TRENDS IN UNIVERSITY TEACHING IN PHYSICS: INTERACTION AND GAMIFICATION

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Abstract

Nowadays, both in primary and secondary levels, active methodologies have a prominent role. Students are the owners of the learning process, while teachers offer situations that allows them to develop their skills. It is clear, then, that there is a lack of coordination between school and university. So, when students get to university their motivation for attending class is really low. In this work, a field survey on the study methods of current university student in the Physics subject is discussed. The current student has evolved as quickly as the information and communication technology (ICT). In particular, he gets all the subject matter of a course by means of only one mouse click from certain websites. Former students have uploaded all kinds of documents in these webs including the class notes. Therefore, they do not require to go to class. The master class as a means to get the subject matter is not a challenge, but, rather, a boredom. The lack of study makes the student lose the thread of explanation after only a few minutes of the beginning of class. Furthermore, the student in the first years is not yet intellectually mature to accomplish a self-learning: he clashes with the complexity of the subject and, sometimes, with his own defects of training. This fact causes him to attend remedial classes of very short duration and focused on passing the course. The meaningful and constructive learning of the subject matter loses its meaning. Thus, the absenteeism in the university courses has skyrocketed. In short, it is necessary to incorporate new strategies to the master class that help teacher in his work, and provide an added value to his classes. In this sense, we show two different actions. On the one hand, we postulate to incentivize the interaction in class between teacher and student. This interaction can be based on posing problems to the student to solve outside the classroom. These problems will be collected, corrected and assessed later and will allow the teacher to accomplish a student's continuous monitoring. This work must be as individualized as possible to prevent originality problems since some students can deceive themselves by resorting to copy from each other. This continued monitoring avoids to a large extent that the student stops studying the subject and represents for him a stimulus almost daily to improve its competencies. On the other hand, we also positively value the incorporation of gamification strategies. The students' skill when managing electronic games is one of the main competencies evidenced by these. In our case, we introduce game elements in the form of interactive simulations on physics problems developed in class. In these simulations, student can play with a set of parameters to discover the dynamics effects produced on the system. They are made from the freeware programme "Easy Java Simulations". These simulations can be displayed as web pages in tablets or smartphones. These activities complement the traditional teaching in class, since teacher attracts the students' attention, and these becomes active participants of their learning.

Keywords: absenteeism, interaction, simulations, gamification.

1 INTRODUCTION

The starting point of this work is a field study about the features of today's university students in a basic subject of any science-based degree such as Physics. Generally, the current university lecturer completed his studies during a stage in which the only teaching method was the master class only aimed at the transmitting knowledge [1] and where he got the content of the course by attending class. This fact has instilled in him a set of values that clash head-on with ones of the current student. These students have changed and evolved as quickly as the information and communication technology (ICT) [2]. Students that arrive at university come from an educational system that is changing. Before, students used to follow the traditional way of teaching; now teachers adapt their lessons to a new reality so that students are eager to learn how to build their own knowledge. This evolution together with the traditional teaching methods used in university influence that current student considers the class attendance to be little motivating. In fact, they can get all the subject matter imparted during the course with just one click by accessing certain websites. Students of precedent courses have

uploaded to this web all type of subject documents until even the class notes. Hence, current student does not need to attend class. The master class as a means to obtain the subject matter is not in itself a stimulus, but on the contrary, a boredom. So, the absenteeism in the undergraduate courses has skyrocketed. Besides, student encounters the additional challenge of the complexity of subject matter presented in classes. This complexity makes him lose the thread after a few minutes of the beginning of class; especially, if he has abandoned the study of the subject a few days, weeks or even months. In short, it is necessary to incorporate new strategies to the master class to help teacher in his teaching work, and that provides added value to his classes. In this work, we propose two that will make students maintain interest in not only passing the exams but also in getting a meaningful learning. On the one hand, we propose to foster the interaction between teacher and student: this latter can conduct different in-class and out-of-class activities that teacher has to assess. This way, students approach science education at school, which is based on the discovery of the phenomena and their causes and on that the physics contents are shown in real situations in which pupils are able to learn by doing apart from that they acquire a wider theoretical basis. Both the problem based-learning and the project based-learning can serve for this purpose. On the other hand, we suggest introducing gamification activities. Gamification consists in incorporating game features in education [3]. In this case, the elements of play are interactive simulations on physics problems (fislets) presented in class by teacher. In a fislet the student can change a set of parameters to realize the effects on the system. These simulations are based on the programming languages: Java and JavaScript, and they are performed using the program "Easy Java Simulations" [4]. The web technology supports this new learning strategy in classroom that complements the traditional teaching. This methodology is used to capture the student's attention using animated graphic and drawing techniques that allow to observe the dynamic behavior of the system in a web browser. As an example, we show in this work some of them: a Foucault pendulum and the rolling motion of a disc on a circular surface.

2 STUDY METHODS

To focus research, we will say that this was accomplished in the subject of Physics belonging to the degree of aerospace engineer of the Polytechnic University of Madrid. In this course, there are about 750 enrolled students in the current year. At the end of the course, these students conducted a voluntary survey via Moodle on their study habits. 174 students answered the survey, that is to say, a very significant sample. The opinion poll was presented to the students in the simplest way. They just should mark yes or no to indicate whether they had used a certain resource to prepare the subject and which had been its origin (how it had been obtained). Next we synthesize the main results.

The first set of questions would allude to the use of theory books by the student. For problems books, the results were similar. 59% of all the respondents utilized the book published and edited by the university. Of this amount, only 14% claimed not to have bought such book. The library, the second-hand purchase, and any other method including the copy of its content could have been its origin. The study of additional bibliography was not excessively significant: 11% of students resorted to another books taken from the library, and other 10% made the same with another books acquired in a bookshop. These three groups (university, library and bookshop book) are not mutually exclusive, that is, in the worst case scenario, only 60% of students had studied using a textbook. Curiously, the academic results show a certain parallelism with the previous percentage since 67% of students passed the subject (only 20% with a very good grade).

Other resource available for the student, where this can review his notes or, in the case of repeaters (34% of all students), check the subject matter, was the computer presentations of the subject. However, only 39% claimed to have downloaded them and used to study. Against these downloads, there was other extremely curious result, clear sign of absenteeism, and in some cases, of abandonment of the subject. 29% of students asserted to use presentations of external remedial courses that they had completed. These courses are often offered by private academics and its objective is to prepare students to pass exams. They are temporarily brief and are only focused on the applied part of subject that most commonly appears in the exams. Together with these two groups, there was other two: one of them was formed by students that downloaded this type of summaries from external web portals (17%); and the other (11%) obtained these documents by other methods, fundamentally the copy.

The collections of problems prepared using a word processor are an essential element within the study of the student, especially, for repeaters. The student usually tries to solve a lot of problems in the belief that thus, his grades will improve, instead of trying to understand the exercises that teacher

offers him as example. In this case, all collections are private. They are made up by compilations of exam problems of preceding years and, to a lesser extent, of problems explained in remedial courses. A large number of students (70%) stated to download this material from external webs and to use it to study. It is very interesting that about half of the students claimed to obtain this type of resource either by attending to external support courses (55%), or by other methods, mainly, the borrowing and the copy (48%). The main conclusions to be drawn of these results is that the download from external webs is the majority procedure to get study materials around which the learning process revolves, and that, the use of collections of problems to study leads to some extent students to attend support classes.

Finally, we pay attention to the traditional method of studying handwritten class notes. The number of students that stated to have study their own individual notes achieved by attending class ranged from 48% (for problem notes) to 55% (for theory notes). In fact, both percentages are a good estimate of the mean class attendance of the subject. At this point, we should remember that 66% is the percentage of new students enrolled this course, and that the repeaters infrequently attend class. Again, the more outstanding result was the percentage of students that utilized problem or theory notes obtained in support courses (about 52%). This value agrees with that relating to the collections of problems and gives an idea of the importance of these courses aimed only at passing the subject. However, in the case of subjects such as Physics, if the student does not know the theory as a whole, and besides, lacks the basic math skills, he cannot tackle the resolution of unpublished problems. The student's solution to this dilemma is the compilation of as many problems as possible with the hope that one problem from the collection is repeated in the exam. Apart from these two, there was other two large groups of students: One of them got the solved class problems and any other type of solved problem in handwritten format from external web portals (43%). Students of previous years have uploaded their manuscripts with solved problems to these virtual libraries. And the other group (34%) achieved solved handwritten problems by any other method (mainly the copy). In the case of handwritten theory notes, the two last groups were about 10% less numerous.

3 DISCUSSION

The previous survey highlights two new actors arisen in higher education, and more specifically, in the field of the teaching of scientific knowledge. The more important is the download of any content related to a scientific subject from external web portals, even the own individual notes of the teacher taken in class by some student with stylized letter. The current university has advanced, without intending it, towards the self-guided study [5] supported by the ICT. Many students reject to some extent the teacher's guidance and encouragement and become responsible for their own learning. In many cases, they do not make this choice for reasons of intellectual maturity to undertake such a strategy, but for reasons of convenience since they get all the information necessary about the subject without attending class. The unstructured and disorganized approach to the subject matter is the first consequence in the case of first-year subjects belonging to any scientific degree. In this line, we can mention an anecdote: One of our students told us whether we can give him some guidelines to study the subject. Then, we asked him what he had studied on the subject matter as repeater that he was. His answer was that he was solved all the class problems, and besides, he was solved an additional huge amount of problems. However, after the revision of his exam, we checked that this student made mistakes typical of a pre-university level. Certainly, a paradox for us, and difficult to understand for any reader. But, let us go one step further, and analyze how a lot of current students tackle the study of the subject. In the absence of the teacher's methodological guidance, orientation that teacher accomplishes in classroom day by day, and therefore, for a long period of time, the intellectually-immature student resorts to the remedial courses to guide him, which means that he spends less time, since these courses are focused on the completion of exams, and therefore, they are shorter than an academic course. The understanding of the subject matter, that is, of laws and theorems, by student now does not matter, since what this looks for is a quick method to pass the subject, a method to allow him to fill the void caused by the lack of teacher's guidance as a result of his irregular class attendance and of disregarding the theoretical study of the subject to just focus on the applied part. The student begins to become a compulsive consumer of problems. We cannot ignore here the influence of training defects of the student that has just started the university. These training defects have worsened in recent years. In this regard, we allow us to mention some examples. In exams many students show basics training deficits of pre-university contents: for example, they do not know how to differentiate between scalar and vector quantities, or how to correctly derive or integrate simple functions. Pre-university education has loosened the acquisition of certain basic specific competencies in favour of other specific and transversal competencies. Finally, we will say that the student's opinion

in this respect is usually quite recurrent and stresses his lack of motivation and the low quality of teaching [6]. As the reader can see, the absenteeism is a serious problem of difficult solution due to its deep roots.

Figure 1. 2D image of the simulation of the rolling motion of a disc on a circular surface as viewed in a Moodle page (above). A graph of the angular deviation in relation to the vertical as a function of the time is also shown (below).

4 IMPROVEMENTS IN TEACHING

As the paradigm in teaching is changing, we have to look for new ways of getting students involved in the construction of their learning. This work has to be done since they start school. There, teacher should display them situations where they have to prove what they have learnt in real situations, allowing them to be conscious of their learning. A previous stage of self-assessment must lead student to the stage of knowledge. The preparation for the university should be based on what student can do with the knowledge acquired from their creativity, reducing the amount of information that pupils can handle and improving his training in his areas of interest.

The university improvements that we propose in this work and we have begun to apply during this academic year are of different nature. The first one is supported by the evaluation method. This method must allow teacher to assess some activities other than the classic exam. These activities must be rooted in the class attendance. In our case, at the end of each topic we posed problems to the students to solve outside the regular class time. Once solved by the student, these problems were collected in class, after assessed, and finally, given back to the students informing them of his grade and errors. This is a simple process, but it requires perseverance in the study and some class attendance. All the evaluation methods that do not require the student's presence has the defect that they raise doubts about the originality of the author's work. It is difficult to assign different problems to all students (or groups of students), so it is inevitable that some of them deceive themselves by copying the solution from other classmates. The final assessment is conclusive in this sense and clearly penalizes these students. But, let us return to the effect that we want to produce, that is, the following of the classes. The ICT here works against teacher because those students that do not wish to come to class simply limit to getting the problem formulations through the trendy messaging

application, and later, once solved, to hand them in making use of a schoolmate. At this point, our method insisted again, and offered to the student the possibility of improving his mark in these problems if this carried out a second work. Curiously, this work was not delivered by those students not attending class, either because this information, not being of general interest, was no longer disseminated suitably, or because these students limited to doing the minimum possible work. This fact clearly indicates the difficulty of attracting again lost students. Nevertheless, the teacher-student interaction in the classroom is a beneficial influence that university must regain because it certainly motivates the learner to attending class and as well as it informs him about the minimum knowledge that he must acquire.

Figure 2. 3D image of the simulation of a Foucault pendulum as viewed in a Moodle page (below). At the upper left part, the x and y -coordinates are depicted; and at the upper right part, the z -coordinate is plotted as a function of the time.

Another methodology to improve the teaching quality in classroom is to use realistic support strategies and very deep-rooted in the mental processes of new generations. In this case, we propose the use of gamification [7] by using simulations. Obviously, the time is a factor playing against teacher. The problems included in the list of topics are a lot and the implementation of simulations about these starting from scratch in any programming language is very laborious. The programme “Easy Java Simulations” is a free computer tool developed by Esquembre [4] and that enormously facilitates the work of teacher with little knowledge in programming languages. This tool encodes physics equations in Java and Javascript languages and, at the same time, it handles a set of high-level graphic routines enabling to depict objects and their physico-mathematical behaviour. In short, it is enough to know the behaviour equations of the system, to have a basic knowledge of writing equations in JavaScript and to study the graphical interpreter of the programme to create realistic simulations on the behaviour of a physical system. These simulations can be observed by students accessing certain web address or inside a Moodle page. Besides, learners can play with them modifying a set of parameters. Thus, the problem solving jumps from the blackboard, where the teacher’s drawings remains immobile, to the students’ tablets and smartphones where it comes alive during the classes. For the reader to get a little idea, we show in Fig. 1 a disc in rolling motion on a circular surface. A graph of the angular deviation in relation to the vertical is also shown, and in Fig. 2 a Foucault pendulum on the earth’s surface, that is, an oscillating mass hanging from the ceiling by means of an ideal thread. The x -axis is

parallel to an earth's meridian and faces from north to south, the y-axis is parallel to an earth's parallel (and it is west-east oriented) and the z-axis faces the vertical direction on the earth's surface. This example is useful to explain whether the earth is an inertial reference frame.

5 CONCLUSIONS

A large proportion of the current students approaches the study of a subject from teaching resources downloaded from web portals outside the university. The need to obtain the class notes has disappeared because it is possible to get them from home with a simple internet connection. Therefore, the guiding and motivating factor attributable to the classes has been overshadowed to a large extent by the convenience linked to the information and communication technology. However, the lack of intellectual maturity of the student enrolled in the first years of a university degree is in many cases evident. Student overcomes his inability to direct his study attending shorter courses oriented at passing the subject and not at the acquisition of constructive and structured knowledge. So the easy and quick solutions prevail over the significant learning based on the effort, the constancy and the perseverance in the study. The path that the teacher offers to the student does not convince this since it is little motivating and not consistent with the principle of minimum effort.

Obviously, the solutions are not easy within the university field where the high student-teacher ratio prevents teacher from implementing assessment strategies sufficiently individualized. Nevertheless, the answer may lie in the monitoring of the learning process throughout the course by using group and individual tests to carry out at home and in the assessing of this evolution (but trying to avoid the copy). This monitoring must produce a teacher-student interaction that motivates the student's class attendance and the study of the subject. At the same time, the class in its purely transmitting traditional form must be modified, and makes use of strategies such as the gamification to capture the student's interest. The use of physics simulations as games where the student directly experiences the dynamic effects of the equations showed in the blackboard is a teaching resource pointing in that direction.

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