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ARTICLE

Rethinking Discussion Sections with Peer Instruction: A Case Study

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ABSTRACT

This study evaluates the role of discussion sections in a course that adopted peer instruction (Mazur, 1997) as its method of instruction. Students were surveyed at the end of the course, and the results indicate that the students preferred discussion sections to be a space to learn new material, rather than to practice material taught in lectures, and that they did not learn any better in a section setting than in a lecture setting. I interpret these results as an indication that traditional discussion sections are a low priority luxury in a course that adopts peer instruction, and suggest that instructors of such courses do away with sections and extend the duration of the lecture instead.

INTRODUCTION[1]

Many universities adopt a lecture-discussion section format of instruction, at least for large-sized courses. Traditionally, "lectures" are presentations delivered by an instructor to all the students at a centralized time and location, and typically represent the students' first encounter with the course material. "Discussion sections", or "tutorials", on the other hand, are conducted within a smaller classroom and provide opportunities for students to engage with the taught material more actively, through application, discussion, practice, and so on. Indeed, within such an arrangement, lectures and sections serve largely complementary purposes, since big lectures are a time-efficient way of disseminating new information to a large number of students, while smaller class sizes, typical of sections, may increase student-faculty interaction and lend themselves better to hands-on activities that improve learning (Lazear, 2001).

While most would acknowledge the benefit of being able to address a large crowd at a single time, some (e.g. Marbach-Ad, Seal, & Sokolove, 2001; Jungst, Licklider, & Wiersema, 2003; Deslauriers, Schelew, & Wieman, 2011) have questioned the instructional efficacy of traditional lectures in favour of active learning methods such as peer instruction (Mazur, 1997) and the flipped classroom (Bergmann & Sams, 2012). In a flipped classroom that uses peer instruction (PI), students' first exposure to the course material is not during lecture, but before the lecture; students are required to read assigned readings or watch assigned videos before going to the lecture. "Lecture" time is instead spent on helping students deepen their understanding of what they had read or watched on their own through discussions, with their peers, of carefully designed PI questions. The PI approach has been shown to help students better synthesize newly learnt information, while providing instructors with immediate feedback that can help identify and address problems that the students may be encountering. As a result, students in PI courses achieve higher grades and better conceptual understanding, and are better at problem solving than students in traditional lecture courses (Crouch & Mazur, 2001; Fagen, Crouch, & Mazur, 2002; Spacco, Parris, & Simon, 2013).

Employing PI during a lecture affords plenty of opportunity for discussion and feedback, which in traditional lecture-section arrangements is only available during sections. It also fulfils the role of sections as hands-on practice sessions, since students are constantly engaged in knowledge application and problem

solving when responding to PI questions (Fagen *et al*., 2002; Rosenberg, Lorenzo, & Mazur, 2006; Simon, Kohanfars, Lee, Tamayo, & Cutts, 2010). This raises the very practical question of whether there remains a need for discussion sections that are separate from lectures that incorporate PI, or whether there are potential cost savings to be had by dispensing with such sections.

CONTEXT OF THE PRESENT STUDY

The goal of the present study is to investigate whether the need for sections is obviated in a flipped classroom that uses PI, and I seek to address this question from the perspective of the primary stakeholders in the classroom—the students. Specifically, the students involved in this study were enrolled in a linguistics course that was taught at the National University of Singapore in 2016. The course was taught in a lecture-section arrangement.[2] However, "lectures" and "sections" were not distinct in terms of how they were conducted; in both lectures and sections, students engaged in PI.

The format for each lecture, which lasted 95 minutes, was as follows: Students were required to read an assigned reading prior to the lecture. Each lecture began with a short reading quiz comprising five questions on the assigned reading—this was to ensure that students did indeed complete the readings before attending class. After the reading quiz, the instructor would present the first PI question on the screen using a slideshow presentation programme. The PI questions differ from the reading quiz questions in that the latter were simple comprehension questions that students would be able to answer with just a superficial understanding of the reading, whereas the former focused on what the instructor identified to be the more important concepts introduced in the reading and required the students to engage in higher order thinking skills such as knowledge application, critical thinking, data analysis, and problem solving (Anderson & Krathwohl, 2001). A PI question used in one of the classes is provided in Table 1 as an example.

Table 1
Example of a peer instruction (PI) question.

(1) Consider the data below from the Avar language (spoken in by a Caucasus native ethnic group). Which of the following best describes the case and agreement systems of Avar?
vas *v-ekerula* boy AGR-run 'The boy runs' *jas j-ekerula* girl AGR-run 'The girl runs' *vas-as jas j-ecula* boy-CASE girl AGR-praise 'The boy praises the girl'
a. accusative case system; accusative agreement system b. accusative case system; ergative agreement system c. ergative case system; accusative agreement system d. ergative case system; ergative agreement system

All PI questions were multiple–choice questions that students responded to using a classroom response system (clickers). Students were required to first answer the PI question on their own (solo vote). Once they had all responded, the instructor would reveal the voting patterns and invite students to discuss their answer with their seatmates, in groups of twos or threes. During this time, students would try to defend their solo votes, explaining how they arrived at their answer or ruled out other answers. Students were expected to come to a group consensus and respond to the question again, this time as a group (group vote). The instructor would then reveal the results of the group vote and lead a class-wide discussion, inviting students to share what they had discussed in their groups. The immediate feedback provided by the classroom response system also allowed the instructor to gauge the level of student understanding and tailor his teaching accordingly. The instructor would end the PI question with a slide that summarised the main concepts underlying the question, related these concepts to other concepts introduced in earlier classes, etc., before proceeding to the next PI question. Typically, each lecture comprised seven PI questions.

In this course, sections were treated as a continuation of the preceding lecture and each section was based on the same assigned reading as the preceding lecture. Sections were conducted in the same format, except within a shorter time frame (45 minutes), with fewer PI questions (three), and no reading quizzes. All 111 students enrolled in the course attended weekly lectures together in a lecture theatre, but each student attended one of six weekly sections held in smaller classrooms. The number of students attending each section ranged from 12 to 25. All classes, lectures and sections, were conducted by the same instructor.

Now, given that students were engaged in PI in both the lecture and section, which constantly involved them in the kinds of hands-on activities that are traditionally associated only with sections, the question naturally arises as to whether there is any benefit to holding six separate sections in a week. In the absence of any such benefit, it would be more efficient, time-wise, to eliminate sections and simply extend the duration of the weekly lectures to include the additional three PI questions that were covered in sections.[3] Thus, I decided to survey the students at the end of the course for any perceived benefits of sections within such a system.

METHODS

An email containing a link to the online survey was sent to all enrolled students after the course had ended, inviting them to take part in research about students' attitudes towards PI in a flipped classroom. The email assured the students that no personal identifiers would be collected from them and that their participation in the research was entirely voluntary. Of the 111 students enrolled in the course, 70 participated in the survey.

The survey comprised 21 questions, the first five of which were demographic. Because we were also interested in finding out whether students enjoyed the PI experience, eleven questions[4] were directed at students' experiences with and attitudes towards PI in general, and only the last five questions were specifically about lectures and sections. As this paper focuses on the role of tutorials in a course taught using PI, I only present the analysis of the responses to the last five questions, which are shown in Table 2.[5] The complete list of questions used in the survey is provided in the appendix.

Table 2
Survey questions related to the role of sections[6] in PI.

a.	Tutorials in this course should be spent on practising material that has already been covered in lecture.
b.	Tutorials in this course should be spent on covering new clicker questions (on material that has not already been covered in lecture).
c.	Even though we do the same activities in lecture and tutorial (i.e. discuss clicker questions), I learn better in tutorial than in lecture.
d.	Discussing clicker questions in a lecture setting provides me with sufficient opportunities for discussion and feedback.
e.	Please share any thoughts that you may have regarding the role of tutorials in the approach taken in this course.

The first four of these questions were posed on a four-point Likert scale, where students had to choose between "Strongly Agree", "Agree", "Disagree", and "Strongly Disagree", while the final question was an open-ended question that allowed students to type their responses in an answer box. Only the final question was optional.

Questions 2(a)-2(b) sought to uncover students' thoughts on the role of sections in PI: should sections be used as practice sessions, as in the traditional lecture-section model, or should sections be used to cover new material, as was done during the course? Questions 2(c)-2(d) were posed to investigate whether students perceived any additional benefit to having tutorials within the format of instruction adopted during the course, or whether discussing PI questions within a lecture-type setting was sufficient for their learning.

For purposes of statistical analysis, the responses to the questions in 2(a)-2(d) were converted into integers, such that "Strongly Disagree", "Disagree", "Agree" and "Strongly Agree" were coded as 1, 2, 3, and 4 respectively.

RESULTS

Overall, students seemed to have had a positive experience with PI: of the 70 students who responded to the survey, only three disagreed with the statement that "clicker questions with discussion is valuable for my learning"; four disagreed that "discussing clicker questions with my seatmates in class helped me better understand the course material", and one disagreed that "the immediate feedback from clickers helped me focus on weaknesses in my understanding of the course material". There were no "Strongly Disagree" responses to any of these questions. Clearly, students appreciated the opportunities for useful discussion and feedback, traditionally associated only with sections, that is afforded by PI.

The means and standard deviations for the responses to questions 2(a)-2(d) are summarized in Table 3, and histograms of the responses to each question are provided in Figure 1.

Table 3
Descriptive statistics

Question	mean	s.d.
Tutorials should be used as practice sessions (=2a)	2.8	0.7
Tutorials should be used to cover new material (=2b)	3.1	0.7
I learn better in tutorial (=2c)	2.4	0.6
Lectures are sufficient (=2d)	3.1	0.6

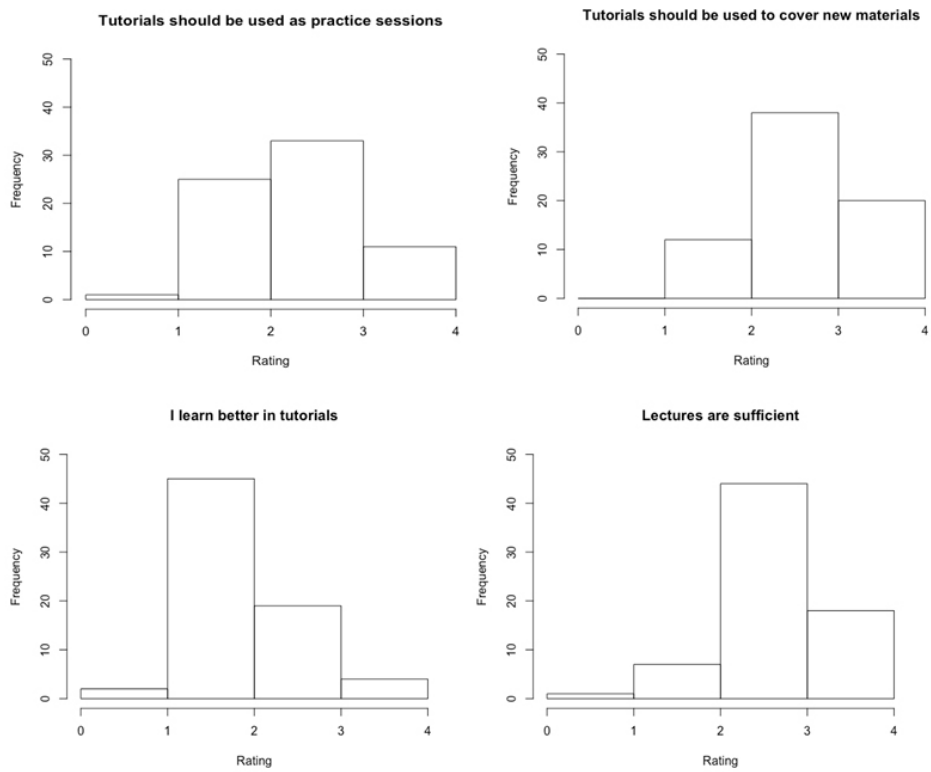

Figure 1. Histograms of responses to Questions 2(a)-(d).
(Rating: 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree)

Overall, students indicated a preference for sections to be used to cover new materials, than as practice sessions. This difference in the preferred role of sections in PI was significant, $t_{two\text{-}tailed}(138)=2.9$, $p=0.004$, Cohen's $d=0.4$. As a group, the students also tended to disagree with the proposition that they learnt better in tutorials than in lectures, and agreed that lectures provided sufficient opportunities for discussion and feedback. This difference was also significant, $t_{two\text{-}tailed}(138)=7.17$, $p<0.001$, Cohen's $d=1.2$.

Paired t-tests further showed that these differences remained significant when we considered each student's response to 2(a) against his⁄her response to 2(b), as well as each student's response to 2(c) against his⁄her response to 2(d): $t(2a\text{-}b)(69)=2.67$, $p=0.009$, Cohen's $d=0.3$; $t(2c\text{-}d)(69)=6.22$, $p<0.001$, Cohen's $d=0.7$. That is, there was a significant tendency for each student to prefer sections to be used to cover new materials than to be used for practice, and to agree that discussing PI questions within a lecture setting was sufficient for their learning, i.e. they felt they did not learn any better in sections.

DISCUSSION

As the results show, students (i) preferred sections, within this instructional model, to be used to cover new material than to be used for practice, and (ii) found discussing PI questions within a lecture setting to be sufficient for their learning, i.e. they felt that sections did not confer any additional benefits. Moreover, these results held when the responses were analysed student-wise as well.

Should sections be used for practicing material introduced in lectures?

The responses to 2(a) reveal that students generally wanted sections to be used as practice sessions for the material introduced in lecture. The responses to 2(e) below reflect these sentiments.

S1: *"I feel that lectures should cover the fundamentals of each chapter while tutorials should cover more exceptional/advanced cases."*

S14: *"I felt that the tutorials should emphasise more on practicing instead of covering new material."*

S30: *"I feel that maybe the typical tutorial style may work better, with the tutor giving a set of questions for us students to prepare and complete at home, before going to class and sharing our answers."*

S32: *"I think tutorials should tackle questions that people are generally weak at. Allow students to do some practices before coming and discussion of practices will be great!...Tutorials should be longer!"*

Students seem to see the need for traditional practice sessions beyond the PI discussions. However, as alluded to in the last quote from S32, there were time constraints on the instructor, who needed to cover a fixed amount of material each week. In the absence of additional contact hours, it would not be possible for the instructor to offer traditional practice sessions while still managing

to "cover all the topic's bases", to quote S35 below. This is because class time in PI is organized around discussions, which trades breadth for depth. This in turns means the PI instructor would not be able to cover as much material as in a traditional lecture, within the same time frame.

Despite the general desire for sections to be used as practice sessions, students *still* preferred for sections to be used to introduce new materials. This may be due to the fact that students were already constantly actively engaging the course material when discussing PI questions in lecture, and thus consider the cost of practice sessions to be relatively high in comparison to the opportunity to learn new materials. Some responses to 2(e) are instructive of students' attitudes towards the novel use of sections:

S5: *"I think it is very effective, as it lets us practice new questions"*

S7: *"I loved how the tutorials were an extension of the lecture. It kept things fresh and interesting instead of the usual boring tutorials with handouts."*

S35: *"Tutorials as an extension of the lecture materials are actually rather beneficial in that we have more time to cover all the topic's bases."*

S58: *"I liked the clicker style for both lectures and tutorials."*

S59: *"I thought it was a pretty good approach to just have the tutorials in essentially the same style as the lectures, that way the learning was consistent across the board."*

The quotes above show that students were happy to be doing the same things in the section as in the lecture, namely, discuss PI questions, albeit on new material.

Given the time constraints, pre-determined syllabus, and the fact that students reported a significant preference for sections to be used to cover new material, it seems fair to conclude that traditional practice-type sections are a low priority luxury in the flipped classroom that employs PI.

Are there benefits to the section setting that are not available in the lecture setting?

Now, even though the need for sections as practice sessions may be low in comparison, there may be other benefits afforded by the smaller section setting that may not be available in the larger lecture setting, which may justify the retention of sections within this system. However, this possibility is not supported by our second finding: as the statistics show, students did not think they learnt better in sections, and found discussion of PI questions in a lecture

setting to be sufficient for their learning. Given that students perceive sections to confer no additional benefit, it would then be more efficient, time-wise, to eliminate sections and extend the duration of lectures. The responses to 2(e) below support this move:

S34: *"I did not feel that the tutorials offered a significant difference from the lectures in terms of their usefulness in understanding the course material."*

S69: *"Since the tutorials and lectures were pretty much 'run' in the same style, I actually see little difference (for the student). My reason for preferring the lecture over the tutorial is completely personal; my friends and I weren't able to schedule the same tutorial slot, so I felt slightly uncomfortable having to discuss with random coursemates during the tutorials."*

As explicitly expressed by these students, sections were not any more useful than lectures with regard to learning the course material.

There was a clear pattern among the students who expressed sentiments to the contrary: they appreciated the smaller class sizes in sections, as reflected in the following responses to 2(e).

S10: *"I think that with the smaller class sizes, I feel more at ease with asking clarification questions."*

S37: *"The tutorials allowed me to gain a better understanding of the chapters due to its conciseness, as well as the proximity between the tutor and the class."*

S40: *"Provide a more conducive and comfortable environment to clarify doubts as the class size is smaller."*

S66: *"Since the tutorial involves lesser people, it is thus easier to clarify our doubts.*

As these quotes indicate, students who felt that they learnt better in sections mostly did so because of the increased faculty-student interaction allowed in the smaller classroom. Indeed, previous studies have suggested that with bigger class sizes, instructors have a tendency to allocate more resources to class-wide activities, at the expense of individual attention (Correa, 1993; Mulryan-Kyne, 2010). But how exactly does class size affect student learning?

Class size effects

Research on the effect of class size on student learning and achievement in higher education presents a mixed picture. Toth and Montagna (2002) reviewed eight studies published between 1990 to 2000, and found that two studies showed no relationship between class size and achievement, three studies reported a negative relationship (i.e. smaller class sizes correlated with better achievement), one indicated a positive relationship (i.e. smaller class sizes correlated with poorer achievement), while two described mixed results. Part of the problem in comparing such studies is that different studies tend to use different methods and measures when investigating the issue. For example, of the eight studies reviewed by Toth and Montagna (2002), six were quantitative and two were qualitative, and the studies measured "achievement" in different ways.

Research on student ratings published after the turn of the century presents a more or less uniform picture. Bedard and Kuhn (2008) reported a large and highly significant impact of class size on student evaluations of instructor effectiveness. Likewise, Monks and Schmidt (2010) found a negative relationship between class size and student assessments of how much they had learned, instructor ratings, and course ratings. The study also found a negative and significant impact of class size on student ratings of the level of critical and analytical thinking required in the course, whether the presentation was clear and understandable, and the instructor's effectiveness in stimulating interest. Chapman and Ludlow (2010), too, reported a significant negative relationship between class size and perceived learning, even after accounting for student and instructor variables. One problem with many studies of class size effects, as pointed out by Johnson (2010), is that they tend to conflate class size and method of instruction, such that it is not clear whether the reported effects were genuinely due to class size alone, rather than differences in how classes of different sizes tend to be taught. Using a two-level cross-classified model, Johnson examined the effect of class size on student performance after controlling for other class-level and student-level characteristics, and found that overall, smaller class sizes were associated with better grades.

At least two studies have shown that the relationship between grades and class size is not a linear one. Kokkelenberg, Dillon, and Christy (2008) reported that increases up to a class size of 20 were associated with sharp declines in grades, but the decline, though monotonic, becomes more gradual through larger class sizes. On the other hand, Bandiera, Larcinese, and Imran (2010) found that changes in class size have a significant impact on student performance on tests only at the very top and bottom of the class size distribution: they witnessed a negative effect associated with increases up to a class size of 55, close to zero effect for further increases up to a class size of 103, and an additional

negative effect with further increases. In addition, there is evidence that any effect of class size is dependent on the subject matter and student ability: De Paola, Ponzo, and Scoppa (2013) report class size effects for mathematics courses but not language courses, and the effect was found to be negligible for high-ability students.

In summary, some studies have reported a negative relationship between class size and student rating—but as pointed out earlier, these results are confounded by the fact that they fail to tease apart the effects of class size and method of instruction—while other studies have demonstrated a more complicated relationship between class size and performance. But even if small classes are indeed much more effective for learning, we cannot ignore the fact that they are a costly form of education to provide, relative to lectures. In this study, the instructor tried his best to maintain the same method of instruction throughout lectures and sections[7], and the student responses showed that they felt they did not learn any better in sections than in lectures[8], and that discussing PI questions within a lecture setting provided sufficient opportunities for discussion and feedback. In other words, class size did not have a statistical effect on the learning process, as perceived by students.

Among those studies that investigated the relationship between class size and grades, there seems to be a consensus that small class sizes are associated with better grades, with some demonstrating that grades remain more or less constant over a large variety of class sizes. However, the operationalization of student learning and achievement simply in terms of grades is a very narrow perspective, as Johnson (2010) admits. This ignores other aspects of "achievement", such as transfer of knowledge to new situations, retention of information, problem solving, critical thinking, and so on (Toth & Montagna 2002), skills that have been reported to improve, alongside grades, with PI (Crouch & Mazur, 2001; Fagen *et al*., 2002; Spacco *et al*., 2013). I did not consider the effect of class size on student achievement, but given that previous studies have mostly focused simply on grades alone, it would be premature to make decisions on class size based on these studies.

CONCLUSION

This paper presented a case study on the role of discussion sections in a course that adopted PI as its mode of instruction. As data were drawn only from student perceptions, the results here paint only a partial picture, and should thus be interpreted modestly; nonetheless, the survey evidence presented here provides a beginning to addressing the question at hand.

In light of the preceding discussion, the results here suggest that sections are not essential in a course that employs PI as its method of instruction. In fact, there are potential cost savings to be had by dispensing with sections. This most obvious benefit of axing sections within such a system is the time saved by offering an additional hour of lecture to all the enrolled students at once, instead of holding separate sections for different groups of students. This, in turn, can help with quality control. In situations where all sections are taught by the same instructor, the instructor may experience burnout after having taught several sections, such that students attending the later sections may be shortchanged in terms of the quality of instruction provided; in cases where sections are conducted not by the instructor on record, but by one or more graduate students, these teaching assistants may not be truly qualified to teach the material, and the quality of instruction may not be comparable across sections. These issues can be avoided by moving away from a lecture-section arrangement towards a centralized lecture-only system. Students' desire for greater faculty-student interaction within the lecture setting can be satisfied to some extent by having the instructor walk around the classroom during student discussions, so that students can pose their questions to the instructor within the sanctuary of their discussion group.

It is important to stress that the potential benefits of eliminating discussion sections suggested here apply only for courses that fully adopt PI as the method of instruction. As McKeachie (1999) cautions, optimal teaching methods and class sizes vary by subject matter and level of instruction (see also Neumann, 2001; Neumann, Parry, & Becher, 2002; Logan, Franke, & Bailey, 2010; *inter alia*). For instance, Udalagama, Tan, Lim, and Tan (2014) discuss the benefits of what they call "activity-based tutorials" in a laboratory-based class, showing that small sections do have an important part to play in certain instructional settings.

ENDNOTES

1. This research was conducted with approval from the NUS-IRB (reference code: A-16-103E). I am grateful to the reviewers and co-editors for providing generously constructive feedback that have led to the improvement of this paper. All remaining errors are mine.

2. This is the default arrangement in the institution for courses involving more than 50 students. When the instructor inherited the course for the first time, there was insufficient time to make any changes, which fortuitously created the conditions for this study. As discussed in the sub-section "Should sections be used for practicing materials introduced in lectures?" (P. 19), the adoption of PI in lectures meant that the instructor could not cover as much material as in a traditional lecture; topics that were not covered in lecture were thus taught in sections, also using PI.

3. An alternative would be to hold two shorter lectures each week, each covering five peer instruction questions. This would still be more time-efficient than having six sections.

4. These eleven questions were adopted from a survey used by Beth Simon (p.c.) at the University of California, San Diego, as part of a larger, ongoing project. Some results from surveys conducted by Beth Simon and her colleagues have been reported in Simon *et al*. (2010) and Simon, Esper, Porter, & Cutts (2013).

5. One of the reviewers pointed out that there is an asymmetry in the questions that creates a strong presumption in favour of lectures; however, and the reviewer agrees, this is addressed to a large extent by the student-wise comparisons in the analysis. A study with the alternative survey structure would verify if this asymmetry has indeed affected the results.

6. In the survey, the term "tutorial" was used instead of "discussion section" as the former is the term that NUS students frequently use when referring to such classes, and hence, are more familiar with.

7. One of the reviewers correctly highlights that there may have been differences that the instructor was unaware of, and which could not be controlled for, e.g. spending more/less time on particular sorts of questions, speaking more/less energetically, etc.

8. As the co-editors point out, it should be possible, in principle, to validate these perceptions with actual performance data, since the instructor used clicker tests in both lecture and sections. Unfortunately, these data were not consistently saved by the instructor as the students were not graded on their clicker performance in class.

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Appendix. Survey Questions

1. Are you a full-time student at NUS?
2. Which faculty/school do you belong to?
3. What is your current year of study?
4. Are you doing a major, or planning to do a major, in linguistics?
5. Are you doing a minor, or planning to do a minor, in linguistics?
6. I have used clickers at this or some other institution before.
7. Thinking about clicker questions on my own, before discussing with the people around me, helped me learn the course material.
8. Most of the time I actually read the required material before class.
9. Most of the time my group actually discusses the clicker questions.
10. Discussing clicker questions with my seatmates in class helped me better understand the course material.
11. The immediate feedback from clickers helped me focus on weaknesses in my understanding of the course material.
12. Knowing the right answer is the most important part of the clicker question.
13. Generally, by the time we finished with a question and discussion, I felt pretty clear about it.
14. Clicker questions helped me pay attention in this course compared to traditional lectures.
15. Clicker questions with discussion is valuable for my learning.
16. recommend that other instructors use this approach (reading quizzes, clicker questions, in-class discussions) in their courses.
17. Tutorials in this course should be spent on practising material that has already been covered in lecture.
18. Tutorials in this course should be spent on covering new clicker questions (on material that has not already been covered in lecture).
19. Even though we do the same activities in lecture and tutorial (i.e. discuss clicker questions), I learn better in tutorial than in lecture.
20. Discussing clicker questions in a lecture setting provides me with sufficient opportunities for discussion and feedback.
21. Please share any thoughts you may have regarding the role of tutorials in the approach taken in this course. ■