Student perceptions of learning scene efficiencies

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1. Introduction

The process of learning has several different shapes. Bruner (1997) defines four categories: i) learning as imitation, ii) learning as unidirectional transfer of knowledge, iii) learning through activities, reflection and discoveries, and iv) learning through interaction and dialogue. The unidirectional transfer of knowledge has been the most widespread approach in higher education. It is teacher or textbook centred, the students are passive recipients of knowledge, it is known as passive-learning. Activity based learning (iii and iv) —or active learning— is now gaining popularity. The term was introduced by Revans (1982) and denotes a learning process actively engaging the students through reading, discussing and problem solving so that the students are not passive recipients but learn as participants in real activities. Examples of active learning activities include individual or group based problem solving, debates, group discussion, games and puzzles, students teaching one another, laboratory work, peer-review of written material, and role play. Active learning has been implemented at several renowned universities, such as MIT, Stanford and Cornell.

The Geophysical Institute offers two courses in chemical oceanography, GEOF236 chemical oceanography and GEOF336 advanced chemical oceanography. These deals with coupled cycles in the oceans, for example between nutrients, biology, ocean circulation, CO_2, and oxygen, and implications for e.g., climate. The topic is also known as biogeochemistry. The students at the institute normally have a very extensive mathematical and physical background as this is required for understanding the dynamics of ocean and atmosphere circulation, which has traditionally been the main focus of the institute. They are thus not well prepared for the courses on biogeochemistry, these require a fundamental understanding of chemistry and biology. Many students struggle with some of the fundamental issues while taking these courses. The aim of this small study was to unravel the perceived efficiency of different learning scenes in tackling this situation.

2. Experimental setting

The course GEOF336 is based on a set of key papers in chemical oceanography. No textbook is used. Learning normally takes place through the students reading, presenting and discussing the papers. It requires prior knowledge at the level of GEOF236, which is a textbook based course dealing with the fundamental principles of chemical oceanography. The aim of GEOF336 is to familiarise students with some key papers in chemical oceanography, its research front and major unresolved issues. Transferable skills include extraction of knowledge of scientific papers and presentation of key findings. It is aimed towards master and PhD students. The papers cover a total of 10 topics. These are quite diverse:

1. Carbon chemistry

2. Air-sea exchange
3. Marine particle production
4. Fate of organic matter in the ocean
5. Land-ocean transfer of carbon
6. Calcium carbonate
7. Oxygen
8. Silicate
9. Ocean acidification
10. Glacial-interglacial cycles

I had no prior teaching experience when I was assigned to run the course in spring 2016. A total of six students had signed up for the course, one PhD and five MSc students. Only two had the required background, GEOF236, one was a master student from Department of Biology and the remainder 3 were exchange students from European countries. Actually, after briefly evaluating the level of knowledge of each student it became obvious that very few —or maybe even none— of them possessed the knowledge required for contextualising and fully grasping the science and implications of each of the 10 scientific papers to be covered at the course. Even basic matters had to be learnt if they were to obtain the learning objectives. Based on this knowledge the following teaching strategy was developed:

1. For each topic I would give a two-hour lecture, each presenting the basic knowledge through to the context of the paper.
2. I would then hand the students the paper and a set of questions to work on.
3. These questions would be the subject of a 2 hour-long colloquia the following week.

This strategy was made possible by the fact that we had teaching hours every Thursday and Friday. My lectures were delivered on Fridays and the following Thursday the associated set of questions were discussed, giving the students almost a full week to work on them.

3. Survey

The teaching strategy included elements of passive and active learning, passive being the lectures while the assigned questions and colloquia were the active elements. To determine the most efficient learning scene I handed out the survey shown in Fig. 1 to the students at the end of each colloquium (concluding every topic):

When did you learn the most?

Topic Y
Scale 0-5

I knew most from before	
Preparing for the lecture	
At the lecture	
Working with the paper and questions	
Colloquia	
I am more confused than ever	
Other (please explain below):	

Figure 1: Survey form handed out to the students

Of the 7 alternatives, the first 5 covers the potential learning scenes; prior knowledge, preparing for the lecture (I always recommended relevant chapters in the GEOF236 textbook in advance of each lecture), the lecture, the individual work with the paper and questions for each topic, and the colloquium. I included alternative 6 'I am more confused than ever' as I consider confusion an important part of the learning process, and option 7 was included to make room for exceptions that I hadn't thought of. This was never used and is not included in the analyses presented here.

The students could score each alternative from 0-5, where 5 indicates the best learning outcome and 0 none. Repetitions were allowed, i.e., a student could give a score of 4 for both alternative 1 and 2.

4. Results

Altogether 37 score sheets were completed, an average of 3.7 per topic. However, the actual number of score sheets per topic ranges from 2-5, reflecting the different number of students who took part in all learning activities of each topic. The average score per alternative is given in Table 1. Quite clearly this show that the students felt that the colloquia gave the best learning outcome, with an average score of 4.3 ± 0.5. The alternative 'Preparing for the lecture' has the lowest learning outcome 1.5 ± 0.5. Likely, this reflects very few actual attempts at preparing for the lecture and not that any such preparations were unsuccessful. This is an interesting observation, in that encouraging the students to prepare for the lectures evidently has limited effect. The students appear further to have gotten similar learning outcome from the lectures and individual work with the paper and questions, with an average score of 3.3±0.4 and 3.2±0.6, respectively. The average score for 'I am more confused than ever' is 2.1±0.5, approximately half of the average score of perceived learning outcome at the colloquia.

Table 1: Average score and it and standard deviation for each alternative.

Alternative	Average Score	Standard deviation
I knew most from before	2.6	0.4
Preparing for the lecture	1.5	0.5
At the lecture	3.3	0.4
Working with the paper and questions	3.2	0.6
Colloquia	4.3	0.5
I am more confused than ever	2.1	0.5

Figure 2 displays the distribution of scores per alternative. The alternative 'I knew most from before' shows a normal distribution centred around 3, reflecting the diverse prior knowledge of the students. For the option 'Preparing for the lecture', the most typical answer is 0, as mentioned above this can likely be interpreted as no preparations were made. Of the scores above 0 for this alternative, most are either 2 or 3, indicating limited learning outcome from the

preparations that were actually made. None of the students indicated that they learned the most while preparing for the lecture. Most of the students scored the learning outcome from being present 'At the lecture' to 3 or 4, only rarely (on 2

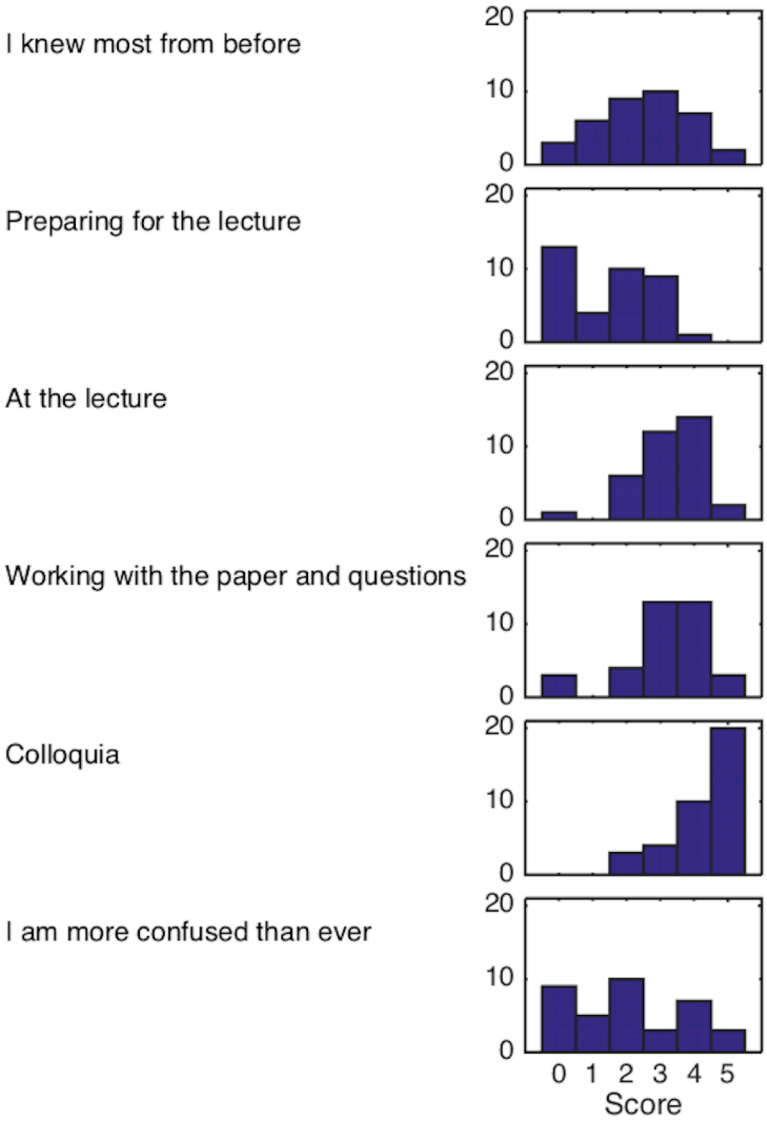

Figure 2: Distributions of scores for each alternative

occasions) did students perceive that they learned learn the most at this learning scene. On the other hand, only once did a student indicate that nothing ('0') was learned at the lecture (fortunately, this was amended during the individual work with paper and questions and the colloquium, which this particular student scored 4 and 5, respectively, for this topic, and level of confusion at the end was scored only 2). The distribution of scores for 'Working with the papers and questions' is by and large similar to that of the scores of the lectures. For the colloquia, the distribution of the scores is clearly skewed to the right. None of the

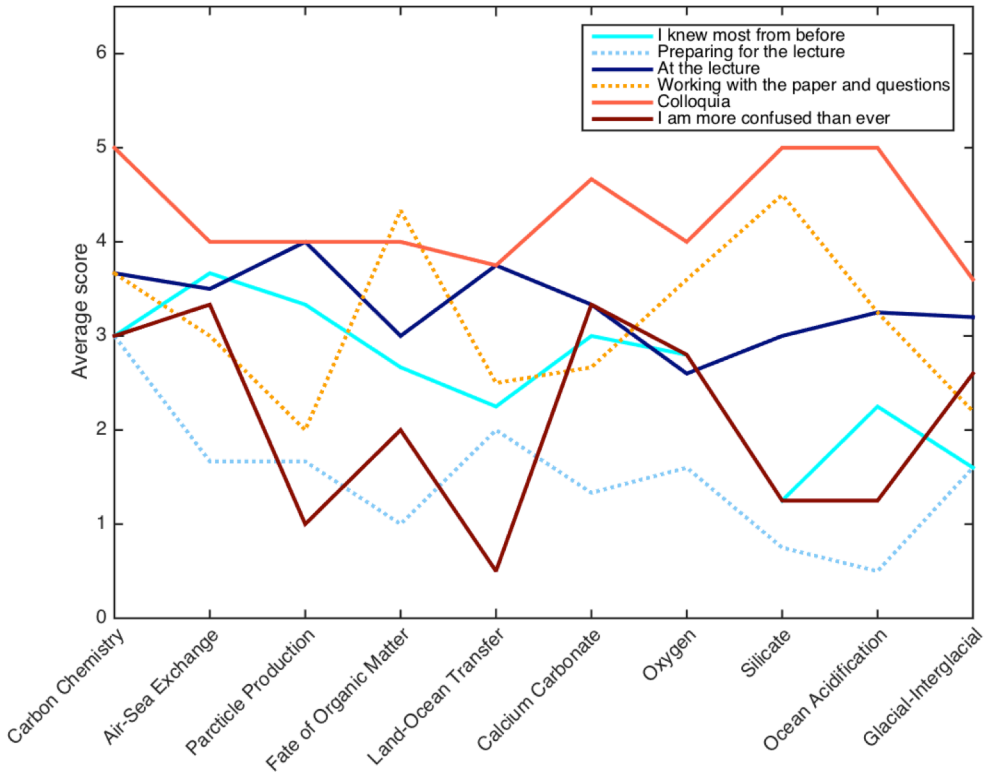

Figure 3: Average score per alternative for each topic

students indicated a learning outcome of 0 or 1 from the colloquia, and the majority of responses indicate that the students felt they learned the most at the colloquia. In fact, with almost 20 scores of 5, this is the most frequently scored value for any of the 5 alternatives considered here. The scores for the final alternative, 'I am more confused than ever', shows a relatively flat distribution, but somewhat skewed to low values.

Finally, Figure 3 shows the mean score for each alternative for each topic. It demonstrates that the students found the colloquia most effective for all but one topic. The score for the option 'I knew most from before' shows a significant decreasing tendency (p-value >0.99), this is not unexpected as we dealt with more and more specialised topics as the course advanced. The score for the alternative 'Preparing for the lecture' is consistently low, and has a significant declining trend (p-value> 0.95). I believe this indicates that the students did less and less preparatory work throughout the course. The average scores for the lectures are typically between 3 and 4. For me personally it somewhat surprising that the lowest score for the lectures is for the topic Oxygen, as this deals with an issue that is conceptually easy to understand —the oceans are loosing oxygen as they warm following climate change because of the reduced solubility— but it could be a consequence of the fact that I at this lecture did a fair bit of repetition on the quite difficult subject of the calcium carbonate homeostat. For the two topics Fate of Organic Matter and Silicate the perceived learning outcome from 'Working with the paper and questions' is exceptionally high. This, I believe

reflects that these topics really engaged the students, spurring an extra effort on their 'homework'. For the alternative 'I am more confused than ever', scores are high for the more complicated topics, with the exception of oxygen, but again, this may in fact be related to the repetition during that lecture. There are no clear correlations between these trends.

5. Discussion

The results demonstrate above all that the students found the colloquia to be the most efficient learning scene at this particular course. I also found them rewarding. Typically 3-6 students participated. Initially, I planned to leave the students alone for the first hour with me participating in the second only. However, I quickly realised that the students were not able to cover all ground by themself; this required my presence at both hours of each colloquium. We had the set of questions to work on, and I would make sure ask every single student about their answers to engage the entire group. This worked well; my sense is that all of the students were quite enthusiastic about the subjects in question. But, more often than not I had to supply the answers, which might not necessarily be a bad thing. One on hand the benefit of the colloquia was that they acted as a site for engagement, in particular helping their students to realise what (critical) knowledge/insight they had not gained just yet while also providing them with an opportunity to correct that situation by getting their fellow students and also me to clarify. On the other hand it gave me direct feedback on their outcomes from the preceding learning scenes: the preparations, the lectures and the individual work on the questions, and provided me with an opportunity to amend any misconceptions or critical knowledge gaps.

Marton and Säljö (1979) introduced the concepts of the surface and the deep approach to learning. The surface approach focus on memorising certain facts to meet course criteria with "the intention to get the task out of the way with minimum trouble while appearing to meet course requirements" (Biggs, 2003). The deep approach, on the other hand, focus on understanding the concepts and ideas, with the added benefit of ensuring a wider set of transferable skills. The course and subject at hand, GEOF336, renders itself in particularly well for deep learning. The focus is not on a set of facts, but on Earth System processes; to acquire factual understanding of basic mechanisms and then applying this knowledge to explain the occurrence of specific features in the distribution of chemicals on the ocean (such as 'why is the concentration of silicate much higher around Antarctica than in other parts of the global oceans?'), often a result of the interplay between several processes (in this case, upwelling of deep waters in the Southern Ocean, iron limitation, and silicate consumption by diatoms), and how any changes in these processes can bring about changes in for instance climate (relaxation of Southern Ocean iron limitation has been hypothesised to be one of the causes of the glacial atmospheric CO_2 drawdown (Matsumoto et al., 2002)). As such it requires and awards cognitive skills, promoted by activities such as explaining, relating, applying and theorising, key elements of active learning, in contrast to elements of passive learning: memorising and note-taking (Biggs, 1999).

The teaching strategy was therefore designed to include three central elements, to ensure the desired level of competence at the end of the course, the lectures, the assignments, and the colloquia. The lectures had two purposes, to repeat the basic knowledge from the required course GEOF236 (or make the students aware that they didn't possess these skills and had to self-study) and to contextualise the paper that had been selected for the topic; to make the students curious so that they would actually read it. The objectives of the questions were to ascertain presence of required knowledge (from GEOF236) and to encourage reading and reflection on the topical paper. Critically, I stated that the examination would be based on a selection of the questions of the assignments. This acurately defined the learning objectives, far better any reading list, and encouraged the students to work on them. Finally, the colloquia served two purposes, as a learning activity for the students to engage in and as an assessment tool of learning outcome —for the benefit of both the students and myself.

While the students perceived the colloquia as the most efficient learning scene, there are no reason to exclude any of the two other learning elements, the lectures and the assignments, from future teaching. It is the combination of these elements that forms an integrated course design: clearly defined learning goals, relevant teaching and learning activities, and adequate feedback and assessment (Fink, 2003), and lays the ground for efficient learning. In that sense, the survey I conducted may have been ill posed, focusing on the efficiency of the individual elements, but it nevertheless informs us on the importance of student-student and students-teacher interactions for the learning process.

6. Conclusions

Having taught this course only once I cannot formally assess the efficiency of my teaching strategy based on comparisons of grades or evaluation forms. I also failed to circulate evaluation forms after the end of the course. However, the informal feedback that I received (also indirectly, from them having told other professors) from the students was very positive. Several stated that this was the best course they had ever participated in. They all preformed very well at the exam, with above average grades. Two out of the six students decided to do a master in the topics we had been covering.

As a teacher I also found the integrated course design rewarding, in particular the increasing enthusiasm from the students throughout the course, the opportunities to discuss with them, and fulfilling their need of having complicated things explained in many different ways. On the other hand, at times there was a lack of dedication from the students. Typically this was a consequence of them traveling to take part in teaching in other places (e.g. UNIS), or being busy with obligatory assignments in other courses. In order to be truly successful active learning and integrated course design requires active participation from the students. In this particular case, that they worked on their questions and papers between the lectures and colloquia. A way to deal with this is to include more compulsory assignments and attendance. But I am a firm

believer in volunteer participation in teaching (apart from lab/field work), it is the teacher's responsibility to engage the students to the extent that they take part in important teaching elements. Overall this worked well in this case.

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