PROMOTING ACTIVE LEARNING WITH VIDEO TUTORIALS AND ONLINE TESTS TO ASSESS THE STUDENTS' THEORETICAL BACKGROUND BEFORE LABORATORY SESSIONS IN ENGINEERING DEGREES

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Abstract

Since the implementation of the European Higher Education Area (EHEA) the subjects of the second course of the Industrial Engineering degrees at *Universitat Jaume I* (Castelló, Spain) include practical laboratory sessions that are evaluated as part of the continuous assessment. One of the objectives of the practical sessions is to carry out experimental tasks related to the theoretical models explained in class to corroborate them. To ensure a good development of the laboratory sessions the students need to have a previous knowledge of the theoretical concepts being under study. For this purpose, apart from the explanation in the theory classes, a written manual including the theoretical explanation, the experimental methodology and the analysis of the results is available before each laboratory session. However, students refuse reading the manuals and the professor must do the explanation at the beginning of the session thus reducing the time for experimentation and data processing. During the course 2021/2022 the in person professor explanation was replaced by video tutorials including the theoretical explanation and a demonstration of the experimental tasks. Students were encouraged to watch the videos before the session but a negative response was observed and only 18 out of 124 students attending classes affirmed in a survey have watched them. In order to promote this video-based active learning the methodology was improved during the following course 2022/2023 including an online test at the beginning of the laboratory sessions to evaluate the students' theoretical background whose qualification accounts for a 20% of the final laboratory grade. At the end of the semester students were ask to fill in a survey to gather their opinion about the methodology and it can be concluded from their answers that the number of students watching the videos increased by a 13.2% and only an 8.6% of the students read the manual being this option the least popular choice according to the survey. To evaluate if the information provided in the video tutorials is appropriate and can replace the professor explanation, the grades obtained by the students in the laboratory reports were also analyzed and compared with the ones in the previous course. In this regard, it can be concluded that the new methodology did not affect negatively the laboratory grades and video tutorials can be used as an alternative to in person explanation. In fact, the percentage of students that preferred watching the video tutorials increased by a 11.9 % according to the survey.

Keywords: Active learning, video-based learning, online tests, laboratory, engineering.

1 INTRODUCTION

In the teaching framework created with the implementation of the European Higher Education Area (EHEA) the teaching-learning process was centered in the learners and two aspects got relevant importance: the continuous assessment and the use of new methodologies for a competency-based learning [1]. Following these new framework, the subjects of the Industrial Engineering degrees at *Universitat Jaume I* (Castelló, Spain) include a continuous assessment (30% of the final qualification) with different tasks: several tests (20%) and laboratory practicals (10%).

The purpose of the laboratory practical sessions is to show experimental activities related to the subject matter, to demonstrate the difficulty of the experimentation, to exemplify the scientific method of verification of the theoretical models and to develop the student's skills related to writing technical reports. In the case of the Fluid Mechanics subject, the laboratory practicals help to assess the generic competency of being able to analyze physical phenomena related to fluid mechanics through experimentation and derive empirical expressions for their description (CG01).

Regarding the methodology used during the practical sessions, they are intended to be fully experimental and let the students to carry out the experiments and process the data. Nevertheless, the technical reports delivered show a lack of ability of students to express what was carried out caused in some occasions by the lack of comprehension of the theoretical concepts [2]. This theoretical background is supposed to be acquired in the theory classes but some difficulties arise in the laboratory sessions. These difficulties are mainly due to the lack of attendance of the students to theory classes and a possible mismatch between theory and practical classes as a consequence of the temporary planning of the laboratory sessions.

To overcome this problem, an active learning was promoted. In active learning strategies students are more involved and engaged in activities and there is greater emphasis on developing student's skills [3]. Besides, in engineering degrees this methodology can help the students to become self-learners and to prepare them for how they will need to learn as practicing engineers [4]. In the particular case of the Fluid Mechanics subject a written manual was given to the students including the theoretical explanation of the phenomena under study, the experimental methodology and the analysis of the results. However, the students are not prone to participating in this task, which is one of the risks of active learning [3]. They felt that reading the manual before practical sessions was a non-worthy time consuming process and preferred following the professor guidelines once in the laboratory. Finally, it was the professor who had to explain the key theoretical concepts, thus reducing the time for experimentation and data processing. Moreover, other drawbacks of the professor explanation were the lack of attention paid by some students and not being clearly heard in a crowded class.

As an alternative to the written manual, a video-based learning (VBL) was proposed. The development of new technologies and the availability of smartphones, tablets or laptops have made the integration of video applications in education easier. In this particular case, the information in the written manual and the in person professor explanation were replaced by video tutorials including the theoretical explanation and a demonstration of the experimental tasks. These videos had the advantage of being available for all the students anywhere at any time. However, although the VBL has shown a positive impact on the learning outcome [5] students must be motivated by this active learning.

One of the principles of the Universal Design for Learning (UDL) is to provide multiple means of engagement with the aim of having expert learners purposeful and motivated [6]. In this regard, individuals are engaged by information and activities that are relevant and valuable to their interests and goals. However, in spite of the multiple advantages of the active learning, most of the students are only engaged in the activities if they get some benefits in the final qualification.

Therefore, in order to motivate the students towards active learning, a methodology including test to assess their background can be effective. This tests must be answered at the beginning of the laboratory sessions and the grades obtained have to be considered for the final qualification. Thanks to the availability of digital resources, the tests can be answered online so the students can get immediate feedback.

The results presented in this paper were obtained in a study carried out with the students of the Fluid Mechanics subject of the Mechanical Engineering, Electrical Engineering and Industrial Technologies Engineering Degrees. The impact of introducing video-based learning in the academic course 2021/2022 and the initial online tests in the next course 2022/2023 on the students' performance was analyzed. An online survey was used to gather their opinion about the methodologies used and the qualifications obtained in the tests and technical reports were also analyzed to evaluate the influence of these new methodologies on the teaching-learning process.

2 METHODOLOGY

The Fluid Mechanics subject is divided in four different groups named M, E, I and Y groups, corresponding to students that get access to the degrees with different academic profiles. Group M is for Mechanical Engineering students, group E is for Electrical Engineering students, group I is for Industrial Technologies Engineering students and group Y is a reduced in size group (20 students) composed by high performance students of all three degrees that are studying the double degree EURUJI (*Universitat Jaume I* – INSA Lyon/Toulouse). These students are selected by their academic record during secondary school and university access tests.

As part of the continuous assessment, the students must carry out a total number of four laboratory practices. To do that the groups are divided in several subgroups of less than 20 students that form working groups of 4-5 members to do the experimental work. The qualification of the laboratory practices (10% of the final qualification) is achieved as the weighted average qualification of a final report delivered by each working group (70%), an individual test about the practical session (20%) and a co-evaluation test among the students in a working group (10%).

Until the academic course 2020/2021 the methodology used during the laboratory sessions was the following:

1 Students were asked to read a written manual available in the virtual classroom (Moodle) before the practical session.

2 At the beginning of the session the professor briefly explained the objective of the practice and how to carry out the experimental tasks.

3 Students carried out the tasks and processed the data.

4 An individual written test was answered by the students about the tasks done during the session to ensure that they have acquired the related knowledge and competencies.

5 In the next laboratory session, the students delivered the previous practice report.

However, most of the students did not read the manual before the laboratory session and the professor had to explain in detail all the theoretical background needed to develop the experimental tasks (step 2) thus reducing time for experimentation and data processing (step 3).

In the academic course 2021/2022, video tutorials with a duration of 25-30 minutes including the theoretical explanation and the experimental demonstrations were recorded and uploaded to the virtual classroom. Fig. 1 and Fig. 2 are examples of the information given in the video tutorials. Students were encouraged to watch the video tutorials as an alternative to reading the written manual but the professor still had to spend a lot of time doing the practical session explanation (step 2).

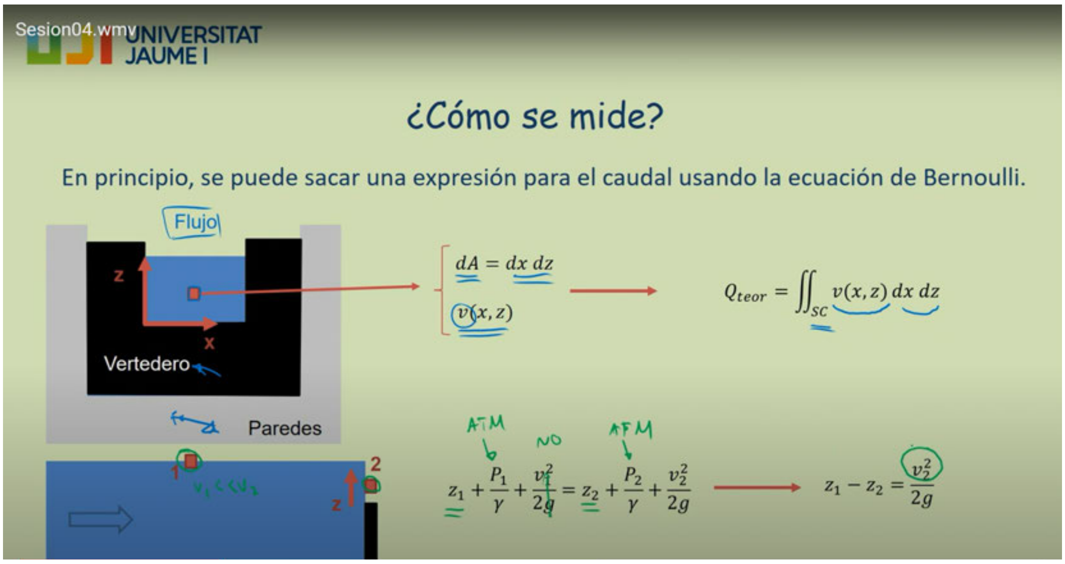


Figure 1. Video tutorial snapshot of theoretical explanation for session #4.

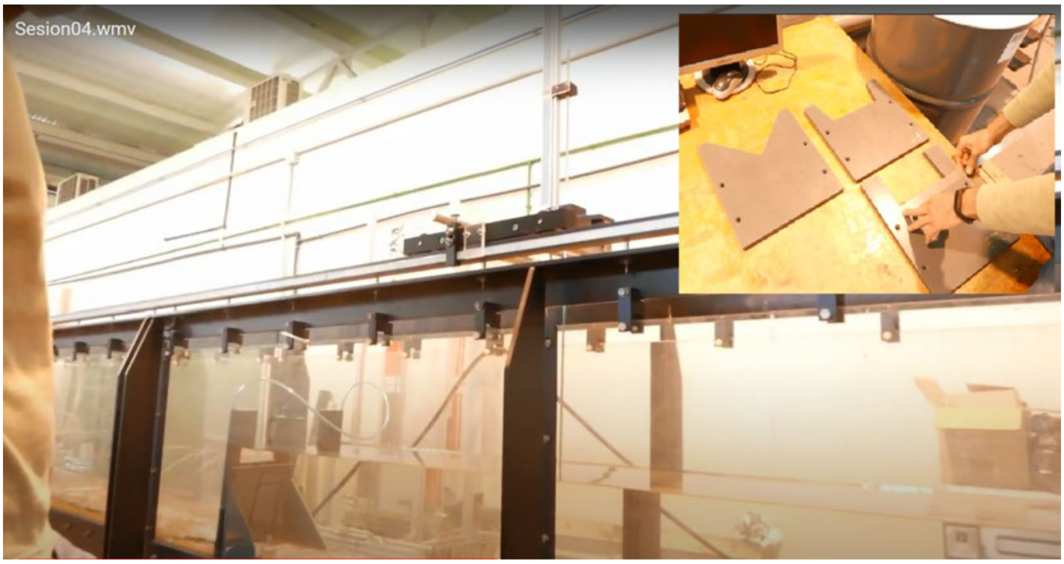
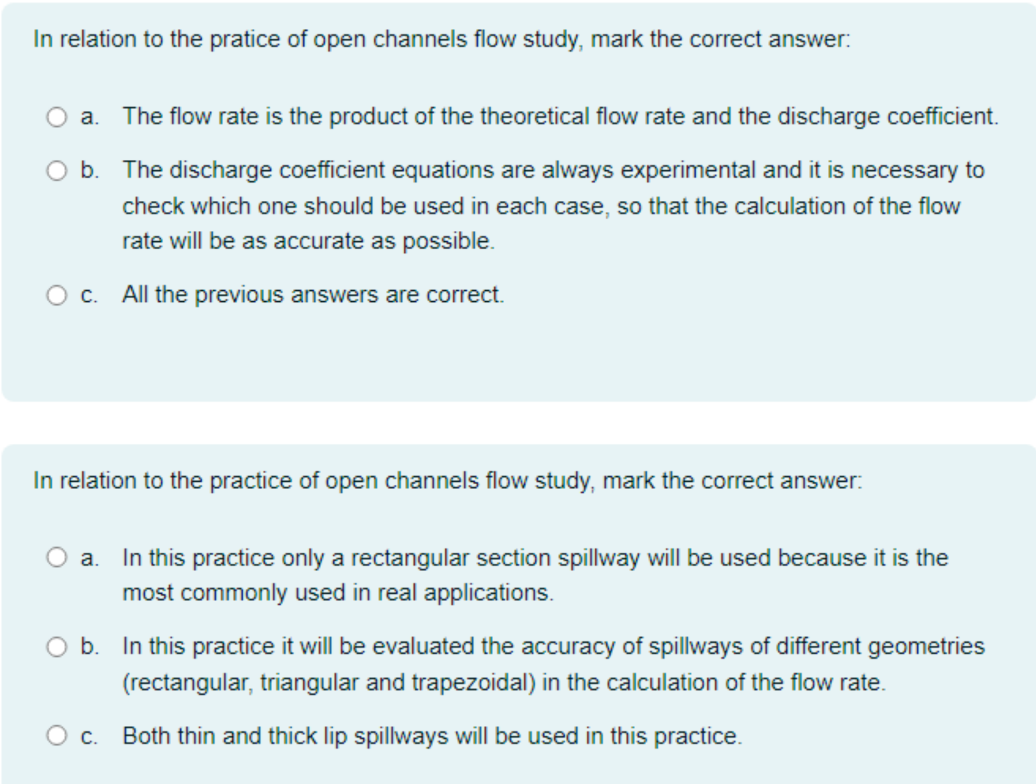


Figure 2. Video tutorial snapshot of experimental demonstration for session #4.

To motivate the students towards active learning before the laboratory sessions, during the academic course 2022/2023 the methodology was changed. The individual written tests answered at the end of the sessions were eliminated and replaced by online initial tests about the theoretical background and the information given in the video tutorials (20% of the laboratory qualification). The new methodology was as follows:s

1 Students were asked to watch the video tutorials available in the virtual classroom (Moodle) before the practical session.
2 An individual online test was answered by the students about the theoretical background related to the session.
3 Students carried out the experimental tasks and processed the data.
4 The professor helped the students doing the tasks and solving doubts.
5 In the next laboratory session, the students delivered the previous practice report.

The tests consisted of four multiple choice questions and were answered through the virtual classroom using the smartphones, tablets or laptops. In Fig. 3 an example of the questions is shown.


In relation to the pratice of open channels flow study, mark the correct answer:

- a. The flow rate is the product of the theoretical flow rate and the discharge coefficient.
- b. The discharge coefficient equations are always experimental and it is necessary to check which one should be used in each case, so that the calculation of the flow rate will be as accurate as possible.
- c. All the previous answers are correct.

In relation to the practice of open channels flow study, mark the correct answer:

- a. In this practice only a rectangular section spillway will be used because it is the most commonly used in real applications.
- b. In this practice it will be evaluated the accuracy of spillways of different geometries (rectangular, triangular and trapezoidal) in the calculation of the flow rate.
- c. Both thin and thick lip spillways will be used in this practice.

Figure 3. Example of questions in online tests for session #4.

Finally, in order to gather the opinion of the students about the new methodologies applied during the 2021/2022 and 2022/2023 courses, an online anonymous survey was prepared using Google Forms including the following questions:

Q1: Have you read the written manual before doing the different sessions? (YES/NO)

Q2: Have you watched the video tutorials before doing the different sessions? (YES/NO)

Q3: Which of the following options do you prefer to understand the development of the laboratory practice before doing it? (A1: Reading the manual; A2: Watching the video tutorial; A3: Professor explanation)

Q4: Do you have any comments to improve the methodology? (Optional open answer)

3 RESULTS

At the end of the academic course 2021/2022 the students were asked to fill in the online survey about the methodology used as an optional homework. However, only 25 of the 124 students attending the classes answered the survey. Among them, 23 students affirmed having done some of the activities proposed: reading the manual, watching the video tutorial or both. In the next course 2022/2023, the students were asked again to fill in the online survey but during the last practical session. In this case, 96 of the 166 students attending the classes answered the survey, 70 students being ones that affirmed have done some of the activities proposed.

Fig. 4 shows the results obtained from the survey (Q1 and Q2), taking into account only the answers of the students that affirmed having done some of the activities. It can be observed that in the course 2022/2023 the percentage of students only reading the manual decreased by 12.3% while increasing mainly the students doing both activities (12.0%): reading the manual and watching the video tutorials. Regarding their preferences, Fig. 5 shows the results obtained from question Q3 in the survey. As observed, the percentage of students that preferred the professor explanation decreased by 12.1% while increasing the preference of watching the video tutorials by 11.9%. It can be concluded that the introduction of the online tests at the beginning of the session to promote watching video tutorials had a positive effect as more students did the activity in the course 2022/2023 and changed their methodology preference. Reading the manual, it can be useful as a complementary tool but is still the least preferred choice for the students. This result is in good agreement with previous studies found in the literature [7, 8] which concludes that the fact of preferring to see and listen than to read seems to be a general social trend for young people.

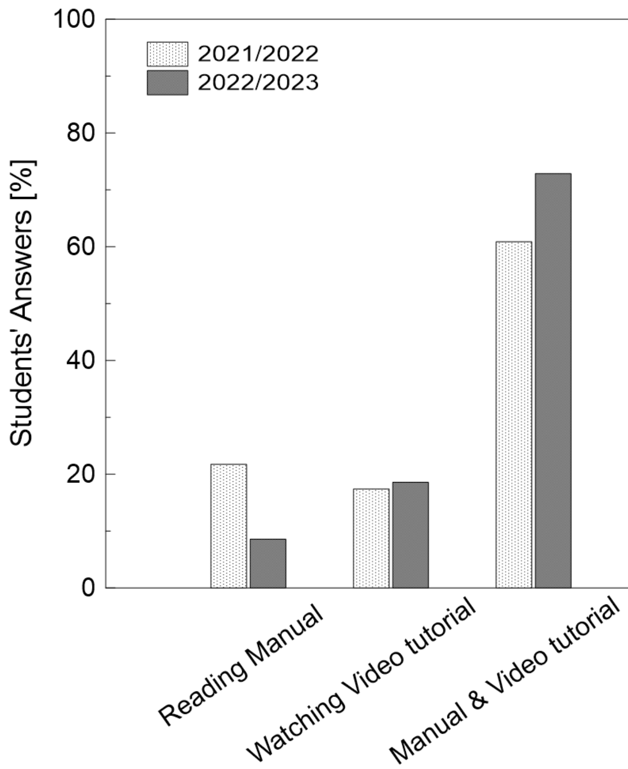


Figure 4. Students' answers regarding activities done in academic courses 2021/2022 and 2022/2023.

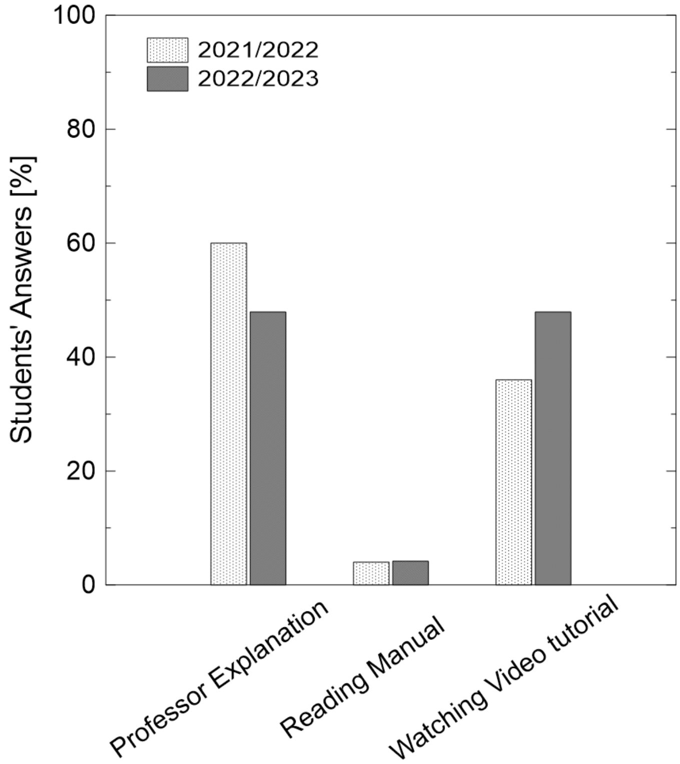


Figure 5. Students' answers regarding activities preferred in academic courses 2021/2022 and 2022/2023.

In order to evaluate the influence of the new methodology applied in 2022/2023 on the student's theoretical background, the grades obtained in the online tests as well as the grades of the final technical reports submitted were analyzed. Results plotted in Fig. 6 show that the average grades for the online tests were higher that 6 in all groups being Group Y (high performance group) the one with the maximum average grade (7.6). If the average grade of the technical reports in 2022/2023 is compared to the one in 2021/2022 it can be observed a slightly decrease in most of the groups. However, many factors can influence this decrease such as a different access profile of the students, different professors for each group and academic course, number of students following the course for the first time, etc.

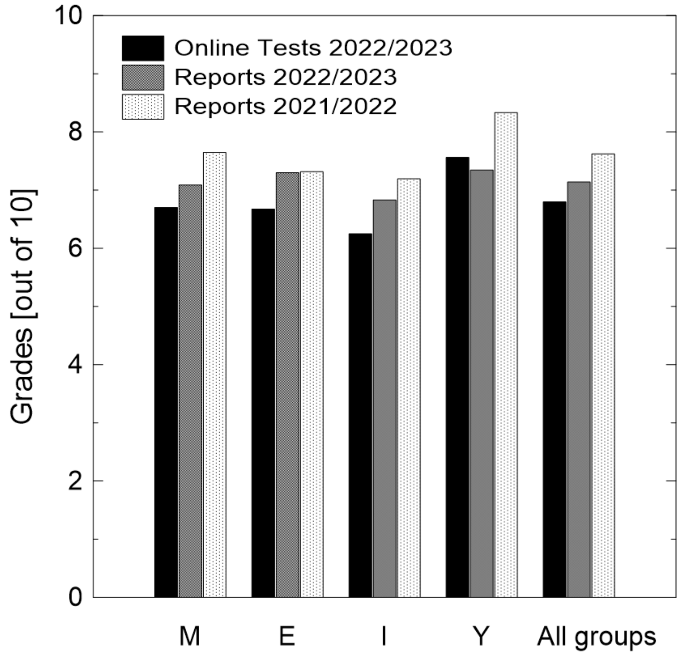


Figure 6. Students' grades in online tests and final technical reports.

Fig. 7 shows the variation of students' grades calculated as the difference between the grades obtained in 2022/2023 (G_{23}) and 2021/2022 (G_{22}) in relation to course 2021/2022:

$$\Delta G\ [\%] = \frac{(G_{23} - G_{22})}{G_{22}} \cdot 100 \quad (1)$$

The variation in the technical reports is compared to the variation in the average academic records of the students before following the course (second semester). As the average academic records do not change (groups M and I) or even decrease (groups E and Y) in relation to the previous course, the lower grades obtained in the technical reports in 2022/2023 could be attributed to the different access profile of the students and not the new methodology. To extend this analysis, Table 1 shows the average grades obtained for the academic records, the technical laboratory reports and the subject final grade including all groups, as well as the grades variation. It can be observed that all the grades under analysis are lower for the 2022/2023 course thus confirming the possible influence of the student's access profile. From these results it can be concluded that the new methodology did not negatively affect the laboratory grades and student's performance, and the information contained in the video tutorials was useful and could be used as an alternative to the in person explanation.

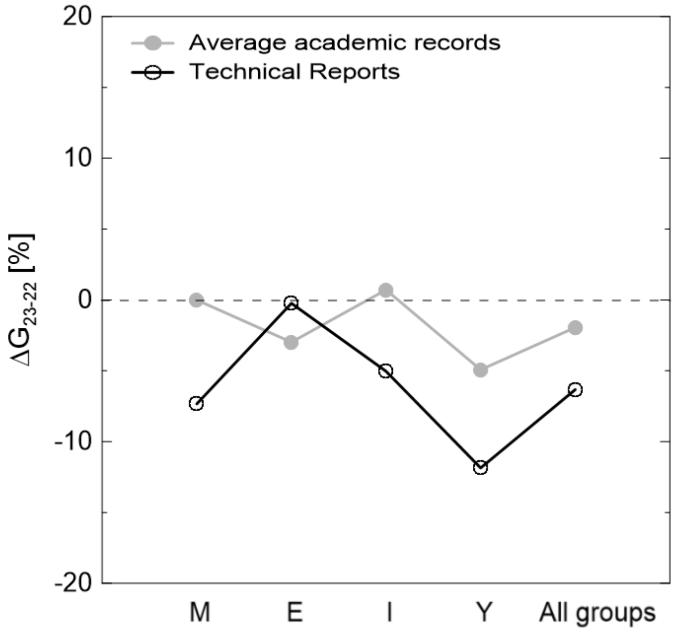


Figure 7. Variation of students' average academic records and technical reports grades.

Table 1. Average grades including all groups.

	Average grade [out of 10]		***ΔG23-22 [%]***
	2021/2022	***2022/2023***	
Academic Records	6.5	6.4	-1.9
Technical Reports	7.6	7.1	-6.3
Subject Final Grade	5.2	5.1	-3.4

Finally, an optional open question was included in the survey to let the students to suggest possible improvements (Q4). In the 2022/2023 survey, 46 comments from the students were received from which 39.1% of them said they would change "nothing" and 28.3% complain about the duration of the videos (25-30 min).

4 CONCLUSIONS

A new active learning methodology was followed including video-based learning and online tests in laboratory practical sessions with the aim of improving the theoretical background of students before the sessions. From the results, the following conclusions were gathered:

- Students need to be motivated to engage the active learning activities. As part of the motivation strategies some benefits must be reported to the students doing these activities.
- The percentage of students watching video tutorials increased with the introduction of the initial online tests accounting for the laboratory grades, proving them as a good motivation technique.
- The students preferring the professor explanation decreased while increased watching the video tutorials. The VBL was a preferred choice as videos were available anytime and anywhere and helped the students in the preparation of the technical reports even after the laboratory sessions.
- Students prefer watching or listening to the professor rather than reading the manual.
- The change in the methodology had no significant influence on the student's grades and the slight decrease observed in the technical reports grades can be attributed to the lower average academic records of the students.
- The information contained in the video tutorials was useful and can be used as an alternative to the written manual and the in person explanation.

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