by doing it.

What is needed here is the good old fashioned de-brief. Sitting down with the student and asking them about the work they have done and what it means in a more general sense. You can ask them how they would do it better if they were asked to do it again and you can prompt them to think about how it relates to the lecture material and to work that is coming up later in the semester.

Working one-to-one with students

Although the students may be working in small groups or teams to work through the problems or undertake the practical – there are many occasions when you will be having one-to-one conversations with individuals. The students will expect that you are able to tailor your 'general' approach to better suit their individual needs and therefore, you need to be flexible and open to their responses and interactions with you. It is important to listen carefully to what is being said (and what is being avoided) and to observe their body language and non-verbal reactions too. Some students will find it very difficult to admit and tell you that they are confused or don't know what to do next – and yet this can be clear from through their non-verbal communications.

A minority of students will seek to monopolise your time (because they are under-confident or hoping you will do their thinking for them!). When talking with such a student, monitor the time you spend with them and if necessary defer them sometimes by giving them a quick prompt or a clue to re-start their thinking and tell them you will come back to speak to them in 10 minutes, to see how they are getting on.

When you are supporting classes you are in a position of authority and are acting as a role model for the students who you are helping. Your attitude and approach will indicate a working standard and your students will look to you to set a good example. It is therefore very important that you are seen to be acting fairly and appropriately with all the students. Not having 'favourites' or treating some students more harshly. This is clearly especially crucial if you are involved in assessing the students in any way.

Giving Face-to-Face Feedback

When many teachers talk about giving feedback to students they have in mind the job of writing comments on the essays or reports that the students have handed in for marking. In problem and practical classes the 'live' feedback that you will be giving has some important differences with this – you will be giving feedback straightaway and face-to-face. So you don't have much time to formulate your feedback comments and you have to be able to deliver it verbally, directly to the student. That said there are many similarities too; the feedback should be:

- Specific to the student and the task.
- Constructive – in that it guides the student's future actions.
- Balanced – both reinforcing, positive comments and critical improving comments.
- Encouraging – to build the student's confidence and self-belief.

What difficulties can you envisage giving face-to-face feedback to your students?

How might you limit these difficulties or avoid them all together?

Tips on giving face-to-face feedback

- Verbal feedback can convey more information than written feedback because you can use your tone of voice, facial expression and body language to convey your meaning. However, you have to ensure your communication is honest and your voice and body language are in harmony.

- You may encourage your students to note down important things that you are saying so they don't forget (and you can see that they have understood you)

- Students reactions, to verbal feedback, do vary depending on their personality, mood etc. They may only hear the positives in what you have said and completely disregard the criticisms. They may react very defensively and seek to justify their errors rather than taking on board the advice. Rather than debate a point, give the student a little time and space and then go back to check they really did hear you.

- The biggest advantage of face-to-face feedback is that it is usually interactive. You can see the effects your words are having and add further explanation if you feel it is helpful. You can also open the way for dialogue and encourage them to ask you further questions. You can ask a student to 're-explain' a point back to you and so check their understanding.

- Do remember to speak quietly and privately with the student - some students will be self conscious and embarrassed to have their feedback overheard by their peers.

- Give timely feedback. It can be very frustrating if you simply want to check that you are working along the right lines but you cannot get the attention of the demonstrator. However, it can also be distracting if a teacher is trying to give you feedback before you are ready for it and whilst you are still thinking it through. Simply asking, ‘Are you ready to talk this through yet?’ might help to get this timing right.

- Observe the students as you give the feedback - monitor the students’ facial expressions and body language and if they seem to be over-sensitive to a critical comment try to soften your approach.

Further reading suggestions

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