Use of active learning techniques in the teaching of surface and colloid science in a small class setting

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1. Introduction

According to Obenland et al. (2013) and references cited therein, active learning refers to a variety of methods were students are engaged in activities such as class discussions, think-pair-share discussions, problem-based learning and Socratic dialog. Machemer and Crawford (2007), on the other hand, distinguish between active learning as "doing", and cooperative or collaborative learning as "doing with others". In either case, the methods described above contrasts the dominant conventional lecture format where students are passive receivers of information provided by the lecturer (Walczyk and Ramsey, 2003).

According to Drew and Mackie (2011), and references cited therein, the notion of the active learner as proactive, self-motivated, self-regulated, independent, responsible and reflective is a recurring theme in literature on educational research. A student that is interested in the subject being thought is likely to be both self-motivated and self-regulated. When combined with the ability to be proactive and reflective, the student is likely to develop deep knowledge, and consequently analytical skills related to the subject of study. The challenge is how to encourage the students to become active learners.

With this in mind, the primary objective of this project has been to provide the students some tools, which may help them to become active learners, and invite the students reflect over their learning experiences in a series of surveys. The tools I will use are active and collaborative learning techniques incorporated in a clear lecturing strategy. In this report, active learning will be used to refer to activities, as specified in section 2, taking place during the lectures to actively engage the students. Collaborative learning, on the other hand, will be used when referring to situations were students work on problem solving in small groups (see f. ex. Prince, 2004).

2. The lecture environment

Lecture setting

The setting for this research was the course in surface and colloid science (KJEM214) at the University of Bergen. Most of the students in this course are in their 7th or 8th semester, i.e. they are at the beginning of their MSc studies. The course is one of the courses at the department of chemistry thought in English. This semester, 22 students enrolled for the course.

At the beginning of the semester, there are a total of four hours of lectures, divided into two sessions, each week. Roughly halfway through the semester, one of these sessions is made into an exercise solving session.

The active learning approach

This year I started the first lecture by presenting the course learning outcomes, as the teaching strategies that would be used. The latter included that I would try to actively engage the students in the lectures, and that preparing for the lectures is key to maximizing the learning outcome from attending the lectures. I also informed them that I would post slides for the lectures on MySpace no later than the day before the lecture, as a means of helping them prepare

I also paid special attention to the structure of the lectures, and actively used a simplified version on the BOPPPS technique (UBC Health Library Wiki) with emphasis on bridge-in, outcome, participatory learning, summary (BOPS). Particularly the bridge-in sessions were actively used to draw attention to every day examples and practical applications of the topics to be discussed. As well as promoting the students interest in the topic, it also further added to my own enthusiasm for the lecture, which inevitably leads to better lectures. Specifying the outcome or learning points from the lecture also helped me when structuring the lecture and deciding on topics to include or leave out.

In each of the lectures, two or more sessions where the students were engaged in the learning process were incorporated. Of the most commonly used learning activities were pair-share, brainstorming sessions, demonstrations and Socratic questioning. Examples of the activities listed above are as follows:

Pair-share: what can be done to promote the wetting of a solid surface? Take 2-3 minutes to discuss with the person or persons next to you, and then we will hear form some of you.

Brainstorming sessions: what are the factors influencing the CMC of a surfactant? We then explore the question together using input from students and lecturer, while we simultaneously gather all the information on the blackboard.

Demonstrations: a few demonstrations of surface and colloid science in every day life were made, including a discussion before and after the demonstrations.

Socratic questioning: was used in connection with all of the above activities to challenge students about their assumptions, investigate alternative perspectives, etc.

The collaborative learning approach

A collaborative learning approach was introduced in the exercise solving sessions. This also involved changing classrooms from the assigned auditorium to a group room. Before the sessions, the students were given a set of exercises gathered from old exams. At the lecture, the students were then placed in groups of three to four, and given a subset of these tasks to solve and present to the rest of the students.

3. Research method

Three anonymous surveys were completed during the course of the semester; one after the first two lectures, one after ten lectures, and one at the end of the course. With 22 students enrolled for the course, of which 70% regularly turned up for the lectures and thus answered the surveys, statistical analysis were not feasible. As an alternative, the observations, together with some of the statements made by the participating students, are summarized and discussed in the following paragraphs.

4. Results and discussion

In surveys 1 and 2 were designed to get feedback from the students on the active learning techniques used, their participation in class discussions, and if their opinion on participation changed from early to late in the semester. Survey 3, on the other hand, was more focused on student attendance in class, and how they rated the learning outcomes from different learning activities. Consequently, surveys 1 and 2 will be discussed together and separate from survey 3.

Surveys 1 and 2

In the first survey, conducted after the completion of the second lecture, 17 students responded. Of these, 11 (around 65%) had prepared for the lecture. According to the survey, a large majority of the students found the active learning sessions to be very useful. Although continued emphasis was put on the importance of preparing for the lectures, the number of students that had prepared for lecture ten was significantly lower than that for lecture two (4 out of 15, i.e. around 27%). Of the students who hadn´t prepared, four said it was the first time they hadn´t prepared, and gave a reason for their lack of preparation. Thus, it can be assumed that late in the semester, around 50% of the students regularly prepared for the lectures.

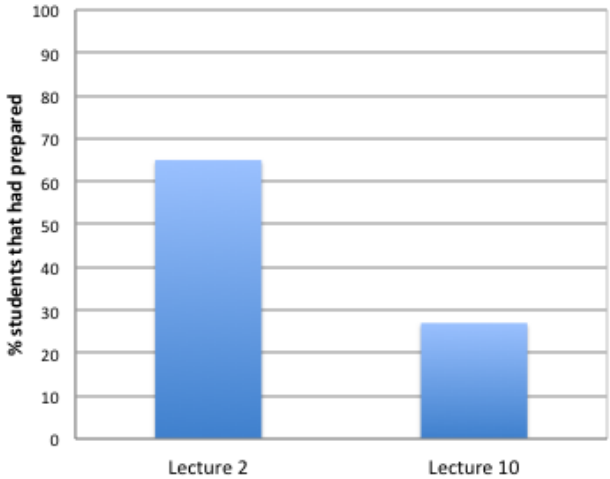

Figure 1: Chart showing the percentage of students that had prepared for the lectures early (lecture 2) and late (lecture 10) in the semester, respectively.

Pair-share: The students evaluation of the pair-share sessions can roughly be grouped in two categories; one related to social aspects and one related to cognitive aspects. With regards to the social aspects, some of the statements were “It gives a

community sense to the class", "I get to know others in the class", and "It gives me a chance to improve sociability". That the social context in which learning occurs may have a strong influence, particularly on the motivation to learn, is well known from educational research. As such, socializing the students into feeling part of a group by involving them in class activities is expected to have a positive effect on their learning.

With regards to cognitive aspects, the students report that they learned a lot from listening to other students approach to solving problems, and that it helped them solve doubts with regards to the topic being discussed. Further, they also described that these sessions made them more skilled in translating their perceptions into words, and to shearing ideas.

Four of the students that said they had prepared for the lecture shared some perspectives that inspire discussion with regards to how the pair-share activities are best conducted. Two of these commented that if the person you pair with is unprepared, the exercise is futile. A third noted that he or she didn´t know if two people was enough, which may be related to the same challenge, i.e. that one or both parts of the pair was unprepared.

Lack of preparation may be a challenge with regards the use of some active learning techniques, particularly if it leads the students to shut off from activities out of fear from sharing misconceptions. If prepared students are paired with unprepared students, or if two unprepared students are paired it may be difficult to get a meaningful discussion of a topic. The activity can then ultimately demotivate both prepared and unprepared students from participation in the lectures. Thus, in retrospect, it may have been a good idea to get an overview over prepared and unprepared students at the start of each lecture, and then adjusted the class activities accordingly.

Brainstorming sessions: Most students replied that they valued the brainstorming sessions. Common factors included that they helped them stay focused, follow the lecture better, and keep track of what they learn. Some also noted that the use of these sessions inspired them to prepare. The survey also revealed that quite a few students suffered from performance anxiety, and were scared of being asked to share their thoughts and not being able to answer. But, as one student puts it: "It makes me very nervous, but I have to admit that the method really helped me focus on the lecture and to open my mind. Generally it is very helpful."

Class participation: In survey 2, the students were asked if they often contributed to class discussions, and if not, why. Further, those who responded that they did not often contribute was asked why this was the case, and if they still felt it contributed to their learning. Finally, they were asked if participation in class discussions got easier, more difficult or was more or less the same later- compared to earlier in the semester.

Of the 15 students, 5 responded that they contributed often, and 10 answered sometimes, when asked, or not often. Of the latter, all blamed their lack of participation on fear of saying something wrong, particularly if they had not prepared for the lecture. However, they still felt it contributed to their learning. When asked if participation had gotten easier, more difficult or was the same as the semester wore on, 5 said easier, 2 said more difficult, while 8 said it was the same. Those who found it easier gave becoming more familiar with the other students and getting more confident as the reasons, while those who found it more difficult said it was because the topics had become more challenging.

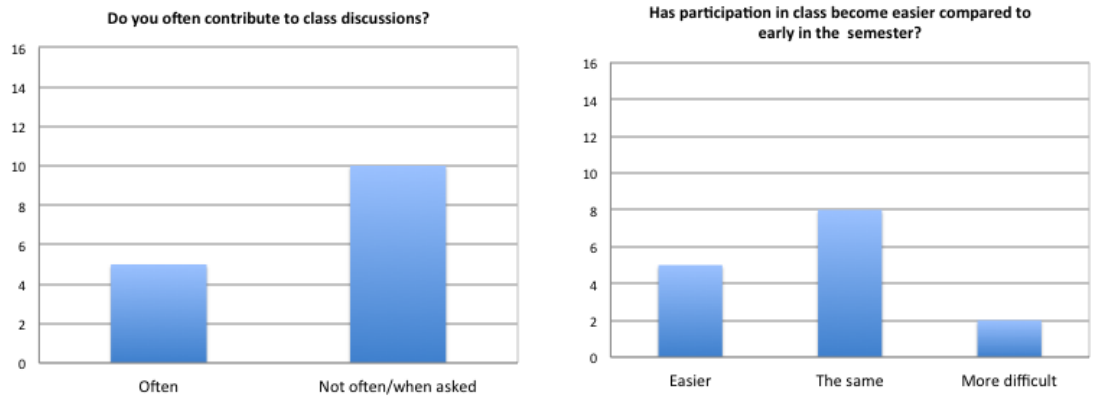

Figure 2: Chart showing students evaluation of their own contribution to class discussions (left) and whether or not participation in class discussions were easier now, i.e. in lecture 10, compared to early in the semester (right). Number of students out of a total of 15 on the y-axis

Demonstrations: One demonstration was done in the second lecture, and in the survey following this lecture the students were asked if it was useful, and if so, why. While 16 of 17 students found it to be useful, one replied "no, but it´s always fun". From those who did find it useful, some of the comments were: "it is useful to see the theory in practice", "good because I´m a visual learner", "better understanding of the theory", "because we used the concepts thought in the following class", and "it makes me more interested and engaged in what we cover in the lectures". It should also be noted that in the final survey, one of the students commented that he or she would like more practical examples if possible.

Survey 3

In the third and final survey the students were asked to give feedback on how large shares of the lectures and exercise solving sessions he or she had been attending, on how they evaluated the learning outcomes of different learning activities, and on how well they felt that the course content was aligned with the learning outcomes. 11 students answered the survey, of which 82% had attended more than 75% of the lectures. The corresponding number for the exercise solving sessions was 64%. With regards to the alignment between the learning outcomes from the course and the actual content of the course, the students score this on average as 4.4, which must be said to be satisfactory.

The students were asked to score their learning outcome from each of the following activities on a scale from 1 (very low) to 5 (very high): the lectures, reading the text

book, reviewing the lecture notes from MySpace, the exercise solving sessions, and discussions during the lectures/exercise solving sessions. The results, in the form of average scores, are displayed graphically in Figure 3. As can be seen from the graph, learning activities based on collaborative and active learning scores significantly higher than self-study in the form of reviewing lecture notes and reading the textbook. It can also be noted that there is general consensus, i.e. little spread in the rating, about all of the learning activities except reviewing the lecture notes from MySpace. Some find this a learning activity with high outcome (4-5), while three students rates it at 1-3. It is possible that this depends on whether or not they consider reviewing the notes before or after the relevant lectures since they only contain key concepts and ideas, and as such does not provide a stand-alone comprehensive treatment of the syllabus.

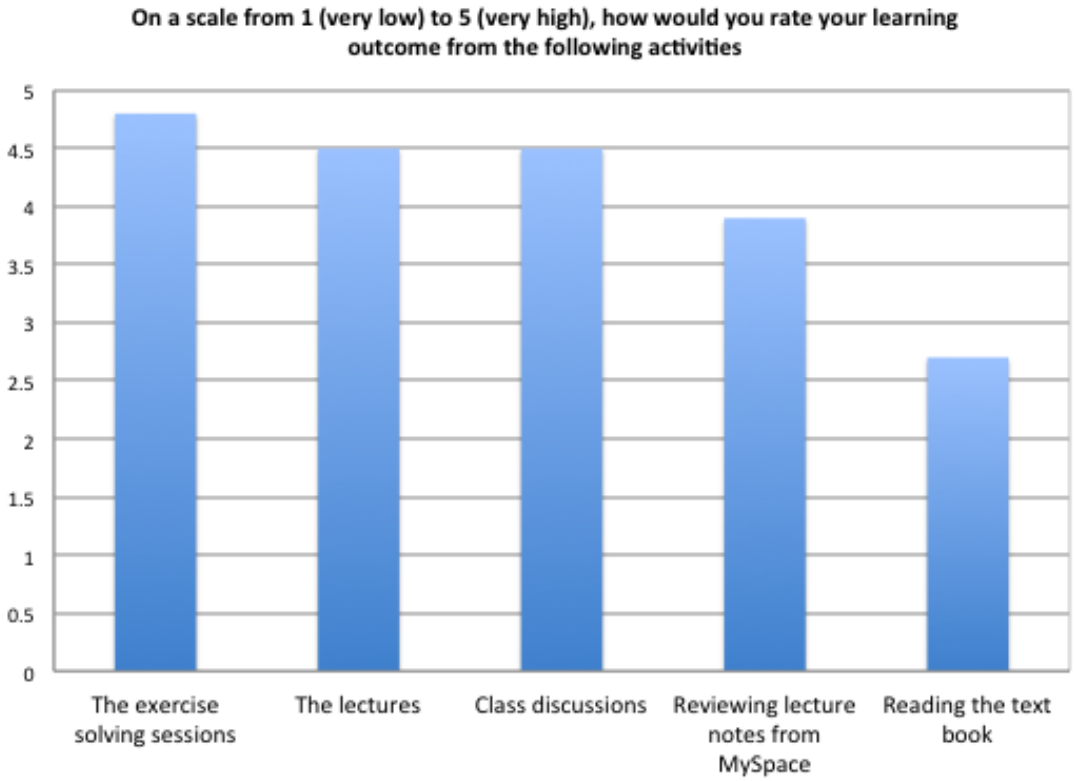

Figure 3: Chart showing the average score of different learning activities with regards to the students perceived learning outcome.

5. Summary and conclusions

The main impression from the two first surveys is that the students find the active learning sessions to motivate learning, to focus their attention on the lectures, and to learn from other students' conceptions or misconceptions. Even the students who report that activities which requires them to communicate their knowledge to a fellow student, or the class, makes them feel nervous and self-conscious see these activities as a valuable part of the lessons.

An obvious challenge related to active learning involving pair-wise discussions arises when one or both discussion partners are unprepared. This is also reflected in comments made in the survey. Even though the students are continuously reminded that preparation is key to maximize the learning outcome from the lectures, the surveys show that the fraction of students that prepare for the lectures is likely below 50% as the semester wears on.

When asked to evaluate the learning outcomes from different learning activities, the exercise solving sessions scores highest at 4.8 out of 5. In the additional comments field, one student also writes: “Should have Monday lectures and Thursday exercise solving all year”. The perceived learning outcomes from the exercise solving sessions are closely followed by the lectures and discussions at an average of 4.5, while self-study in the form of reading scores significantly lower.

6. Some directions for the future

Judging from the students’ feedback, there should be continued emphasis on the use of active and collaborative learning techniques in future teaching of this course. However, some adjustments with regard to which activities that should be used may be necessary to further improve the quality of the teaching. Specifically, it may be beneficial to cut back on pair-share activities in order to overcome possible challenges related to lack of student preparation.

The exercise solving sessions scores high on the students´ perceived learning outcome, and one student comments: “Should have Monday lectures and Thursday exercise solving all year”. A natural consequence of this is to start with the exercise solving sessions much earlier. Also, the format this year of having the students work in groups and then reporting their results, will be continued.

Most of the students found the class demonstrations to be very useful in terms of increasing their interest in the topics covered in the lectures and to see the theory that is thought in practice. Another student commented that he or she would like to see more practical examples and applications. One way of further improving the link between theory and practical examples and applications is to include laboratory exercises as part of the course. This has been discussed previously, and the results from this report indicate that it may be worthwhile to consider more closely.

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