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Real Collaborative Environments Using Technologies Based on Mobile Devices and Internet Tools

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Introduction

At present, the professional environment of our engineering graduates requires stronger competences for communication and teamwork. In the specific case of Marine Engineering, the ability of facing complex situations without external help, and the capacity of managing working groups at highly dynamic work conditions are both required. Besides, these professionals should be able to update their knowledge as fast as naval technology does. From an operation and maintenance point of view, or even related with modern antipollution and safety rules, these competences are usually acquired out of university today, as there is not a clear link between learning and maritime professional environments after graduation. For example, Prasad[1] states that acquisition of inappropriate competences according to the professional reality, is one of the factors that contributes to the rise of accidents on board. This author describes the impossibility to train each engineer for every possible situation, due to the high dynamism that these professionals are usually involved. This causes that experiences should be shared for allowing mutual learning between the members of the engineering crew.

By other hand, the profile of competences required by maritime industry, as emphasized by Simonsen et al.[2], is T shaped, as these engineers should have a multidisciplinary profile –horizontal competences–, but their training should also give them the possibility to specialize in one or more specific areas –vertical competences–. In this regard, the survey by the Danish Maritime Foundation, at Andersen et al.[3], describes the competences profile required nowadays by the maritime industry, clarifying the link between horizontal and vertical skills depending on the involved stakeholders referred. On one hand, classification societies, consultants, offshore industries and equipment manufacturers usually approach candidates owning a more vertical competences profile; on the other hand, ship operators and naval authorities commonly prefer candidates with a wider and more horizontal profile.

These requirements by the environment where future graduates will have to evolve cannot be satisfied through a traditional learning scheme, focused on the teacher, through a one-way knowledge stream. In our opinion, the solution to this requires the combination of active learning environments with suitable technologies which may grant an easier access to knowledge, and also increase the flow of information between students and lecturers, giving the chance to interact with elements or situations that were unavailable otherwise. The adoption of these methodologies may approach students to their future professional environment, while acquiring knowledge and skills in a more efficient way, improving their motivation and the engagement with their own learning process.

Active learning ITs in engineering education

The use of methodologies related to active learning strategies in engineering has been mentioned in the enquired literature since the end of the 80s. The search for an alternative model at universities is the answer to needs like the ones already stated. Perrenet and Bouhuijs[4] comment the validity of problem based learning (PBL) in engineering education, describing the experiences at the Eindhoven Technical University whilst applying this learning method on their mechanical engineering and bioengineering degrees –the first one

was restructured in 1994 meanwhile the second began on 1997–.
Authors such as Alcober et al.[5] and Tomkinson et al.[6] both describe their experiences in implementation of active learning environments –the first one based on projects while the second was based on problems–, with positive results acknowledged by both students and lecturers. One of the best known successful cases of implementation of this kind of learning environments applied to engineering, was described by Woods et al.[7] at the McMaster University, where problem based learning has been used in their chemical engineering degree since the early 80s.

However, despite the positive experiences, student-centered methodologies have not become a standard in the engineering learning, perhaps due to certain inertia in the teaching staff for not to research through methodologies which promote active learning, partly caused by having learned in a lecture-centered scheme. Catalano and Catalano[8] state that some of their colleagues believe that student-centered classes suffer from lack of accuracy, presumably due to the idea that keeping 'high standards' require to teach the same way they we were taught in the past. Furthermore, the implementation of active learning environments in engineering degrees has been heterogeneous, opting in the vast majority of cases for a combination of methodologies. Mills y Treagust[9] conclude in their study that an adequate solution is adopting a mixed methodology which combines the use of conventional classroom teaching for the earlier courses and problem-based learning for the advanced ones. Heitmann[10] goes even further, considering that a curriculum set by projects and problem-based learning may satisfy any demand of knowledge, competence and attitudes required from engineering graduates. Therefore, the design of a suitable curriculum may not just get limited to the use of these methodologies but also can contemplate the use of any kind of active learning environments where students may be involved with, both individually or in groups. These uses would comprise professional practices, learning based on ICTs and extracurricular activities, among other traditional activities which commonly take place at universities, such as performing exercises or laboratory practices. Other authors such as Northwood et al.[11] defend problem-based learning as the most appropriate for training future engineers, who may own adaptability, flexibility and self-learning skills along their professional career.
Related to the maritime field, Baylon[6] brings up the change of concept between the maritime STCW-78 IMO training code –based on knowledge– and the newer STCW-95 –based on competences–, outlining the advantages of problem-based learning as the most adequate method for developing competences required by marine professionals. In spite of this, the impact or active learning environments has been low. As pointed out by Emad and Oxford[12], the theoretical contents taught traditionally in the maritime training centres doesn't have a great range of applicability on board, keeping differences between theoretical and practical contents. However, there are some remarkable examples, such as the start-up of programs based on PBL at the School of Maritime Business and Management as described on Tuna13 et al., as well as the experiences in the environment of marine engineering technologies (MET) documented by Baylon[6,14,15] in several maritime schools of Philippines. In the particular case of marine engineering degrees, active learning environments would allow the development of the transverse competences required by this industry mentioned by Simonsen et al.[2], permitting the acquisition of more vertical competences in subsequent specializations.

Regardless what learning method is adopted –either problems or project based, or any other student-centered approach–, it's logical and reasonable to state that use of appropriate technologies, in conjunction with these active-learning environments, may catalyse the flow of knowledge exchange between students and facilitators, as a more dynamic work environment is now possible.

These concept of information exchange is essential for teamwork as it is closely linked to active learning environments. Prince[16] establishes his definition of problem-based learning included in the framework of different active learning modalities, which may usually be combined with either collaborative or cooperative work, according to the student's assessment procedure. These tools also ease and invigorate the immediate access to information through ICTs, as well as permit training and access to elements or situations which may be unavailable otherwise, e.g., using virtual technologies and augmented reality. The combination of methodologies and technologies in education is not new; Roschelle[17] breaks down some use possibilities offered by wireless devices one decade ago. However, it was the rise of mobile devices what pushed new dynamics at the classroom which were previously inconceivable, modifying the way of both teaching and learning, especially at K12 level. Actual mobile devices give the flexibility and the easy-to-use requirements one-to-one and group interactions always dreamed by teaching innovators. Authors like Murray and Olcese[18] link the collaborative possibilities offered by the iPad with the competences needed by students this century, emphasizing the need to use modern learning models. By contrast, technological tools have usually been used in simulation environments, laboratory practices or as basic tools for creating either work or reports in higher education, regardless the chosen methodology[19, 20]. This implies that, even when mobile devices are widely used by university students, mobile technologies still has not had the same impact as on lower educational levels.

Technology available to students

Based on the above mentioned, it's obvious that intensive use of technological tools is recommendable when designing active learning environments, as they allow an effective flow of information. However, the availability of updated devices is usually quite limited at institutional levels. One of the options may adopt the concept 'bring your own device' which is already being used at lower educational levels adapting it to the learning needs of an engineering degree.

Having the purpose of measuring the availability of computer equipment and mobile devices among our students, a survey was completed by students of different degrees between October and December 2013 at University of La Laguna (Spain): Marine Engineering, Radio electronics Engineering, Nautical Science, Industrial Engineering and Electronic Engineering. The mean age value of the surveyed students was around 23 years old with over 95% of them comprised between 22 and 24 years old (Figure 1). From a total of 121 surveyed students, 118 stated to have a computer available, owning more laptops or notebooks than desktops (comparison between figures 2 and 3).

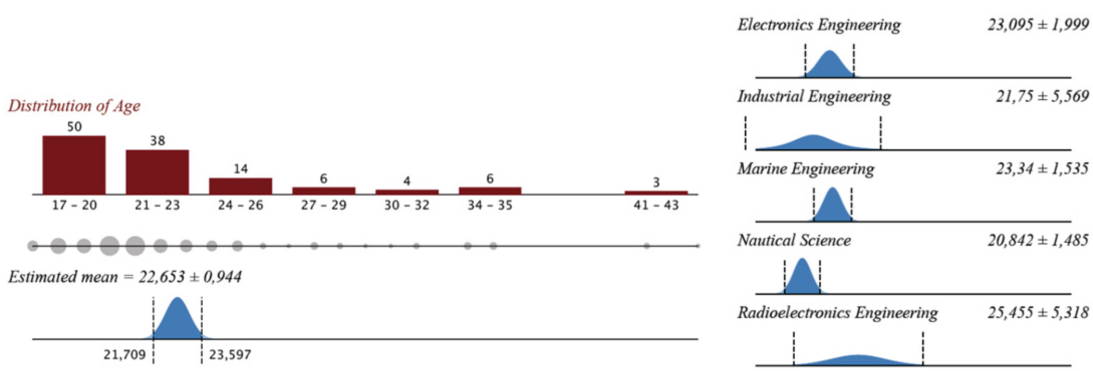

Fig. 1: Age range of the surveyed students.

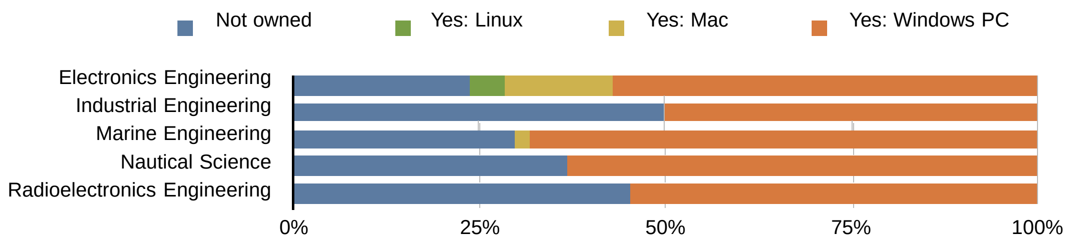

Fig. 2: Answers to question: ‘Do you own a desktop computer?

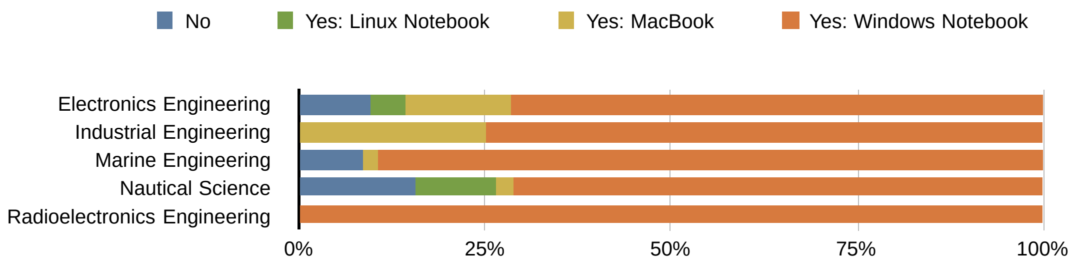

Fig. 3: Answers to question: ‘Do you own a laptop or notebook?

They were also asked about the availability of smartphones or tablets for their personal use, as well as which OS used by their devices. As expected, most students from the survey have smartphones (Fig.4), although they don’t associate its use with educational purposes. In fact, on the free text field left to point out which spare use was given to their mobile devices, we obtained answers such as ‘play games’, ‘read eBooks’ or ‘watch movies’ but nobody suggested to had used it at the classroom previously. In any case, it’s also true that the number of tablets owned by our students is significantly lower than smartphones at this moment. The use of tablets, specially iPads, allows a greater flexibility for teamwork due to a wider screen size and the increased number of specialized apps available. Although the use of laptops prevails now among this group of students, we may foresee that the amount of tablets will rise significantly in two years, as the younger students opt is increased for these devices, as appreciated in the distribution of the group under 20 years old in figure 5.

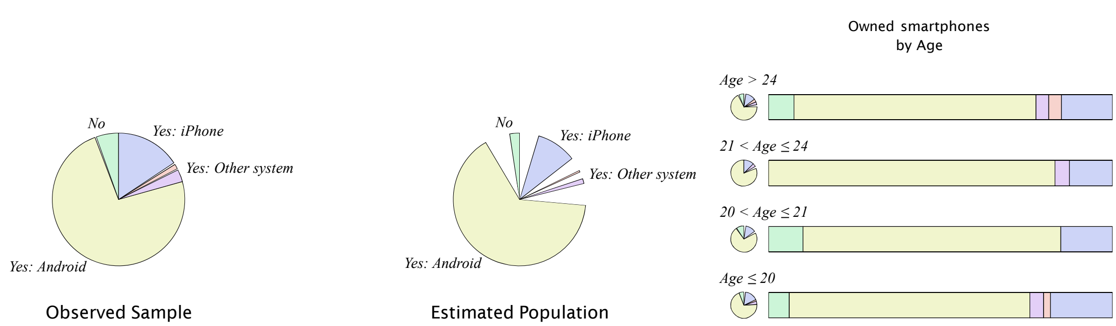

Fig. 4: Answers to question: ‘Do you own a smartphone?’

When our students were asked about their best private internet connection available, it was pointed out that most of them have an acceptable band with at home (figure 6), which is es-

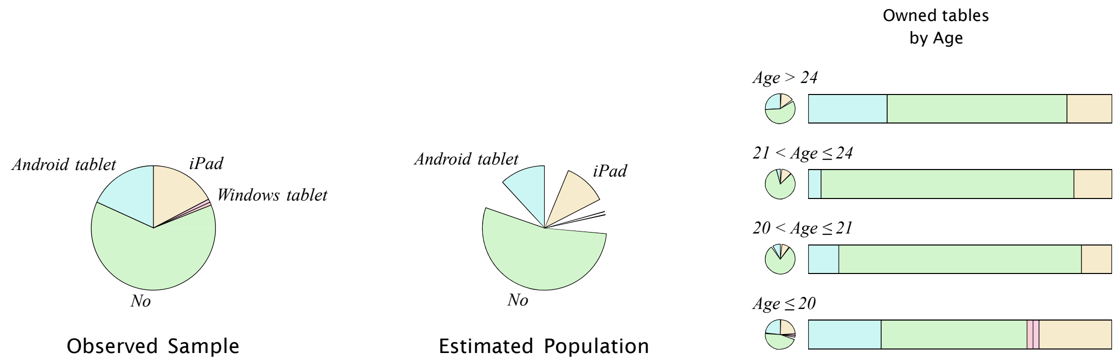

Fig. 5: Answers to question: ‘Do you own a tablet?’

sential for an educational model based on teamwork, as it allows use of chats, videoconference, audiovisual material access, virtual tutoring and any other internet-based activity. However, these students have also Wi-Fi connection available in their centres, both in and outside their classroom.

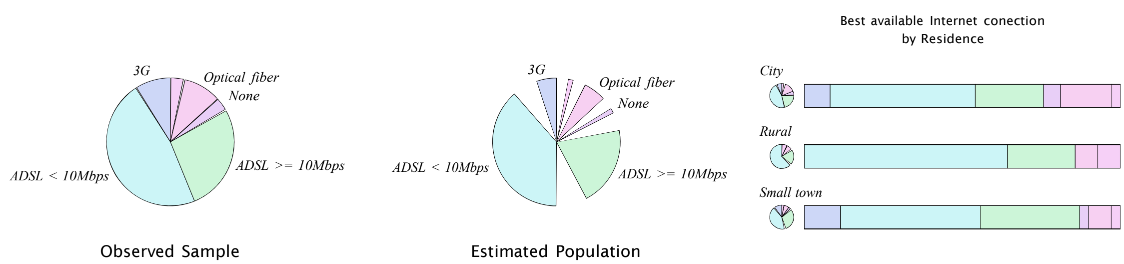

Fig. 6: Answers to question: ‘Which is your best Internet connection available?

Methodological approach

According to the acceptation of student-centered methodologies such as learning based on problems by teachers and students of engineering degrees at various universities –as seen in Northwood et al.[11], Perrenet and Bouhuijs[4] or Tomkinson et al.[22], and focused on Baylon and Tuna et al.[13]–, we decided to start our experiences with several randomly selected groups of students, belonging to the Marine Engineering degree at La Laguna University. We mixed different methodologies, which allowed us to create customized active learning environments to suit our needs. Three experiences were performed by the first semester of the 2013-2014 course (the corresponding distribution of students and subjects can be appreciated on table 1).

These implementations were different according to the subjects involved:

- For chemistry subjects (experiences 1 and 2 on table 1) there were partial implementations, affecting just one matter and a student’s experimental group. The approach for this subject, detailed in Mora et al.[23], was based on projects with the aim of performing a final measure at the laboratory. Familiarization of students with the concepts needed for performing the final practice was achieved through applying challenge based learning (CBL) where students had research for finding creative answers to several questions relating their subject.

- In the third experience a complete implementation was adopted, affecting all matters and every enrolled student. In this case, the approach was mainly problem-based, as students had to create their own material from problems stated along the course, although smaller projects were also developed. Some seminars were also included in the design, as a starting point was required for student for being able to address problems and projects, given the time limits.

Table 1: Distribution of students according to subjects.

Experience no.	Subject	Matter	Course	Semester	Total of students enrolled	Total of students involved
1	Applied Chemistry (morning shift)	Densidad	1st	1st	156	9
2	Applied Chemistry (afternoon shift)	Viscosidad	1st	1st	42	7
3	Ship's automation & Control	All	3rd	1st	42	42

In both cases, a collaborative work scheme was followed using every technology available for creating, editing and sharing contents (as seen on figure 7). The lecturers who took part in these experiences adopted the role of the facilitators, as described by Tusof[24] et al. Instead of preparing their classes with theoretical contents for solving predetermined problems later, they generated series of open questions as well as complementary activities which served as a guide to students along the search for solutions to problems stated. Performance was far more active than in a traditional class as an open approach was undertaken, solving issues, generating debates, revising the student's work, etc.

Organization was based on working groups which members were randomly assigned, excepting the case of the first experience, where students set themselves up at their own free will. The distribution of working groups and technological tools used for the three experiences is shown on table 2.

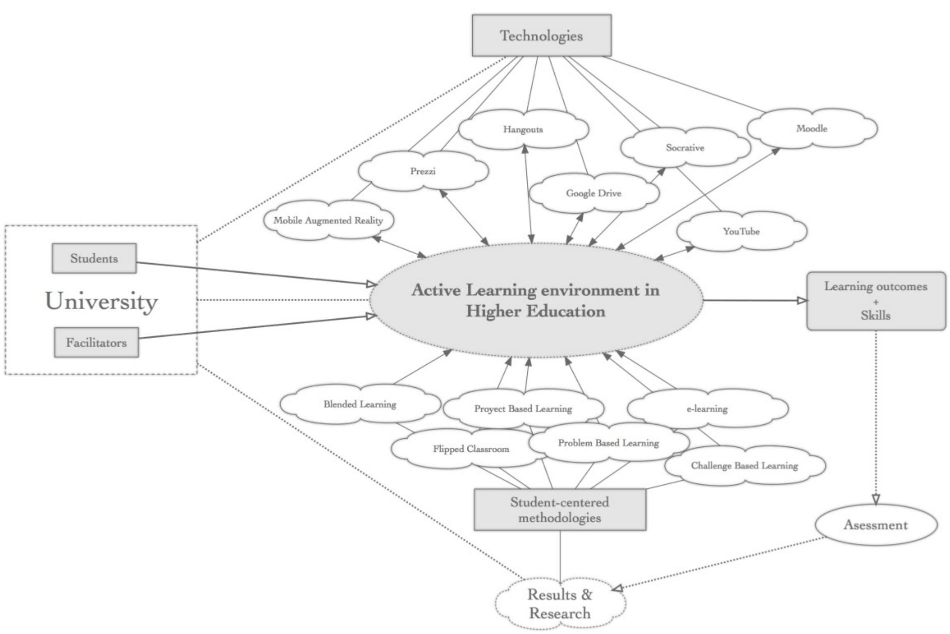

Fig. 7: Technologies and active learning environments in Higher Education.

At the beginning, this kind of setup seemed quite chaotic, as students were not used to this sort of teamwork, especially in the third experience, given the number of students. After one week of work, this initial disorganization become ‘order inside chaos’: in spite of certain informality inside the classroom, each student knew his responsibilities inside his working group, allowing a much more dynamic setup.

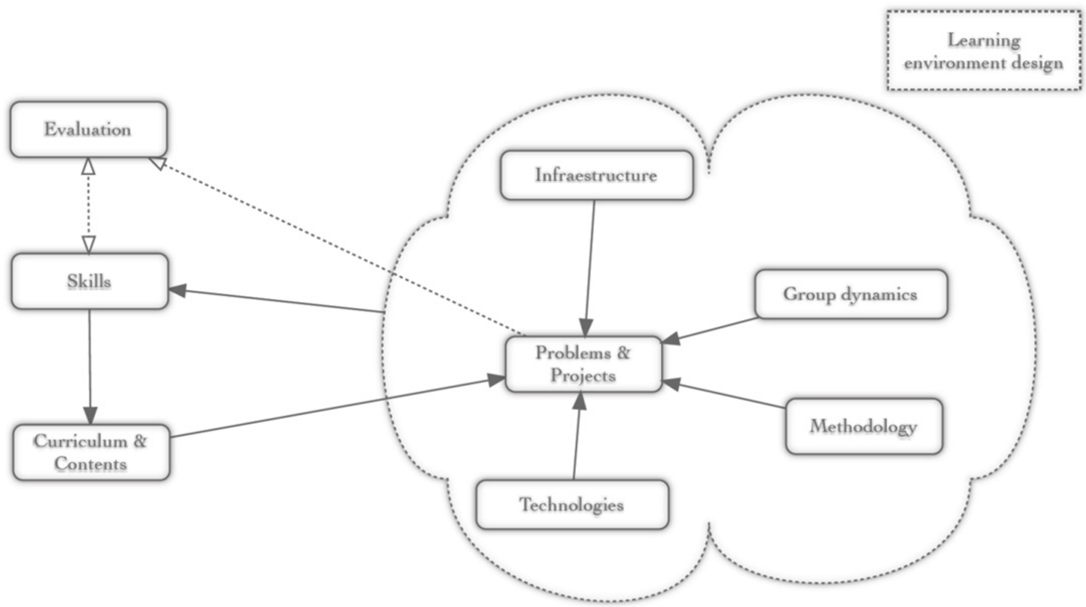

Fig. 8: Design and transmission of results in-out of the learning environment

Even it may look simple, the structure and design of subjects is far more complex than in any conventional statement. The transition from teacher to facilitator requires that problems and questions stated allow the acquisition of desired competences, which demands a careful choice of questions, challenges and guidance activities. Having this in mind, we had to recon- sider completely the programs for adapting them to these needs step by step:

1. Detailing the relation between academic and professional competences established by university and the STCW95 code where applicable.
2. Choosing a selection of appropriate matters and temporizing them according to the weight of the established competences and the number of credits previously assigned to the subject.
3. Designing problems and/or projects which may cover the chosen matters having into ac- count the time limitations.
4. Elaborating a list of challenges, guide questions, open questions, open issues, expositions subject to development by the students, etc., associated to each matter to allow the acqui- sition of the needed knowledge and competences by the students themselves with oriented by their facilitators.
5. Setting up the learning environment defining the infrastructure requirements and the tech- nologies to be used mixed with any chosen methodologies
6. Choosing the appropriate group dynamics aiming for students engagement while obtaining proper feedback (e.g. debate and discussions, quick questions challenges through e-clickers, hypothesis polls, etc.).
7. Defining a continuous assessment strategy through a proper designed rubric which should considere not just teamwork but also individual competences assessment.

Table 2: Number of working groups and technologies used for each experience

Experience no.	Subject	Total of groups	Setup	Devices used	Technologies used
1	Applied Chemistry (morning shift)	3	Voluntary	Smartphones, tablets & netbooks	Augmented Reality, Google Drive, Prezzi, YouTube, Moodle
2	Applied Chemistry (afternoon shift)	2	Random	Smartphones, tablets & netbooks	Augmented Reality, Google Drive, Prezzi, YouTube, Moodle
3	Ship's automation & Control	8	Random	Smartphones, tablets & netbooks	Google Drive, Prezzi, YouTube, MindMeister, Moodle, Hangouts, Socrative

Following this approach, real acquired competences are fed back (see figure 8), so every previous experiences are used for improving the next ones. Inside this loop-process, a proper assessment plays an important role as it also may be used for determining if the process followed for achieving the desired competences is adequate or not. This is precisely one of the most complex aspects while adopting this kind of methodologies, as the acquisition of competences cannot be measured just through a theoretical written exam. In any case, we opine that both collaborative work weight and the measure of individual competences should be taken into account, especially when managing large groups of students. In experiences 1 and 2, the assessment method was not redesigned since they were limited to a specific matter inside the subject, meanwhile the students were graded following the same criteria as the rest. In the specific case of experience number 3, a rubric had to be elaborated, combining and individual test with the every-day competences assessing of all students. In a more precise explanation, the assessed aspects were:

- Performance of individual reports
- Skills acquired while elaborating projects
- Involvement degree of each student inside his group from the records performed by each group's members.
- Achieving proposed aims for diverse problems and projects.
- Tests results.

It should be outlined that once the learning environment has been designed and started, facilitators' main task is giving support to the students and asses them continuously, both at classroom and virtually using the appropriate tools.

Results obtained

Besides the acquisition of competences, motivation of students should be measured, as it is relevant when getting the students engaged into a problem-solving learning environment which they were not used to before. With the aim of measuring this variable a motivation questionnaire was adapted based on the work of Tuan et al.[25], which questions were answered using a Likert's scale: 1, strongly disagree; 2, disagree; 3, no opinion; 4, agree; 5, strongly agree. Without detailing a complete study, some results are being disclosed:

At both experiences, mean values obtained related to self-confidence, predisposition to face challenges and doing their own research, were similar. However, in the case of partial experiences (experiences 1 and 2) there is more variability, probably due to the combination of a reduced number of students and not having followed a student-centered methodology for the entire course. It should be underlined the importance given by first-year students to final scores (see figure 9d) in contrast to those who undertook the complete experience, more in- terested in the acquisition of knowledge and competences. This effect may be due to the lack of maturity and, unless exceptions, the first-year students show less interest in learning beyond what is needed to pass the exams. In any case, these conclusions are not conclusive as a more detailed motivation study with more experiences and students involved should be carried out first.

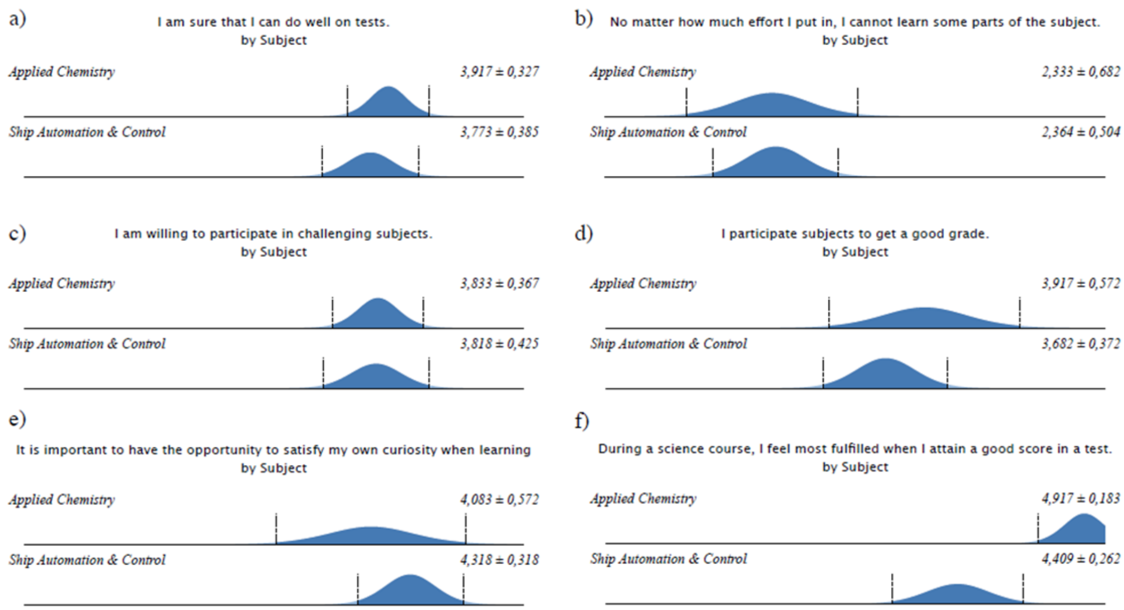

Fig. 9: Partial results from motivation surveys.

Regarding assessments, they are still ongoing right now, however the corresponding results will be included in the final version of this paper.

We also wanted to obtain additional feedback from third course students who undertook the experience, so we prepared an open-question anonym survey. Despite there was a positive feedback, we appreciated some aspects may still be improved such as the huge difference of previous knowledge and competences between students.

> "It's a different and interesting method. Concepts are easily understood but I would change the starting level as it's too high given our actual standards".

> "Looks like a good method to me, the fact of making us research is correct; maybe the timing of the teaching guide should be adapted so rhythm of activities become more homogeneous".

> "This initiative is one of the best I have seen during these few years; I would add a deeper set of subjects, everything else is perfect and I hope other teachers follow your path".

Most suggestions coming from students refer to the subject's level, especially from those who accessed this degree straight from high school. In contrast, those who accessed from professional training courses or other degrees, would like to have more time available to deepen even more in.

Observations and encountered issues

From a teaching point of view, the experience was quite motivating as students become able to handle concepts by themselves applying knowledge otherwise unthinkable, also becoming a real challenge to the lecturers involved in the experience. However, we did find out several assessments and issues which should be underlined:

- Classroom adaptation is essential. Spaces adapted to teamwork and suitable communication infrastructures should be available for working with mobile devices on team groups. Unavailability of proper Wi-Fi networks allowing to simultaneously connect a large number of devices interferes in the usability of those tools that require an internet connection. Bandwidth may also become a limitation factor if it doesn't allows a fats enough connection.

- Use of audio-visual system allowing wireless exchange of screens, presentations and videos is also advisable. Use of tools such as the iPad & Apple TV set would allow us generating more fluent group dynamics.

- Despite familiarization with student's private computer tools, it is usually just limited to online web surfing and basic use of productivity tools. On both short experiences this interfered on development of activities since many doubts arisen among students. In the case of the third experience, the plan of a complete subject dedicated to the use of collaborative tools was also included. In any case, despite the initial lack of awareness, one of the things most appreciated by students were precisely those collaborative tools as they eased their collaborative work both on classroom and online.

- In the case of partial experiences, except just one exception, the concept collaborative work and student-centered environments was strange for them, generating rejection among the students, as there was a common trend at the start aiming for individual work, instead of splitting tasks and gather all work afterwards.

- The search for creative answers to questions proposed was encouraged by the fact that results and conclusions had to be presented online, avoiding simple plagiarism.

- The creation of random working groups generated some conflicts at the start of the experience, caused by the differences of skills and involvement attitudes of the group's members. This required several interventions of the facilitator, trying to make them to realize the advantages of teamwork and splitting the assigned tasks. Several students admitted upon completion of the experience that the advantage gained from it could be quite similar to the experience to be found after the end of their studies.

- One of the facts greatly acknowledged by student was the availability of online sessions which included part of the knowledge needed for further application on projects or solution of problems.

Conclusions

At academic level, both our perception as well as the student's was quite positive. The own nature of methodologies used allowed their combination according to their needs. From a strictly technical point of view, an engineer from any field may be able to apply his knowledge for solving the problems which may arise during his professional career. The combination of methodologies centered on the student with prompt seminars, may ease student's tasks afterwards at strongly technical degrees such as Marine Engineering, by giving them an accurate starting point. For these purposes, we have regarded very positively the elaboration of online audiovisual material following the Flipped Classroom concept. This learning method plays an essential part taking the theoretical contents out of the classroom giving teamwork any time necessary for solving problems and elaborating projects. In our experience, we deepened beyond this concept as any student have available contents generated by other student groups besides those provided by the teacher, given that all contents published have been already validated.

From a professional point of view and focusing on the Marine Engineering field, we believe that use of this kind of methodologies centered on the student encourage the exchange of information on board as well as self-learning, making the T skills profile available as described by Simonsen et al.[2], which is also required by the maritime industry from these sort of professionals. Broadening these kind of experiences to every other subject would encourage even more this competences profile, although it will require a greater involvement from the academic institution, as well as the teaching staff. The actual assessment of the curriculum with few coordination between subjects greatly complicates those learning models focused on the student. Concretely, problem-based learning needs support from previous courses, which caused an additional issue for many students who had not applied any of these required knowledge ever before. This was reflected in the answers to open questions belonging to students who had less experience in the practical application of knowledge. Besides, many universities, inside their management structures, had not developed any mechanisms or adaptation strategies to evolution of productive sectors, so it would be quite advisable to establish procedures allowing the adaptation of learning models to these new needs.

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