EOLES Course, 4 years and going…results and experiences.

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ABSTRACT

The EOLES (Electronics and Optics e-Learning for Embedded Systems) course consists of a 3rd year Bachelor degree that relies exclusively on e-learning and remote laboratories, developed as the result of an EU funded ERASMUS+ project, involving 15 institutions from four European and three North African countries and concluded in 2015. The developed course was accredited as a specialization year in most partner institutions and has been running non-stop since then, mainly with students from North African institutions. Although no longer supported by an EU project, the course is a good example of sustainability as it already had 4 effective editions with successful approval rates and always with many more candidates than available vacancies. This paper presents an overview and overall results for this initial period and a more detailed analysis of the Digital Systems Teaching Unit. The focus is on the course specific characteristics and features, student and teacher experiences and the methodologies that were applied to enhance learning results. Although being a fully online course, several synchronous activities and communication tools are included in the methodology to enhance student and teacher iteration and also to provide an impartial grading process, as required for accreditation. The course expositive material is provided as the student progresses, with progressive unlocking of content depending on each teaching unit timeline, and automatic quizzes results. In short, students are allowed and encouraged to adjust their learning rhythm within the limits allowed by time restraints and evaluation criteria.

1 INTRODUCTION

The preparation of the degree had into account the characteristics of the target students and the national priorities defined by Maghreb governments for the development of higher education in advance engineering fields. Training is entirely conducted in English, allowing students to substantially improve their English skills, a fundamental tool in technological areas where the information, being it study materials or manufacturers' data, is only available in this language. Therefore, candidate

students would have to have a minimum English level evaluated through a TOEIC or a TOEFL test or equivalent, recognized by the different partners of the consortium.

The degree is fully delivered on-line using e-Learning 2.0 [1][2] synchronous and asynchronous tools, allowing students to be part of a “virtual learning community” and empowering teamwork, even if the team members are far apart. An innovative remote laboratory based on virtual experimentation and modelling and simulation platforms, and on remotely operated real instrumentation equipment installed in different universities was used by students to acquire essential practical skills.

Degree accreditation is still a major requirement for course validation and recruitment. This is a major advantage of the EOLES course and with particular interest to its main target group. The degree was recognized by the educational authorities of France, Morocco and Tunisia. As a result, all successful students receive a diploma recognized inside the European Higher Education Area (EHEA). Another important aspect was that the curriculum program should allow graduated students to later apply for postgraduate degrees in any other University. Therefore, all students from Morocco and Tunisia will receive a Joint Diploma issued by the University where they are enrolled in their own country and by the University of Limoges.

2 THE EOLES DEGREE

2.1. Organization

The program was defined in cooperation with the North African Universities participating in the project, considering the priorities defined by their countries’ governments. The program’s focus on electronics and optics for embedded systems responds to the current tendency for integration of hardware/software into single reconfigurable platforms and to the increase on the amount of data produced and transferred requiring high-speed optical transmission, and to the need of training highly qualified professionals able to keep their countries’ pace with these new technologies. The program is divided in fourteen technical units (TUs) and in three optional units, as presented in Figure 1. The TUs are divided in two semesters and the detailed content of each one of the TUs is available in the project website [3]. The degree runs for 31 weeks, plus 3 weeks reserved for examinations – one in the end of the first semester, another one in the end of the second semester, and a last one in the final week of the course for make-up exams.

The Learning Management System (LMS) that supports TU organization, materials’ access and delivering, on-line assessments, virtual and experimental lab access, tracking and reporting, forums and chats and all other course related activities was initially based on a Moodle 2.7 version platform [4], since then upgraded to version 3.5 for the 2018/19 edition.

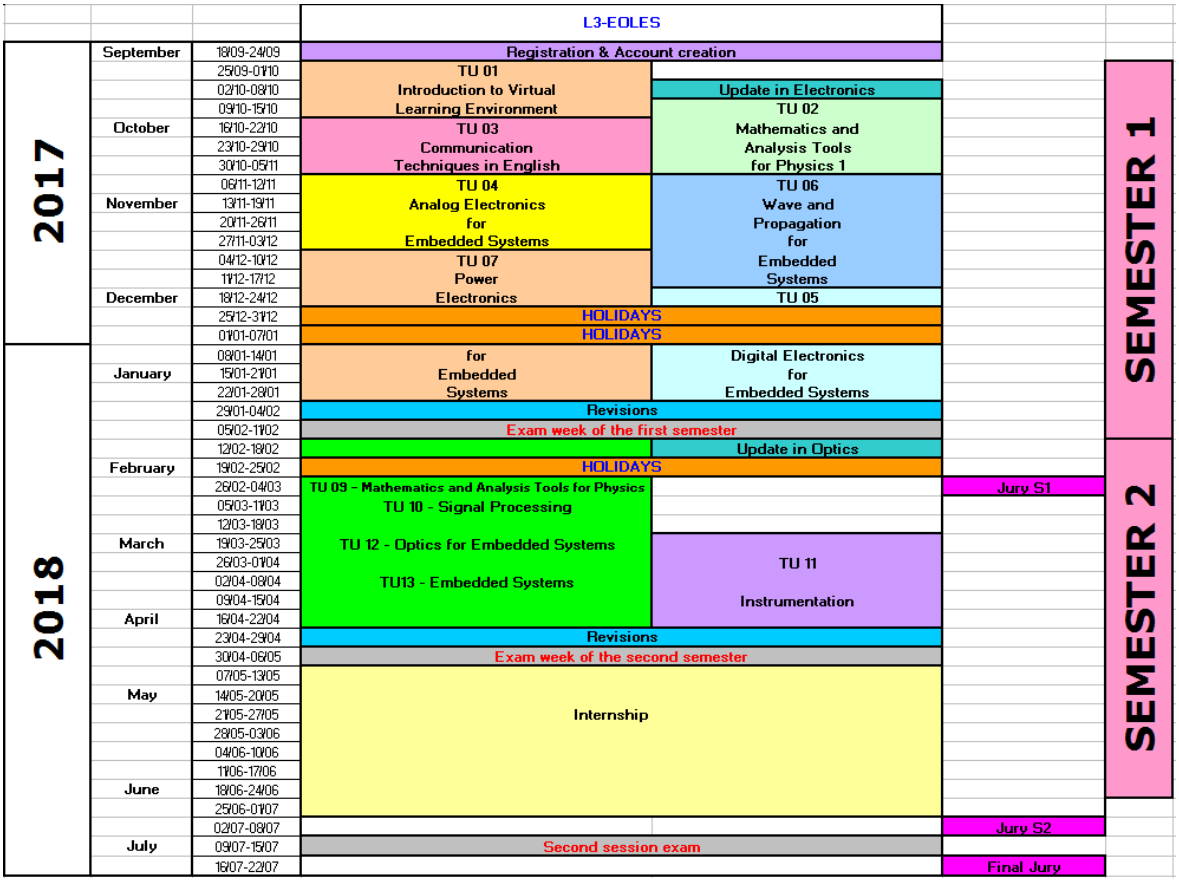
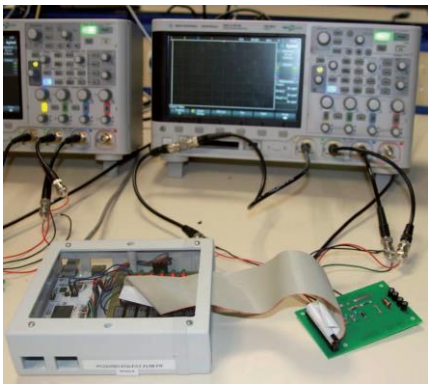


Fig. 1. TU listing and schedule (17/18 edition)

2.2. Remote Laboratories

An effective practical innovation of the L3-EOLES degree are the remote laboratories used to perform on-line practical works. A multi-user approach is implemented allowing a group of students to work and interact in real time over the same Practical Work (PW), guaranteeing a strong collaboration among them during the training. Each hardware setup (function generator or oscilloscope, for instance) is connected to the internet. From each TU's Moodle page students have access to the related lab's webpage and to the TUs' proposed lab works. Students are able to change the hardware configuration in real-time and have an immediate feedback of their actions, via the virtual instrument interfaces that are deployed remotely and through a high-definition camera (or another interface).

Figure 2 shows one of those lab setups using internet-controlled instrumentation and a camera and Figure 3 shows part of the user interface. This enables students to see what is going on the real lab and how the real instruments react to their remote commands. This feedback is important for students to be sure that the interface they are seeing in their own monitor is not the visible face of a virtual world but the virtual interface of a real instrument.



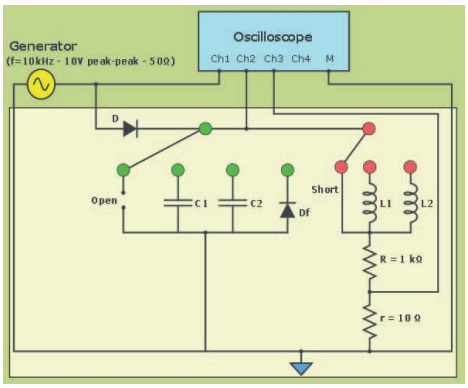


Fig. 2. Remote Laboratory Setup *Fig. 3.* Remote Laboratory Interface

The remote laboratory is expected to have a substantial learning impact as each student or group of students have the possibility of repeating the same experiment several times and trying different configurations in a controlled and safe environment. These remote laboratories are used in subjects where the real equipment is more important and were presented and demonstrated on several technical events [5][6]. In some TUs those online labs are replaced or complemented by simulator tools or remote access to advanced software tools.

2.3. Assessment and Grading

The EOLES degree follows the French university assessment system with some adaptations. Grading is made on a 0-20 scale, where 10 is the passing grade. Each student is required to have an average of 10.0 or more at the year's end for successful graduation, being possible to have less than 10 on any individual TU, although no grade can be below 5. At the end of the year, there is a final recourse exam, where each student can try to improve his grades on any specific TU in order to achieve passing results. Students that fail to graduate at years end, can repeat only part of the degree (where the failed to achieve a passing grade) on the following year. On each individual TU the grade is composed of three components, namely: (1) mandatory practical works or assignments; (2) an one-hour on-line exam held at the end of each TU; (3) a two-hour final exam held by the semester's end is worth 50% of the TU's final grade.

The on-line exam is designed to allow the students to consult any technical or pedagogical resource they deem necessary, therefore having a strict time limit and requiring students to be online and visible (through webcam) during the entire exam. The final exam is performed at a university room on a scheduled date, requiring the students to be physically on the same space and under staff supervision during the duration of the exam. A bonus between 0 and 2 points could be attributed at tutor's discretion to each student according to his/her level of participation in the synchronous sessions, forums and live chats. The specific weight of the grading components can be adjusted by each TU staff, varying between 20% and 35% for components 1 and 2 and 40% and 50% for component 3. The higher weight of the final exam being mostly due to the more controlled environment which provides a fairer grading.

3 DIGITAL ELECTRONICS TU

3.1 Organization

To better illustrate the degree, we will present and discuss the pedagogical solutions implemented on TU05-Digital Electronics for Embedded Systems. The proposed framework was similar in all TUs, but some implementation adaptations were required as the subjects and difficulty levels are considerably different in some cases.

In TU05 the lectures consist of a set of 21 pre-recorded asynchronous classes with a duration never exceeding 20 minutes, where an instructor explains the theoretical basis of a subject supported by different types of visual materials as illustrated in Figure 4. Most classes relied on PowerPoint slides presentation, recorded as online videos, with the teacher image superimposed and several visual aids (arrows, circles, etc...) used to illustrate key points. When required the classes also used external links and access to simulated equipment. The classes are interspersed with self-evaluation quizzes, composed of multiple-choice, fill-in-the-blanks, matching exercises. These are intended to keep students' interest and attention, breaking long expositive classes and have no weight on the TU grading. Additionally, these self-evaluation questions provide students with an immediate feedback about their degree of understanding of the subjects being taught. A Quiz example is presented in Figure 5.

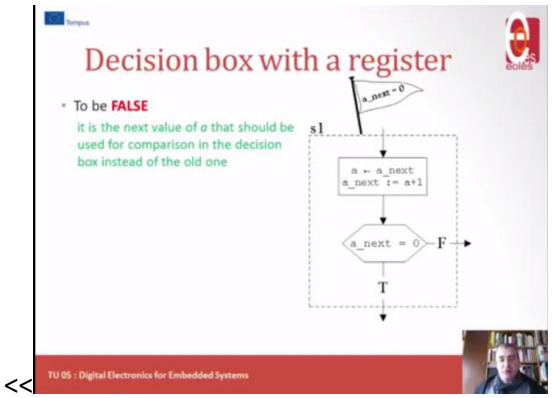


Fig. 4. Synchronous Class

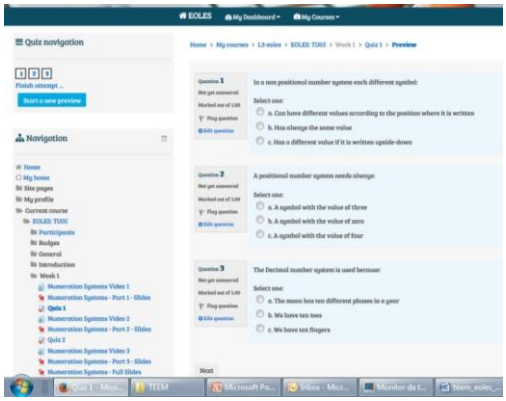


Fig. 5. Self-Assessment Quiz.

Students can progress at their own pace, viewing or reviewing this visual material anytime, any number of times, without restrictions. However, the student can only proceed to the next lecture after the successful completion of the self-evaluation questions associated to the previous one. A range of other materials is also available to support the study, including companion books freely downloadable from Internet, web links to other sites containing specialized information and other complementary data, depending on the TUs subject.Tutorial classes are synchronous classes based on the use of a web conferencing tool. Their aim is to enable students to clarify any issues and ask questions related to the content of the TUs. These classes are also recorded, and the records made available to students. During the synchronous classes tutor and students are required to have their cameras on. The aim is to have a visual feedback of the whole class making students feel part of a group and be able to interact not only with the tutor but also among each other.

4 RESULTS

4.1 EOLES Degree

The number of applicants on all degree editions largely exceeded the expectations, albeit and the number of vacancies were highly concentrated in one of the EOLES partner countries (i.e. Morocco). Each edition also included lifelong learning students that enrol already planning to take 2 years to conclude the degree and also repeat students, which try to make the remaining TUs in order to graduate. Interestingly, the last editions also included a few students with geographic origins outside the Maghreb countries (i. e. Canada and Spain) which illustrates the interest and demand for this type of courses worldwide. Table 1 presents the number of students that were enrolled in the degree, those that finished (were present at the final exam) and the approval rates, defined as the number of approved students compared with the number of students that finished the course (attended the exams) or the number originally enrolled, respectively.

Table 1. EOLES Degree Results

EDITION	ENROLLED	FINISHED	GRADUATED	APPROVAL	
14/15	25	21	11	52%	44%
15/16	32	26	21	81%	66%
16/17	37	34	26	76%	70%
17/18	27	22	19	86%	70%

The results are very satisfactory, proving that the issues present in the first edition were sorted and an adequate success rate was achieved. It should be noted the degree is deemed as challenging and requiring effort equivalent to a normal 3rd year degree in a French University, hence the adequacy of the presented success rates. Even so, failure to graduate is always analysed and three main reasons were identified, namely (1) abandonment of the degree for personal reasons (usually professional); (2) inability to complete some specific TU due to lack of previous knowledge or lack of adequate effort; and (3) language problems, albeit having prior English knowledge attested by their TOEFL certificates.

The effectiveness of the use of virtual and remote laboratories in e-engineering courses was demonstrated by an extensive study published by James Brinson [7] and by our own experience after four L3-EOLES editions [8]. As to the effectiveness of the learning environment, several non-quantitative conclusions were possible from the first years' experience, namely: (1) Students are more used to interactive classes, preferring those as an initial approach. This solution is feasible for simpler subjects; (2) Recorded classes are a much more time efficient way to deliver complex subjects, as they allow the students to study and repeat at their own pace; (3) Interactive classes are required to clarify doubts and answer questions. The use of recorded classes is not a complete solution to most students; (4) Student participation in interactive classes is very diverse, requiring the teacher to be proactive; (5) Additional

asynchronous resources (forums, emails) are often preferred by some students, namely when lacking communication skills (e.g. English language)

The practical assignments were a mixed experience. In some TUs the experiments were simpler and direct, with the assignment being the best grade of the students. On others, the assignments were more complex and was frequent that some were not even executed by the students (with the negative effect on the final grade) and several works being obviously rushed by the students. There was also some need to analyse the uniqueness of the delivered reports, as the online character of the course sometimes promoted the sharing of results between students. The online exams usually present much better grades that the final exams, as was to be expected, and showing that some type of attendant assessment is still required for a fairer grading.

4.2 Digital Systems Technical Unit

In the particular case of TU05, the results were in general good, with approval rates of more than 80% every year and average grades above 12,5. The online quizzes to get access to content are a key feature of this TU and allowed some specific conclusions. Students would sometimes require several attempts to progress, some had to review the online classes after failing a quiz and others posted their doubts in forums or sent messages to the teachers. These actions were monitored using the Moodle logging functions, and show the quizzes working as intended, promoting interactivity and the need for seeking additional information.

The synchronous classes were not used to present new subjects, although several times it was necessary to clarify and repeat issues presented on recorded classes, as some doubts remained. Participation was very variable, with between 25 and 80% of students present as viewers. However, video and audio participation were limited, with a few students being responsible by the majority of questions and discussion. A very important feature was the ability to share documentation and visual aids, as several questions required the discussion and revision of available materials.

In this TU, most grades were above the 50% mark, confirming that the TU subjects were adequately delivered. The examination results were better than assignment work results, by a considerable margin in several cases, due to somewhat tough learning curve of the high-end software being used on assignments [7]. Nevertheless, this experimental work is deemed as a vital learning resource and every year the documentation and support is improved.

4.3 Degree Assessment

At the end of each EOLES edition students are asked to fill a compulsory anonymous questionnaire with 8 questions, for each individual TU, in order to assess the degree, as perceived by the students. The following figures present the questions and their answers for the last edition analysed (2017/18), with some comments to better present the results and their relationship to previous editions.

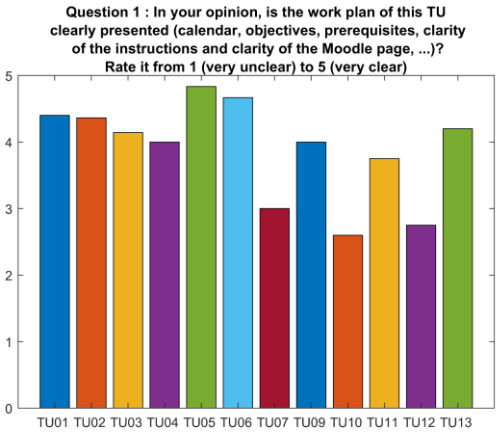


Fig. 6. Question 1

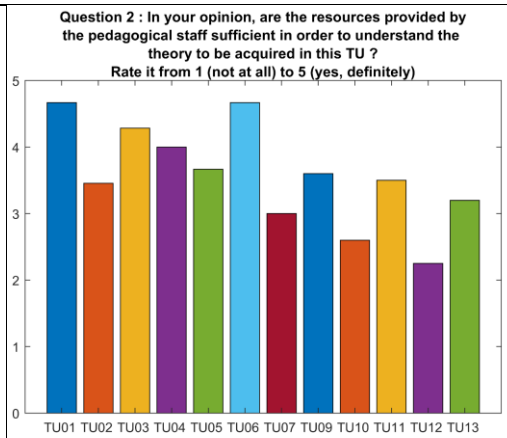


Fig. 7. Question 2

From the first 2 questions it can be derived that the overall presentation of the degree and the available resources is mostly adequate, as perceived by the students. There are a few TUs that can be improved on this regard and efforts have been made in that aspect. There is a steady improvement since the first edition, although some subjects are still difficult to convey on a format that is well accepted by the students. This type of analysis is important, and the teachers of the different units often use the comparative analysis for mutual benefit.

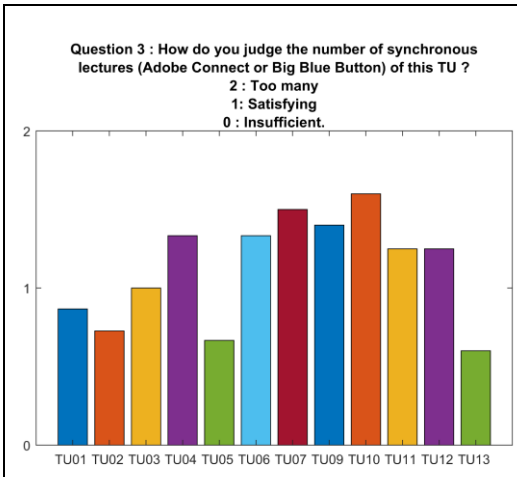


Fig. 8. Question 3

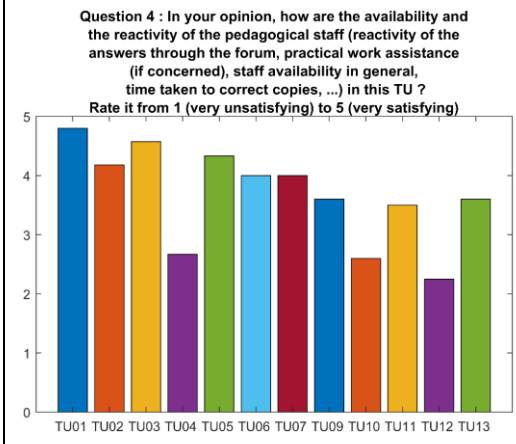


Fig. 9. Question 4

From questions 3 and 4, we can see that the number of synchronous sessions is always a reason for debate. It should be remembered that in the 2 years prior to the EOLES degree, students' study in "standard" presential university classes, and the transition to online courses takes some adaptation. In all editions of the EOLES degree it is necessary to educate the students on the remote, web-based and asynchronous formats and tools, and the need for independently consulting the available resources. Even so, the staff is rated highly in its availability and reactivity, showing that that is not the root of the problem. Students are simply used to normal classes and one year is not enough to change the paradigm. This can also be confirmed by the results from lifelong students (and partially confirmed by repeat students) that show an obvious improvement on the second year.

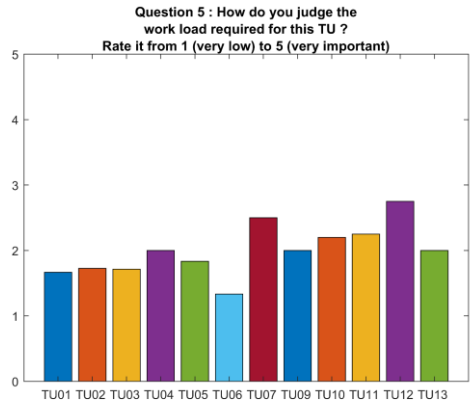


Fig. 10. Question 5

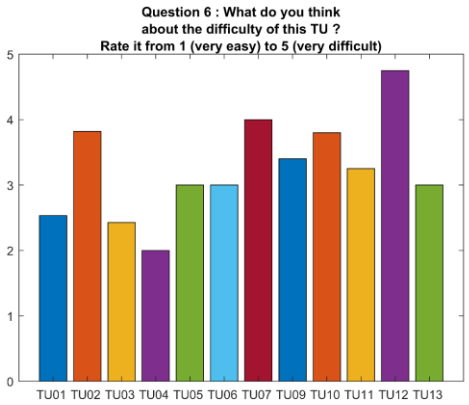


Fig. 11. Question 6

By the analysis of questions 5 and 6, the workload and difficulty of the TUs is considered adequate by the students, which usually are very candid when comparing that information with the final results. Their usual rationale is that the less good results are often due to the lack of time or effort invested by themselves, particularly on the harder TUs, with some mentioning high temporal requisites. There is an initial adaptation where the students need to realize the time, they need to invest is the same as a presential degree, but managed more autonomously, which is not always perceived adequately in due time. Most students adjust quickly during the year.

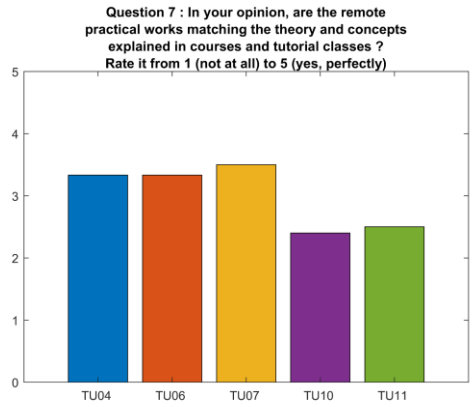


Fig. 12. Question 7

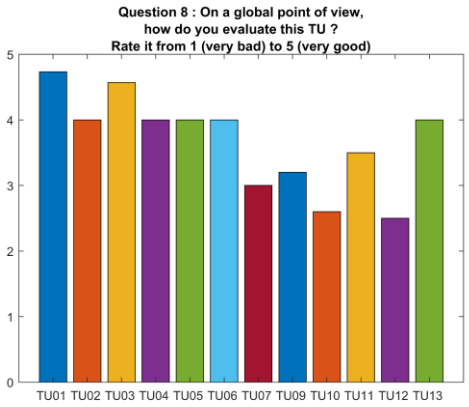


Fig. 13. Question 8

The remote experimentation results are adequate, but still show a visible difference toward the overall satisfaction. This shows that considerable work is still necessary on this area and is one where most of the improvements are planned and introduced on each EOLES edition. It is still hard to achieve remotely the same level of immersion and practical experience as possible on real labs, and the student's answers show this. Overall, the EOLES is positively assessed by the students and the retrieved data is constantly analysed in order to improve it. The evolution of student assessments (not presented in detail due to space constraints) show an overall steady improvement over time, and also some fluctuation between TUs and editions which usually relate with adjustments on the teaching resources and methodologies of each TU.

5 CONCLUSIONS

The EOLES degree is a successful example of a practical and useful outcome from an EU ERASMUS+ project. It represents a sustainable and accredited online degree that achieved a high level of maturity as a result of its 5 years of operation. The experiences and results are very interesting, and it also represents a testbed for this type of environments. The experience gained from the development of this degree is being used as a base of an ongoing ERASMUS+ project [10], where it is intended to develop a set of practices and methodologies to be used in the implementation of other online courses and laboratories in general, but with particular attention to engineering degrees. The overall experience of the teaching staff is extremely positive and allows for a permanent improvement of the teaching process. There are new challenges on each edition, and it is necessary to keep improving and evolving in order to keep up with the technological advances and the student's expectations.

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