Improving students learning process in a small class setting

- chemistry course in spectroscopy -

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Abstract:

1. Introduction

Organic chemistry is a traditionally difficult subject with high failure and withdrawal rates and many areas of conceptual difficulty for students (Grove *et al*., 2008, Flynn 2015). The author teaches a small group of students (10-25) in organic spectroscopy each fall. This course handles the traditionally organic analytical spectroscopy techniques (UV-vis, IR, NMR), including mass spectrometry (MS), used for getting structural information at molecular level. Students attending the course are at Bachelor and Master Level and the course includes laboratory work.

Active learning has received considerable attention over the past several years (Prince 2004, Obenland *et al*., 2013). The traditional "engineering" educations, including chemistry, are already "active" through assignments/problem-solving and laboratory work, but Prince (2004) states that many engineering faculties do not always understands how the common forms of active learning differ from each other. According to Obenland *et al.* (2013) and references therein, "active learning" generally refers to any of a variety of teaching methods that engage students in participation during class times, including class discussions, "clicker questions", think-pair-share discussion, peer-learning, problem-based learning (PBL) and Socratic dialog. Included in the principle of "active learning" plays collaborative learning an important part. Collaborative learning can be viewed as all group-based instructional methods, including cooperative learning – where the latter focus on cooperative incentives rather than competition to promote learning (Price 2004). The basic of both collaborative and cooperative learning is constructivism: knowledge is constructed, and transformed by students (Dooly 2008).

Active learning requires students to do meaningful learning activities in the classroom and think about what they are doing, in contrast to the traditional lecture where students passively receive information from the instructor. Research and practice have shown that students as a group in active learning environment perform better, enjoy their courses more, and remain in the classes at a higher rate (Obenland *et al*., 2013, Michael 2006, Price 2004).

Flipped learning is an additional principle of learning that has grown in popularity in recent years as a mechanism of incorporating an active learning environment in classrooms (Teo *et al*., 2014, Seery 2015, Flynn 2015). It is originally a means of allowing all learner to engage with lecture material (Lage et al., 2000, Seery 2015), but it has been formalized into a pedagogical approach for presenting material to student in advance of calls and enabling active learning environment to take place during formal class time. The Flipped Learning Network issued the following definition (Flipped Learning Network, 2014):

"Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter"

There is long traditions for handing out material in advance of calss, but flipped learning aims to harness this pre-lecture preparation to subsequently change the formate of the lecture time, from mainly passive activity to one primarily focussed on student activity (Seery 2015).

The object of this project was to get the students engaged in the traditionally lectures though collaborative learning; including pair-share discussions/group-sessions and elements of flipped learning strategy. The intention, in addition to engaged the students, provide learning-tools and increases the learning outcome, was to create a "safe" and more "familiar" learning environment to encouraged students to engage more (Obenland 2013). It may be a bit provocative to state this, but in general Norwegian students have no strong tradition for being highly active in a class setting. At least not at higher educational level at the Open University at natural science disciplines where there often is a lack of "class-feeling". It is also a part of the picture that the traditional disciplines, as chemistry, have a long history of individual learning and problem solving and often attract people who prefer this.

2. The class setting

The course which gives the setting for this project is 50% (5ECT) of the Analytical Organic Chemistry course (KJEM230 – 10ECT) lectured at the Department of Chemistry (UIB). This course is divided into a spectroscopy part (50%) and a chromatography part (50%). Five laboratory exercises are included. Here the students work together in groups of 2-3 persons.

The author teaches the spectroscopy part where the traditional organic analytical techniques as UV-visible, IR (Infrared), NMR (Nuclear Magnetic Resonance) and the metric method MS (mass spectrometry) is handled. The students attending the class are at bachelor and master level and the numbers of students varies from approximately 8-25 each fall. This fall (2015) 9 students follows the course. Some international students take the course this year, so the 2 hours of lectures each week are therefore given in English. The regular lectures are based on the author explaining concepts and the students take notes. The full lecture can be downloaded from 'My Space' after the lecture. On a regular basis assignments will be uploaded to 'My Space'. It is then announced when these assignments will be explained in the lectures by the author/teacher at the board.

The five laboratory exercises govern to some extend how the spectroscopic syllabus is presented in a timeline. The students download the exercises from the University student portal "My Space"/"Mi side" and prepare for the laboratory work on their own. In spectroscopy understanding the different concept of the different techniques and understanding how to analyses data from these techniques, to be able to characterize organic molecules and to be able to perform a full structural elucidation, is essential. The fifth and last exercise the students are handed an unknown compound. They are then recording analytical data (IR, MS, NMR) themselves and perform the structural elucidation based on their own data. The students prepare a journal after each exercise which is corrected. When we have finished the syllabus approximately 4 double lectures are devoted to explanation of old exam questions handed out on forehand, and the main focus here is *training* the students in structural elucidation.

3. Object and Method

The object of this project was to get the students engaged in the lectures and problem solving's through collaborative learning; including pair-share discussions/group-sessions and elements of flipped learning strategy. The intention, in addition to increase the learning outcome, was to strengthen the "class-feeling" and create a "safe" and more "familiar" learning environment believing that this is crucial to facilitate active learning.

3.1 Course setup

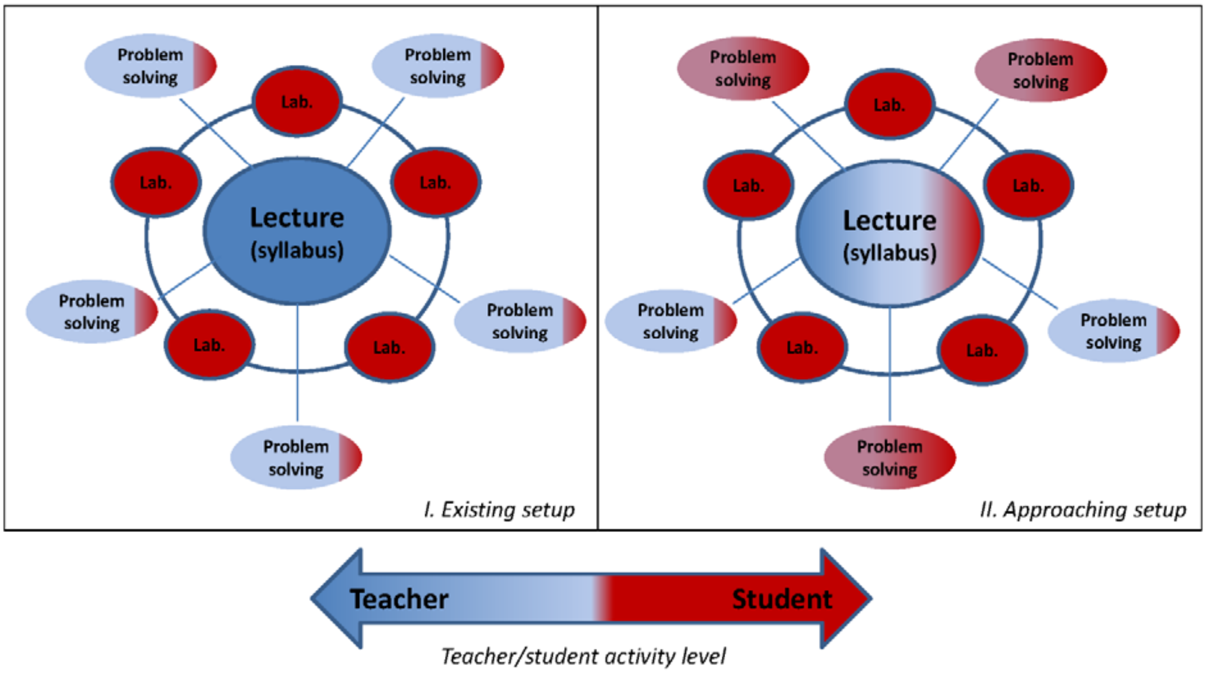

Figure 1: *Illustration of course setup. The gradient use of blue (teacher) and red (student) colors is aiming to illustrate the teacher/student activity level.*

Fig. 1 illustrates the existing and approaching course setup with respect to teacher and student activity level. Below is the two setups (I & II) explained.

I. Existing setup

- Contains high level of student activity with respect to laboratory work, which is both cooperative and collaborative – where the cooperative part relies on the student's contribution/engagement.
- Has assignments/problem-solving. The weakness with the problem-solving is that it relies on the fact that students have prepared themselves before the teacher solve the problems in class. It is also difficult to get the students engaged during the solving with discussion and answers since most of them don't prepare and the threshold for speaking out loud seems high.
- Has a highly "traditional type" of lecture where the students are passive receivers.

II. Approaching setup

- Contains the same level of student activity in laboratory work as existing setup.
- Has assignments/problem-solving's where the students are *active learners*.
- Has "traditional" lectures, but has elements of *flipped classroom philosophy* where the students perform "self-directed" learning.

3.2 Method

- *Pair-share discussion/group-session* was introduced into the problem-solving settings and the lectures. The students were divided in to pairs and given problems. They were also given the theoretical information they needed to solve the problems. Sometimes the problems given were similar for the groups, sometimes different. After 20-30 min of pair-share discussion the problems was discussed in class and the teacher summarized the results at the board.
- *Elements of flipped classroom* were introduced in the traditional lectures for one of the key elements of the course – structural elucidation. In the fifth and last exercise the students were going to perform a full structural elucidation based on recorded spectroscopic data and a given unknown compound. An extended guideline for this exercise was uploaded on My Space, where

new syllabus was introduced and the students had du read this on their own as a pre-lesson. The students then performed the exercise in their lab-groups. The lab-groups solved the structural elucidation collaborative. As an end product the different lab-groups presented their results in class as presentations (PowerPoint/board), and educated the other students in this manner – since every group had different unknown compounds. During the pre-class period and executive steps the teacher played a facilitator role in supporting students learning outside the classroom.

3.3 Testing the Student response

A questionnaire, estimated to take 10-15 minutes to complete, was given each student on the final lecture day. The four first questions were designed to get information about the student-participation, with respect to attending the lectures and preparing for class. The rest of the questions were designed to give the students the opportunity to rate the learning outcome of the different activities and to evaluate the introduced group solving sessions/pair-share discussion and exercises 5 with elements of flipped learning strategy. The questions from the questionnaire are shown in appendix A.

4. Findings and Discussion

The fall (2015) 9 students followed the course. 7 students answered the questionnaire (about 78%). The findings of the questionnaire are discussed together with the observations and experiences made by the teacher.

4.1 Preparation

The weakness with the problem-solving in the previous existing course set-up (**I**, Fig. 1) is that it relies on the fact that students have prepared themselves before the teacher solve the problems in class. It is difficult to get the students engaged during the solving with discussion and answers since most of them don't prepare if it's not mandatory. The first part of the questionnaire was designed to get an impression of the student preparation time. The questionnaire showed that 6 out of 7 prepare themselves less than 50% of the time and 3 out of 7 prepare themselves less than 25%. The lack of preparation before lectures and exercises is expected and the smaller the class is the larger the visible negative effect will be on the learning environment. Most of the techniques facilitating active student learning are based on the fact that the students prepare themselves before class. A part of this study has been to introduce pair-share discussion/group work that can be performed without pre-class preparation.

What the teacher has experienced the last ten years is a decreasing trend considering the time the students use for preparing. This can be a result of many things. Introducing the European Credit Transfer and Accumulation System (ECTS, studiepoeng (nor)) in Norway reduced the size of the individual courses and increased the number of courses for the students to attend each semester. The previously given courses have in many cases not been adjusted properly to fit in to smaller ECTS courses, giving the students a possible work overload. Having three or more courses per semester in the new system contra two in the old system can also affect the student's ability to have a deeper focus on each course. What is also observed the last years is the lack of the full-time-student. The governmental financial student support has not increased proportionally with the increasing living cost in Norway – resulting in mots Norwegian students working outside the University during full time study.

4.2 Learning Environment

One of the main goals in this study has been to get the students engaged. The intention, in addition to increase the learning outcome, was to strengthen the “class-feeling” and create a “safe” and more “familiar” learning environment believing that this is crucial to facilitate active learning. Different parts of the questionnaire (Fig. 2) were designed to see how successful the “Approaching” setup (Fig. 1, II) had been related to the learning environment.

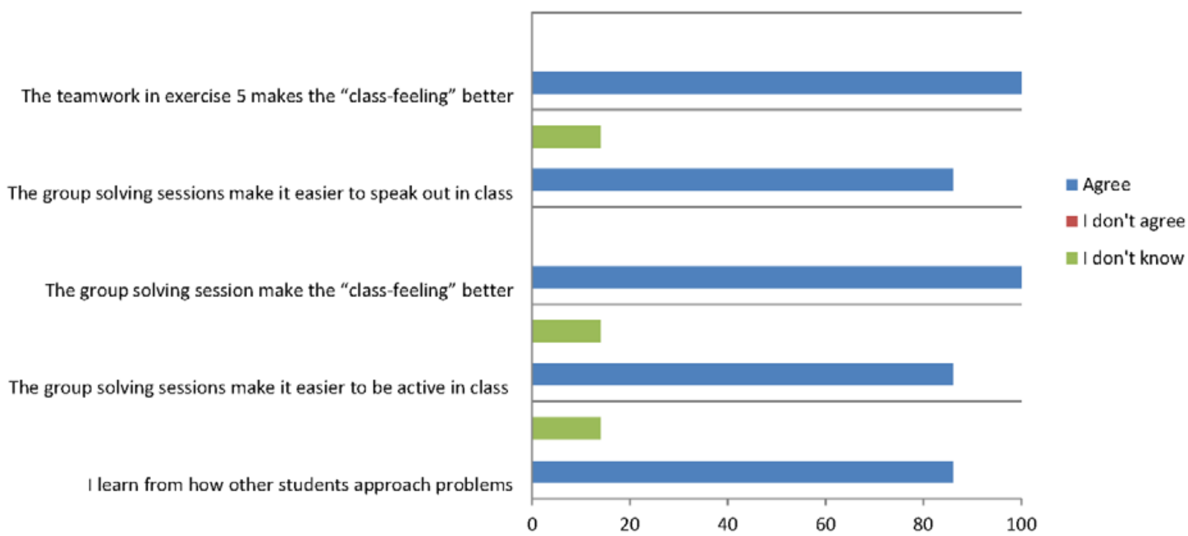

Figure 2: *Student evaluation of learning environment.*

All of the students found that the both the group solving session’s (pair share discussions) and the extended teamwork in exercise 5 increased the “class-feeling”. Most of the students also found that the group sessions made it easier to speak out in class and to be active. 85% answered that they learn from other students approach to problems and it helped them to solve doubts connected to the problem, in accordance to how collaborative work has shown to improve learning (Price 2004, Obenland 2013). All of the students also answered that they felt that the group solving session’s motivated learning. During the semester it was observed that the enthusiasm for the group sessions and the activity level in the groups increased, and a positive and “familiar” atmosphere was created. A total of six group solving sessions were held in addition to the traditional problems solving by teacher. In the questionnaire 100% of the students answered that they wanted to have more of these sessions with co-student(s).

4.3 Learning Outcomes

The fifth question of the survey was given to let the students themselves rank the learning outcome of the different activities from very low (1) to very high (5). Fig. 3 gives an overview over the different activities evaluated and the average student scores.

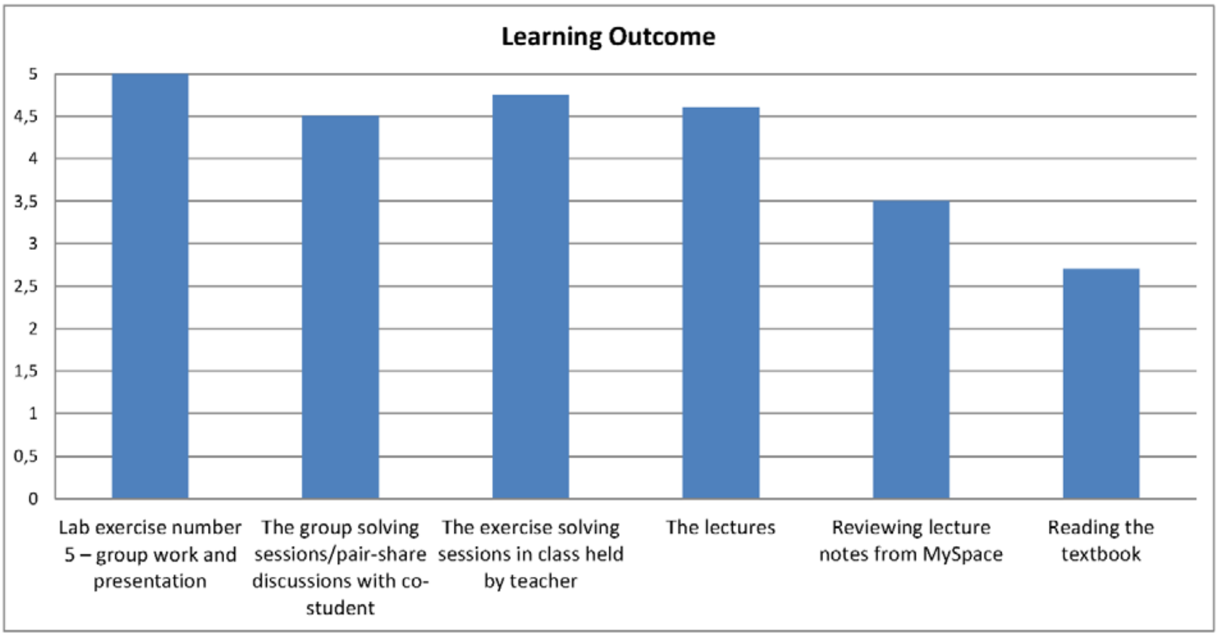

Figure 3: *Student evaluation on learning outcome.*

From Fig. 3 one can see that self-study in the form of reading the textbook and reviewing lecture notes from MySpace have the lowest average score, as expected. To read and understand difficult concepts only by self-study is demanding. The exercise solving sessions held by teacher is ranked with slightly higher learning outcome than the traditional lectures, also as expected – since the solving by teacher is a highly “guided” and exam related session. The students also find that the learning outcome is slightly less for the group solving sessions/pair-share than for the solving session held by teacher. For both of the latter cases it is also difficult, based on the questionnaire, to differentiate on what the students prefer and what is their real learning outcome. The groups solving's though highly relay on the effort of the students, and lack of participation and engagement from one of the students will to a large extend reduce the learning outcome. The group solving's also does not motivate the students to the same extend as the maximum ranked activity 'Lab exercise number 5'. This may be related to the fact that the performance of the group solving's are not tested or evaluated. In 'Lab exercise number 5' elements of flip learning was introduced and the students were in charge of the learning activity, by pre-classroom preparation, executing laboratory work, performing structural elucidation and preparing a presentation of the result – all in a group setting. All of the students answered that preparing the presentation forced them to understand the concepts of exercise 5 more in depth and that they learned from the other student's presentations. The teacher experienced that exercise 5 facilitated deeper learning and prepared the students for more advanced problems at an earlier stage, in addition to increased student engagement and positive effects on the classroom environment (Seery 2015, Flynn 2015).

5. Summary and conclusion

The object of this project was to get the students engaged in the lectures and problem solving's through collaborative learning - and the intention, in addition to increase the learning outcome, was to strengthen the "class-feeling" and create a "safe" and more "familiar" learning environment. Based on a previously 'Existing setup' (I) an 'Approaching setup' (II) was constructed, including group session and elements of flipped classroom in a collaborative setting connected to executive activity in lab exercise 5.

It is difficult to ascertain exactly how effective the 'Approaching setup' is related to the students learning outcome, since the student number is small and the students who attend the course are not familiar with the 'Existing setup' as a reference point. There was no notable difference between the grades of the students in 'Existing setup' previous years and the 'Approaching setup' – but again, the number of students is too small to make conclusions.

The results from the questionnaire shows that the 'Approaching setup' succeeded in strengthening the "class-feeling" and made it easier to be more active in class. Even though the students ranked the learning outcome of problem solving with teacher slightly higher than problems solving in pairs - 100% of the students answered that they wanted to have more of these sessions with co-student(s). The teacher also experienced a strengthening of the class-room feeling in the 'Approaching setup' in contrast to the 'Existing setup'. An interesting result is that all of the students ranked exercise number 5 as the activity with the highest learning outcome – this activity is by far the activity which demands most from the students with respect to preparation, self-study, engagement and cooperative learning.

From the teachers perspective the elements of flipped classroom introduced in this exercise was highly successful. Besides from making the students more self-directed learners, removing some of the syllabus out of the traditional lectures gave room for dealing with more advance problems at an earlier stage. Introducing flipped classroom though, demands that the teacher is available supporting the students learning also outside the classroom, but the teacher did not feel that this increased the overall work-load. Instead introducing flipped teaching elements made the time in the classroom and the teaching feel more meaningful.

In conclusion, in the future the 'Approaching setup' will be used for this class and possibilities of introducing more element of flipped teaching will be explored.

6. References

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