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Student activation and active learning

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Summary. Student activation and active learning have been proposed as tools through which students acquire knowledge and develop problem-solving skills. On the other hand, traditional teaching is still preferred in Physics courses with abstract and theoretical content. By employing student activation, I intend to explore whether the latter improves the student performance in theoretical courses.

Motivation

Being a theoretical physicist, I have thought by applying traditional teaching methods (i.e., with minimum involvement of the students). Nevertheless, when teaching, I encouraged discussions with the students both offline and at the end of the lecture.

A wide branch of the literature proofs that, through case-based learning, students develop technical competences as well as boost their problem solving skills and easily reach higher levels of abstraction ("Case-based and Problem-based Teaching and Learning", 2018). As shown in Figure 9.1, a teacher-centered approach corresponds to a minimum potential for the learning outcome of the students (Rienecker, Jørgensen, Dolin, & Ingerslev, 2015), while a problem-based teaching, requiring the maximum participation from the students, allows the best learning outcome (Shulman, 1996).

It has been empirically proved that once students become used to be an active part of the lecture, they find the interactive approach more engaging (Egidius, 1999; Pettersen, 2005). Students experiencing active learning

generally have higher marks than students used to traditional methods. This is related to the fact that some competences (e.g., critical thinking) are more difficult to develop through passive learning. The active involvement of students strengthens meta-cognitive and reflective academic competences (Wassermann, 1994).

The main challenge of employing student activation is to encourage the students to step out from their role of passive listeners (Barrows, 1996). At the same time, the outcome of this approach is strictly related to the degree of involvement of the students. Noticeably, the employment of active learning methods gives an immediate feedback to the teacher on the level of understanding of the students.

Another form of student activation revolves around the peer feedback and related group work. The student benefits from working with peers and of the peer's feedback (Boud, Cohen, & Sampson, 2001). Group work enables students to delve further and deeper into disciplinary problems because the more students the more facets of the same problem can be covered (Savin-Baden & Major, 2004).

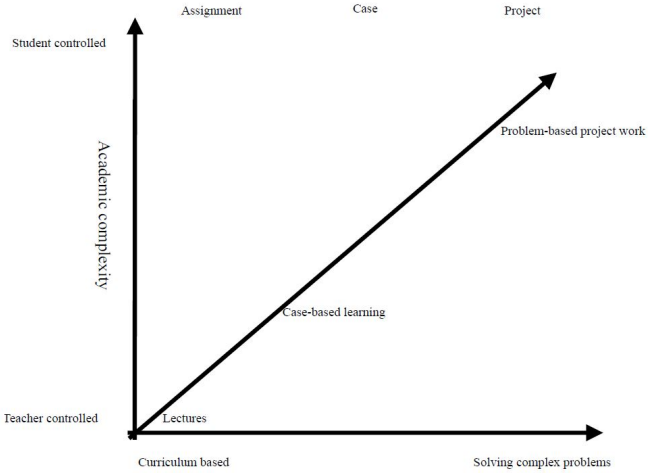

Fig. 9.1. Teacher-centered approach vs. student-controlled approach. Figure adapted from Rienecker, Jørgensen, Dolin, and Ingerslev, 2015.

Through this project, by trying out different tools for encouraging and engaging the participation of the students in theoretical lectures, I explored how the learning performance of students is affected with respect to traditional methods. I also aimed to use these same tools as a way to receive a prompt feedback on the learning level of the students and on the quality of my teaching.

Project description

I taught the course "Gravitational Dynamics and Galaxy Formation." This is a course of the first year of the MSc Program in Physics. The number of students was about 12 and I shared the course with other two teachers. Each teacher was responsible for a thematic module. Each module was independent from the other ones. I coordinated with the other teachers the connections among modules and stressed those during classes. My task was to introduce the physics of the Early Universe and discuss the role of dark matter particles in the formation of large-scale structures in the Early Universe.

In order to engage the students, I alternated the following during my lectures (Barrows, 1996; Boud et al., 2001; "Case-based and Problem-based Teaching and Learning", 2018; Shulman, 1996):

1. Discussed with the students about the Intended Learning Objectives of my module of the course, in such a way to align their expectations with the course content.
2. Adopted a continue dialogue during the lectures in order to encourage the students to think critically beyond the equations.
3. Assigned a research-based project to the students to be solved by the end of the thematic module during classes and within small groups.
4. Employed the peer feedback on the solution of the problem (then institutionalized by myself).
5. Involved the students in summarizing the take home messages of each lecture, in order to evaluate their level of understanding.

I tried to create a welcoming environment for the students to be active and relaxed. First, I introduced the Intended Learning Objectives and asked the students to present themselves and comment on why they had chosen to attend this course. This helped to align my expectations to the ones of the

students and at the same time helped the students to grasp what to expect from the course.

I divided my thematic module in two parts. In the first part, I introduced the theoretical framework useful to work on the research-based project. In the second part, the students worked on the research-based project during classes. The students were allowed to work on the project within small groups and discuss among themselves the results. On the basis of the project results, I extrapolated the takehome messages at the end of the module and institutionalized them.

While the second part of the course required an active engagement of the students, the first one was meant to introduce the theoretical notions. However, also in the first part, I established a dialogue with the students. For example, I asked the students to guess which results we should expect or gave them small problems to be solved during the lecture. Some of the questions I asked required a short and direct answer; some others required logical thinking and more thought. In the latter case, I gave them a few minutes to discuss the problem among themselves and think about the answer. I then guided the students towards the solution. Given their level of participation, I had the feeling that the students were clearly involved and paying attention. Moreover, I stimulated the participation of everybody in the class.

At the end of each lecture, I asked the students to write down a note on the main notions that they had learnt and to hand it in before to leave the class. I then started the following lecture by summarizing the take-home messages from the previous lecture. This was a very useful tool for me to catch the concepts that were poorly understood and evaluate whether the main concepts had passed through.

During the last week of my module, the students were assigned a project on which they had to work in groups. The project was involving many of the concepts introduced during the theoretical lectures in the first part of the module. The students worked during classes on the project and I encouraged them to use oral peer feedback and discuss among themselves the solution. I then institutionalized the project solution and main outcome during the last lecture and contextualized it within the bigger picture of the research field.

I motivated why the topic is interesting by using recent research papers. I also used a YouTube outreach movie. My goal was to highlight the main notions beyond a list of equations. I taught by using the blackboard to proceed slowly and help the students taking notes. I then relied on slides to

summarize the main messages and showed simulation images of the formation of large-scale structures in the Early Universe in the presence of different kinds of dark matter relics.

Results and discussion

All students, except for two, were able to successfully solve all the assignments. This gave me hints about the quality of my teaching. Interacting with students, while they were solving the project and the assignments, also helped me to understand the notions that resulted more critical to be understood from the students.

The fact that the second part of the module was research based helped the students to grasp the importance of the theoretical notions presented in the first part of the module. I asked questions (either requiring a short answer or a longer one) to engage the students and let them think about possible solutions to the problems I was posing. They were all actively involved in the lectures and looked very interested.

Employing an active engagement of the students pushed them to reflect on the teaching material and address more complex issues already during classes. The research-based project constituted a link between theory and practice.

I had to carefully weight the project session allowing enough time for the students to solve the project. Working on the project trained the students to apply theoretical knowledge and suggest solutions. In addition, this strengthened the interdisciplinary dimension of their education.

A challenge for me was related to my role as teacher. The active approach required me to be a facilitator of the work of the students. I had to listen the interpretations provided by the students and initiate discussions if they did not arise. I had to pay special attention to the level of the discussion, also during the peer feedback phase, to sense when the students were in need of assistance.

Another challenge related to the active engagement of the students concerns the amount of theoretical notions that can be thought in a course. Given the active participation of the students and the time required to solve problems, I realized I could teach far few notions than if I had relied on traditional teaching. On the other hand, I found the learning quality to be higher.

Although all students were actively engaged and they easily established a dialogue with me, it was more difficult to trigger a dialogue among them. This was a limitation also in the second part of the module, when the peer feedback happened into small groups of students that formerly knew each other.

I mostly evaluated the outcome of this experiment through the direct feedback from the students. In fact, dealing with a small group of students, helped me to establish a connection with each of them and clearly evaluate their learning performance.

The project and the tools I intended to use for this project were discussed beforehand with my department supervisor and educational supervisor that also acted as observers in some of my lecturers. They supported my ideas and agreed on the overall positive outcome of this experiment. They also gave me small practical suggestions to encourage the students to be active during the class. For example, I was suggested to specify the nature of the answer I was expecting (i.e., a yes/no answer or a more elaborate one) when I posed questions to encourage a safe environment and also to walk around the class to oblige the students to look at each other and foster interactions among themselves.

Conclusions and outlook

Overall, my experiment led me to conclude that the active engagement of students is a positive tool to their learning, although it reduces the amount of notions that can be taught. Almost all students were actively engaged in answering and discussing in the class. When asked to solve exercises or work in groups, the students actively worked on the assignments.

I got immediate feedback on their learning as the students both answered properly to all questions, exercises, and the final summarizing notes were mostly correctly written. This means that the fact that I constantly challenged the students in class helped them to keep their attention high and learn about the main messages. This would not have been possible by employing passive teaching methods.

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