Responses to Questions arising during
the Open-Book On-Line Assessment TALMO Webinar
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I am very happy to engage in further discussion and to develop examples so as to elaborate on my responses.

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#### **1** These questions (e.g. explain why theorems X, Y, and Z, are important in their context) are interesting (especially for formative assessment). However, formulating a  bulletproof marking scheme for these questions seems very difficult. This could weaken their use in summative assessment. Any suggestion?(Anonymous)

*Observation one*: at the Open University, a study of double marking revealed considerable variation between markers, even in mathematics. Of course over the years we got better at specifying mark schemes, but it would be worth checking on variation before assuming that marking even routine procedural questions has little or no variation between markers.

*Observation two*: in mathematics education students submit essay-type answers. It is possible to state the sort of thing that is being looked for (eg coherent reference to three course constructs in response to a given probe), but there can always be some variation in the way markers interpret mark schemes. That is what exam boards are for, closely looking at borderline cases.

*Observation three*: a principle that I insisted upon in mathematics education mark schemes is that *anything markers are told to look for, students are also told about.* For example, if you are looking for three ‘points’, then tell students that three points are required for full marks. Don’t make students assume that 3 marks for a question means 3 points. And perhaps you might want three points, each justified by reference to a later theorem or application … then tell students that that is what is sought, and illustrate this in sessions, not just before the exam. For example, when reflecting on a topic, ask students to consider which theorems are most important and why, and indicate what a complete answer would look like, as part of the teaching strategy, encouraging reflection by instantiating (modelling) it.

#### **2** First year undergraduates, following their school experience, usually complain that they aren't given "enough" examples at university.  I think the "real" problem is that they don't understand the purpose of examples and so don't know how to use them to build their understanding.  How do we change their mindset?(SallyB)

Students at the Open University generally, when surveyed in the 1980s, fell into those who claimed to know what to do with case studies (examples), and did it, those who knew what to do but only sometimes did it, and those who did not know what to do with them. I vaguely recall that they were roughly equal sized groups, but may be different in mathematics.

The point is that it seems that students often do not know how to study effectively and efficiently, nor what to do with examples.

Again at the OpenU students routinelty asked tutors for yet more examples. I am confident that this was because they were not being shown what to do with a collection of ‘worked’ examples. The tendency is to look for a worked example that closely matches an assessment probe (question), and then try to use it as a template. *Templating* may be a step towards appreciating and comprehending, but it is only a step. Generating your own worked examples, so you have a sense of what can be changed and still the reasoning proceeds, articulating what it is about a question that alerts you to use this procedure, and narrating the various steps which make up the procedure are steps beyond templating.

During teaching, do students encounter the tutor asking themself “can I find an example of this”, say when contemplating a theorem, or a theorem and its proof, or explicitly demonstrating how an example can be useful in finding a proof (known as Hilbert’s method … as described by Courant), and useful in reflecting on a proof to see what the various steps are achieving.

As homework before a theorem is to be proved in the next session, asking students to construct an example, or even as Bob Burns has done, asking them to construct an example with properties inconsistent with the theorem … in order to then say “the reason that you could not find any examples is because there are none. …”. That way students appreciate the role of the conditions in the theorem more than simply seeing them invoked during the proof.

#### **3** When you make reference to open book exams returning similar results to closed-book equivalents (because students need to be familiar with the material to make use of it), are you speaking about time-restricted open book exams? [short version are you restricting time on your open book exams?] (Alison Fisher)

Philip Walker from CHAT : We found exactly this (no major effect) when we ran a "bring a one-page summary" open-book style exam a year or so ago.

Brien Nolan : Same here Philip. And when students prepared their one-pager well, they didn't need it.

Julia Goedecke : IN school my maths teacher always said "make yourself a crib sheet and then leave it at home". Because making it makes you engage with the material

Certainly for time-restricted open book exams, a lot of time can be wasted looking for something relevant when you don’t know what to do or what is being asked.

For open-book exams lasting 12 or more hours, students who have to search extensively may be less disadvantaged, but the time and effort required might be extensive. They might easily decide that in future they will do this sort of work beforehand.

But what is being assessed? Surely it is more useful to have an employee who knows where to look and how to look, than expecting an employee to have all required actions internalised and available, where problem solving is required (as distinct from instant reaction which is achieved through training). The slogans “Only behaviour is trainable” and “Only awareness is educable”, complemented by “Only emotion is harnessable” capture this for me. Here *awareness* refers to internalising actions and what could trigger those actions.

Consequently, what matters in open-book exams is the nature of the questions posed, provided that during the teaching students have been exposed to such questions as a natural part of the teaching, and had their attention directed to *how* such questions can be tackled. I tried to offer some examples of the sorts of questions that could be asked, including generalising, or asking about the role of specific parameters, and so on.

#### **4** Many of the things you're saying seem good for formative tasks but maybe not all suitable for an exam? Like you said with the topic web. (Julia Goedecke)

Yes, that is fair. I allowed myself to drift between tasks which could be useful formatively, and tasks which could be used summatively. I was rather taken with the notion of *gauging* learning/teaching as distinct from *assessing* performance. Except that I am tempted by the following conjecture:

If students have encountered a task type formatively, and have had their attention directed specifically to how the tutor addresses such a task, then they can be used summatively as well.

In mathematics education most tasks are of essay type … and mark schemes can be devised. You have to declare what exactly constitutes a good answer, an ok answer and a poor answer, then work out how to tell markers without giving the actual answers themselves, so that you can give the same advice to students.

#### **5** These are good kind of questions to test the higher end of student understanding. But I would be worried that many of our students would not get near this kind of understanding. Do you find that with training the students attain this level? (Julia Goedecke)

I am proposing that all students (who undertake a course seriously) can achieve the comprehension and appreciation required, if the course is constructed to those ends, and the teaching draws attention to those processes or mathematical actions.

There is a potential downward spiral of expectation and instantiation: students don’t do well on this item, so the item is removed or watered down in the future. (Geometry in schools is a case in point.) But perhaps it is the teaching which is not drawing attention to the actions necessary in order to perform as expected. Vygotsky asked what the point is in setting tasks that students can do … what matters is the tasks that they cannot yet quite do without the support and guidance of someone more experienced. This says to me that students may be shown procedures, definitions and theorems, but they may not have experience in putting these together, in working out what the theorem really says and what conditions are really necessary (and why), in recasting a problem into a format that brings mathematical actions to ‘mind’, ready to be enacted.

#### **6** What is the best/clearest/least ambiguous way to phrase questions where you want students to solve a problem without using a concept/definition/idea which would simplify the problem? (Anonymous)

I think I need an example. I might be tempted to turn the questioning around. “What features of (some problem) indicate that (some procedure or idea) could be useful?” At least ask this sort of question and answer it during teaching. Then try it for assessment purposes as well, in parallel with questions posed more directly. What actions/behaviour do you really want students to display?

#### **7** How would you balance questions suited for online open book assessments with the practicalities of marking (e.g. marking online, large class size, different markers)? (Anonymous )

Again I conjecture that if you are clear and articulate about what you want students to gain from a course, and what counts as evidence, then you are in a position to craft questions and mark scheme.

#### **8** The examples you have shown are really nice. What I find is that my students have a lot of contact hours across all modules and the maths modules (typically service modules) tend to be very content-heavy. How do you manage in terms of time with this type of learning? I find that I struggle to have enough time to get through the content/teach the students the basic concepts/techniques and I feel the basics would need to be done before getting to expose the students to this style of deeper questioning and thinking. Thanks ! (Clodagh Carroll)

What are the modules trying to achieve? What do you really want students to get from the course?

If might you want students to acquire the facility of someone experienced and well-practised in procedures, then you want to work at training behaviour. If you want students to be able to think about problems, then an open-book exam allowing students access to procedure steps seems ideal. But to be fair, the teaching has to involve explicit work on recognising which procedures are called for, if that is what you are going to probe on exams. If you seek facility ion the use of technical terms (definitions) then you can construct test items that focus on these (and these can be done as multiple choice (I call them ‘multiple guess’) questions which can be answered and marked electronically.

#### **9** Our main concern is indeed students working together, or getting someone else to do the exam for them. Especially if we are required to have say 24h for a 2h exam. (Julia Goedecke)

I can’t comment from experience on this … accumulating student work during the course for comparison with exam answers is one way to check, when it matters, as to whether it is likely the student received help. We used this sort of evidence (with the ultimate choice of an oral interview) during exam board meetings at the OpenU.

#### **10** I suppose this is a more general question, not exclusively relating to online assessment. (Anonymous Attendee)

#### **11** What worries me with a lot of these questions is that they are not very precise and it would be impossible to write a mark scheme for example. “What role does the 3 play” would be open to many interpretations. Although a very good student will perform well, a poor student may just crash on them. (Steven Abel)

I would certainly expect that a weak student in a ‘standard’ course where attention was not directed explicitly to the powerful nature of this sort of ‘question’ , would not fare well. But my conjecture is that it would be more useful to students to have been encouraged to ask that sort of question, than to have memorised the steps in several more procedures. To appreciate the limitations and effectiveness of a procedure, and even more importantly, to be alerted to the power of thinking in this way, is closer to what I would like students to get from a course.

#### **12** On Validity, are there other ways to prevent collusion? I teach mathematics in engineering, and our professional body require a proportion of teaching to be ‘controlled conditions’. How can we convert online open book to be classified as such? (Benjamin Drew)

Using a system such as STACK (Edinburgh) makes it possible to set questions, even ‘construct an example-type questions’ which are both machine marked and randomised for each student. I am not sure any professional organisation could ask for more. Also, as earlier, accumulating work done during the course for comparison to work done on the exam (and where a discrepancy is identified, have an oral discussion with the student) provides further confidence.

#### **13** I have used open book exams for a 3 hour traditional invigilated exam. I have used an open book take home exam done over say 2 weeks, but then only for a pass/fail scenario. If grades matter, what is your opinion of how long the students should have for open book take home exam type scenarios. (Jitesh Gajjar)

I don’t have experience to draw upon here. I do know that during lockdown and self-isolation, caring responsibilities have to be combined with on-line tasks for some people at least.

#### **14** How do you gauge the difficulty of new types of questions so that the average mark is similar to what they achieve now? (Anonymous Attendee)

The best way is to use similar tasks for ongoing assessment. As long as this is combined with explicit attention to the aspects chosen to probe while teaching, it gives both students and tutor opportunities to gauge effectiveness of learning, and to adjust mark schemes accordingly.

#### **15** Thank you for your answer to my earlier question, John. I have one further question: It sounds quite mistrusting, but do you have any recommendations for exam validity/integrity that doesn't rely on students' honesty and maturity in realising that they are really harming/disadvantaging themselves for future learning if they access external help? (Clodagh Carrol)

Short answer is no. Longer answer is … what is the validity of a timed 3 hr paper, whether at the end of the course, or at the end of three or four years? It seems to me that the most that can be said about one or more exam marks is that these provide a snapshot of what performance was possible on a given day at a given time in an unusual context in response to given probes. It hardly offers validity as a measure of what is possible in other contexts and in response to different problems. I think that is why people move to more open-book and longer time scale probes, even project work, even collaborative as well as individual.

It all comes down to ‘What do you want students to gain from studying a course?’. The more precisely and specifically this question can be addressed, the more closely the probes used (problems set) can provide sensible evidence.

#### After Thoughts

There is a notion called the *didactic contract* (Guy Brousseau): students assume that if they attempt the tasks they are given, the expected learning will take place.

But there is more to learning mathematics than this. Thus it behoves the teacher to be explicit about what is expected from students. (Relevant construct is the *hidden curriculum*: actions that students have to pick up without having attention directed explicitly, such as how to study mathematics, what to do with examples, how to learn from a proof, etc.)

Associated with the *didactic contract* is the *didactic tension*: the more clearly and explicitly the teacher indicates the desired behaviour, the easier it is for students to display that behaviour without actually generating themselves.

This needs to be borne in mind when providing ongoing experience of currently-unusual probes to be used for final assessment. It is necessary to distinguish between *training behaviour* and providing stimulus for students to *educate their awareness* (that is to internalise mathematical actions through encountering them in multiple contexts).

### From the Chat

#### Gabor Megyesi to All panelists : Who decides what is "mathematically coherent"?

Surely a competent tutor can decide this? As long as students have been exposed to examples which do and which do not display mathematical coherence.

#### Julia Goedecke : (concerning quadrilaterals with opposite sides perpendicular) do you mean opposite sides parallel? or are you meaning to make impossible

Perpendicular is intended. Sometimes people actually here *parallel* because it is so expected! I inserted this to offer a bit of a challenge, so as to provide a little experience of what it is like to encounter an unexpected question. The last one is indeed not possible … raising the opportunity to justify why it is not possible.

#### Gabor Megyesi to All panelists : What do you mean by a proof failing? If it fails, it is not a proof.

What I meant was, tinker with the example so that the proof no longer works, either because the theorem does not apply to the example, or because the proof is not sufficiently general to cope.

#### Peta Kirk to All panelists : the marking time will increase with these styles of questions

It need not increase if students have been appropriately prepared, and the mark scheme made sufficiently precise (and shared with students!) without actually providing specific answers.

#### Julia Goedecke : how do you deal with students working together in this context? we had to do 24h in may and it really didn’t work very well

Some people assign a collective mark; others ask each to estimate the degree of their personal contribution to the collective. How much prior experience do they have of collective responses to probes/problems?

#### From Julia Goedecke : Lots of good ideas I want to use in my live lectures in "flipped" version. But I'm also afraid that I now have to redo all my questions and I don't have the time...

Don’t try to change a lot at once … allow changes to develop slowly so that students participate in the evolution!

#### Carol : The question about consistency of marking , when several markers, these more open questions

See earlier responses

#### Ruaraidh McPike : Getting students to generate their own examples based on course material could be good preparation for doing honours projects. But hard to get them to do for earlier year classes

Conjecture! For what I hope students get from a course, constructing their own examples so as to comprehend a theorem or procedure is core mathematical thinking and so to be encouraged from the earliest possible age (primary school!). After all, it is what mathematicians do when reading a paper, isn’t it?

#### Philip Walker : I'm planning to do a "tweaked" definition of the derivative question, getting the students to explain why it \*doesn't\* work for getting at the same thing as the tangent.

#### Julia Goedecke : I think my main worry is "students who do not want to engage at this level"

I conjecture that *all* students want to study efficiently and effectively. I also conjecture that many, especially those who ‘don’t want to engage …’ are being wildly inefficient and ineffective (viz thewir grades).

#### Hayley : I think that the questions are excellent for developing (and demonstrating) understanding, but it seems hard to come up with a robust mark scheme if they were used in an exam (esp if there were several markers)

See earlier responses

#### Colin Steele : They will answer questions on “differentiate f(x) = ..... “ but not want to spend time on “list some points on differentiation”

Conjecture! They might not need to spend time on ‘list points’ if they have developed the habit of constructing their own narrative, their *own explanation* through being prompted by the tutor, and experiencing its effectiveness in learning.

#### Alex Watson : Everyone saying "students won't want to do this", i don't understand you. If it is part of the assessment, students will want to do it.

#### Colin Steele : But they refuse to practice it in advance

#### Alex Watson : Even if they know it is on the exam? You can't spring it on them, of course, but if it is assessed and they have a chance to practice it, I find it hard to imagine students, no matter what motivation they have for study, not trying to do them.

#### Julia Goedecke : We do have several students who do not engage with the material at all even though they know it will be assessed.

The most I can do is offer opportunity to learn. That is what distinguishes people from computers! Teachers cannot force students to learn. Desire to learn is a prerequisite for learning mathematics.

#### Bridget : I'm just marking an exam question that asks for an ordering of items such that one packing algorithm needs fewer boxes than another. That turned out easier than I'd thought, but convincingly explaining why another could never use less was turned out to be more challenging. If students are used to non-standard questions (and see them in specimen and past papers) they accept them and answer them to the best of their ability.

#### SallyB : My mantra to students is that mathematics is about asking questions not answering them.... That is having answered any question they should then ask themselves are there other answers, what was the key information etc Only when they are asking questions can they really understand what they are doing - but many students simply stop once they have "an answer".

Hear Hear!

#### Chris Sangwin : I'm just writing some linear algebra problem for my students: find a 3\*3 example \(A\) for which none of the entries of \(A\) are zero, but \(A^2=0\) Kevin Houston might reconise the recent Tweet as the source of inspiration for this!

#### Kevin Houston : @chris: https://twitter.com/robinhouston/status/1306539901576503297

### Overall Observations

#### SallyB : raises the question of how often students focus on the "wrong thing" and miss the point of an example.