

# Changing Lectures in Higher Education in Physics Classes for Future Civil Engineers

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Science Courses in Higher Education (HE) are facing in the last years some problems, namely the lack of students' motivation, the number of students' failure and drops out, in particular in Physics courses [1]. A possible reason for that, which has been referred in current research in Science Education in HE, is that the levels of interaction between teachers and learners in formal instructional settings is very low [2, 3]. Still according to research there is a need to change the curriculum from a teacher-centred to a student-centred model

In this paper we describe changes we have introduced in the way lectures are given and analyze its effects in the classroom environment towards the promotion of active learning. The introduction of conceptual questions and peer instruction in lectures seem to make students more motivated in the classroom and more engaged in their learning process. These strategies have been used in the first year of an introductory physics course for civil engineers. Data has been collected through questionnaires and interviews to students.

## 1. Lectures: from passive to active learning

The lecture method continues to play a prominent role in the teaching of most courses in universities.

A lecture is a teaching method where, traditionally, the lecturer talks, acts, persuades ...where the lecturer has a perfect freedom to do whatever he desires, except to ask students to rise and have time to answer to their questions. Therefore, traditionally, students do not discuss the information given neither question the lecturer verbally. If we think about teaching as a spectrum of techniques, at one end we may have the active learning where the students have an important role in their learning process and are free to make questions, in the middle the pure Socratic Method where the teacher only asks questions, and only the students give answers. At the other end of the spectrum, we have the straight lecture with no active or verbal participation by students at all.

It has many advantages like [2]

It enables to give the same information to a high number of students.

- a) the teacher has the control of the lesson, namely in what concerns the contents to be taught, the relevance he gives of each subject and the time spent in each;
- b) it does not imply the exposition of the students. They do not feel intimidated by the possibility to be requested to speak so they can relax and pay more attention to what is being said.

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Besides these advantages these kinds of lectures also have many limitations. Many limitations however have been referred to this kind of lectures limitations, which arise from certain factors about human learning [2]:

- a) sustained and unchanging low-level activity lowers concentration. Sitting listening to a lecture is such an activity.
- b) the attention span of students under these conditions can be maintained about 10 to 15 minutes, after which learning drops off rapidly (figure 1).
- c) traditional lectures are quite ineffective for stimulating higher-order thinking.
- d) traditional lectures can not be relied to inspire, or to change, students' attitudes favourably.

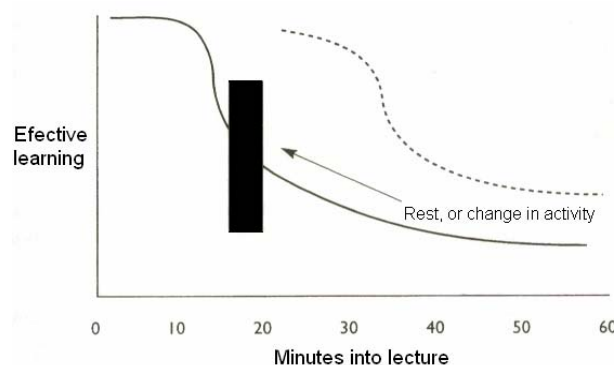


Figure 1: Effect of rest or change of activity on learning.  
Source: Biggs (1999, pp 101)

So what can be done in order to use the advantages of lectures and, simultaneously, avoid their limitations? Several things can be done. A short rest period, or a simply change in activity, after every 15 minutes, leads to a restoration of performance almost to the original level, so after this 15 minutes of explanation we can [2]:

- a) ask students to think about what has been said and in groups of two or three write the most important aspects of what they had learned;
- b) ask students to write a question about what has been said. In the end of each lesson they can give those questions to the teacher. This is also a way of understanding what are the difficulties of students and how deep is their knowledge about those subjects;
- c) ask questions and let students discuss it (in groups of two or three);

All these strategies permit to make something that is not common in lectures and that is formative for students. After the lecture, when teacher analyse the questions made by students or analysing how did they answered the questions made by him, he can access student's knowledge and is a way to prepare the next lecture, interacting with the student's and give some feedback to them.

## **2. The study: the implementation of strategies to promote active learning strategies in a lecture**

Our research was conducted during the academic year 2006-2007 and involves six teachers (one of them is the first author of this work) and a group of 80 first year undergraduate students, drawn from the 300

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students attending an introductory physics subject (Física I) given to Civil Engineering at the Instituto Superior de Engenharia do Porto (Portugal). This Curricular Unit (CU) had three kinds of classes: lectures (2 h/week), practical (2 h/week) and laboratory (2 h/week). In this CU it was used the Moodle as a Learning Management System (LMS). There the students had all the information about the CU (the lectures notes, problems to be solved in practical classes, grading system, interested web sites, bibliography and finally multiple choice questions).

The age range of students attending it is very wide as this CU is given to full and part time students (75% full time students). In spite of this, 60% of the students have less than 20 years old. In terms of gender 65% of students are male.

The main changes introduced in lectures were:

- reading tasks;
- conceptual questions with discussion;
- questions/doubts about the topics under discussion.

### **Reading tasks**

Before each lecture some reading material were given to students with the topics to be taught (mainly physics concepts, theorems and expression deduction). Reading task were introduced aiming that students could do a previous preparation on the topic and so they would be able to discuss it in class [4]. To motivate the students to do the “reading tasks” multiple choice questions were created in the platform LMS. The students had to answer these questions before each lecture to achieve a bonus points in their final classification. Another way that the students had to achieve the bonus points was to send an e-mail to the teacher (before the lecture) with a questions or doubts about that reading task. Nevertheless the option used by students, the teacher is aware, before the lecture, about what students know (or do not) and therefore he can give feedback in the lecture.

### **Conceptual questions with discussion**

The conceptual questions are multiple-choice questions about a particular concept and whenever possible with a connection to real world.

A typical lesson within this approach started with a conceptual question to introduce the subject or, instead, the teacher could start by answering the questions or doubts send by e-mail to the reading task. The aiming of this approach is to focus students’ attention to a particular topic. In this way the teacher could know how deep is students’ knowledge and from there started a brief review (15 min) about the particular topic. Then, in order to promote and improve class discussions during the lecture conceptual questions are again used. After revealing the questions students had 1 minute to think about its answer. Then they vote in the option they think is correct. After this they have 1 minute to influence the student seat nearby about its option. Next the teacher and students discuss that questions and the correct answer. If the teacher felt that the concept under study has not been well understood he makes another conceptual question. Otherwise he repeats the process by reviewing another topic followed by conceptual questions and discussions.

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In this approach two types of conceptual questions were implemented. The first aiming to introduce some topic (figure 2) and the second to verify if the concepts were understood by the students (figure 3).

### Formula 1

Imagine that you are watching a Formula 1. The cars are travelling at constant speed of 300 Km/h and a friend says:  
- Did you saw those cars accelerating?  
And you answer:



Figure 2: Conceptual question to introduce the concepts of velocity and acceleration

### HELP!!!

Imagine that you fall into a river and you don't know how to swim very well. In that river you have two life-buoy one in front of you and another in your back, they are attached and can't move. The best way to save your self is:

- a)swimming to the life-buoy in front of you;
- b)swimming to the life-buoy in your back;
- c)independent of which life-buoy i choose;
- d)ups...I don't know...



Figure 3: Conceptual question to verify the concept of relative motion

### Questions/doubts about the topics under discussion

At the end of some lectures students were also invited to write in a piece of paper questions or doubts about the topics taught in that lecture. This approach aims to make students to reflect about the topics under study. In the next lesson the teacher gives feedback to students' questions/doubts.

### 3. Results and Discussion

In this paper we present the results obtained through a questionnaire and an interview, done with the students, at the end of the scholar year. Both these instruments aimed find students opinion about the several strategies implemented in the CU and evaluate the general opinion about: good teaching and methodology used; clearness of goals and standards defined; appropriated workload; assessment; interaction between teachers and students. . In this article we only analyze the questions with related lectures.

The questions of the questionnaire were close ones with a likert scale (1-5) where 1 is less suitable and 5 most suitable. In the analysis we count as a positive opinion an answer equal or higher than 4. The interviews were made with 20 students.

Looking at the questionnaire' results we can say that (figure 4):

- 55% of the student' said that the **conceptual questions** were a motivating factor to attend lectures.
- 78% of them said that the **discussion** in the class **was helpful for their learning process**.
- 69% of students **prefer this type of lectures** compared with traditional ones.

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- 76% of students answered that the **lectures are effective** and contribute to their **learning process**.

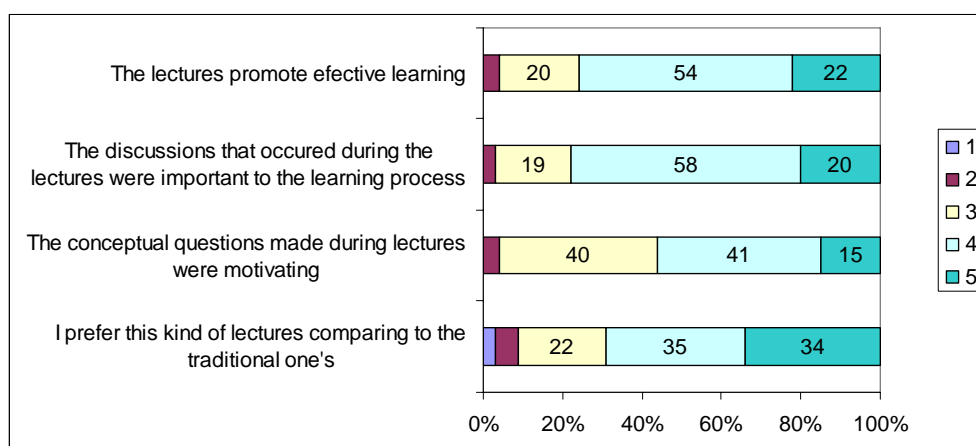


Figure 4: Student's answers to the different questions from the questionnaire

Analysing the responses to the interviews we can state that almost all students said that conceptual questions were an important element that contributes to their learning process and that they were a motivating factor to attend lectures. Quoting some of them:

- “...conceptual questions were an important element to promote learning because those questions encourage also the sharing of ideas and this is important to clarify ours difficulties...” (E1).
- “... the conceptual questions were a motivating factor to participate in the lessons. (...) ...this type of lectures are better than the traditional ones because students are requested to participate and be active in the lesson... traditional lectures are boring and sometimes we feel like sleeping...when students are not requested to participate they only listen or pretend to listen, they don't understand the topics...”(E7).
- “... the discussion that occurred among the students and then with the teacher were very important because it makes us to think...” (E10).

Analyzing the average participation of students in reading tasks activities, in the Moodle platform, we verify that is very low (26%). We believe that two main reasons justify it: the short deadline given to students to answer the questions (in a week they had to participate two times, one for each lecture) and the fact that they did not fully understand the importance of this task. In the interviews, many of the students recognize that they only understand the importance of the reading tasks at the end of the semester. We believe that changes in teaching and learning methodologies take some time to be understood. In fact in traditional lectures students are not used to prepare lectures before they occurred. Nevertheless students assume, in the interviews, the importance of the reading tasks, as can be illustrated through the following student's quotations:

- “...when I read the reading tasks it was easier for me to understand the lecture... unfortunately I only realize the importance of this readings at the end of the semester...”(E5)

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- “...when I read the reading tasks before the lecture I recognise that I understand much better the subjects taught and I could clarify some topics that I didn’t well understood before...”(E7)

In the interviews, when students were asked about the methodology of writing questions or doubts at the end of the lecture they said that it was an important moment because they had time to reflect about the topic under discussion and also it was another way of communicate with the teacher. Quoting some of the students:

- “...during the time we were writing ours questions/doubts we were reviewing the subjects taught in that lecture and we could ask the teacher to help us in what we didn’t well understood...”(E3)
- “... this is an indirect method of speaking with the teacher... the feedback given in the next lesson is very important to us because is a review of the previous lecture...”(E5)

#### 4. Conclusion

Although any change takes time to be effective and understood by the actors involved, the results found, both through the questionnaires and the interviews, indicate that students recognize the importance for their learning process of the approaches which have been carried in their lectures, namely through the introduction of reading tasks, conceptual questions and the writing of questions/doubts at the end of each class. Among them the reading tasks seems to be the strategy less understood by the students as effective, at least during the teaching process. Therefore our study suggests that it is possible to change the ways lectures are given in order to promote active learning. It is important, in future studies, to look also at the way these changes have an effect in students’ achievements.

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