Promotion of open and efficient communication in tutorials

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Abstract

We tested a variety of techniques that have been suggested as ways to promote active student participation and discussion in tutorial sessions. We implemented these strategies in two different courses: Space Vehicle Design and Differential Equations and Fourier Series.

Broadly, we found the strategies were successful in that they consistently increased at least one of: number of student questions, degree of openness, or efficiency; while never causing a decrease in any of these metrics. Student opinion on the strategies was slightly favorable

Overall, we favor small group discussion as a strategy for promoting open communication in tutorials because it was found to be the most effective in eliminating private questions, was easy to implement, did not generate any negative survey/SELT comments, and did not give the students the opportunity to ask humorous/offensive questions due to anonymity, thereby placing the teacher in a difficult position.

Background and rationale

In mathematical and engineering sciences, the tutorial has long been used as an interactive learning opportunity. The purpose of the tutorial is primarily to reinforce theoretical or empirical knowledge introduced in lectures and its application. Tutorial sessions involve several activities, one of which is receiving and answering student questions related to course material.

In practice, these tutorials are often the size of small lectures. Consequently, students are often reluctant to ask questions. This leads to one of two situations: either the question is not asked, or students ask questions individually. In the former case, student learning is impaired because issues are left unresolved and the teacher is not made aware of any deficiencies. In the latter case, the teacher will often have to answer the same question repeatedly. This is time consuming, inefficient and may prevent some questions from being asked in the time available.

In ideal circumstances, students would openly communicate their questions to the teacher so that the whole class would benefit from hearing the question and subsequent answer. This would resolve the two problematic situations mentioned above. Such questions are a form of active learning, where students are actively engaged in seeking and creating knowledge in an interaction with their peers, teachers and the subject matter (Kahn & Kyle, 2002). It is part of the transactional approach to teaching, in which knowledge is actively constructed rather than being passively received (Miller & Seller, 1990).

Reluctance to ask questions in large classes has been attributed to student shyness and awkwardness (Race & Brown, 2001) or “because individuals do not generally like to be in the foreground” (Cannon & Newble, 2000). Some students may not feel entitled to ask a question, either through lack of preparation or because they think it is too trivial. Many probably do not want to admit to a deficiency in their knowledge in front of a large group of their peers.

In this project, we test a variety of techniques that have been suggested as ways to promote active student participation and discussion. We implement these strategies across different disciplines and teachers, thereby enabling a crude assessment of their independence of these factors.

Differential Equations & Fourier Series (DEFS) is a 2nd Year course that aims at equipping students with the ability to model physical problems using differential equations, solving the differential equations, and interpreting the results. Students come from a variety of backgrounds, including mathematics, science, economics and engineering. Although this is a large class, students are divided up for tutorials into groups of about 30, although the tutorial class used for this study was smaller, with an average attendance of about 20. These tutorials are run every second week. Tutorial problems are issued the week before the tutorial. During the week of the tutorial, students are issued with Assignment problems that are designed to be related to the tutorial problems. The tutorial format is not fixed and individual tutors are allowed to respond to student preferences, but typically they involve both demonstration of solutions as well as student practice.

Space Vehicle Design is a 3rd Year course that introduces students to the knowledge and process of designing space vehicles. All students are enrolled in either Aerospace Engineering or Mechanical Engineering. The entire class of 56 attends a single tutorial session. These tutorials are run every week. The tutorials alternate in format between a demonstration and explanation session, and a question and answer session.

Project aims

The aim of this project is to identify those strategies that encourage students to ask questions in large tutorials, independent of discipline and teacher.

Method

The approaches for enhancing open communication in tutorials were carried out in the tutorials for two different subjects: Space Vehicle Design, an Aerospace Engineering course taught by Dr Vincent Wheatley, and Differential Equations and Fourier Series (DEFS), a mathematics course taught by Dr Trent Mattner. At the time the project was carried out, there were 56 students who were enrolled to attend the Space Vehicle Design tutorial, and 20 students assigned to Dr Mattner's DEFS tutorial group.

First, a baseline was established by running tutorials in the normal manner, verbally inviting students to ask questions. We then implemented the two following strategies in subsequent tutorials:

Small group discussion: Students were asked to arrange themselves in groups of four to eight. Groups were given five minutes to formulate at least one question, after which a group spokesperson communicated their questions to the rest of the class and the teacher.

Post-it notes: Students were given five minutes to write down questions on a small piece of note paper. These were submitted anonymously to the teacher, who read out and answered each question during the remainder of the tutorial.

In each case, the teacher counted:

- V: the number of unique questions that were asked publicly
- P: the number of unique questions asked privately
- R: the number of repeat questions asked privately
- $N = V + P + R$: the total number of questions

by keeping a tally in a log book. Note that these counts included all questions asked during the tutorial, not just those specifically associated with each strategy, hence indirect effects of each strategy on open communication are included.

We also surveyed the students to determine their opinion on which strategies were most useful in enhancing their learning experience and why.

Limitations

Our study is limited to two classes with a total of only 76 students. A wider study would be needed to increase statistical confidence in our findings. This study is also limited to courses within physical sciences and engineering. It cannot be reliably inferred that students in other faculties will react to the active learning strategies in the same manner. A further limitation of this study is that we trial multiple approaches on the same students. If the earlier strategies trialed were successful in promoting open communication, this may artificially increase the success of later strategies. Conversely, if the early strategies were unsuccessful, students may resent the later strategies, decreasing their success. In other words, the strategies were not tested in an independent manner. Finally, the number of questions is likely to be dependent on the subject matter itself, which changed from tutorial to tutorial.

Analysis of results

The raw data obtained from our tutorial sessions is shown in Figures 1 and 2. Compared to the baseline tutorials, the total number of questions asked increased in all cases bar one when the active learning strategies were used. Furthermore, a greater fraction of the questions were asked openly when the active learning strategies were used.

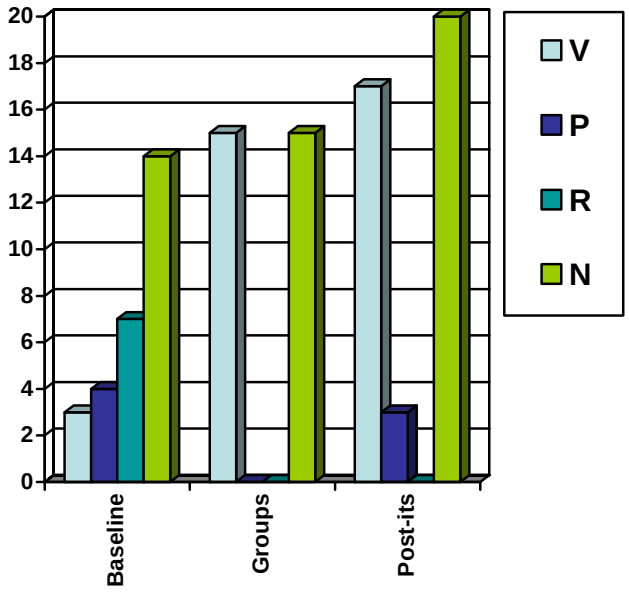

Figure 1: Number of questions recorded during Space Vehicle Design tutorials for each teaching strategy. V, P, R, and N are the counts for each class of question defined in the Method.

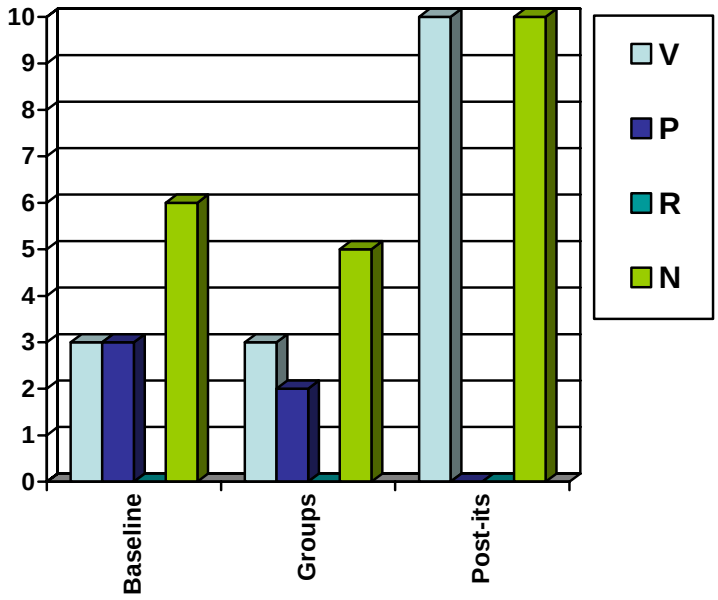

Figure 2: Number of questions recorded during DEFS tutorials for each teaching strategy. V, P, R, and N are the counts for each class of question defined in the Method.

The primary statistics that we are interested in are those that indicate the value that students derive from tutorial questions-and-answer (Q&A) sessions. It is our belief that students benefit from hearing the answers to their peer's questions. The student surveys we conducted confirm that our students share this belief. Thus, we can take the total number of distinct questions that the students hear answered, normalized by the number of students (n), to be an indication of the value (v) of a tutorial Q&A session:

$v = V/n$

While this is a useful variable, a high value of v may be obtained if the students simply ask many questions, both publicly and privately. As we are interesting in promoting open communication, we also are need an indication of the "degree of openness". The number of public questions V, divided by the total number of questions N is such a measure:

$\tau = V/N$

Finally, we want to measure how efficiently the teacher spends his time in the tutorial. Inefficiency comes from answering the same questions repeatedly. Thus we define efficiency η as the faction on questions answered that are not repeated:

$\eta = (N - R)/N$

We calculate these statistics and the mean student response for each strategy against that of the baseline. We will rank each strategy based on these separate metrics.

Analysis for Space Vehicle Design

Strategy	Basline	Small Group	Post-its
Value	0.05	0.30	0.36
Openness	0.21	1.00	0.85
Efficiency	0.50	1.00	1.00

Table 1: Performance metrics for Space Vehicle Design tutorials.

The performance metrics computed from the data gathered from Space Vehicle Design tutorials is shown in Table 1. The first striking result is that the strategies were both highly successful: the value, openness and efficiency of tutorials all increased dramatically from the baseline case. Note that the numerical values of v are low because it is normalized by the class size, which at 56 is quite large for Space Vehicle Design.

Let us first discuss the efficiency of tutorials. Both strategies trialed completely eliminated repeat questions, thus the teacher was able to use his time to convey more information to the students. This lack of repeat questions can be directly attributed to the fact that the vast majority of questions transitioned from being asked privately in the baseline tutorial, to publicly in the trial tutorials. This is because if the students hear all of their peers' questions, they will not repeat them in that tutorial, provided they are answered clearly by the teacher.

The value of the tutorials was significantly increased by the application of both strategies. The total number of unique publicly asked and answered questions increased from 3 in the baseline tutorial to 17 in the tutorial with small group discussion and 20 in the tutorial where post-it notes were utilized. This success can be attributed to several factors. Both strategies allow the students to ask questions in a less intimidating fashion than simply standing up in front of your peers and speaking out publicly. In addition, both strategies in some way "force" participation: groups are told they "must" formulate a question by the end of their discussion time and students are "required" to write a question on a post-it note.

While the value of tutorials was enhanced to a similar degree by both strategies trialed, the increase in open communication within the session was found to be quite different for the two sessions. For the small discussion group strategy, after each group had put forth its required single question, the students continued to ask questions openly so that all could benefit from hearing the query and answer. This was exactly the desired effect: students were actively learning in an interaction with their peers, teacher and the subject matter (Kahn & Kyle, 2002). There were no questions asked in private, making this strategy 100% effective in increasing the openness of the session. In the following tutorial, where no strategies were trialed, it was noted that some of the openness from the previous session had carried over and students were much more willing to ask questions publicly. On the other hand, it was found that while the post-it note strategy resulted in many questions being answered, it did not encourage the students to speak openly. This may be due to the format in which the questions were heard. After the students had written their questions on the post-it notes, they were read aloud and answered by the teacher. This did not "get the students talking". The result was that, after the questions on the post-it notes had been answered publicly, the students returned to their prior practice of asking questions in private.

The post-it note strategy was found to raise new issues for the teacher to deal with. As the students' questions are anonymous, they took the opportunity to be humorous. Humorous questions that were written down included:

"How many roads must a man walk down, before you can call him a man?"

"What is the flight speed of an African swallow?"

"What is your perfect Sunday?"

"So I have this rash …"

The teacher then has to make on-the-spot decisions on how to handle such questions. Fortunately none of the questions were offensive, although the potential for such questions is present with the post-it note strategy. How to handle humorous questions such as these is not an issue Wheatley was familiar with. He made the decision to answer the questions for the most part, leading to a good atmosphere in the tutorial session, but compromising the efficiency of the tutorial as the time spent answering course related questions. We believe that putting the teacher in the position of either disappointing the students by ignoring their attempts at humor, or alternatively spending valuable contact time on frivolities, is a negative aspect of the post-it note strategy that is not shared by the group discussion strategy. Another event that reflects negatively on the post-it note strategy is that upon hearing about it, two students from Space Vehicle Design immediately left the tutorial rather than participate. Despite this, there was only one negative comment on the course and teacher SELTs regarding Wheatley's attempts to increase participation in tutorial sessions. This was "Don't bother with post-it notes, wastes time". On the other hand there were three positive comments on the topic.

Analysis for DEFS

Strategy	Basline	Small Group	Post-its
Value	0.15	0.15	0.50
Openness	0.50	0.60	1.00
Efficiency	1.00	1.00	1.00

Table 2: Performance metrics for DEFS tutorials.

The performance metric computed from the data gathered from DEFS tutorials is shown in Table 2. The first thing to notice is that no repeat questions were ever asked, resulting in a efficiency of 1 for each strategy. Clearly, repeated questions didn't turn out to be a significant issue for this class. Of course, this class was not large (especially in comparison with Space Vehicle Design) and it would be less probable for students to ask the same question.

Group discussion had little effect on both the value (the number of questions) and openness (public versus private). On the face of it, post-it notes appear to have increased the value and openness. Unfortunately, the data do not distinguish between questions that were asked as a result of the strategy and those that were spontaneous. In fact, in this case the post-it notes elicited only 2 questions, whereas a further 8 questions were asked throughout the course of the tutorial. It is impossible to tell if these additional questions were a residual effect of the post-it note exercise or just that students had more questions about the material itself. Anecdotal evidence suggests that the students found the material in the final tutorial more difficult to grasp and would support the latter conclusion.

Analysis of Survey Results

In the final session, students were asked to complete a survey. The aim of the survey was to establish students' views regarding the importance of questions, their willingness or otherwise to ask them and the efficacy of the tested techniques and other tutorial activities. Students were asked to indicate the extent of their agreement or disagreement with the thirteen statements listed in Table 3 on a five-point scale from Strongly disagree (1) through to Strongly agree (5). Statements 1-5 aimed at establishing whether students were comfortable asking questions and if not, why not. Statements 6-7 were designed to find out how students regard the importance of questions and their answers. Statements 8-11 deal with the specific strategies tested in this project. Statements 12-13 deal with other common tutorial activities including tutor demonstration and student practice of problem solving. Students were also given the opportunity to provide written responses to the questions:

- How can class participation and communication be encouraged in tutorials?
- In what way could tutorials be made more useful?

Tables 4 and 5 summarize the student responses to the survey for Space Vehicle Design and DEFS respectively.

1.	I am comfortable asking questions in tutorials whenever I need something clarified.
2.	I usually prepare for tutorials by attempting the tutorial questions.
3.	I am reluctant to ask questions in tutorials because I don't feel properly prepared.
4.	I am reluctant to ask questions in tutorials because I do not want to make my gap in knowledge public.
5.	I am reluctant to ask questions in tutorials because I do not like to speak in public.
6.	I do not need to ask questions in tutorials.
7.	Hearing answers to other students' questions is beneficial to me.
8.	I feel comfortable discussing my questions and concerns in a small group of my peers.
9.	Small group questions are a good way to encourage class participation and communication.
10.	I am more likely to ask a question if I can ask it anonymously.
11.	Written questions are a good way to encourage class participation and communication.
12.	In tutorials, I learn best when the tutor demonstrates the solution of a problem.
13.	In tutorials, I learn best when I try to solve problems under the guidance of a tutor.

Table 3: Student survey questions. Students were asked to respond with Strongly disagree (1), Mostly disagree (2), Neutral (3), Mostly agree (4), or Strongly agree (5).

Q	1	2	3	4	5	6	7	8	9	10	11	12	13
AVG	3.8	2.8	3.0	2.6	2.6	2.4	4.1	3.8	3.6	3.1	3.4	3.9	3.6
MED	4	3	3	2	2.5	2	4	4	3	3	3	4	4
%>3	70	25	28	28	35	15	83	70	47	32	45	79	58

Table 4: Student survey responses for Space Vehicle Design. Q is the question number, AVG is the average student response, MED is the median student response and %>3 is the fraction of students who mostly or strongly agreed with the statement. The highlighted questions specifically refer to the tested techniques.

Q	1	2	3	4	5	6	7	8	9	10	11	12	13
AVG	3.9	3.1	3.1	2.7	2.1	1.9	4.1	3.6	3.3	3.1	3.3	3.9	3.4
MED	4	3	3	3	2	2	4	4	3	3	3	4	3.5
%>3	72	28	39	33	6	0	78	61	33	28	44	78	50

Table 5: Student survey responses for DEFS. Description as for Table 3.

The trends in the survey results from the two classes are broadly similar, especially if one focuses on the median response. Evidently, the two separate student bodies hold similar views. We therefore discuss the survey results collectively and point out particular differences as they arise.

The survey results indicate that students recognize both their need to ask questions and the value of hearing answers to other students questions. Less than 15% of students thought they didn't need to ask questions (statement 6) and about 80% of students believed they benefited from hearing the answers to other students questions (statement 7). This result reinforces our view of the value and importance of questions in teaching and the need to ensure that students are not inhibited from asking them.

Most students in the two classes say they felt comfortable asking questions in tutorials whenever they needed clarification, with about 70% agreeing to statement 1. This contrasts with our original perception that students were not comfortable asking questions in tutorials because the number of questions asked publicly in the tutorial was low and many questions were asked privately or even outside the tutorial. Perhaps students felt that there was little that needed clarification. This might be the result of superb teaching, however it is more likely a symptom of students not engaging actively with the course material and therefore not encountering circumstances that raise questions. Indeed, only 25-28% of students claim to prepare for the tutorial by attempting the set questions (statement 2). If this is the case, then it may be possible to improve student participation in tutorials by implementing strategies that encourage students to actually attempt the set questions.

Although most students are apparently comfortable asking questions in tutorials, there is still a significant minority who are not. The survey suggests that there are a range of reasons why these students are sometimes reluctant to ask questions. Indeed, for Space Vehicle Design the proportion of students who are reluctant to ask questions for each of the reasons given in statements 3-5 is roughly the same at around 30%. For DEFS, the results are somewhat more stratified. The most popular reason that DEFS students were reluctant to ask questions was that they didn't feel properly prepared (statement 3), followed by concerns about publicly admitting their lack of knowledge. Such feelings would be consistent with a lack of preparation. Less than 6% of DEFS students felt reluctant to ask questions because they didn't like public speaking, whereas 35% of Space Vehicle Design students felt this way. This is the most significant difference in student opinion between the two classes. Perhaps students in DEFS felt less threatened about public speaking because the class was smaller.

Small group discussion has the potential to alleviate fears of public speaking and embarrassment by reducing the immediate number of listeners and providing a certain degree of anonymity. It also allows students to clarify their thoughts by interacting with other students. The survey confirms that most students (60-70%) are comfortable discussing their questions or concerns in a small group (statement 8). Given that about the same proportion of students already felt comfortable asking questions generally, group size may not be an issue for most students. More Space Vehicle Design students thought that group discussion was a good way to promote class participation and communication than those in DEFS, although in both cases this view was not overwhelming. To some extent, the difference in opinion between the two classes mirrors the difference in the statistical data which indicates that the DEFS students did not respond to class discussion. The difference in opinion may reflect the different nature of the two subjects. The problems considered in Space Vehicle Design are more open in nature than those studied in DEFS, which generally have a unique solution. Problems in Space Vehicle Design are therefore likely to be more amenable to group discussion.

Asking questions by post-it note guarantees complete anonymity. As most students say they are comfortable asking questions when they need to, it is not surprising that such a guarantee does not make most students more likely to ask a question (statement 10). Again there is a significant minority (28-32%) who see this as beneficial. Nevertheless, about 45% of students felt that written questions are a good way to encourage class participation.

Out of interest, the final two statements deal with some conventional tutorial activities. Nearly 80% of the students think that they learn best when the tutor demonstrates the solution of a problem, whereas 50-58% think that they learn best when they try to solve a problem for themselves with the assistance of a tutor. Evidently, some students think they learn best doing both! Clearly, there is strong student preference for the more passive of the two activities. This preference may reflect the limited level of student preparation for tutorials. It may reflect a relatively

superficial notion of learning as the emulation of certain procedures or practices. On the other hand, there may be some value in studying how experts solve problems after all.

Evaluation and conclusion

Broadly, we found that both strategies were successful in that they consistently increased at least one of: number of student questions, degree of openness, or efficiency, while never causing a decrease in any of these metrics. The difference in success between Space Vehicle Design and DEFS might be attributed to the smaller class size. Perhaps below a certain number of students these strategies are not required. Student opinion on both strategies was slightly favorable. For DEFS the students favored the post-it note strategy over group discussions, mirroring that fact that only this strategy increased the number of student questions. In Space Vehicle Design, the students favored the group discussion strategy, even though this resulted in fewer student questions. We believe this is due to the group discussion strategy being more effective in promoting open communication of questions, which our survey results show the students value greatly.

Overall, we favor group discussion over post-it notes as a strategy for promoting open communication in tutorials for a variety of reasons. Firstly, in Space Vehicle Design, it was found that group discussion was much more effective in promoting open communication, outweighing a small decrease in the total number of questions answered. The statistical results from DEFS are inconclusive. Secondly, both teachers found that the group discussion strategy was easier to implement and there were no negative survey/SELT comments on the group discussion strategy. Finally, the post-it note strategy gives the students the opportunity to ask humorous/offensive questions due to anonymity, potentially placing the teacher in an awkward position.

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