PRACTICAL TEACHING OF FLUID MECHANICS FOR FIRST YEAR ENGINEERING STUDENTS

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Summary

In the teaching of fluid mechanics, laboratory classes are normally imparted on separate sessions from the theory classes where theoretical contents are given to understand the practical demonstrations. In this paper it will be described and evaluated the teaching efficiency of an innovating didactic system in which theory and work lab are integrated in the same teaching session.

KEYWORDS: Fluid mechanics, teaching, engineering, laboratory

Introduction

Traditionally, and in particular, in the educational Centre where the experience took place, the teaching of fluid mechanics presented the following pattern: theory teaching, resolution of numerical exercises and laboratory practice.

Real fluid mechanics is one of the contents in the matter Physics II, this one is imparted during the second four month period. Ideal fluid mechanics is another content of Physics I, this one is given in the first four month period of the first year of the three years Agricultural Engineering degree.

In the "theory-exercises-laboratory" system, the time distribution among these activities usually appears in a 3-2-1 proportion. This means that three thirds of the available time is dedicated to explaining the theory of the subject, two thirds are for resolution of exercises and only one third of the total is left for laboratory practice.

Laboratory practices in Fluid Mechanics are done in groups of fifteen students. Under the supervision of a teacher, these students examine certain physical phenomenon and make some calculations. The physical phenomenon which are currently examined in the laboratory are the following: Venturi tube, the head losses in a pressured conduction, and the Reynold's experiment. In these three cases, water is the fluid in motion.

During the accomplishment of the laboratory practices of Fluid Mechanics it was noted that a significant number of students found it difficult to apply theoretical concepts although those same students proved to know the corresponding theory. Besides, some students seemed unable to calculate problems in the practice but they could do so if those problems were part of a numerical resolution of an exercise. [1]

In order to amend this contradictory situation, it was decided to design a type of learning that provided a major connection between theory and practice [2]. For the same reason, and to obtain information about the efficiency of such a learning experience, it was decided to evaluate the academic output of this innovating teaching system.

Methology

It is necessary to start with a collective of student administratively divided into two groups: group "A" and group "B". Each group corresponds to a different degree; nevertheless, both groups study the same contents of Fluid Mechanics.

Entry requirements to enrol on the degree that correspond to group "A" are higher than those that are necessary to enrol on the degree that corresponds to group "B". Students in group "A" usually obtain higher marks than students in group "B"; for instance, in the Physics I exam that took place immediately before the experience we refer to in this article started, students in group "A" obtained a 15% higher average in comparison to students in group "B".

With the aim of improving the academic output of students in group "B", and hoping that the innovating teaching would help to do so, it was decided to apply the teaching experience to group "B". It was expected an increase in the output of group "B" so that the difference between both groups "A" and "B" was lessened.

According to the aforementioned organization, group "A" received conventional classes: theory sessions in the classroom and laboratory practice in the Laboratory whereas group "B" 's classrooms were given in the Laboratory where students received theory sessions and practical demonstrations with the laboratory equipment.

It has to be pointed out that the students belonging to the group "B" and group "A" are taught the same theory contents and have the same practice in the Laboratory. The only difference between those groups was that students belonging to the group "B" received the theory classes in the Laboratory and watched the laboratory practice immediately after the teacher's explanation of the theory on which they must support the laboratory practice. Students belonging to the group "A" received theory sessions in the classroom and do each laboratory practice once the theory associated to it has been completely explained in the classroom.

Group "B" had to be divided into two subgroups "B1" and "B2" in order to receive theory class in the laboratory. These subgroup's size is similar to the conventional groups that attend laboratory practice which is approximately 15 students in each group.

Finally, exercises were done in both groups in an identical way, after the theory in which they are based on was explained.

Content

As it has already pointed out, students of real Fluid Mechanics have already studied Physics I. That means that students have already learnt Bernoulli's theorem for ideal fluids mechanics and have solved a number of numerical exercises to do with this important theorem.

Theory contents of real Fluid Mechanics are equal for each group: fluid characterization, viscosity , fluid friction, Reynold's experiment, characterization of fluids in motion depending on the value of Reynold's number, extent of Bernoulli's theorem and calculations of head losses in pressured pipes.

Before beginning the classes, students were provided with a detailed development of the theory contents. These points are collected in a book published by the University Press Services [3]. This book summarizes the theory of Fluid Mechanics and gives 15 exercises on fluid mechanics. These exercises and the solutions are explained in detail. This book also gives the student the outline of three laboratory practices about Fluid Mechanics.

In the exercise classes, nine hypothetical practices about pressured pipes with hydraulic machines in plain and rough tubes were explained to the students.

Finally, the equipment used to do the laboratory practices on the Laboratory was: Bernoulli's theorem by means of Venturi Tube, determination of head losses coefficient "k" in accessories put on a pressured pipe and a study about laminar or turbulent flow with a similar equipment that used by teacher Reynolds. Both three experiences are based in water flow. The first one is described in an aforementioned book [3]; the description of the equipment used to do the other two experiences is given just before the use of that equipment.

Evaluation

The evaluation on the academic output of this innovating experience has been the same for all the students and it consisted of solving two numerical exercises about Fluid Mechanics. One of them, denominated self-evaluation exercise, was proposed along the course so students could have information about assimilation of content that this exercise deals with. Therefore, the exercise of self-evaluation took place before the final exam of the subject (Physics II), whereas the other second exercise was proposed among those of the final exam of the mentioned subject.

Results

The marks that students of both groups obtained are shown in table 1. The results obtained by the students show, for each group, those students who have attended regularly the activities - in bold letter in the table - and those who did not attend with the same regularity. The table gathers the average and the standard error of the mean.

GROUP	SELF-EXAMINATION EXERCISE	FINAL EXAM
A	**7,2 ± 0,2**	**5,9 ± 0,2**
A	6,2 ± 0,7	5,1 ± 0,4
B	**6,4 ± 0,7**	**5,7 ± 0,5**
B	3,6 ± 0,9	2,8 ± 0,6

Table 1.-Academic marks of innovation

Resources employed

Talking about the resources that have been necessary for this innovating teaching system, it has to be pointed out that the time spent in the fulfilment of the teaching integrating theory and practice of Fluid Mechanics was of 5 hours against the 6 hours that were spent in teaching the subject using a conventional academic system. Therefore, there has been a 17% reduction of time dedicated by the students. This time saving is interesting for the current scheme of the reform of the Spanish University engineering curricula. This reform has supposed a general reduction of the time dedicated to the teaching of basic subjects.

In the innovating teaching system, students in group "B" were organized in subgroups of a similar size to those used in conventional practices: approximately 15 student per group.

The cost of the used equipment was 2 million Pta., that is, approximately, 12.000 euro.

The equipment was acquired using the academic founds for the teaching of the subject, although is has been necessary to use a few years budgets in order to pay off some of the equipment. At present, and to acquire new Fluid Mechanics equipment, it has resorted to educational investigation projects, including the equipment as stock material that can be obtained by subvention, if this subvention is allowed. The two Fluid Mechanics equipment that we have got this year have been acquired in this way.

Teacher's efforts are also to be taken into account because they are important: written material is necessary in order to facilitate theory explanations [3] and specific outlines for integrated teaching are also to be prepared. It doesn´t have to be forgotten the time teacher to be dedicated to setting, gauging and learning how to use the equipment. Occasionally, some of the results obtained during the gauging of the equipment are presented in specific symposiums on laboratory teaching [4].

Conclusions

Students in group "B" who regularly attended the activities, had in the self-evaluation exercise a 77% higher average mark than the rest of the students in the same group, whereas the improvement in the final exam reached a 103%. This result is interpreted as the innovation bettered the students attitude towards the study of fluid dynamics.

Students in group "A" that regularly attended the activities, had in the self-evaluation exercise, a 13 % higher average mark than the students in group "B" that were as regular as those in attendance.

In the exercise given in the final exam, the improvement obtained by group "A" in respect to group "B" was only of 4%.

These results prove that it has been reduced the difference between the academic results between both groups. The biggest reduction was obtained in the final exam results, where the difference in the average mark of each collective only reached a 4%.

As a final conclusion, we have to say that the experience has been satisfactory because it has been obtained a much better academic output in a group of students typified by its low output. For this reason, the innovating teaching system here described will take place again in the present academic course.

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References

[1] Celemín, M. and Palencia, C., "Teaching Bernoulli's theorem in practice".Copenhagen, (Denmark): http://www.pwg.vsli.cz/recent/ptee97/ptee97.htm,1997.

[2] Cottle, P.D. and Lunsford, S.E., "Increasing Student Participation in Recitation". *The Physics Teacher*, Vol.33, pp. 33-25.

[3] Celemín, M., "Lecciones de mecánica de fluidos". Servicio de Publicaciones de la Universidad de León, León, (España): 1996.Not translated book. ISBN: 84-7719-537-4.

[4] Celemín, M. and Barnechea, E., "Measuring Fluid Mechanics Magnitudes".: European Society for Engineering Education, Brno (Czech Republic),1998. ISBN: 80-214-1232-2

[5] Celemín, M., Soriano, M., et al. "Formación para el saber hacer en Enseñanzas Técnicas: Aplicación a la mecánica de fluidos". Not published report. León (Spain), 1999.