Development of an active learning methodology for a course of radioactive contamination in an engineering higher school

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Abstract
One of the objectives of European Higher Education Institutions in order to improve the formation of their graduates is to promote the use of active learning methodologies. On this subject an experience developed at the Polytechnic University of Valencia (Spain) in connection with Radioprotection is presented in this paper. Students in the 5th year of Industrial Engineering (branch Environment) have a course on Radioactive Contamination, which includes basic concepts on radiations and radiation protection, as students have no background in this field. Nevertheless, they are invited to actively participate in the class by discussing each lesson. To stimulate their participation objectives of the lesson are proposed by means of questions. Students have been previously provided with the information necessary to prepare the discussion. Results obtained over the five last years have demonstrated that the application of this methodology enhances the student learning performance.

1. Introduction

The teaching methodology must be focused on an active participation of students in their own learning. They will learn –if they want!– and the role of their teachers is leading their learning and preparing and providing the material necessary to help them to achieve learning objectives [1].
This is a general declaration, but really one of the main objectives of European Higher Education Institutions to improve the formation of their graduates is to promote the use of active learning methodologies. In this paper, an experience developed at the Polytechnic University of Valencia (Spain) in connection with Radioprotection is presented and analysed. It refers to the course on Radioactive Contamination included in the 5th year of a degree in Industrial Engineering (branch Environment).
Students arrive to this course with scarce or no background in this field. Therefore, some basic concepts on radiations and radiation protection should be learnt before starting the study of radiation applications, contamination features and decontamination techniques. One can say that they start from scratch. Nevertheless, they are invited to actively participate in the class by discussing each lesson and to stimulate their participation objectives of the lesson are proposed by means of questions. Of course, students have been previously provided with the information necessary to prepare the discussion. During several years this information was included in a web page, but finally a textbook has been published [2].
The development of the class is then centred on basic concepts and practical applications, being complemented with works in group and practical exercises in the laboratory.
An important aspect of the methodology is evaluation since it strongly conditions the learning process of the student.

2. Methodology

The student should be the active subject of his own learning. Teachers should supervise and direct this learning process in order to optimise teaching results. It is thus necessary to involve students in the development of lessons being indispensable their personal motivation.
One of the strategies used with this goal is to present a short list of questions the first day of the course, so that students can express their expectations for the course and the professor could know about gaps in their knowledge. Another way to motivate the students is to carry out without announcement an exercise at the middle of the term, so that they could realise about the concepts well learnt so far.
The main component of this active methodology is the development of each lesson at the classroom. Lessons are not exposed in a traditional way but they are discussed in the classroom following some guidelines with several objectives in mind. It is necessary that students prepare the lesson previously and obviously they need some guidelines as well as a reference text. In a first stage, this was done by

means of a web page but finally a text book has been published [2] as well as a booknote for laboratory practical exercises [3].
During the development of the class, different questions are proposed to the students in order to perform an analysis of the lesson achieving the objectives previously established. These objectives shall include, if possible, the following points:

- what must be learnt by the student;
- trying to find out why must he learn it; and
- maintaining a connection between the different matters.

During the discussion students shall present their points of view as well as their doubts and problems of understanding. The professor shall lead the discussion directing it to fix and understand the objectives proposed for each theme. After clearly understanding the concepts of the lesson, it will finish with a summary of the most important points to underline them and stress its comprehension. This development should be complemented with practical exercises.
The participation of students in the development of the lesson is first timid, but increasing with time. They carry out many exercises and works proposed at the classroom and this contributes clearly to their formation. Besides exercises proposed during the class, a list of questions for self-evaluation is provided at the end of each lesson.
Practical exercises include laboratory and computer calculations (shielding and doses) but one of the most innovative tasks –very appreciated by students– is the analysis of a real situation, usually a radiological accident. Students should prepare their work reading the available information and preparing in small group a presentation of their analysis in a public session at the seminar. They are provided with a summary of the accident and some guidelines to develop their work [4].

3. Evaluation

The learning process of all students is actively conditioned by the evaluation method applied. For an active learning methodology the best evaluation method should be the continuous evaluation of the student participation in classes. Of course, it shall be complemented with other traditional evaluation methods such as written or oral exams. Also, for each exercise (numerical, computer, laboratory reports, other works,…) performed and presented during the course a mark should be given.
The participation in the class as well as the presentation of exercises are a free decision taken by students. Therefore, in those cases when students do not actively participate in the activities of the course, they must pass an exam. Nevertheless, whenever it is possible the final evaluation is carried out by means of an oral presentation of a work developed by a group of 2-3 students. The mark obtained with this work will complement the continuous evaluation taking also into account all marks obtained from voluntary individual exercises and works.
The final written exam, when it is done, has a non-traditional structure. Usually it is divided into three parts. In the first one, students should demonstrate their good knowledge of basic concepts and solve some single numerical exercises. In the second part, a practical analysis of some situation (usually an accident, real or imaginary) was proposed and the student should summarise some guidelines for a possible solution. The third part contained free questions. For instance, the student has to choose a theme and underline its main objectives with a clear justification of them. Whenever these free questions were proposed, students showed an initial surprise, but usually results obtained could considered quite good.

4. Results

The number of students in the group never exceeded 30 students over the last five years and this is a advantage to apply an active learning methodology.
Results (final marks) obtained by students in the last five years are listed in Table 1. Marks in Spain range from 0 to 10. It is necessary a mark greater than 5 to pass the course and the students passing the course are classified into 4 groups: Approved (5-6), Notable (7-8), Excellent (9) and Honour (10) the highest mark.

Year	Number of students	Presented	Refused	Approved	Notable	Excellent	Honour
2000/01	29	23	0	12	8	2	1
2001/02	29	28	3	7	14	3	1
2002/03	23	18	2	4	7	3	2
2003/04	15	14	0	3	6	3	2
2004/05	21	17	0	5	6	4	2

Table 1. Marks obtained by students when an active methodology was applied.

Marks obtained by students in previous years, when master classes were given with greater groups, are listed in Table 2, where it can be seen that final marks were not so good.

Year	Number of students	Presented	Refused	Approved	Notable	Excellent	Honour
1996/97	29	21	7	10	1	2	1
1997/98	73 (#)	53	6	23	18	4	2
1998/99	33	30	8	11	10	0	1
1999/2000	32	24	4	8	7	2	3

(#) There was a greater number of students because students from Chemical Engineering joined the group.

Table 2. Marks obtained by students when master classes were given without an active methodology.

Differences observed between tables 1 and 2 can be attributed to the methodology. The main differences are the lower number of students refused, the increase in the number of students participating in all activities, so that they are fully evaluated, and finally the increasing number of students with higher marks. Nevertheless, the main difference is the satisfaction shown by students although they have more work and the knowledge by the professor that the learning level is increased.

5. Conclusions

The active participation of students in the class permit them to improve their learning. To achieve this goal, the class should not be a master class but it is necessary to maintain a discussion with questions addressed to the comprehension of concepts as well as to fix objectives for each lesson, checking out that they have been completely achieved.

It is indispensable to obtain the adequate motivation of students. A possible strategy for this is to permit them to express their expectations in the course and to adjust the development of the classes in terms of the feedback obtained from their attitude and work.

It is necessary to provide students with documents so that they can prepare lessons before attending the class. It is useful to upload the information in a web page but the best solution is to provide them with an appropriate textbook.

All activities proposed in the class should stimulate the participation of the students. They must be not compulsory but with positive repercussion, if any, in the final mark.

The elaboration of the lesson objectives by the students themselves as an exercise is very useful to enhance their learning process.

The continuous evaluation seems to be the best method when this active learning methodology is applied. On the other hand, an evaluation taking into account the understanding of basic concepts, its application to practical cases and the free exposition of the objectives of the course by the student has been shown, in general, very positive. The marks obtained by the students as well as their satisfaction seem to confirm this point.

References

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