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Using conceptual questions and clickers – can it improve learning for environmental economics students?

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Introduction

In 2010 I became course responsible for the course "Economic Valuation Methods and Cost-Benefit Analysis" which is compulsory for students attending the master program in Environmental and Natural Resource Economics at LIFE. I have been teaching parts of this course for several years, but last year I took over teaching the entire course. There are about 25 students in the class of which approximately 60% are attending the master program, 30% are international students on short stay (half year), and 10% are guest students from other Danish universities/institutes.

The central themes of the course are the methodologies and techniques applied in economic valuation and cost-benefit analyses and the underlying economic theory. Economic valuation and cost-benefit analysis are being increasingly applied as support for environmental policy decisions. The many services provided by the environment contribute to human wellbeing directly as well as indirectly by supporting productive activities. However, the characteristics of environmental benefits imply that they cannot usually be traded in markets. The absence of economic incentives in terms of prices means that political intervention is required to guarantee a socially optimal supply of environmental services. Economic valuation methods and cost-benefit analysis provide tools to assess the benefits and cost of environmental policies and projects.

Teaching is in the form of classroom lectures and exercises. Lectures present the essential elements of the curriculum in a rather traditional way with relatively limited student activation. In the exercises the participants

are much more active as they get the opportunity to apply the methodologies and techniques introduced in the lectures and they work on actual environmental policy issues. The final summative assessment of students is in the form of a four-hour written open book exam that is constructed so as to test to what extent the intended learning outcomes (ILO) have been accomplished – also known as criterion referenced assessment (Biggs & Tang 2007).

Problem

Last year's exam in my course revealed that some important yet rather simple and basic concepts in the course material had been misunderstood by a surprisingly large proportion of students. Even though these concepts had been explained thoroughly in lectures and trained extensively in exercises, it was clear that these teaching/learning activities (TLA) had not sufficiently promoted a deep approach to learning (Biggs & Tang 2007). Hence, the aim of this project is to develop and test a learning activity that will hopefully engage students in deeper learning approaches and ultimately improve students' understanding of these basic concepts.

Theory and methods

It is generally recognized that motivation and activation are important drivers in promoting deep approaches to learning (Biggs & Tang 2007). Hence, I chose to test a TLA that involves a high degree of student activity and at the same time focuses on increasing the understanding of basic concepts.

In particular a "conceptual questions" session where clickers are used for obtaining real-time student responses is tested. The idea of using conceptual questions in teaching was originally developed by Eric Mazur at Harvard University for students in large physics classes (Mazur 1997, Foundation 1996). Conceptual questions 1) Focus on a single concept, 2) cannot be solved using equations, 3) are formulated as multiple-choice question, 4) are clearly worded, and 5) they are of intermediate difficulty. While until now the conceptual question technique has mainly been used in teaching natural sciences, especially chemistry and physics, there is no reason why the technique should not be equally useful in teaching economics.

Nevertheless, I have not been able to find any previously documented attempts in this regard, so this represents a first novel effort in that sense.

The first and, in retrospect, most time-consuming and challenging task was to develop the conceptual questions according to the five principles set out above. Initially, based on last year's exam, a number of "typical" conceptual misunderstandings among my students could be identified. However, as the actual TLA was planned to take place only two weeks into the eight-week course, a restriction was that the relevant curriculum should be covered in lectures and exercises before this TLA. As such, it was intended to serve as a review activity summing up the most important concepts presented in these first two weeks. Hence, using the experience from last year's exam eight conceptual questions relating to the first two weeks' curriculum was developed. See appendix A for an example of one of the conceptual questions used and how it was presented to students in class.

The TLA was planned to take one hour, and the process (also depicted in figure 17.1) was the following. The multiple choice questions were asked one at a time, displayed on a whiteboard using MS PowerPoint. A real-time voting clicker system from TurningPoint Technologies was used. Each of the 20 students present in class was given a clicker that enabled real-time recording of their answers. Students were instructed to look at the question posed on the whiteboard and then – without talking to their fellow students and without looking at their books or notes – give their individual answer using the clicker. Using radio technology to connect the clickers to a receiver plugged into the USB-port on the computer running the presentation, the TurningPoint add-in software to PowerPoint was then used to show the distribution of answers in the class immediately after the last of the 20 students had provided his/her answer (see appendix A for a screenprint showing an example of how the distributions were incorporated into the Powerpoint presentation). In seven of the eight conceptual questions, there was clearly disagreement among the students as to what the correct answer should be[1]. Hence, students were then given 1-2 minutes to discuss with their neighbor. In particular, they should try and explain to their neighbor why they think that the answer they just gave was the correct one. Mazur (1997) refers to this as peer instruction or "think-pairshare". During these neighbor discussions, the noise level in class reached new heights and

[1] It should be noted that for some of the questions there were more than one correct answer. While this is normally not recommended for multiple choice questions, in the current experiment it turned out to Ibe quite beneficial as it lead to really involved discussions among students.

I have not personally before experienced so much active discussion in class. After that (it took some time to gain control of the class and get the word again), they were asked to vote again, and in some of the cases the distribution of answers had markedly shifted towards the correct answer whereas in other cases where there was more than one correct answer, distributions only shifted slightly between the first and the second vote. After the second vote, I revealed what the correct answer(s) was, and I gave a brief explanation and invited them to comment on this, before proceeding to the next question.

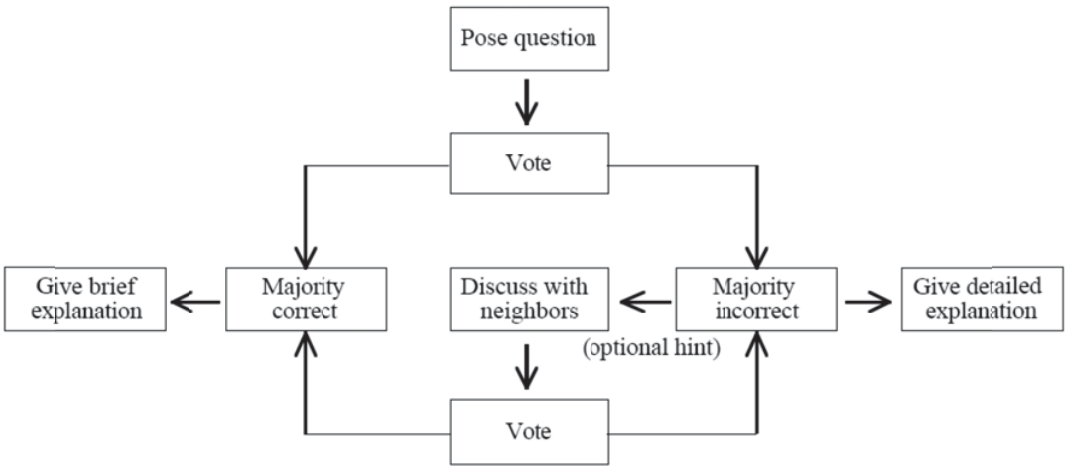


Fig. 17.1. Question flow.

Results

In order to assess the outcome of the TLA, immediately after the lesson students were asked to give their initial thoughts and comments on this type of TLA. Furthermore, during the following week they were asked to answer an evaluation questionnaire online in the Absalon system. The evaluation questionnaire is available in appendix B. Of course, a proper scientific assessment of the outcome would entail externally testing the students' knowledge in a more objective way, e.g. comparing scores in the final exam across two samples of students who have and have not been subjected to the

TLA. However, time restrictions do not permit this for the current project report.

The oral assessment

In the oral assessment, all students agreed that the TLA had been a success. Their comments circled much around the fact that they felt very engaged and active during the TLA, mainly because the nature of the TLA forces them to be active – but they did not actually feel being intimidated or coerced as they otherwise sometimes do when teachers force them to take active part in other types of TLAs. They also generally agreed that the clicker system enabling an instant overview of the answers in the class was not only fun and interesting, but also beneficial in the sense that realizing that quite a lot of heterogeneity in answers is present among your peers makes you reflect on your own answer – and especially having to argue why you think your own answer is right (and maybe also why your neighbor's is not) was mentioned as particularly fruitful.

Furthermore, their comments suggested that it was not perceived as a problem that some of the questions had more than one correct answer. Finally, they all agreed that the TLA had worked perfect as a review activity summing up on the important concepts taught in the previous two weeks of lectures and exercises, and it was suggested to do this type of TLA every two weeks throughout the course or even more often after each single curriculum topic.

The questionnaire assessment

Out of the 20 students present in class at the TLA, 18 have answered the questionnaire that was issued through Absalon about one week after the TLA. Out of the 18, only one student indicated to have had previous experience with TLAs using clicker systems, so in general it can be considered a "first time" experience for the majority of the students. In the following the distributions of the students' degree of agreement with the statements presented to them in question two are summarized[2].

[2] Apparently, one student started answering the questionnaire but did not answer any of the statements in question 2, hence the 5% "Not answered" in all figures. This will be disregarded when commenting the results.

Figure 17.2 provides an assessment of the "discuss-with-neighbors" element of the TLA. The vast majority of students agree that it made them reflect and reconsider their initial response, and for most of them it actually made them change their initial answer to some extent when the vote was reopened. It is not surprising that not all agree with this since some of them could have been giving the correct answers initially in all questions. Nevertheless, it is somewhat surprising to me that it actually makes two out of three students change their initial response. Speaking highly in favor of the "discuss-with-neighbors" element, all students agree that it increases their own understanding. One thing that I was unsure of during the TLA was how much time should be allotted to this element. It seems however that spending 1-2 minutes on this part was sufficient as almost 50% find it to be sufficient. Even though 26% would have liked more time to discuss with neighbors, I do not think it would have been beneficial in terms of learning outcome to spend more time on this. It is not surprising to find some disagreement here, since some students generally like to discuss and talk more than others.

Figure 17.3 shows that the large majority of students felt more involved and active in the TLA than they otherwise feel in both the regular lectures as well as the regular exercises in my course. This is not surprising since the regular lectures are quite old-fashioned blackboard lecturing with only some student activity. It is however slightly more surprising that they also felt much more activated than in the regular exercises in which I would say the level of student activity is relatively high and where they are encouraged to discuss. An explanation could be that in regular exercises they also have to spend some time writing down their answers, thoughts and results and as such there are many more elements to it than just thinking-reflecting-discussing.

Figure 17.4 reveals again that the majority of the students felt that the conceptual questions helped them engage in deeper learning, and for at least half of the students this lead them to realize that they had actually misunderstood some of these very basic and important concepts and topics. This corresponds quite well to my knowledge from previous year's exam where it surprised me that quite a lot of students had misunderstood these basic concepts. Based on figure 17.4, I expect this to be less of a problem at this year's final exam.

While this type of TLA using conceptual questions could clearly also be conducted without the clicker realtime voting system, figure 17.5 suggests that using such a system is beneficial in the sense that it facilitates

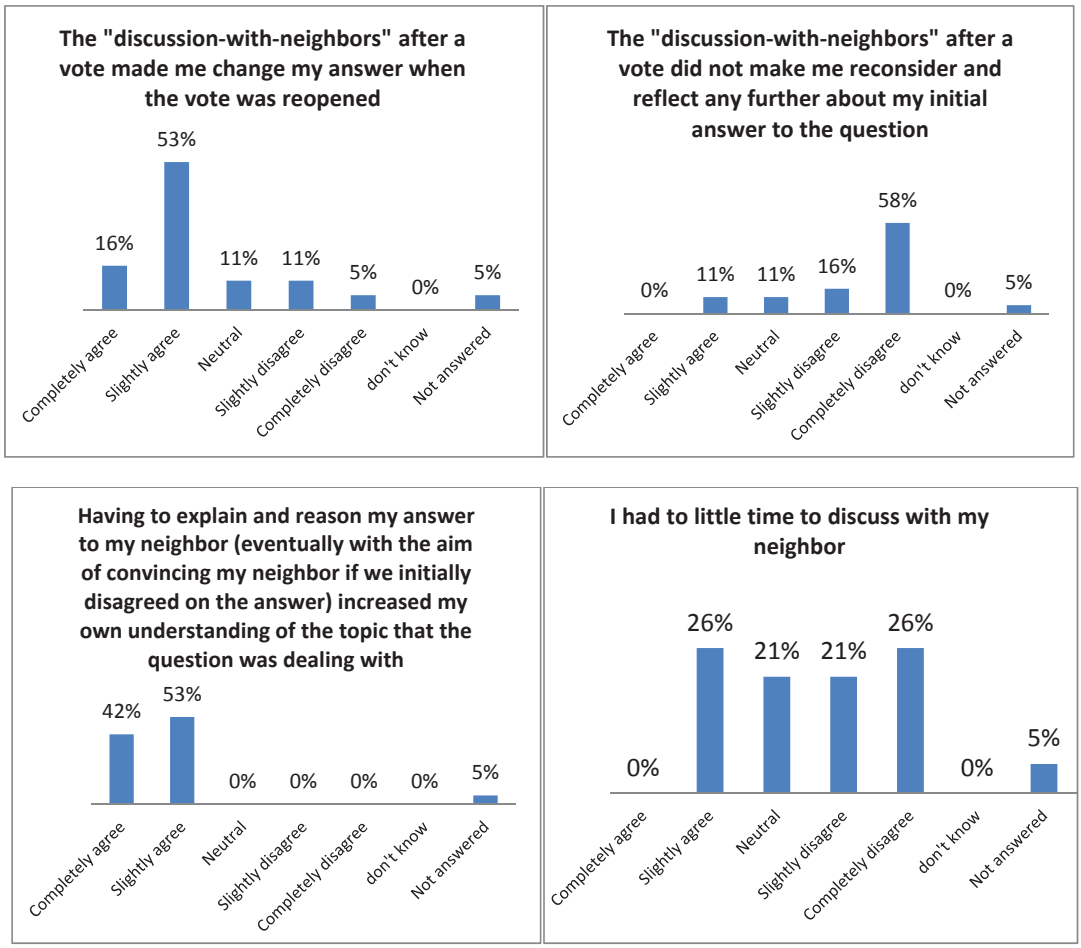


Fig. 17.2. Answer to questions 1, 2, 3 and 9 addressing the usefulness of the think-pair-share process.

and supports the "discussion-with-neighbors". Considering the importance of this particular element of the TLA as indicated by figure 17.2, using clickers or a similar real-time response system would seem highly recommendable. Furthermore, figure 17.5 suggests that it was not perceived as a major problem that some of the multiple choice questions had multiple correct answers. Only a couple of students found this annoying.

One important consideration in relation to this TLA is where it fits into the current structure of my course and the current TLAs in the course. Basically, my concern is whether this TLA could be seen as a replacement for some of the current TLAs or rather as a supplement. Figure 17.6 suggests that it should mainly be considered as a supplement since the majority of students agree to some extent that it cannot replace the regular TLAs in

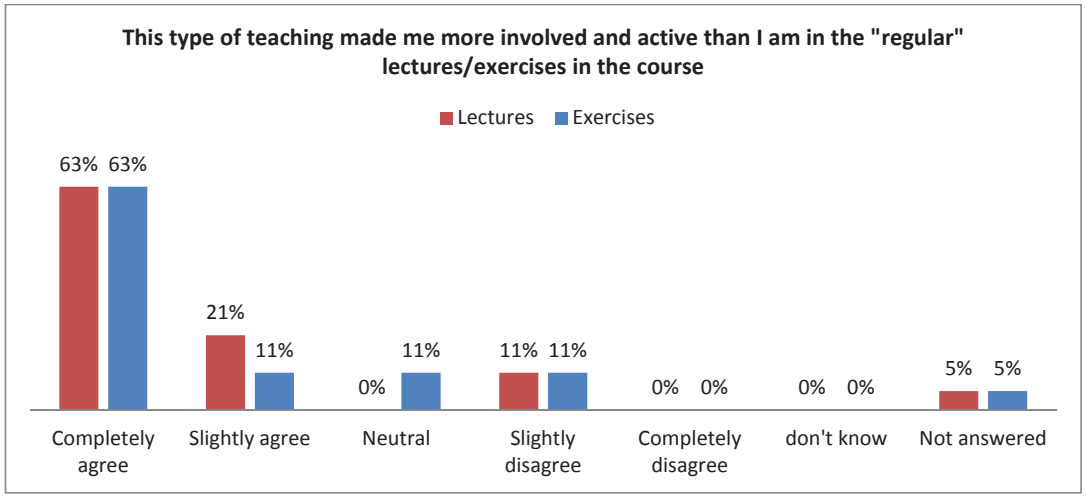


Fig. 17.3. Answers to questions 4 and 5 concerning activation and involvement.

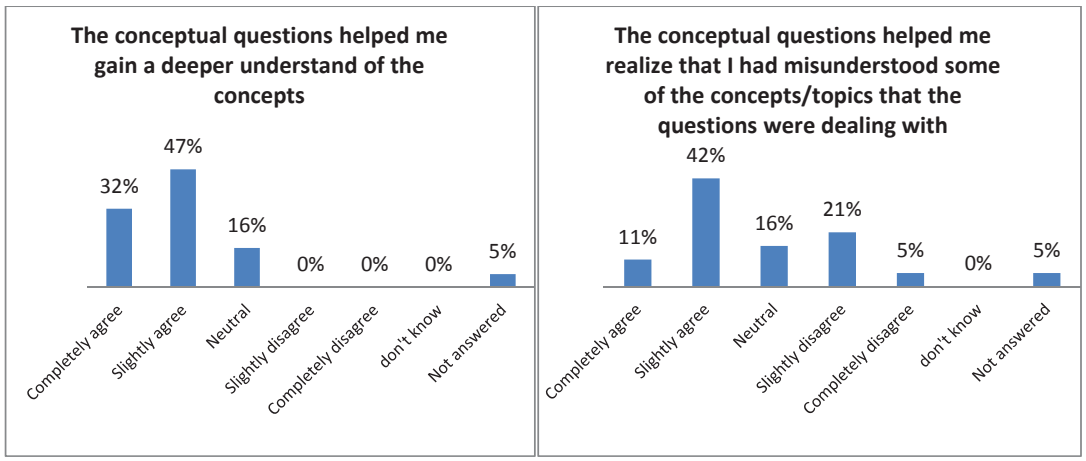


Fig. 17.4. Answers to questions 6 and 7 concerning students' understandings and misunderstandings.

the course. It is, however, evident that in order to introduce this new TLA on a regular basis in the course, something else has to go. Based on figure 17.6, it would seem most reasonable to replace some of the regular exercises with the new TLAs. Also considering the fact that the purpose of the regular exercises is quite close to the purpose of the new TLA, namely increasing students' understanding of the topics and concepts introduced in the lectures, this would seem a more relevant replacement to make than to replace some of the lectures with the new TLA.

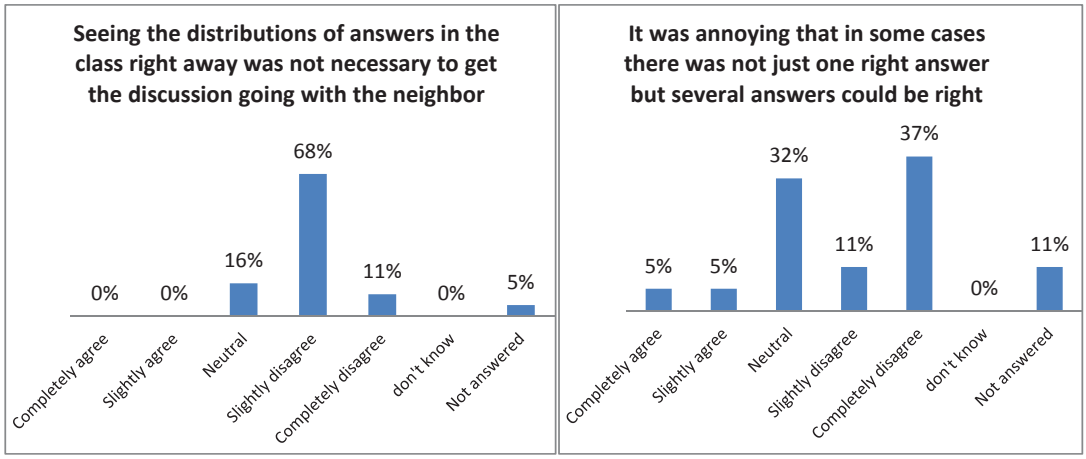


Fig. 17.5. Answers to questions 8 and 10 regarding the usefulness of seeing the answer distribution in class real-time and the atypical multiple choice format with more than one correct answer.

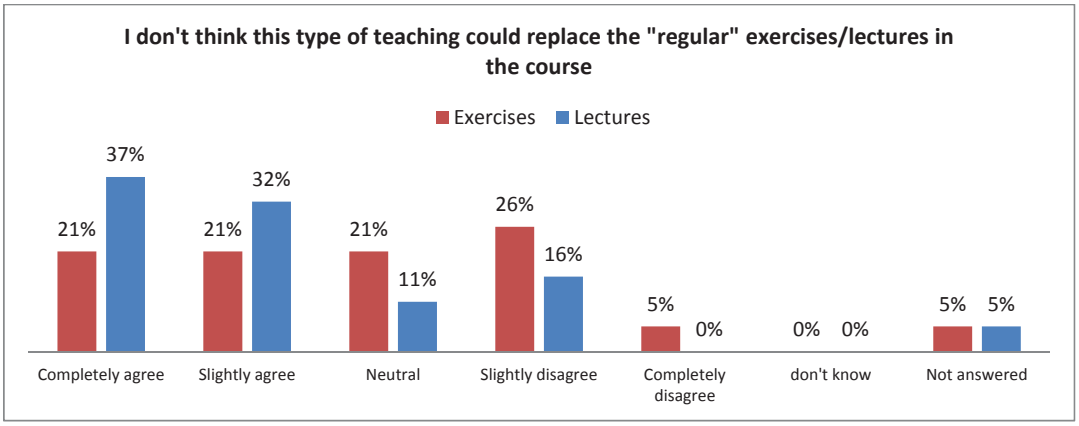


Fig. 17.6. Answers to questions 12 and 13 concerning to what extent this TLA could replace other TLAs.

Figure 17.7 summarizes the students' overall impression of the TLA, and again it is very clear that they like this type of TLA. All but one of them agree that it has increased their learning and understanding to some extent and they generally agree that this type of TLA should be used more. Of course one has to keep in mind whether it has actually improved their learning and understanding more or less than an hour of regular lecturing or exercises? In the current case the answer is most likely more. This is due to the fact that the TLA was conducted as a review activity, so they had

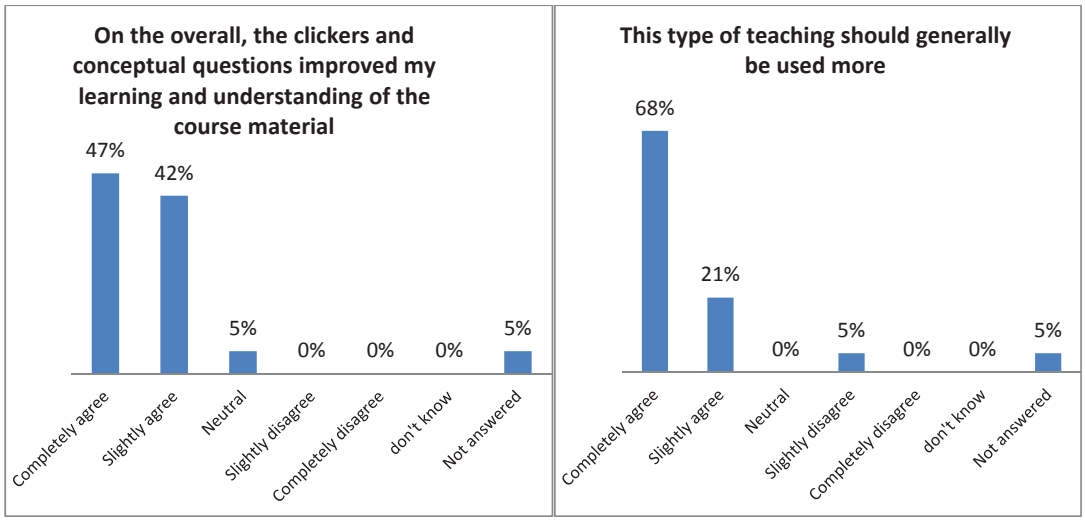


Fig. 17.7. Answers to questions 11 and 14 addressing the students' overall opinions about the TLA.

already been subjected to all the regular lectures and exercises that they would normally get before the final exam – relating to these concepts and topics. Hence, the students' answers indicate that the TLA has increased their learning and understanding beyond what they acquired through the regular lectures and exercises.

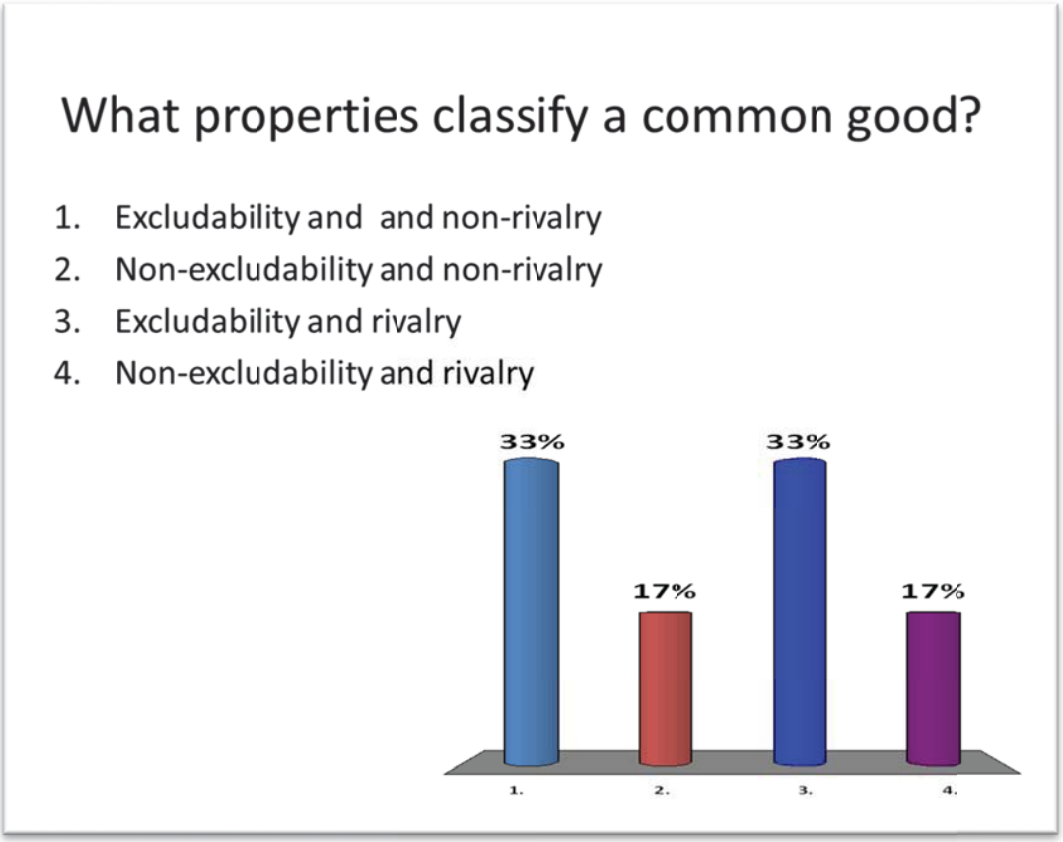
Conclusion

On the overall, testing conceptual questions and clickers as a review activity in my course has turned out very positive. My own impression from the discussions in class during the TLA was that the students benefitted greatly from it, and they were all activated and engaged to an extent I have not experienced previously. Judging by the oral as well as the written follow-up assessment, the students generally agree on this. Hence, my preliminary conclusion is that this type of TLA is extremely useful as a tool to improve learning and understanding of important topics and concepts – also for students in environmental economics, an area where this type of TLA, to my knowledge, has not previously been tested. Of course, the final exam will to some extent confirm or reject this conclusion. Another benefit of this type of TLA is that it also serves as a useful formative assessment that provides the teacher with an immediate view of student understanding in class.

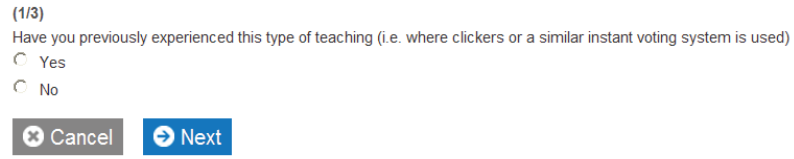
Having tested this type of TLA, I am certain that I will from now on take it in as a regular TLA in my course. Ideally, I would like to conduct this TLA every two or three weeks throughout the course when larger overall topics have been dealt with in lectures and exercises and are supposed to be finished. In order to reach this goal, I see two obstacles to overcome. The first and most important is the workload associated with developing the conceptual questions. Of course, with experience everything gets easier, so it might not take two days to construct another ten conceptual questions for another topic, but it certainly will be time demanding. However, this will to a large extent be a one-off time investment. Once a proper set of conceptual questions has been constructed, it can be re-used with little additional time investment in the following years. In the greater perspective, a database of conceptual questions for environmental economics could be developed and made available to other environmental economics teachers, similar to what has been done in chemistry and physics teaching. The second obstacle is of a more technical character, namely acquiring a set of clickers or adopting another solution for real-time voting. My institute does not currently have clickers available, so I had to borrow them at another institute, and there is no guarantee that they will always be available. One solution is to convince my own institute to buy a set of clickers. Considering the financial crisis and economic cutbacks at the university, this might not be realistic. In a foreseeable future smartphones with instant voting apps would be a possible solution. While such apps are already available, not all students have smartphones, so this solution seems irrelevant at least for now. Another solution that I might pursue is to ask students to bring their own laptops to these TLAs. Instant voting web-based solutions are available that should be able to work just as well as the clickers and our students are expected to have laptops, i.e. teachers can ask students to bring their laptops and plan their teaching on this basis.

A Conceptual questions

Example of conceptual question as presented to students in class – here with graphical bar-chart illustration of the distribution of student responses collected real-time and shown to students immediately after last vote had been registered.



B Evaluation questionnaire



(1/3)

Have you previously experienced this type of teaching (i.e. where clickers or a similar instant voting system is used)

- Yes
- No

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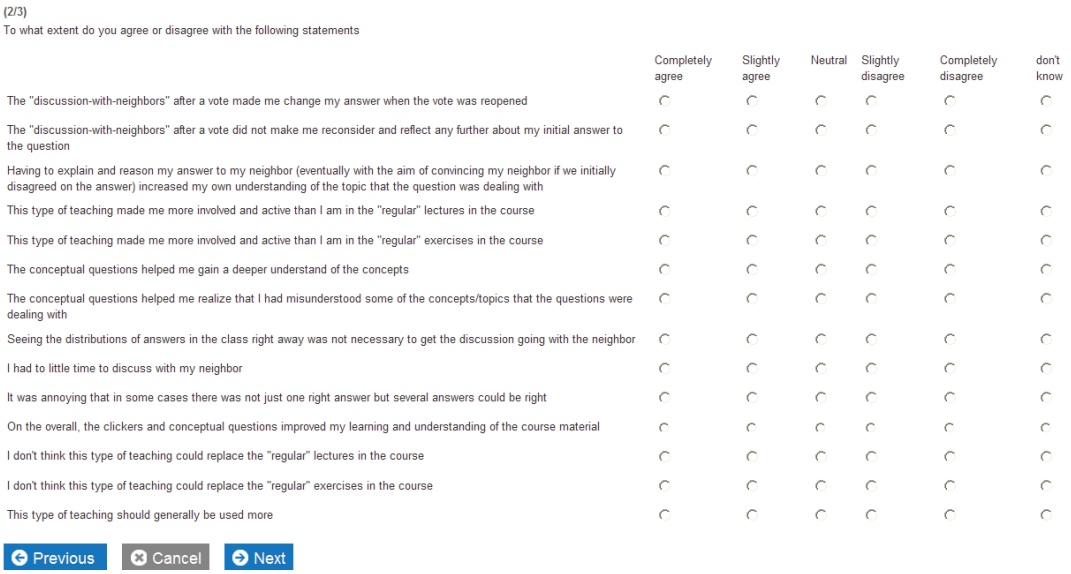

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To what extent do you agree or disagree with the following statements

	Completely agree	Slightly agree	Neutral	Slightly disagree	Completely disagree	don't know
The "discussion-with-neighbors" after a vote made me change my answer when the vote was reopened						
The "discussion-with-neighbors" after a vote did not make me reconsider and reflect any further about my initial answer to the question						
Having to explain and reason my answer to my neighbor (eventually with the aim of convincing my neighbor if we initially disagreed on the answer) increased my own understanding of the topic that the question was dealing with						
This type of teaching made me more involved and active than I am in the "regular" lectures in the course						
This type of teaching made me more involved and active than I am in the "regular" exercises in the course						
The conceptual questions helped me gain a deeper understand of the concepts						
The conceptual questions helped me realize that I had misunderstood some of the concepts/topics that the questions were dealing with						
Seeing the distributions of answers in the class right away was not necessary to get the discussion going with the neighbor						
I had to little time to discuss with my neighbor						
It was annoying that in some cases there was not just one right answer but several answers could be right						
On the overall, the clickers and conceptual questions improved my learning and understanding of the course material						
I don't think this type of teaching could replace the "regular" lectures in the course						
I don't think this type of teaching could replace the "regular" exercises in the course						
This type of teaching should generally be used more						

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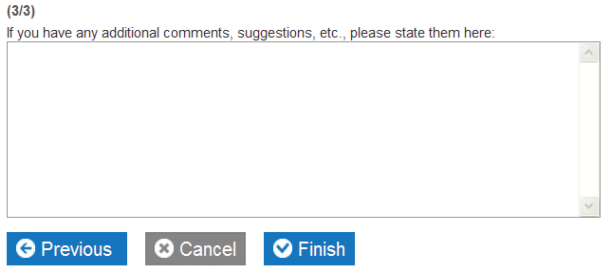

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If you have any additional comments, suggestions, etc., please state them here:

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