

Teaching Philosophy, Logic and Critical Thinking using Peer Instruction

Sam Butchart

Toby Handfield

Greg Restall

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Introduction

Peer Instruction (or PI for short) is a simple and effective technique you can use to make lectures more interactive, more engaging, and more effective learning experiences.

PI was developed by a physicist, Eric Mazur, who was teaching an introductory physics unit to freshmen at Harvard, the vast majority of whom were not going to go on to complete a major in physics (Mazur 1997). The method has gone on to become reasonably well known, and reasonably widely used, in science and mathematics where it has been very successful. The technique appears to be very little known in the humanities however.¹ In what follows, we hope to convince you that PI has enormous potential to improve teaching and learning in philosophy and many other humanities subjects too.

We proceed as follows: In the first several sections of the paper, we review material which will be largely familiar to those who already know about PI. In the next section we discuss the motivation to adopt a method like PI. We then describe the method in some detail. We report what is generally known about the benefits of PI and similar techniques and discuss some of the practicalities of implementing the technique.

Then, in the second part of the paper we focus on how PI can be applied to the teaching of philosophy, critical thinking, and logic, and on the results of our evaluation of the success of PI in these contexts. For those already familiar with the method, therefore, we advise you to skip straight to the section 'But does it work in philosophy?'

Background: Lectures are (mostly) rubbish

Teaching lectures is, by and large, a frustrating experience. Although we all try to craft our lectures to be gems of clarity, wit, and wisdom, it is a common experience to find that the audience, apart from one or two very bright or confident students, are extremely unresponsive and evidently much less inspired than they ought to be. What is missing? Most crucially, it is interaction and other forms of active engagement with the material.

Indeed, there is an emerging consensus in higher education research that the traditional lecture is of very little value as a method of teaching. (Brandford *et. al.* 1999, Bligh 1998, Redish 1994, Wulff *et. al.* 1987). It has been found that students learn best when *active learning* takes place; that is, when students are required to actively engage with the material and apply the concepts being taught (Smith *et. al.* 2005, Maloney *et. al.* 2001, Hake 1998, Thornton and Sokolof 1998, Johnson, Johnson and Smith 1991).

Unfortunately, the traditional lecture format leaves little room for active learning. Typically, the lecturer presents the material as a monologue, while students listen passively, perhaps making notes. Only the most exceptional lecturers can hold students' attention in this way for the full lecture period. Of course, many lecturers stop and ask questions at various points, but what usually happens? A handful of students with much more self-confidence than average raise their hands and get the very mixed blessing of a very public, high-risk dialogue. If a lecturer wishes to disagree with a student's answer, it can inadvertently embarrass or humiliate the student, and the other students may become irritated by the apparent interruption of the 'important stuff' – the content of the lecture. Even fewer students are willing to initiate questions themselves, even when invited to do so and reassured that they will not be made to feel foolish by asking a 'stupid question'.

At the same time, the high student to instructor ratio makes it very difficult for the lecturer to get any idea of how well the class has understood the material, so that they can adjust their teaching accordingly. This makes for a highly unresponsive method of teaching, involving little or no student-teacher or student-student interaction. Hence, in a typical lecture, "the information passes from the notes of the professor to the notes of the students, without

passing through the mind of either one” (Smith *et. al.* 2005, p. 88).

Improving lectures with Peer Instruction

Peer Instruction is a simple way to incorporate some genuine interaction and engagement in lectures. It is cheap, simple to implement, and delivers useful feedback to both students and to the lecturer. Typically, the method works in the following way. After lecturing on a topic for 10-15 minutes, the lecturer stops and asks a multiple-choice quiz question that tests students’ understanding of the topic under discussion. These questions are often designed to test common misunderstandings of the topic. All the students in the class then “vote” on the answer to the question. This can be done in a number of different ways; using an electronic response system (“clickers”), flash cards, or simply by show of hands. (See ‘How do students vote on the answer?’ below for more detail).

If most students have the right answer, the lecturer can confirm it and move on. If most have the wrong answer, this suggests the lecture was opaque and the students didn't get it. The lecturer can then double back and explain the topic again or give some hints before trying again with the same (or a different) question.

If there is a mixture of answers, the lecturer does not tell students the answer. Instead, students are given a few minutes to discuss the question with their neighbours and try to persuade them that their answer is correct. The whole class then gets to vote a second time. Typically, more students give the correct answer the second time around; students with the right answer usually convince others of it. The lecturer can then confirm the answer and move on, either to another question, or to the next topic in the lecture.

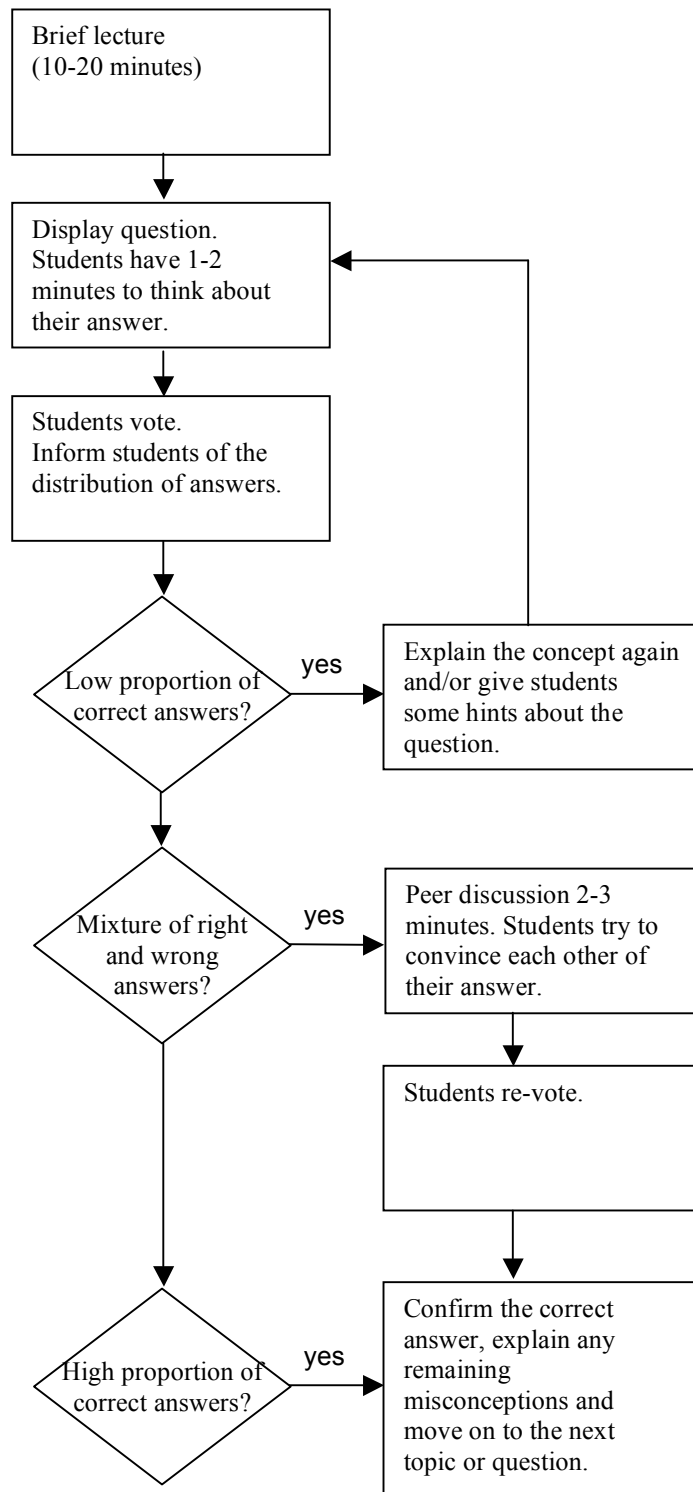
Format of a Peer Instruction lecture

Here, in a bit more detail, is the general format for a Peer Instruction lecture (see also Figure 1):

1. The lecturer lectures on a topic for a short period. In our experience, 15 minutes is about the longest you would wish to lecture without a break.

2. The lecturer then displays a multiple-choice question on the topic just covered.
3. Students are given a short time to think about their own answer, without conferring. Make sure students are given enough time to read the question and think about it, but don't give them too long.
4. All students then vote on the answer. If flash cards are used, all the students should hold up their cards at the same time.
5. Without telling students the correct answer, the lecturer then reports back the general distribution of answers to the class. For example, she might say "About half of you have voted for answer 'A', the rest of you are split between 'C' and 'D'".
6. If most students have the right answer, the lecturer confirms it and continues.
7. If most students have the wrong answer, the lecturer may go back, explain the topic again and then re-assess, either by asking the question again, or using another question.
8. If a reasonable number of students have the correct answer, but a reasonable number also have an incorrect answer, students are given a brief period, often as little as 1–2 minutes to discuss their answers with their neighbours. For example, the lecturer says something like "Now, turn to the person sitting next to you and try to convince them that your answer is correct. I'll give you 2 minutes to talk about the answer and then we'll vote again." If you like, you can wander around the lecture theatre while this is happening and listen in on a few of the discussions.
9. After 1–2 minutes, bring the discussions to a close. The class then votes on the answer again and we go back to step 5.
10. If the proportion of students with the right answer has increased after the discussion, the lecturer can confirm it and move on to the next topic or question. If not, the lecturer might wish to explain the right answer before moving on.

Figure 1
Format of a PI lecture



The benefits of Peer Instruction

The advantages of a Peer Instruction lecture over the traditional format are many and varied. The quiz questions provide you, the lecturer, with instant feedback about how well students have understood the material, allowing you to adjust the pace and content of your teaching accordingly. The questions also provide valuable feedback to the student on how well they have actually understood the material and how they are progressing relative to the rest of the class.

The ‘convince-your-neighbour’ sessions allow for valuable peer interaction between students. This promotes active engagement: students have to do more than passively assimilate material, they must think about it and try to explain it to someone else. The convergence on the correct answer suggests that brief one-on-one discussion among the students is a useful learning tool. Students who have understood the topic are able to explain it effectively to students who have not, perhaps at times more effectively than the lecturer.

The anonymous nature of the voting system encourages participation by not just some, but *all* students. This is most apparent when an electronic response system is used, but also holds to a lesser extent when flashcards are used, especially in very large lectures. This makes it much easier for students who would not normally participate by publicly answering questions to engage with the material being taught.

The monotony of the traditional lecture is avoided by breaking up the lecture into short segments interspersed with a sequence of questions in which students must actively engage with the material. In this way, student concentration and retention is increased.

Finally, it is worth mentioning some more indirect benefits for you, the lecturer. The first time you try out PI and ask students to try to convince each other of their answers, you’ll get a big kick out of it. Suddenly there is a great buzz of conversation in the lecture theatre as students eagerly begin arguing and discussing the ideas you’ve just been trying to get across. That is a rare occurrence in a large lecture class. For this reason, teaching using PI can put a lot of the joy back into lecturing. Lectures feel a bit more like a conversation or dialogue between you and the students, rather than emptying yourself out into a void of apparent student indifference.

Of course, we all know a few rare and brilliant lecturers who can keep students mesmerised

an engaged for a whole hour. But most of us – if we are honest – are not that good. It would be a great shame if the only way we could improve our lectures is by becoming as good as, say, Richard Feynman was reputed to be. One nice feature of Peer Instruction is that it is a simple way to improve lectures that *anyone* can make use of straight away – you don't have to already be a brilliant lecturer to use it.

By now a substantial body of research exists on the effectiveness of Peer Instruction. Studies on the use of PI in physics have consistently shown impressive gains in conceptual understanding and problem solving. Student surveys show that student satisfaction is also increases. (See for example, Mazur 1997, Hake 1998, Crouch and Mazur 2001, Fagen *et. al.* 2002, Meltzer and Manivannan 2002, Kennedy and Cutts 2005, Sharma *et. al.* 2005). The technique has also been successfully adopted in many other disciplines, including law (Burton 2004), economics (Elliot 2003), business (Williams 2003) chemistry (Landis *et. al.* 2001), engineering (Nicol and Boyle 2003), mathematics (Pilzer 2001, Cline 2006), psychology (Chew 2004, 2005), astronomy (Green 2003), geology (McConnell *et. al.* 2006), statistics (Wit 2003), computer science (Cutts and Kennedy 2005, Kennedy and Cuts 2005), biology (Knight and Wood 2005), pharmacology (Piepmeier 1998) and medicine (Robertson 2000, Rao and DiCarlo 2000). In the 'Evaluations of PI' section below, we report similar successes from our use of PI in philosophy, logic and critical thinking.

How do students vote on the answer?

There are several different ways in which students can vote on the answer to a peer instruction question. We will briefly describe three of these and compare their advantages and disadvantages.

The simplest (and cheapest) system is to use show of hands. After students have read the question and thought about it, the lecturer says 'Hands up everyone who thinks the answer is A', then 'Hands up everyone who thinks the answer is B', and so on. There are two serious disadvantages to this system: the first is that it is not anonymous. If an option is unpopular, students will quickly realise that they are putting themselves at risk of embarrassment by raising their hand, and hold back. Overall participation will drop, and thereby engagement with the material will drop.

The second disadvantage is practical: a serial method of collecting answers such as this is substantially slower than a simultaneous feedback method. For these two reasons we strongly recommend against using show of hands.

A better, but still cheap and simple alternative is to use flashcards (see Meltzer and Manivannan 2002, 1996, Mazur 1997, pp. 17-18, Dunn 1969, Harden *et. al.* 1968). Each student is provided with a set of flashcards, labelled 'A', 'B', 'C' etc. Students vote by simultaneously all holding up the card corresponding to their answer. The lecturer can then make a visual tally of the distribution of answers and report it back to the class; "OK, so about half of you have voted 'A', the rest seem to be fairly evenly split between 'C' and 'D'".

This widely used method has the advantage of being low-cost and simple to introduce. Voting is fairly anonymous because students cannot easily see how other students are voting; all students raise their cards at the same time and the cards are single-sided. This is the method we have been using and we have found it to work very effectively.

The most sophisticated voting mechanism is to provide each student with an Personal Response System of 'clicker'. This is a small keypad which sends a signal to the lecturers' computer. The computer then tallies the votes and the results can be instantly displayed in graphical form, such as a bar chart. Most systems also allow the lecturer to keep track of individual students' responses to questions (Simpson and Oliver 2007, Sharma *et. al.* 2005, Kennedy and Cutts 2005, Duncan 2005, Draper and Brown 2004, Boyle and Nicol 2003, Elliot 2003, Williams 2003, Draper, Cargill and Cutts 2002, Dufresne *et. al.* 1996).

The main advantage of using clickers is that voting is as anonymous as possible. Students cannot see other students answers until the results for the whole class are displayed. This encourages participation and requires students to think for themselves about their answer.

Another advantage is that the lecturer can keep accurate records of how students answered each question. This is very useful for identifying questions that are either too easy or too difficult. If data is collected on individual students' responses to questions, this information can be used to identify students who are struggling and to keep records of attendance. The main disadvantage of using an electronic response system is the initial cost and the technical

support and training required to use it.

Some research has been done comparing the effectiveness of these alternative voting mechanisms. The research suggests that clickers are much better than show of hands as a voting mechanism. (Freeman, Blayney and Ginns 2005, 2006, Sharma *et. al.* 2005). However, there appears to be little measurable difference between flashcards and clickers in terms of learning outcomes; both are equally as effective in improving students conceptual understanding of lecture material, although the benefits of having a permanent record for question analysis and student tracking still apply (Lasry 2007). These findings are borne out by our own research. We have found that although flashcards are not completely anonymous, this does not seem to significantly detract from the effectiveness of PI (see ‘Flashcards as a voting mechanism’ below for more details).

We suggest then, that flashcards should be used in preference to show of hands. Clickers are great if you can afford them, but we have used PI very effectively using just flashcards. Cards are not only cheap to manufacture² and replace, but also very easy to distribute in class. Personal response systems can be a little more complicated to set up, unless the system is integrated into the lecture theatre.

We provide each student with an envelope containing a set of four cards, labelled ‘A’ to ‘D’. We have found the most efficient way to distribute them is to wait until a reasonable number of students are seated, and then hand piles of 20–50 envelopes to students who are then asked to take one and pass them along. Latecomers can pick up a set from a box conveniently placed at the front of the lecture theatre as they enter. At the end of the lecture, students put their cards back in the envelope and return them to the box on their way out. We recommend colour coding the cards – A's are red, B's are yellow, for instance – to make it easier for the lecturer to get a visual impression of the distribution of answers.

The important thing is to try to encourage all the students to hold up their cards at the same time. This makes it harder for students to wait to see how the majority is voting and go with that – and this forces them to think about the question themselves.³

But does it work in philosophy?

It might be thought that PI could only work in subjects such as physics and mathematics, where there are clear-cut right and wrong answers and that its use in subjects such as philosophy would be inappropriate. Such worries are entirely misplaced. Firstly, it is entirely possible to construct useful conceptual questions with clear right and wrong answers in these subjects. Examples are questions that ask how a particular concept or theory would apply in a particular case; questions about the logical relationships between concepts or theories; questions about the correct definition of a concept and questions that elicit well known student misconceptions about a particular theory or idea.

Secondly, the opportunities for student discussion and active engagement offered by PI can be achieved even with open-ended questions which do not have a unique correct answer. For example, questions which elicit from students one of several conflicting intuitions in response to a particular situation or case-study can be used to introduce and motivate general theories or principles. Such questions can generate lively discussion and interest.

Thirdly, the opportunity to discuss the ideas and concepts being taught provides students with invaluable practice at actually doing (for example) philosophy. That is, students gain real experience with the actual practice of the discipline they are studying.

Our own research on the use of PI in philosophy, logic, and critical thinking courses shows that the method can indeed be used in these subjects to great effect. The results of our evaluations are described in more detail below, but we can say here that the response from students has been *overwhelmingly* positive. We have consistently found that the majority of students really enjoy our PI lectures and comment on the positive effects of the method on attention, the provision of feedback, and improved understanding. (See the section below on ‘Evaluations of PI’).

What kind of questions can you ask in philosophy lectures?

There are in fact many different types of question that can usefully be asked in a philosophy lecture. Here are just a few examples, offered in the hope of further convincing you that using PI is both possible and worthwhile in philosophy subjects.

Questions about theories and principles

Given a particular theory or principle, you can ask what it would entail about a particular example or case. When thinking about how to make use of PI in your lectures, it is good idea to use as much of your existing material as possible. You may already have a lecture where you want to compare competing theories by discussing what they entail about particular cases or examples. You might already verbally ask students questions like: “So what would this theory say about this particular case?” You can quite easily turn this into a PI question. For example, in a lecture on ethics, you might use some standard thought experiments to discuss two different general moral principles; a sanctity of life principle and a consequentialist principle. Having explicitly defined these principles, and ideally distributed a lecture handout which includes them, you might then introduce the following case:

THE SPARE-PARTS SURGEON

Five patients are in need of transplants in order to save their life. One patient has five healthy organs, which could be used to save the five. The surgeon can kill the one such that no one knows, and such that the five others are saved.

QUESTION: May the surgeon kill one to save the five?

What does the Sanctity of Life principle say?

- A. Yes, it is permissible.
- B. No, it is not permissible

What does the Best Consequences principle say?

- A. Yes, it is permissible.
- B. No, it is not permissible

You can have a sequence of questions of this kind which ask how the theory would apply to different cases. Where you have two or more competing theories, you can ask how each of them would apply to the cases and compare the differences.

You can make this kind of question more interesting by asking students to vote on what they think about the case first. So in this example, you might first ask students to vote on whether they think it is permissible for the surgeon to kill one patient to save five, before asking them about what the two competing principles say. That can make vivid to students the process of evaluating philosophical theories by comparing them to intuitions about particular cases. In this way, it gives students a little practice at actually doing some philosophy, as well as serving as a useful check for you and them on whether they have understood your explanations of the theories themselves.

Which principle applies to a given case?

A variation on this kind of question asks which one of several principles applies to or conforms to a given case. For example:

Jones believes that his wife is having an affair on the grounds that he saw his wife with a strange man in a cafe. As it turns out, his wife is having an affair, but not with the man Jones saw her with.

On which theory of knowledge would Jones count as *knowing* that his wife is having an affair?

- A. Justified true belief
- B. Causal theory of knowledge
- C. Nozick's theory
- D. None of the above

Which case conforms to the principle?

A second variant of this kind of question asks which of several cases or examples (listed in the responses) a particular principle or theory applies to:

1. Suppose somebody takes your wallet, and runs away with it. Afterwards they are caught, and asked why they did it. Consider these possible replies:

- A. Anyone in my position would have done it.
- B. It was in my interests to do it. Too bad if it harmed someone else.
- C. Although the person I robbed is worse off, I needed the money more than they did.
- D. None of the above.

According to Singer's theory, which of these might be considered attempted *ethical* justifications?

2. Which of the following arguments would be valid according to the *compatibilist* theory of freedom?

- A. The world is deterministic, therefore there is no freedom.
- B. Freedom exists, therefore the world is not deterministic.
- C. There is no such thing as freedom, therefore the world is deterministic.
- D. None of the above.

3. Suppose you endorse the Sanctity of Life principle. In that case, which of the following types of killing are impermissible?

- I. Executing a murderer as a form of punishment.
- II. Inadvertently killing civilians during warfare.
- III. Turning the run-away trolley to save the five.

- A. I and II.
- B. II only.
- C. II and III.
- D. III only.

Questions about concepts, definitions and distinctions

Given a tricky concept or definition, there are various types of question you can ask that check students' understanding of the concept. You can ask whether the concept or definition applies to a particular case. Here is an example, involving the concept of an *argument*:

Do the following passages contain arguments or not?

1. A number is said to be 'prime' if it is divisible only by itself and one. The first five prime numbers are 2, 3, 5, 7 and 11. Long ago, Euclid proved that there is no end to the sequence of prime numbers – that is, for any prime number, there is a greater one.

A. Yes, the passage does contain an argument.

B. No, the passage does not contain an argument.

2. Capital punishment is justified if it deters people from committing violent crimes. However, the statistics on violent crime show that capital punishment does not act as a deterrent. Therefore, capital punishment is never justified.

A. Yes, the passage does contain an argument.

B. No, the passage does not contain an argument.

More generally, you can ask about the logical consequences of definitions or concepts. For example, you can ask questions of the form: supposing this concept applies, what else can we infer? Here is an example involving the concept of having a *right* to something:

Suppose you intend to do X, and you discover that Bloggs has a right that you not do X. Which of the following is entailed by Bloggs's having that right?

A. You ought not to X.

B. You ought not to X without Bloggs's permission.

C. You may X provided you compensate Bloggs for any harm suffered as a result.

D. None of the above.

Similar types of questions can be asked about distinctions – pairs of concepts that go together. For example, you can ask which of the two concepts applies to a particular example (or series of examples). Here is an example involving the distinction between *intrinsic* and *relational* properties:

For each of the following properties, are they intrinsic (A) or relational (B)?

1. being taller than John Howard
2. being a potential genius
3. being 2 kg in weight
4. being inside a womb

Note that not all of these items have clear-cut answers. Item 2, in particular, is controversial, and has never generated consensus in our use of it. But it is not always necessary to have clear-cut answers, as long as the questions direct students to thinking and talking about the relevant issues.

Questions about arguments

Philosophy of course is full of arguments and there are lots of good questions you can ask about a given argument. For example, you can ask:

1. Which of the following best represents the conclusion of the argument?
2. Which of the following are premises in this argument?
3. Is this argument valid? Do the premises (evidence) support the conclusion?
4. Which of the following is an assumption (missing premise) required for the conclusion to follow?
5. Which of the following describes a flaw in this argument?

Some examples of each of these types of question follow:

Identify the conclusion

One simple way to construct questions which require students to identify component parts of an argument is to number sections of the original text and then ask students which numbers represents the main conclusion and which represent premises in the argument. Here are some examples:

(1) The second way is based on the nature of causation. (2) In the observable world causes are found to be ordered in series; (3) we never observe, nor ever could, something causing itself, for (4) this would mean it preceded itself, and (5) this is not possible. (6) Such a series of causes must however stop somewhere (7) One is therefore forced to suppose some first cause, to which everyone gives the name of "God".

Which of the numbered statements in the passage represents the main conclusion of the argument?

- A. (7)
- B. (1)
- C. (5)
- D. (6)

Identify the premises

(1) The second way is based on the nature of causation. (2) In the observable world causes are found to be ordered in series; (3) we never observe, nor ever could, something causing itself, for (4) this would mean it preceded itself, and (5) this is not possible. (6) Such a series of causes must however stop somewhere (7) One is therefore forced to suppose some first cause, to which everyone gives the name of "God".

Which of the numbered statements in the passage represent premises of the argument?

- A. (1), (2) and (3)
- B. (2) and (3) but not (6)
- C. (2), (3) and (6)
- D. (3) and (6) but not (2)

Questions like these can be a good way to introduce and explain the argument contained in a difficult text. Bear in mind that they may require more than just a minute of thought to work out the answer, since students must be given enough time to read and interpret the text before considering their answer. Provided the lecture is structured with sufficient time, such a sequence of questions can be used effectively.

Is the argument valid?

Consider the following argument:

1. Some things exist and their existence is caused.
2. Nothing causes itself.
3. There cannot be an infinite regress of causes.

Therefore:

C. There is a first cause – something that causes other things, but is not itself caused – and that thing is God.

Which of the following statements about the validity of this argument do you think are correct?

- A. The argument is valid because if all the premises were true, the conclusion would have to be true.
- B. The argument is invalid because there are some things which exist, but do not have any cause.
- C. The argument is invalid because there is no contradiction in the idea of an infinite regress of causes, so an infinite regress of causes is possible.
- D. The argument is invalid because it does not show that the first cause has all the necessary attributes of God.

Identify an assumption (unstated premise) required by the argument

Consider the following argument schema:

P1. All and only beings have a significant interest in living.

P2. Other things being equal, it is seriously wrong to kill a being who has a significant interest in living.

Therefore:

C. Other things being equal, it is seriously wrong to kill a being which is

Is the argument schema valid?

A. Yes

B. No

Anselm's ontological argument begins as follows:

Suppose (for reductio) that:

1. The greatest conceivable being exists in the mind, but not in reality.

2. If something exists in the mind, it can be conceived to exist in reality as well.

3. ...

Therefore: (1, 2 and 3):

4. Something greater than the greatest conceivable being can be conceived.

What assumption best fills the gap at premise 3?

A. The greatest conceivable being exists not only in the mind, but also in reality.

B. Nothing that is greater than the greatest conceivable being can be conceived.

C. Something that exists in reality is greater than something that exists only in the mind.

D. Anything that can be conceived to exist in reality, must actually exist in reality.

Identify a flaw in the argument

Capital punishment is justified if it deters people from committing violent crimes. However, the statistics on violent crime show that capital punishment does not act as a deterrent. Therefore, capital punishment is never justified.

This argument is most vulnerable to criticism on the ground that it

- A. assumes what it is trying to prove
- B. fails to consider that capital punishment might be justified in other ways
- C. equivocates with respect to the central concept of 'violent crime'
- D. too readily accepts a claim by appeal to inappropriate authority

In constructing PI questions for critical thinking, we have found that LSAT logical reasoning questions are an excellent source. These consist of a short example argument followed by a well-designed multiple-choice question. (See for example LSAC 2002).

Worked examples

A common task in a lecture is to work through an example in order to show how to solve a particular kind of problem. The lecturer might write up a problem on the board and then show students how to solve it, step by step, perhaps asking questions at various points ('so, what should we do next?', 'how can we apply this rule at this step?' and so on). This type of worked example is often quite easy to turn into a sequence of multiple-choice questions. Just break the worked example up into a sequence of steps and think about what questions you can ask at each step. Then turn those questions into multiple-choice questions. In doing this, it is useful to think about common mistakes that you know from experience that students often make. That will help you think of good incorrect options (also known as 'distractors') for the multiple-choice question.

Here is an example taken from a formal logic course. The problem to be solved is to decide whether a particular argument is valid or not. This is done by first translating the argument into a formal language and then applying a formal method (truth-tables in this case) to test the validity of the argument form. The following sequence of questions takes students step-

by-step through this process.

1. Translate the following argument into symbolic form:

If the printer is unplugged or the ink cartridge is empty, the page will not print. The page did not print. Therefore the printer is not plugged in.

p = the printer is plugged in

c = the ink cartridge is empty

g = the page was printed.

A. $(p \vee c) \rightarrow \sim g, g$ therefore $\sim p$

B. $(p \vee \sim c) \rightarrow \sim g, g$ therefore $\sim p$

C. $(\sim p \vee c) \rightarrow \sim g, \sim g$ therefore $\sim p$

D. $(\sim p \vee c) \rightarrow g, \sim g$ therefore p

2. What truth values go in the missing spaces in the truth table for this argument?

A. T

B. F

	p	c	g	($\sim p \vee c$)	\rightarrow	$\sim g$	$\sim g$	$\sim p$
1	F	F	F	T	T	F	T	T
2	F	F	T	T	T	F	e	F
3	F	T	F	T	T	T	T	T
4	F	T	T	T	T	T	F	F
5	T	F	F	F	c	F	d	T
6	T	F	T	F	F	F	T	F
7	T	T	F	F	a	T	b	T
8	T	T	T	F	T	T	F	F

3. The truth table shows that the argument is:

A. Valid

B. Invalid

C. Impossible to tell.

4. Counter-examples to the validity of this argument are found on lines:

- A. 5 only
- B. 5 and 6
- C. 1 and 3
- D. 5 and 7

A worked-example question like this should be presented as a sequence of separate slides or overheads. As students answer each question, the gaps in the truth table should be filled in with the correct answer before going on to the next slide in the sequence. Questions 3 and 4 would then be presented with the completed truth table. Alternatively, students could be provided with a printed handout or work sheet on which they can fill in the answers.

With this series of questions, different parts of the technique of truth table analysis of arguments are tested: (question 1) the *formalisation* of natural language arguments; (the questions in part 2) the *technique* of completing a truth table (although we do not go through *all* of the truth table, which would be too time-consuming); and (questions 3 and 4) *interpreting* the results. In addition, stepping through the four parts of the question provides the students with a concrete example of the process of using a truth table to evaluate an argument. Students are learning the component parts of the process, as well as the way those components fit together.

Opinion polls: questions that elicit intuitions or start a discussion or debate

There is nothing wrong with sometimes including questions that have no clearly right or wrong answer. You might just want to poll students' opinions about a topic, or use a question to get a discussion going in class. We have already mentioned one context in which you might want to do this. When discussing how a theory applies to a particular case, you might want to first ask students for their opinion about the case, before going on to see how what various theories imply about it. (see 8.1 above). In this way, students get some practice with the method of thought-experiments - testing theories against considered judgements (or intuitions) about particular imagined cases or examples.

‘Opinion poll’ questions can also be used to introduce a topic or illustrate a problem.

Consider the following example:

OPINION POLL:

Which of these outcomes is worse?

- A. Five people contract a fatal disease that can only be treated at great cost and with difficulty. They are not treated, and die of it within a year.
- B. A person murders a completely innocent stranger. The murderer feels no guilt, but never re-offends.
- C. Neither: they are equally bad.

Suppose an all powerful being asks you to choose which of these outcomes to bring about at some point in the future? Which one would you think is the worse possible outcome?

This can be a useful introductory activity before thinking about different consequentialist theories, and the plausibility of various theories of value. The above question on classifying properties as intrinsic or relational can also be used as a poll before attempting to give an analysis of the concept of intrinsicness.

Sometimes you might want to discuss a number of different candidate theories or solutions to a problem. In this case you might give students an opinion-poll question, asking them to choose from a range of theories or solutions. You can then go on to explain those theories and possible problems with them in more detail. However, students are now more likely to be interested and engaged because they have already taken a position on one side of the debate or another. After you have lectured on the topic and considered objections and problems, you might poll the students again, to see if there has been any change of opinion. Questions like this are often a good trigger for a class-wide discussion. After the initial poll, you could ask students who picked one option to explain why they did so. Then ask someone who picked one of the alternatives to explain their answer. Then you can ask students to evaluate the arguments offered; ‘who agrees with that?’, ‘can anyone think of any objections to that argument?’ and so on. This is a good way of getting a debate on the issues going.

A different use of opinion-poll questions is to ask students which topics they have been finding especially difficult, or which they'd like to focus on. This can be especially useful in a

revision class. Sometimes, you the answer to such a question may not be what you expect. (See for example Stuart, Brown and Draper 2004, p. 98). Instead of trying to second-guess what students are finding difficult, you can simply ask them and then change the focus of your lecture to fit.

What makes a good question?

The main requirement for a good question is that it have the right level of difficulty. You ideally want a question which some, but not all of the students, can successfully answer without too much difficulty. It is a very good idea, if you are trying your own Peer Instruction questions for the first time, to make a note of the responses, to assist you in future question refinement.

A second thing to aim for is that the incorrect answers are good "distractors" which elicit common student misconceptions. If, even after discussion, you get a class response evenly divided between the correct answer and a particular incorrect answer, you can then get a dramatic demonstration of the sort of misconception that students are most prone to, and can tailor your subsequent teaching to address it.

Of course, sometimes questions will fall flat, in one way or another. It therefore won't always be appropriate to invite the students to discuss the answer among themselves. The two main contingencies which arise are: first, not enough students getting the right answer. This suggests the lecture was opaque, the students didn't get it, and you'll need to double back, perhaps giving some hints, before students will be able to tackle the question. And second, you might find not enough students get the wrong answer: the question was just too easy.

If everyone gets the question straight away, there is not much point having them talk about it among themselves. (Indeed, if you invite discussion, students tend to think it is a trick question, and make a guess at an alternative!) Rather, it is a good moment to give some positive reinforcement to the students, congratulating them on having picked up the point so quickly.

Of course, inviting student discussion about the question is only one option of many, but it is

in a sense the option which the lecturer should be aiming for. The more you can get opportunities for fruitful discussion between students, the better you are approximating the ideal of *peer* instruction.

That said, there can still be a great deal of value in questions which do not generate much discussion. A good example is the sequence of questions described above (under ‘Worked examples’) which takes students step-by-step through the process of analysing the validity of an argument using truth-tables. Here the point is to break down into smaller components the parts of a long chain of reasoning. This type of ‘worked example’ question is of benefit in demonstrating to students how a complex task should be broken down into a number of manageable steps.

With this type of question, there is no small set of different mistakes a student is likely to make: to complete the task, the student must make a number of correct moves along the way. Using Peer Instruction here is a useful technique for ensuring that the whole class keeps up, by providing a sequence of ‘checkpoints’ along the way. This is valuable even if most students are getting the right answer at each stage. The reason is that even in a task where all the component tasks in the sequence are completed correctly by most students, it is still possible (and often quite likely) that most students will make a mistake at some point in the sequence. By breaking down the task into its components and providing checkpoints, we minimise student discouragement. This kind of question can also be used to illustrate to students how a complex task should be broken down into a number of manageable steps.

Evaluations of PI in philosophy, critical thinking and formal logic

Over the last two years, we have used Peer Instruction in several undergraduate philosophy courses, with great success. Here we report the results from our evaluations of the method for four courses; *Thinking: Analysing Arguments* (critical thinking), *Life, Death and Morality* (an introductory course in ethics), *God, Freedom and Evil* (an introductory philosophy course focusing on arguments for and against the existence of God), and *Logic* (a first year formal logic course). In all the courses, we used flash-cards as the voting mechanism.

We evaluated all four courses using the same anonymous student questionnaire. In addition, students in the critical thinking course were pre- and post-tested using a standardised test of critical thinking, the California Critical Thinking Skills Test (Facione & Facione 1992). The results are described below under ‘Gains on critical thinking tests’.

In the following sections, we report and discuss the results from the student evaluations. The questionnaire used consists of 15 items. Most items ask students to respond to a given statement on a 6-point Likert scale (Agree strongly -- Disagree strongly). Three of the items ask students for their comments on the advantages and disadvantages of PI. The questionnaire was distributed in lectures and tutorials towards the end of the semester (around the tenth week). For all courses except Formal Logic, the questionnaire was also available online for three weeks after the end of the course and many students completed the questionnaire this way. A full copy of the questionnaire is available from the Monash *Peer Instruction in the Humanities* website (Monash 2007) in the ‘Resources for evaluation’ section.

<http://arts.monash.edu.au/philosophy/peer-instruction/>

The table below contains further information on each course and the numbers of students who completed the questionnaire.⁴

	Critical Thinking (2006)	Ethics (2007)	Philosophy of Religion (2007)	Formal Logic (2007)
Course duration	13 weeks	13 weeks	13 weeks	13 weeks
Course level	First year	First year	First year	First year
Number and duration of lectures	1 one-hour lecture per week.	1 one-hour lecture per week.	1 one-hour lecture per week.	2 one-hour lectures per week.
Approx. number of PI questions used per lecture	3-5	3-5	2-3	5-6
Number of students who completed questionnaire	34	84	84	29
Total enrolment	61	195	195	58
Response rate	56%	43%	43%	50%

Effect on understanding of lecture material

In all the courses in which PI was used, students overwhelmingly agreed that the questions helped them to understand the lectures. 95-100% of students agreed with this statement. In Critical Thinking, Ethics and Philosophy of Religion 46-56% of students agreed strongly. In the Formal Logic, although 100% of students agreed, only 28% agreed strongly -- the majority (58%) indicating moderate agreement.

Q2. The use of the multiple-choice questions and flash cards helped me to understand the material when I attended lectures.

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(6) Agree Strongly	56%	56%	46%	28%
(5) Agree Moderately	35%	33%	36%	58%
(4) Agree Slightly	9%	10%	13%	14%
(3) Disagree Slightly	0%	1%	1%	0%
(2) Disagree Moderately	0%	0%	1%	0%
(1) Disagree Strongly	0%	0%	1%	0%
Total agree	100%	99%	95%	100%
Total disagree	0%	1%	3%	0%
Mean	5.47	5.44	5.22	5.14
Std. Dev.	0.66	0.72	0.96	0.64

Below are some sample comments from students on this aspect of the use of PI.

Sample comments

- Multiple choice questions throughout the lecture were very good in terms of practically using and understanding what he had just learnt about and consolidated my learning.
- They were a good way to reinforce the theory we were learning in the lectures. I wanted to do more of the multiple choice questions. I felt they helped me understand the course material and gave me an opportunity to practice my critical thinking skills.
- I think in this subject they are helpful as there can be many misconceptions.
- When I got something wrong, and the right answer was explained, it helped my understanding.
- Getting instant assessment for my answers which, when answers were explained, helped me understand things better. Also helped me to understand/made clear the things I was having trouble with.

We also wanted to find out whether students found the discussions with their neighbours helped improve their understanding. To assess this, we asked the following question:

Q6. The discussions with fellow students helped to improve my understanding of the topic.

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(5) Every time	21%	13%	12%	7%
(4) Most of the time	32%	36%	36%	42%
(3) Some of the time	41%	36%	31%	34%
(2) Rarely	3%	14%	18	14%
(1) Never	0%	1%	1%	3%
Did not take part in discussions	3%	0%	2%	0%
Some or all of the time	94%	85%	79%	83%
Rarely or never	6%	15%	21%	17%
Mean	3.79	3.45	3.40	3.34
Std. Dev.	0.91	0.94	0.97	0.94

The peer discussions appear to be a very popular part of the method. Participation levels are high, with only 2-3% of students reporting never taking part in discussions. From 85-94% of students said that they found the discussions helped improve their understanding of the topic all or some of the time. In our lectures we have often observed the effect (described by Mazur and others) of convergence on the right answer following these discussions, which is often quite striking.

Although we did not attempt to collect precise data on how often there was an increase in the number of correct answers after the discussions, from informal observation, we would estimate that it occurs for approximately 2 out of every 3 questions which generate a discussion. The convergence effect is probably not as large in philosophy as it is in the sciences, but this does not appear to detract from the effectiveness of the method as a way of improving comprehension, interaction and attention in lectures.

Sample comments

- It was really good how we gave our initial answer and then tried to ‘sell it’ to each other and then revote.
- The discussion with other students is by far the most interesting and useful part of the experience. It allows a brief moment to gather one's thoughts and bounce them off another mind.
- The discussion and back and forth really solidified my understanding of topics and theories.
- Talking with other students allowed me to hear the information in a different way and consolidate it more thoroughly.
- Talking to students re. the question - I often found they explain things really well ;-)

Effect on participation and engagement

Peer Instruction was also found to have positive effects on students’ participation and engagement during lectures. 99-100% of students agreed that the method made the lectures more interesting, with 59-79% agreeing strongly.

Q4. The use of the multiple-choice questions and flash-cards made the lectures more interesting.

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(6) Agree Strongly	79%	67%	60%	59%
(5) Agree Moderately	18%	24%	27%	34%

(4) Agree Slightly	3%	8%	11%	7%
(3) Disagree Slightly	0%	1%	1%	0%
(2) Disagree Moderately	0%	0%	0%	0%
(1) Disagree Strongly	0%	0%	0%	0%
Total agree	100%	99%	99%	100%
Total disagree	0%	1%	1%	0%
Mean	5.85	5.56	5.47	5.52
Std Dev.	0.44	0.70	0.74	0.63

We also asked students how often they voted using the flash-cards when asked to do so:

Q1. When I attended lectures, I voted using the flash cards

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(5) For every question	79%	58%	48%	56%
(4) For most questions	21%	38%	42%	38%
(3) For some questions	0%	4%	7%	3%
(2) For just a few questions	0%	0%	1%	4%
(1) For none of the questions	0%	0%	0%	0%
Did not attend lectures	0%	0%	2%	0%
All or most questions	100%	96%	90%	94%
Some or none	0%	4%	10%	7%
Mean	4.79	4.55	4.39	4.45
Std. Dev.	0.41	0.57	0.68	0.74

Despite the relative lack of anonymity with the use of flash-cards, we still found participation levels to be very high. 94-100% of students said that they voted all or most of the time. This was borne out by observation in lectures. The general impression is that the great majority of students always vote, with just one or two students choosing to opt out now and again.

In order to evaluate the effectiveness of PI as a technique for getting students to actively think about and engage with the material being lectured on, we asked the following question:

Q14. When the lecturer asked a question, I was more likely to try to work out the answer if:

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
1. The class was asked for a verbal response to the question	9%	6%	6%	4%

2. The class was asked to vote on one or more answers using the flash-cards	56%	42%	42%	57%
3. None of the above (I never tried to work out the answer)	0%	4%	4%	0%
4. Both of the above (I always tried to work out the answer)	29%	36%	36%	39%
Not answered	6%	12%	12%	3%
Mean	2.38	2.45	2.45	2.66
Std. Dev.	1.18	1.35	1.35	1.14

Students were more likely to try to work out answers to questions when they were asked to vote using the flashcards (42-57%) than when they were asked for a verbal response to a question (4-9%). This is almost certainly due to the fact that voting is both compulsory and moderately anonymous, whereas volunteering a verbal response to a question is neither. This encourages students to think about the answer to a question for themselves, rather than leaving it up to those who are brave enough to volunteer a verbal answer. (The same result has been found in many other studies on PI, see for example Sharma *et. al.* 2005, Freeman, Blayney and Ginns, 2005, 2006). Below are some sample comments from students on the increased levels of participation and engagement in PI lectures:

Sample comments

- ... broke up the lecture and gave us something to actively do instead of just passively listening and taking in the information. ...
- They made me think about the question properly, and come up with an answer. I had to utilise the stuff that was being taught immediately, rather than simply remembering it and trying to use it later on when I've forgotten half of it.
- Had me more engaged with the lecture. Provided a challenge and so enabled me to try to understand the materials so as to have the right answers.
- It makes the lecture more interactive and thus more interesting and impressive
- Forced me to engage with the material
- The flash cards allow students to participate in the lectures much more than verbal question and responses ...

Flashcards as a voting mechanism

We have already noted (see the responses to Q1) that despite the lack of complete anonymity using flashcards as the voting mechanism, participation was still very high, with 90-100% of students saying that they voted for all or most of the questions asked. The responses to Q14 also suggest that the lack of anonymity did not have an adverse affect on engagement; the majority of students were still more likely to think about the answer to a question when asked to vote than when asked for a verbal response.

Is lack of anonymity using the flashcards an issue for students? To check on this directly we included the following question:

Q7. A disadvantage of using the flash-cards is that the lecturer and/or other students can see my response.

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(6) Agree Strongly	12%	1%	1%	0%
(5) Agree Moderately	9%	6%	6%	3%
(4) Agree Slightly	12%	15%	14%	17%
(3) Disagree Slightly	9%	10%	11%	17%
(2) Disagree Moderately	32%	35%	35%	39%
(1) Disagree Strongly	26%	33%	33%	24%
Total agree	33%	22%	21%	20%
Total disagree	67%	78%	79%	80%
Mean	2.79	2.30	2.29	2.38
Std. Dev.	1.72	1.31	1.29	1.15

Only 20-33% of students agreed that lack of anonymity was a disadvantage of using flashcards. Although there is far greater individual variation in the responses to this question (note the higher standard deviations) it seems that the majority of students did not feel that this is a significant problem. Nevertheless, the fact that students can see the responses of other students may have an adverse impact on engagement with the lecture; students can wait to see how everyone else is voting and then go with the majority, rather than thinking about the answer themselves. In order to test this and to find out more about the different strategies students use when answering questions, we asked the following question:

Q13. When I voted using the flashcards, I usually:

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
1. Thought about the answer and then voted accordingly.	73%	61%	54%	60%
2. Didn't try to work out the answer for myself, but waited to see how everyone else voted and then voted the same way.	0%	0%	0%	3%
3. Thought about the answer myself, but then waited to see if most people agreed with me before voting.	3%	7%	11%	10%
4. Just guessed the answer	3%	0%	4%	0%
5. Sometimes one of the above, sometimes another.	15%	24%	24%	24%
Sometimes 2 or 3	12%	12%	12%	17%

Perhaps surprisingly, most students said that they usually thought about the answer for themselves and then voted accordingly (54-73%). Almost none of the students said that they just voted with the majority. A small proportion (3-11%) said that they usually thought about the answer first, then waited for confirmation from the majority before holding up their card. Some students said that they used a mixed strategy, often depending on the difficulty of the question. However, only 12-17% reported sometimes relying on the majority vote. We conclude that the lack of anonymity of the flashcards did not lead to a reliance on a 'vote with the majority' strategy for answering questions.

Benefits of the method

We asked students what benefits they found from the use of PI in lectures. Not all students responded to this question, although the response rate was quite high, ranging from 71-83%. After reading through the comments, we found that the benefits students listed could be classified into four groups; improved understanding, increased interaction and engagement, useful feedback (to either the lecturer or the students themselves) and improved levels of attention. In the following table we have listed the proportion of comments falling into each category as a percentage of the total number of responses to the question. The actual number of comments in each category is given in parentheses.

Q10. What were the benefits (for you) of the multiple-choice questions and flash-cards (if any)?

	Critical Thinking	Ethics and Philosophy of religion	Formal Logic
Response rate	71%	62%	83%
Improved understanding	38% (9)	44% (23)	38% (9)
Interaction and engagement	38% (9)	33% (17)	33% (8)
Useful feedback	29% (7)	19% (10)	17% (4)
Improved attention	21% (5)	12% (6)	12% (3)

Sample comments

Interaction and Engagement
It made lectures interactive and also gave me an opportunity to demonstrate if I had or hadn't grasped the material just taught and then if so, to clarify them ... they're fun and interesting!
I enjoyed being able to test my knowledge and ability to apply that knowledge right there in the lecture. It also broke up the lecture and gave us something to actively do instead of just passively listening and taking in the information. ... I wish more lecturers would use this method - well done!
It made the lectures more interesting and interactive. The primary advantage being that I could argue a point with other students. Partly because of this I found philosophy lectures far more engaging and memorable than my other lectures.
Forced me to engage with the material.
Improved understanding
They consolidated the content of the lecture and helped build confidence that the things I was taking from the lecture were the right ones. ... They should be done in more classes.
They were a good way to reinforce the theory we were learning in the lectures. I wanted to do more of the multiple choice questions I felt they helped me understand the course material and gave me an opportunity to practice my critical thinking skills.
the discussion and back and forth really solidified my understanding of topics and theories
Made things more interesting and intellectually stimulating; When I got something wrong, and the right answer was explained, it helped my understanding.
Feedback to students and lecturer
Cleared up misunderstandings. Sometimes I thought I understood and the flash cards showed that I hadn't.
Allowed me to see how I was doing in comparison with others in the class. I was not put down by being wrong, because I could see that at least I was not the only one who answered in a particular way. Also allowed the lecturer to address where and why people went wrong in their reasoning without singling out individuals. I hope it continues to be used, perhaps it will spread to other subjects ...
Let me know if I was on the right track and understanding the topic or not
Improved attention
Made me more alert during lectures. Helped sustain my attention and interest during the lecture. ... Good, innovative approach.
Broke up lectures a bit, kept me alert and focusing on the material.
It gave the lecture a short break so that we could concentrate better, as well as being interactive meant that you had to pay attention and follow the lecture.
Helped to gauge how well I had understood the topic. Also indicated my progress compared to the rest of the class.

Disadvantages of the method

We also asked students whether they thought there were any disadvantages to using PI. Response rates to this question were much lower than the ‘benefits’ question, ranging from 50%-72%. There was a much greater variety of disadvantages listed by students. In the table below, we have classified the comments into eight different groups. Again the proportion of comments falling into each category is shown as a percentage of the total number of responses to the question. The actual number of comments in each category is given in parentheses.

Q11. What were the disadvantages (for you) of the multiple-choice questions and flash-cards (if any)?

	Critical Thinking	Ethics and Philosophy of religion	Formal Logic
Response rate	56%	50%	72%
No disadvantages	53% (10)	38% (16)	24% (5)
Not enough time given to think	11% (2)	24% (10)	19% (4)
Too easy to vote with the majority	21% (4)	4% (2)	0%
Takes up time	5% (1)	5% (2)	24% (5)
Embarrassed when answered incorrectly	0%	7% (3)	0%
Discussions with peers not always useful	0%	10% (4)	5% (1)
Problems with questions	0%	5% (2)	9% (2)
Other	11% (2)	7% (3)	9% (2)

For all the courses we evaluated the most popular type of comment for this question was ‘No disadvantages’ (24-53% of comments). This was followed by ‘not enough time given to think’ (11-24% of comments) or (in the case of Formal Logic) ‘takes up time’ (24%). We note the very low numbers of students who said they were embarrassed when they got the answer wrong. In their comments, several students suggest a possible explanation for this;

students can see that many other students also have the wrong answer, so they are not singled out. One student, for example wrote: "I was not put down by being wrong, because I could see that at least I was not the only one who answered in a particular way".

Sample comments

No disadvantages
There were none, it was great, we should have that for every class.
None.
None really. If I wasn't sure of the answer I just abstained. Anyone uncomfortable with voting in front of everyone else could do the same, I suppose.
No disadvantages.
Not enough time given to think
I was not given enough time to think about the answer. Because of this, I ended up voting with the majority of people because I was unable to answer the question myself in the time given.
The questions often were worded in a way that required some thought to establish what they were asking. So sometimes there wasn't enough time to decide on the correct response
Sometimes not enough time was given to think about or compute the answer before voting was required.
Too easy to vote with the majority
Very easy to vote according to how the rest of the class votes.
If I didn't know the answer I would just put up the card, from what I could see, the majority had put up.
I reckon some people voted deliberately in conformity with the rest, which is a disadvantage of being able to see what everyone else is voting for.
Takes up time
Time consuming
Maybe takes quite a bit of time
I felt that the lectures had a slow pace when we used this system, but we didn't actually miss out on any material ...
Embarrassed when answered incorrectly
Sometimes if I was unsure of an answer it was embarrassing holding up the flash cards when others could see my answer, especially if I got it wrong!

Bright colours made me hesitant to answer when I realised my answer was different from others.
Discussions with peers not useful
I did not find the discussion part with the person sitting next to you very effective, because usually neither had a real logical reason to back up their answer, and this could lead us in the wrong direction.
Sometimes I wasn't sitting next to/near somebody so I couldn't discuss my ideas.
Sometimes I felt that speaking to my peers wasn't of much benefit as both parties were unsure. This, however, was not always the case.
Problems with questions
Can introduce confusion that did not exist before the questions was presented (when question was obscure).
Too bad if you don't understand the question.
Other
I listen online and they are not as effective this way.
Questions weren't posted over the internet to be accessible later.

It is worth noting that 'not enough time given to think' is not so much a disadvantage of the method itself as a problem of implementation. It is very important to try to give students enough time to think about their answers before getting them to vote. How much time you allow depends on the question, though 1-2 minutes should be enough. Some straightforward questions might only require about 30 seconds thinking time. But if you say "I'll give you a minute to think about it...", try to actually give students a whole minute. It can be quite difficult to do this at first, to wait in silence for a whole minute while students think about their answers. Use a watch to make sure you give students enough time.

Of course, giving students plenty of time to think about their answers is in tension with the other main disadvantage students commented on (in particular in the formal logic course) which is that the method 'takes up time'. The worry (presumably exacerbated in a course like formal logic, where there is a lot of difficult technical material to get through) is that there won't be time to cover everything that students will be assessed on. This is a legitimate concern. Using PI in lectures certainly does affect the amount of material you'll be able to cover in a lecture. The question and discussion sessions take up a fair chunk of time, so you may not be able to cover as much material in a lecture as you are used to.

Having said that, it is always worth asking yourself the question: am I trying to cover too much material in this course? Are students really getting a grip on all the material I'm trying to pack in? If your syllabus is too packed, a decision to use PI might well serve as a good excuse to cut some of the excess material. Indeed, several of the current authors would not now want to put *more* material into our lectures, even if we stripped out the PI questions.

In our opinion, the apparent disadvantage of 'taking up time' is far outweighed by the advantages (and our students agree – see the next section). Although you might cover less material in lectures, this does not necessarily imply that you will need to cut material from the course as a whole. Some material that was once discussed in detail in lectures might be more usefully moved into tutorials or seminars. The payoff is that the material you do cover in the lectures will be better understood, because students are having to actively engage with it during the lecture itself.

Overall benefit

Any new teaching method will always have some positive and some negative effects. As the above results show, our students identified many advantages to the use of PI in lectures, as well as some disadvantages. The crucial question from a pedagogical point of view is whether the advantages outweigh the disadvantages or vice versa. (As emphasised by Draper *et. al.* 1996 and 2004). To find out what students thought about this, we asked the following question:

Q12. What (for you) was the balance of benefit vs. disadvantage from the use of the multiple-choice questions and flash cards in the lectures?

	Critical Thinking	Ethics	Philosophy of Religion	Formal Logic
(5) Definitely benefited	70%	59%	56%	52%
(4) Benefits outweigh any disadvantages	18%	25%	24%	38%
(3) Neutral	6%	8%	11%	10%
(2) Disadvantages outweigh any benefits	0	0	1%	0%
(1) Definite negative net value	0	0	1%	0%

Not answered	6%	8%	8%	0%
Total net benefit:	88%	84%	80%	90%
Total neutral or net disadvantage:	6%	8%	13%	10%
Mean	4.76	4.67	4.55	4.73
Std. Dev.	0.65	0.75	0.92	0.77

Other comments

Q15. Any other comments on the use of the multiple-choice questions, flash-cards and discussions:

	Critical Thinking	Ethics and Philosophy of religion	Formal Logic
Response rate	53%	25%	45%
Positive	100% (18)	67% (14)	84% (11)
Neutral	0%	29% (6)	8% (1)
Negative	0%	5% (1)	8% (1)

The majority of comments received for this question were positive (67-100%). Some comments were neutral (several of these consisted of suggestions for how the method could be improved or modified). Only two negative comments were received.

Sample comments

Positive
They're great! They are also good because they highlight times when a particular part of a concept hasn't been fully explained (or where people have misinterpreted the lecturer). I wish more lecturers would use this method - well done!
All lecturers should try incorporate them into their lectures. Its a great idea and kept us active during the lecture. Would definitely help with the 'boring' factor a LOT of other lectures have.
Multiple choice questions throughout the lecture were very good in terms of practically using and understanding what he had just learnt about and consolidated my learning. I also think that they make [the lecturer] feel good about his teaching because it always seems like most people are paying attention and learning stuff! Flash cards are fun! Discussions are good for reasons mentioned previously.
They're fun and interesting!

It's awesome!
Promoted discussion among class members (good thing). Encouraged progress and understanding.
They should be used in teaching in many other faculties.
They are good! Stops people from falling asleep and most importantly makes you think in lectures rather than just take what is given - better learning.
The discussions were really beneficial, and the relaxed approach to the lecture allows us to think and feel confident in asking questions.
The flash-cards are good because they allow us to communicate with the lecturer more. Sometimes in lectures in other subjects I feel as if I am just having a speech thrown at me and cannot contribute in any way, whereas the cards make me feel as if I am benefiting more from lectures because I contribute and learn more.
I think it is a very good technique seeing as there are topics in philosophy that require in-depth thinking and discussion and a constant need for confirming correct understandings of the material, as is discussing with peers as you are exposed to other ideas and approaches.
...Students have a tendency to not participate if they are singled out to give a response, but with everybody responding simultaneously, it creates a more dynamic and engaged studying environment. I hope it continues to be used, perhaps it will spread to the other subjects, and perhaps eventually they will build electronic multiple choice buttons built into the chairs :) .
Neutral
Instead of having to discuss the multi choice questions with a person next to us perhaps (this is only a suggestion) it would be beneficial if the class was open to discuss their own views voluntarily on why they decided on the answer they chose and thus tried to sway others in order to establish a majority vote if the responses were mixed.
There should be more instances of students being asked to justify their answer.
Negative
Discussion just do not seem effective, and flash cards should mainly be used for the benefits of the lecturer to see if students are understanding the concepts. Also, it is not the greatest experience when a lecturer points out you specifically because you got the wrong answer, and can cause a feeling of embarrassment and humiliation. Clearly some people understand this subject better than others and they are the ones that most probably enjoy the flash cards, compared to the people that are not quite sure what is going on, As a student who sits in the lecture, it is obvious that a lot of people wait for others to hold up their cards and then hold up theirs which is the majority so as they wont feel singled out of basically an 'idiot'.
Not very efficient.

Gains on critical thinking tests

Students in the critical thinking course were pre- and post-tested using a standardised test of

critical thinking ability, the California Critical Thinking Skills Test (Facione & Facione 1992). This is a timed (45 minute) multiple-choice test, coming in two equivalent forms A and B. Each form consists of 34 items which test students' ability to clarify the meaning of claims, analyse and evaluate arguments and draw correct conclusions from given information. Facione and Facione 1992).

Students completed the CCTST during the first half of the scheduled two-hour tutorials for the course. The pre-test was completed in the first tutorial (week 1) and the post-test in the final tutorial (week 13). The tests were completed under examination conditions, as outlined in the test manual. Students were not informed of their test scores until after the end of the course. Forms A and B of each test were randomly distributed among the participants for the pre-test and students were given the opposite test form for the post-test.

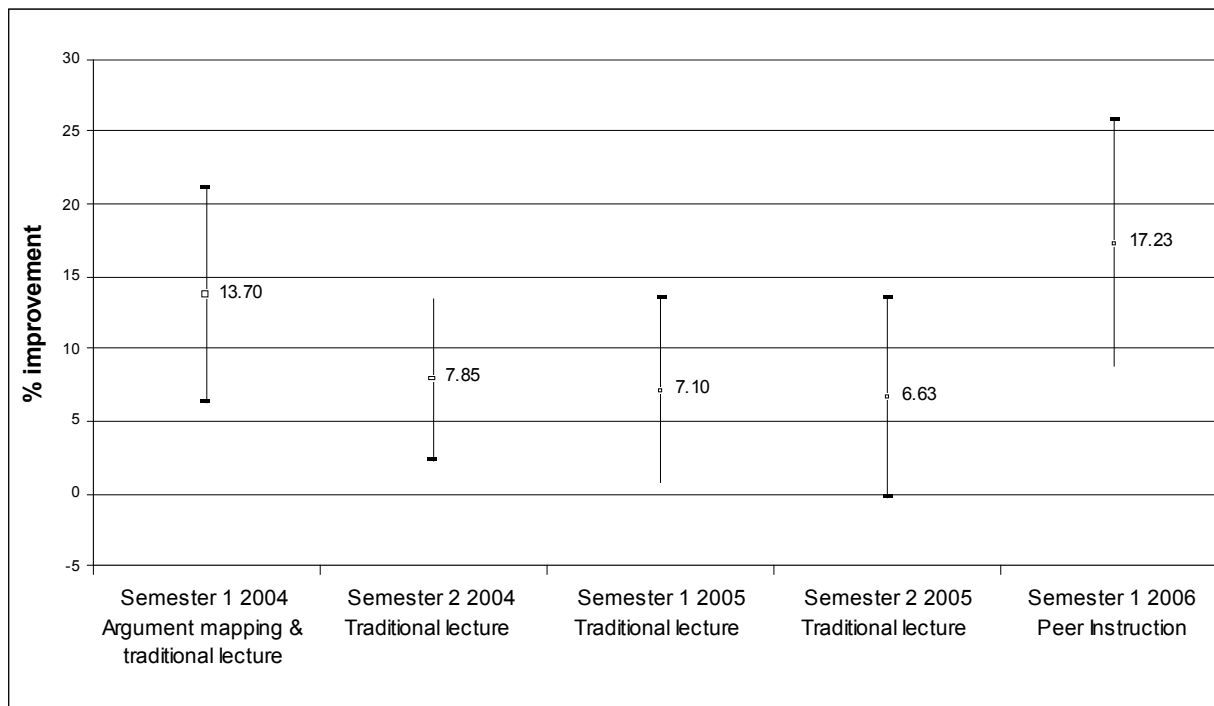
All students taking the course were required to complete the pre- and post-test. They were informed about the purpose of the study and asked to sign a consent form giving permission for their test scores to be used. A grade incentive was offered – the pre- or post-test score (whichever was highest) could be used to replace the student's lowest scored assignment. 40 of the 61 students enrolled in the course completed both the pre- and post-test and gave permission for their scores to be used as data for the study. The sample consisted of 18 females and 22 males. Ages ranged from 17 to 26. The median age was 19 years. The largest proportion of students were in their first year of university (52.5%) and enrolled in an Arts degree (57.5%).

Students showed a statistically significant gain in critical thinking test scores of $17.23\% \pm 8.5\%$. For comparison, students enrolled in the same course in semester 2 2004, taught without PI, showed an average improvement of just $7.85\% \pm 5.5\%$. The chart below (see also Figure 2) compares this result to that obtained in previous semesters, in which the course was taught using a variety of pedagogical methods. PI compares favourably with the most successful method we have investigated – intensive computer-assisted argument mapping exercises (Semester 1, 2004).

Semester	N	S.D.	Mean improvement (%)	95% lower	95% upper
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S1 2004	43	21.08	13.70	6.31	21.08
S2 2004	65	22.36	7.85	2.31	13.39
S1 2005	41	20.27	7.10	0.70	13.49
S2 2005	49	23.93	6.63	-0.24	13.51
S1 2006 (PI)	40	26.64	17.23	8.7	25.75

Figure 2
Critical thinking course taught with PI vs. other methods



Less successful applications of PI

The authors have had only one occasion where the use of PI was less obviously successful. This was in an intermediate to advanced level political philosophy unit. The lecturer in this unit reported frustration that it was very difficult to craft questions that were sufficiently focused, given the nature of the material being studied, and found himself using fewer questions per lecture than he ideally would have liked. Less detailed data was collected on the students' reception of PI in this unit, and the lecturer intends to try again next time he teaches the class. However, he suspects that the best way to improve the questions will be to change the material to be taught! This suggests that there is some material which is intrinsically less suited to the method, but we are unable to say with confidence precisely why some material is more suited to the method than other material. It is possibly due in large part to the degree to which the principles used in the material admit of precise analysis or definition. It is also perhaps due to the sheer simplicity of the ideas involved. The core concepts in utilitarianism, for instance, are far less complex than the core concepts in Rawls's political philosophy.

Conclusion

These results strongly support the view that Peer Instruction can be just as effective in philosophy as it is in the sciences. We have consistently found that the great majority of students are very positive about the use of PI in philosophy lectures. They enjoy the increased interaction that it brings and find that it has positive effects on attention, provision of useful feedback and understanding. It can also make lectures much more enjoyable for both students and lecturer. The results from the critical thinking tests are also encouraging, suggesting that PI can lead to significant improvements in students' critical thinking skills.

If time and money were no object, how would you choose to teach philosophy? Speaking for ourselves, we would almost certainly never use a large-group lecture. We would use a variety of methods, but by and large, they would be variations on the theme of the small-group tutorial. Sometimes a period of one-on-one discussion would be useful. Sometimes periods of group work without academic supervision would be useful. But the default mode would be to have students working in close contact with one another, interacting with each other, while maintaining reasonably close academic oversight. It would not be that different from Socrates talking in the agora with a couple of young acolytes and notable visitors from out of town.

But of course, time and money are very real objects. And largely for this reason, the large lecture format has become a default mode of teaching in many humanities disciplines. The delight for us, in Peer Instruction, is that a technology as simple as a set of four A5 cards in a manila envelope has enabled us to bring a bit of the atmosphere and engagement of the tutorial room into the lecture theatre. We strongly recommend it.

Peer Instruction Website

Further information on using Peer Instruction in philosophy can be found at the Monash *Peer Instruction in the Humanities* website (Monash 2007):

<http://www.arts.monash.edu.au/philosophy/peer-instruction/>

Here you will find more information and advice on using Peer Instruction, more detailed reports of our evaluations of the method in philosophy (and other humanities subjects) and many teaching resources to help get you started. In particular, you will find a large bank of tried and tested questions on a wide range of topics that you are free to use and adapt for your own classes.

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References

Bligh, D. A. (1998). *What's the use of lectures?* Exeter, Intellect Books.

Boyle, J. and D. Nicol (2003) "Using classroom communication systems to support interaction and discussion in large class settings", *Association of Learning Technology Journal*, 11, 43-57.

Brandford, J. D., A. L. Brown, et al., Eds. (1999). *How people learn: brain, mind, experience, and school*. Washington, D.C., National Academy Press.

Burton, K. (2004). "Interactive Powerpoints: Is there any point in giving power to students?", *Murdoch University Electronic Journal of Law*, 11 (4).

Crouch, Catherine H. and E Mazur (2001) "Peer Instruction: Ten years of experience and results", *American Journal of Physics*, 69, 9, 970-7.

Chew, S. L. (2005) "Student misperceptions in the psychology classroom". In B. K. Saville, T. E. Zinn and V. W. Hevern (eds.), *Essays from excellence in teaching, 2004*. Retrieved 9th April, 2006 from the Society for the Teaching of Psychology Web site: <http://teachpsych.lemoyne.edu/teachpsych/eit/eit2004/index.html>

Chew, S. L. (2004) "Using conceptTests for formative assessment", *Psychology Teacher Network*, 14, 1, 10-2.

Cline, K. (2006). "Classroom voting in calculus." *Mathematics Teacher*, 100 (2).

Cutts, Q. I. and G. E. Kennedy (2005) "Connecting Learning Environments Using Electronic Voting Systems". In Alison Young and Denise Tolhurst (eds.), *Australasian Computing Education Conference. Newcastle, Australia: Conferences in Research and Practice in Information Technology, vol. 42*.

Draper, S. W., M. I. Brown, et al. (1996). "Integrative evaluation: an emerging role for classroom studies of CAL." *Computers and Education* 26, 17-23.

Draper, S. W. and M. I. Brown (2004) "Increasing interactivity in lectures using an electronic voting system", *Journal of Computer Assisted Learning*, 20, 81-94.

Draper, S. W., Cargill J. and Q. I. Cutts (2002) "Electronically enhanced classroom interaction", *Australasian Journal of Educational Technology*, 18, 13-23.

Dufresne, Robert J., William J. Gerace, William J. Leonard, Jose P. Mestre and Laura Wenk (1996) "Classtalk: A classroom communication system for active learning", *Journal of Computing in Higher Education*, 7, 3-47.

Duncan, Douglas (2005) *Clickers in the classroom*. San Francisco: Pearson Education Inc.

Dunn, W. R. (1969). "Programmed learning news, feedback devices in university lectures." *New University*, 3 (4): 21-2.

Elliot, C. (2003). "Using a personal response system in economics teaching." *International Review of Economics Education*, 1 (1).

Facione, P. A. and N. C. Facione (1992). *The California Critical Thinking Skills Test and Manual*. Millbrae, CA, California Academic Press. Available from: <http://www.insightassessment.com/>

Fagen, Adam P., Catherine H. Crouch and E Mazur (2002) "Peer instruction: results from a range of classrooms", *The Physics Teacher*, 40, April, 206-9.

Freeman, M. and P. Blayney (2005). "Promoting interactive in-class learning environments: A comparison of an electronic response system with a traditional alternative." *Innovation for Student Engagement in Economics: Proceedings of the Eleventh Australasian Teaching Economics Conference*.

Freeman, M., P. Blayney, et al. (2006). "Anonymity and in class learning: The case for electronic response systems." *Australasian Journal of Educational Technology* 22 (4): 568-580.

Green, P. (2003) *Peer Instruction for Astronomy*: Prentice-Hall.

Hake, Richard R (1998) "Interactive engagement vs. traditional methods: A six-thousand-

student survey of mechanics test data for introductory physics courses", *American Journal of Physics*, 66, 64-74.

Harden, R. M., E. Wayne, et al. (1968). "An audio-visual technique for medical teaching." *Journal of Medical and Biological Illustration*, 18 (1), 29-32.

Johnson, D. W., R. T. Johnson and K. A. Smith (1991) *Active Learning: Cooperation in the college classroom*. Edina, MN: Interaction Book Company.

Kennedy, G. E. and Q. I. Cutts (2005) "The association between students' use of an electronic voting system and their learning outcomes", *Journal of Computer Assisted Learning*, 21, 260-8.

Knight, Jennifer K., Wood, William B. (2005) "Teaching More by Lecturing Less". *Cell Biology Education*, 4, 298-310.

Landis, C.R., et. al. (2001) *Chemistry ConcepTests: A Pathway to Interactive Classrooms*. Prentice-Hall.

Lasry, N. (Forthcoming). "Peer Instruction: Comparing Clickers to Flashcards." *The Physics Teacher*, Forthcoming. Preprint available from: <http://arxiv.org/abs/physics/0702186>

LSAC (2002). *The Official LSAT PrepTest (nos. 7-53)*. Newton, PA, Law School Admission Council.

Maloney, David P., Thomas L. O'Kuma, Curtis J. Hieggelke and Alan van Heuvelen (2001) "Surveying students' conceptual knowledge of electricity and magnetism." *American Journal of Physics, suppl.*, 69, S1-23.

Mazur, E (1997) *Peer Instruction: A User's Manual*. Saddle River: Prentice Hall.

McConnell, David A, Steer, D. N., Owens, K. D, et. al. (2006) "Using Conceptests to Assess and Improve Student Conceptual Understanding in Introductory Geoscience Courses", *Journal of Geoscience Education*, 54, (1), 61.

Meltzer, D. E. and K. Manivannan (1996). "Promoting interactivity in physics lecture classes." *The Physics Teacher*, 34(2), 72-76.

Meltzer, David E. and K. Manivannan (2002) "Transforming the lecture-hall environment: The fully interactive physics lecture", *American Journal of Physics*, 70, 6, 639-54.

Monash University (2007). *Peer Instruction in the Humanities*. Website: <http://www.arts.monash.edu.au/philosophy/peer-instruction/>

Nicol, David J. and James T. Boyle (2003) "Peer Instruction versus Class-wide Discussion in the large classes: a comparison of two interaction methods in the wired classroom", *Studies in Higher Education*, 28, 4, 458-73.

Piepmeyer, E. (1998) "Use of conceptTests in a large lecture course to provide active student involvement and peer teaching." *American Journal of Pharmaceutical Education*, 62.

Pilzer, Scott (2001) "Peer Instruction in Physics and Mathematics." *Primus*, 11, 1, 185-92.

Rao, Sumangala P. and Stephen E. DiCarlo (2000) "Peer Instruction Improves Performance on Quizzes." *Advances in Physiology Education*, 24, 1, 51-5.

Redish, E. F. (1994). "Implications of cognitive studies for teaching physics." *American Journal of Physics*, 62, 796-803.

Robertson, L. J. (2000). "Twelve tips for using a computerised interactive audience response system." *Medical Teacher* 22 (3), 237-239.

Sharma, M. D., J. Khachan, et al. (2005). "An investigation of the effectiveness of electronic classroom communication systems in large lecture classes." *Australasian Journal of Educational Technology* 21 (2), 137-154.

Simpson, V. and M. Oliver (2007). "Electronic voting systems for lectures then and now: a comparison of research and practice." *Australasian Journal of Educational Technology*, 23 (2), 187-208.

Smith, Karl A., Sheri D. Sheppard, David W. Johnson and Roger T. Johnson (2005) "Pedagogies of Engagement: Classroom-Based Practices", *Journal of Engineering Education*, January, 87-101.

Stuart, Susan A. J., Brown, Margaret I., Draper, S.W. (2004) "Using an electronic voting system in logic lectures: one practitioner's application", *Journal of Computer Assisted Learning*, 20, 95-102.

Stuart, S. A. J. and M. I. Brown (2003). "An evaluation of learning resources in the teaching of formal philosophical methods." *Association for Learning Technology Journal* 11 (3), 58-68.

Thomason, N. (1990). "Making Student Groups Work: "To teach is to learn twice"." *Teaching Philosophy*, 13 (2): 111-125.

Thomason, N. (1995). "Philosophy Discussions With Less B.S." *Teaching Philosophy* 18(1): 15-30.

Thornton, Ronald K. and David R. Sokoloff (1998) "Assessing student learning of Newton's Laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and curricula." *American Journal of Physics*, 66, 338-52.

Williams, J. (2003). "Learning by remote control: exploring the use of an audience response system as a vehicle for content delivery". *Interact, Integrate, Impact: Proceedings ASCILITE Conference*, Adelaide, 7-10 December.

Wit, E. (2003) "Who wants to be... The use of a personal response system in statistics teaching", *MSOR Connections*, 3, 2, 5-11.

Wulff, D. H., J. D. Nyquist, et al. (1987). "Students' Perceptions of Large Classes" in *Teaching Large Classes Well*. M. E. Weimer (ed.) San Francisco, CA, Jossey-Bass.

Notes

1. There are a few exceptions, see for example (Stuart et. al. 2004, 2003, Draper and Brown 2004). Neil Thomason of the History and Philosophy of Science department at the University of Melbourne has been using the method in philosophy classes for many years. In two papers published in *Teaching Philosophy* (1990, 1995) Thomason describes a wide variety of techniques for encouraging active learning in philosophy classes. The method of 'Cooperative Learning in Brief, In-Class Problem-Set Groups' (1990, p. 117) is probably the closest to the Peer Instruction method we described here.
2. About 30c - \$1 per set, depending on the quality of the materials.
3. It may also be a good idea to avoid 'amphitheatre' style lecture theatres, so as to minimize students' looking at each others' vote.
4. The Ethics and Philosophy of Religion courses are two components of a single course. Each component has its own one-hour lecture (repeated once a week) but there is one one-hour tutorial each week for both components. A single questionnaire was distributed in lectures and tutorials with two columns for each question, one for the Ethics component and one for the Philosophy of religion.