ENHANCING STUDENTS' COMPETENCIES BY INTEGRATING MULTIPLE COURSE-UNITS ON SEMESTER PROJECTS

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ABSTRACT

Despite the important advances observed, nowadays, the Engineering programmes keep being challenged to better prepare their students to work on complex and multidisciplinary projects while demonstrating awareness of environmental and socio-economic issues and other soft skills as communication and teamwork. Recently, to meet these challenges, the ISEP' Informatics Engineering programme (LEI) successfully adopted a project-based learning approach. In this approach, throughout the entire semester, students develop a real-world project that allows the application and assessment of the competencies taught by all course units of the semester in an integrated, multidisciplinary, and transversal way. In this paper, the authors (i) present this approach as well as the main challenges faced in implementing it; (ii) report the major findings and the perceived benefits and drawbacks; and (iii) discuss the on-going adaptations and/or others seen as required to improve the approach and its results.

KEYWORDS

Project-based Learning, Informatics Engineering Degree, Multidisciplinary and Multi-Course Project, Standards: 3, 5, 7.

INTRODUCTION

Currently, in addition to intrinsic technical competencies, an Engineer must be prepared to work on complex, multidisciplinary projects and with the capacity to adapt quickly to change (Mazzurco, Crossin, Chandrasekaran, Daniel, & Sadewo, 2020; Centea & Srinivasan, 2021). Soft-skills (such as communication and leadership skills, teamwork, and an awareness to environmental and socio-economic issues) are also becoming increasingly important (Chen, Kolmos, & Du, 2021; Centea & Srinivasan, 2021). Moreover, despite the significant advances that have taken place in recent decades in the teaching practice of Engineering (Chen, Kolmos, & Du, 2021), it is still observed that Engineering programmes and their respective course units continue to be excessively oriented towards (uni)disciplinary/technical content and the resolution of small and simple problems/projects, providing students with a reduced: (i) integration between the covered technical topics; (ii) ability to manage complexity; (iii) relationship with current industrial practices; and (iv) quantity and diversity of design-implement experiences (Mazzurco, Crossin, Chandrasekaran, Daniel, & Sadewo, 2020; Centea & Srinivasan, 2021; Chen, Kolmos, & Du, 2021; Routhe, et al., 2021; Thevathayan, 2018).

In this regard, it is worth highlighting that the importance of the above mentioned competencies and concerns are also acknowledged by well-known international organizations responsible for worldwide (i) promoting Engineering education best and modern practices as the CDIO Initiative (cf. section 2.4, 2.5, 3.1 and 3.2 of the CDIO Syllabus and Standards 5 and 7); and (ii) carrying out the accreditation of Engineering programmes such as the European Network for Accreditation of Engineering Education (ENAEE) which awards the EUR-ACE quality label or the Accreditation Board for Engineering and Technology (ABET) as is easily observed on the respective accreditation criteria (cf. (ENAEE, 2015) and (ABET, 2020)), namely the ones regarding the expected programme outcomes.

Being aware of these demands, since the Bologna implementation process on 2006, the 1st cycle programme on Informatics Engineering (LEI) at the Instituto Superior de Engenharia do Porto (ISEP) follows/adopts best international practices, namely the ones promoted by CDIO, and is awarded with the EUR-ACE quality label since 2013. Although LEI-ISEP's approach allows achieving very relevant results highly recognized by the programme stakeholders (i.e., students, the software industry, research centres, and the society in general), after a decade of Bologna operation, it is considered by past and current LEI-ISEP management as well as by several faculty members that it falls short on what is intended. An overview of LEI structure, (past) operation and found limitations is provided on the next section.

Taking into consideration the above observation, between the 2015-16 to 2018-19 school years, a pilot approach was carried out on the 4th and 5th semesters (Martins, Bragança, Bettencourt, & Maio, 2019), comprising approximately 30 (out of 400) students on each semester, where all the course units of the same semester participate in the development of a single complex software project throughout the entire semester. This software project, usually proposed in a partnership with a company, allows the application and evaluation of the various competencies taught by all courses of the respective semester in an integrated, multidisciplinary, and transversal way. Along the academic years this pilot has run, several refinements were progressively introduced having in mind the feasibility and challenges of expanding this teaching-learning approach to all LEI' students and faculty. In this work, we describe how this approach, called Semester Integrative Project-Based Learning (SI-PBL), was expanded and is being successfully applied to all LEI students as well as we present and discuss preliminary results, faced and open challenges and ongoing/future work.

OVERVIEW OF LEI-ISEP PROGRAMME

LEI-ISEP is the largest Bologna 1st cycle programme on Informatics Engineering / Computer Science in Portugal, admitting between 300 and 350 new students every year and producing over 200 graduates per year.

It is sought after mostly by two different target audiences: (i) students that have recently completed their high school studies (a total of 12 years study) and are willing to continue their education on a Higher Education Institution (HEI); and (ii) persons that by some reason (e.g.: economical) are working (usually) on a non-qualified job and are seeking to improve their qualifications to change to a career on the software industry. Considering this, LEI-ISEP is provided on two consecutive shifts: (i) the daily shift from 8 a.m. to 6 p.m., mostly attended by the former audience and (ii) the after-work shift from 6 p.m. to 11.30 p.m., mostly attended by students already working (the latter audience). Students enrolled in the after-work shift correspond to approximately 17%. Moreover, this also impacts the students' commitment with the programme since approximately 23% of students are enrolled in partial time.

Structure and Operation

LEI-ISEP is structured in 6 semesters (cf. Table 1) and consists of two distinct sets of course-units:

- Disciplinary (or Traditional) courses: focused on conveying technical and disciplinary knowledge and competencies adopting a more traditional approach. These ones can also be split on two sub-sets:
  - The ones dedicated to conveying core concepts of mathematics (i.e.: ALGAN, AMATA, MATCP, MDISC), basic science such as physics (i.e.: FSIAP) and management (i.e.: GESTA, CORGA) considered as fundamental to any engineer; and
  - The ones dedicated to conveying technical aspects regarding software engineering (i.e.: APROG, ESOFT, PPROG, BDDAD, ESINF, EAPLI, LPROG, ALGAV, ARQSI), computer networks, graphics, and systems (i.e.: PRCMP, ARQCP, RCOMP, SCOMP, ASIST, SGRAI) and experimental procedures (i.e.: ANADI, INFOR).
- Integrative and project-based courses: focus on the application and integration of the knowledge, skills and competencies introduced and acquired previously by the disciplinary courses. These courses (i.e.: LAPR 1 to 5 and PESTI) are seen as a design-build courses fully aligned with the CDIO Standard 5 (CDIO Standards 3.0, 2020) incrementally ranging from a basic level of complexity/difficulty (LAPR1) to an advanced one (LAPR5 and PESTI).

Table 1. LEI-ISEP structure and previous operation method.

		Week 1 to 12	Week 13 to 16
1st Year	**1st Semester**	ALGAN, AMATA, APROG, PRCMP	LAPR1
	2nd Semester	ESOFT, MATCP, MDISC, PPROG	LAPR2
2nd Year	**3rd Semester**	ARQCP, BDDAD, ESINF, FSIAP	LAPR3
	4th Semester	EAPLI, LPROG, RCOMP, SCOMP	LAPR4
3rd Year	**5th Semester**	ALGAV, ARQSI, ASIST, GESTA, SGRAI	LAPR5
	6th Semester	ANADI, CORGA, INFOR, PESTI	

Each semester is 20 weeks-long and worth 30 ECTS. The first 16 weeks are devoted to classes and continuous assessment while the last 4 weeks are exclusively for final exams (written or oral). Furthermore, during the first 5 semesters the classes period is split on two distinct sub-periods: (i) a 12 weeks-long period for traditional disciplinary courses; and (ii) 4 weeks-long period for the respective integrative and project-based course (i.e.: LAPR 1 to 5). Yet, it is worth noticing these courses aim at introducing and practicing some of the software industry best practices and methods such as teamwork, adopting an agile (iterative and incremental) approach, continuous integration/deployment (CI/CD) and software testing. The technical requirements of the projects are fully aligned with the disciplinary subjects learned during the first 12 weeks of the semester. These courses are a key component of LEI, as they allow students to practice and enhance their skills in larger projects. The last semester is mostly dedicated to the capstone project/internship (18 ECTS) usually developed on a software company or research center located in the north region of Portugal.

Students Assessment

There are school-wide pedagogical rules/recommendations trying to promote students' assessment during the classes period and, therefore, reducing the weight of the final exam on the course grade or even eliminating the final exam. Despite that, most ISEP courses do have final exams. Within the LEI programme there are three major scenarios: (i) traditional courses of math, basic science, and management whose final exam have a weight of over 50%; (ii) most of the other disciplinary courses also have final exam with a weight ranging between 30%

and 50%; and (iii) the integrative courses whose assessment is 100% based on project development without any final exam. As so, due to continuous assessment, most of the LEI disciplinary course units already have one to three assignments, being its majority of a practical nature based on small and/or simple problems/projects developed in teams that (i) are somehow lacking a more realistic and broader context; and (ii) do not foster and/or value the correct adoption of best professional practices by students.

Finally, it is worth stressing that to avoid personal drifts and enforce consistency among courses, a pedagogical consensus was achieved around the definition of common rules and pedagogical patterns that should be adopted by all courses (Martins, Ferreira, & Costa, 2016).

Found Limitations

As previously stated, this structure and operation allows achieving relevant results that are highly recognized by the programme stakeholders. Even though, in the context of a continuous improvement process of the LEI-ISEP programme (cf. compliance with Standard 12) the following major limitations and concerns were identified:

1. The overall students' effort required to complete the practical assignments during the classes period is often seen as being exaggerated, namely due efforts resulting from students constantly changing from one (unrelated) project context to another.
2. The lack of a broader and more realistic context means that students often do not feel motivated towards the technical aspects addressed in the disciplinary course and/or have difficulty understanding its usefulness, integration, and relevance in larger and more complex projects.
3. Since most practical assignments carried out in the disciplinary courses do not adequately promote and/or sufficiently value industry best practices, it contributes, on the one hand, to students not to internalize these best practices and, on the other hand, to students acquire inappropriate practices that, once internalized, are difficult to combat later in the integrative courses (LAPR 1 to 5).
4. On the contrary, assessment of the integrative projects tends to (over) value criteria related with the development process, methods, and tools as well as the fulfillment of functional requirements at the expense of technical quality criteria, which are mostly considered as being previously assessed on the disciplinary courses. Despite that being true, there is no guarantee that students achieve the required technical quality during the development of the integrative projects. Faculty often argues that ensuring such technical quality is a very time demanding task to which there is not enough available time.
5. Although projects developed in the context of the integrative courses (LAPR 1 to 5) provide students with short team-based system-oriented development experiences applying an iterative and incremental (agile) methodology as well as other best practices quite common in the industry, the short timespan (4 weeks) does not allow more than 2 or 3 iterations of very limited scope. It is too short and too fast; thus, it does not promote reflective observation as it should. From evaluation it becomes evident that some of the results were not going beyond the "apply" Bloom level (Krathwohl, 2002).
6. The short period of time devoted to the integrative projects together with the fact that projects are entirely conceived and operated by faculty is inhibiting fully simulating an agile software development context in line with best practices, while exploring real contexts and conditions such as the need to seek requirements clarifications from the software client, dealing with evolving requirements and evolving architectures as well as cultivating a biggest and deepest integration among the topics addressed in the disciplinary courses.

The operational changes introduced in LEI-ISEP to overcome/minimize these limitations and concerns are described in the next section.

SEMESTER INTEGRATIVE PROJECT-BASED LEARNING

Initially motivated by the conclusions of (Edström & Kolmos, 2012) that Project-Based Learning (PBL) can be productively combined with CDIO principles and standards to equip graduates fully and better for engineering practice and, further, reinforced with our 4 years-long pilot experience (Martins, Bragança, Bettencourt, & Maio, 2019), its results and lessons learned, a Semester Integrative Project-Based Learning (SI-PBL) approach for 4th and 5th semesters of LEI-ISEP was devised and put in operation since the school year of 2019-20.

Approach Overview

While devising the SI-PBL approach, it was clear that some hard constraints need to be mandatorily satisfied, namely that neither the curricular structure of LEI-ISEP nor the programme learning outcomes could be changed/revised. Moreover, as a soft constraint, there was no will or intention to revise courses' contents and/or courses' learning outcomes. Thus, the SI-PBL approach was restricted to only revise programme and courses operation together with the employed teaching-learning process.

At the LEI-ISEP operation level, two major changes were introduced:

- It was created the notion of a Semester Integrative Project (SIP) common/shared by all the course units of the respective semester. The SIP general idea is to be used as a replacement for the smaller and/or simple projects/problems of each course unit and an extension for the LAPR courses, thus fostering the integration of cross and multidisciplinary knowledge and competencies earlier in the semester.
- The original model of 12+4 weeks of classes was replaced by a new one as depicted in Figure 1. As can be observed, each semester is split into four periods (a.k.a. sprints) and the end of each sprint also represents a semester milestone. Contrary to sprints B, C and D, the first sprint (i.e.: A) is 6 weeks long mainly by two reasons: (i) to let faculty provide students with a minimal background/theoretical knowledge and skills required for SIP development; and (ii) to teams' formation and general setup of the project environment (e.g.: source code repositories, CI/CD tools). The last week is exclusively devoted to concluding students' continuous assessment.

Thus, through the entire semester, students are focused on developing a single but complex software project that allows the application and assessment of the wide-ranging competencies taught by all semester' courses in an integrated, multidisciplinary, and transversal way to the courses. Yet, the integrative project allows for four iterations on the requirements in which students gradually deepen the theoretical knowledge of each course and apply it to satisfy these requirements, which, in turn, focus on the complementarity of knowledge between course units and not on its exclusivity.

To operate in this manner, a few generic basilar rules/guidelines were also established:
R1. SIPs must be conceived, preferably in a partnership with a software company, to (better) encompass, for instance, environmental and socio-economic issues, among others. Furthermore, SIPs should be designed to be ideally developed in teams of 4 students working in an iterative and incremental way. However, to accommodate foreseen exceptions it might be prepared to fairly be adjusted for development by teams of 3 to 5 students.

R2. At least two courses should be committed to the SIP development throughout the entire semester. This is ordinarily ensured by the integrative course unit (i.e.: the LAPR course) and a technical disciplinary course covering software engineering topics (e.g.: EAPLI, ARQSI).
R3. A late adherence of a course to the SIP development is left open to the course coordinator and validated by the LEI management during semester planning meeting(s). However, such adherence is only possible to occur at the beginning of a new sprint (at weeks 7, 10 or 13) and, after adherence, courses remain committed to SIP development until the end of the semester.
R4. In the scope of each SIP' adherent course, each sprint must be thought as a students' assignment through which faculty can provide students' feedback and/or to assess the students' achievement of (some) course learning outcomes.

As a result of this change to the semester, each course revised/adjusted as needed (i) its operation mode (including planning); (ii) its pedagogical approach; and (iii) the learning outcomes assessment methods to better fit in with the general semester' operationalization.

Learning Outcomes Assessment

The described transformation naturally led to adjustments/adaptations in the way students' learning objectives are transmitted and assessed. Regarding assessment, these adaptations aimed at two aspects: (i) to avoid duplication and/or overlapping of assessment criteria among the courses involved in the SIP and (ii) to respond to limitations 3 and 4 previously presented.

Therefore, integrative courses (i.e.: LAPR) are focusing on the fulfillment and adoption of best practices related to the software product development methodology/process itself. This involves criteria that goes from interacting with the client for requirements clarification as well as demonstrating the fulfillment of those requirements, passing to the way how the team organizes itself, distributes the tasks among its members and works, towards the team members' ability to understand and communicate about the project as a whole and not simply as a set of disconnected modules/components. In this sense, the names of some well-known ceremonies in agile methodologies, namely in Scrum (Sutherland, 2014), are formally introduced and applied (in an adapted way) as follows:

- *Sprint Planning*: takes place at the beginning of each sprint (i.e.: first sprint week) with the aim of supporting students to plan and distribute tasks in a suitable way.
- *Sprint Review*: takes place at the end of each sprint (i.e.: during the week after the sprint ended) to assess the level of satisfaction of the sprint requirements from a functional and/or quantitative point of view as well as the communication capacity of the team about the project/sprint and its functioning as a team.
- *Sprint Retrospective*: it also takes place at the end of each sprint, without direct faculty intervention, aiming to promote the students' ability to improve by themselves the way the team is functioning.

Complementarily, the technical disciplinary courses are focusing, as was the case before, on technical aspects (from practical to theoretical) and mostly adopting a qualitative perspective. In this sense, after the end of each sprint, it is common that each course carries out a *Technical Sprint Review* session with the aim of, on the one hand, to provide feedback to students and, on the other hand, to assess the degree of the learning objectives achievement. Optionally, some courses also support students regarding task distribution, namely, to ensure that every team member is allocated to requirements involving the application of some sort of the course technical components.

This approach also allows for strengthening and consolidating the application of some pedagogical patterns presented in (Bergin, et al., 2012) and that were already being adopted in the LEI-ISEP (Martins, Ferreira, & Costa, 2016). In this respect, it is worth noticing that each sprint assessment provides "*feedback*" and "*early warning*", so students can "*embrace correction*" and therefore justify "*grade it again, Sam!*" (NB.: pattern names are denoted in quotes and in italic). Moreover, regarding teamwork "*Fair Project Grading*" and "*Fair Team Grading*" are applied too.

Implementation Details

This integrated project-based learning approach has been implemented in the 4th and 5th semester of the LEI-ISEP and, currently, is running for the third consecutive year.

In the 4th semester, the SIP focus on developing an information management system (e.g.: shop floor data collection, processing, and management system) for a given business area (e.g.: cutlery production) adopting a Domain-Driven Design approach (technical content of EAPLI). The resulting system comprises more than one application to enforce students employing by the first-time some client-server communications according to an application protocol (technical content of RCOMP) and, therefore, to apply some parallel and/or concurrent computing techniques (technical content of SCOMP). Some system requirements also lead students to specify and interpret some simple but effective task-specific languages (technical content of LPROG). The courses' adherence to the SIP development throughout the semester is depicted in Figure 1 (Left side). Accordingly, LAPR4 and EAPLI participate on all project sprints while RCOMP, LPROG and SCOMP participate only on the last two sprints.

Regarding the 5th semester, the SIP focus on developing another information management system adopting a full web-based client-server architecture (technical content of ARQSI), comprising multiple server-side applications, each one developed in a distinct technology (e.g.: ASP.NET, NodeJS, Prolog) and, at least, one client-side Single Page Application (SPA) for user interaction. Client-side application is also enriched with a graphical 2D/3D visualization module of some information (technical content of SGRAI). On the server-side, one application is devoted to providing some "intelligence" to the system through the application of some advanced algorithms (technical content of ALGAV). At last, students also must study and develop a Disaster Recovery Plan as well as configuring and monitoring a system infrastructure for system deployment (technical content of ASIST). The courses' adherence to the SIP development throughout the semester is depicted in Figure 1 (Right side). Accordingly, LAPR5 and ARQSI participate on all project sprints while SGRAI, ALGAV and ASIST participate on the last three sprints. GESTA does not adhere to SIP mainly because it is a management course shared by multiple programmes running at ISEP and, therefore, it operates identically on all such programmes.

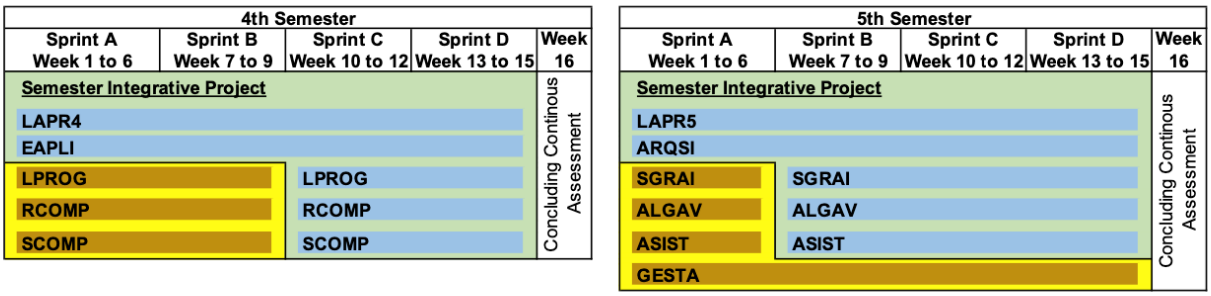

Figure 1: Courses' adherence to the SIP development through the respective semester.

RESULTS & DISCUSSION

In this section, we discuss and evaluate this approach using objective and subjective data considering four inter-related dimensions: (i) the semester and courses operationalization; (ii) students' feedback; (iii) the faculty perspective; and (iv) the companies' appraisal of students during their internship (capstone project) and of fresh graduates (i.e.: first job position).

Operationalization Dimension

This approach implies, at every course, an even more careful and rigorous planning of the pedagogical activities than before, since the occasional existence of any deviation may influence the development of the integrative project and, consequently, negatively impact the other courses as well. As such, the initial planning of both courses and SIP, includes some margin/flexibility to accommodate potential deviations more easily. Over these two years, this margin proved to be, in fact, useful and necessary.

Another aspect that cannot be neglected is the teams' formation. Ideally, each team has 4 students enrolled in all courses of the semester. This is achieved almost autonomously by students in a large majority (75% to 80%) of the cases. However, the remaining cases, caused by students that for some reason (e.g.: enrolled in partial time; have previously reproved) are only enrolled on 1 to 3 courses, imply an additional effort of faculty to ensure that these teams also have the necessary conditions to succeed. Preferably, these cases are solved by distributing these students to the remaining teams, working as a 5th element of these teams. Given the high number of students enrolled in each semester (approximately 400), these cases need to be seen with some naturalness. However, regarding the after-work shift students, we acknowledge that this aspect is particularly relevant and needs to be improved.

The effort to design, for each semester' edition and in partnership with a company, a distinct SIP capable of conveniently integrating the contents of all adherent courses is significant, but not exaggerated. Considering the courses' contents and its greater/lesser complementarity and interconnection, this effort is slightly greater in the 4th semester than in the 5th.

Students Dimension

Concerning students, we attempt to assess two criteria: (i) the students' general feeling/perception regarding the integrated approach; and (ii) the (in)existence of an abrupt change/variation in the effective approval rate of students per course.

Regarding the former criterion, a students' survey was considered. However, due to some pedagogical survey's constraints, this option was discarded. Instead, it was decided to carry out informal conversations between several professors and students of different classes and enrolled in different shifts and (amount of) courses. Overall, students, even those who showed some sort of disappointment, acknowledge that this integrative approach brings added value to their training. This acknowledgment is even greater on students enrolled in the after-work shift which is reasonable due to their greater maturity. Nevertheless, the after-work shift students together with students enrolled in partial time are the ones that more frequently express the most restrictions, constraints, and difficulties to the adoption of this integrative approach. There is here a kind of paradox that is justified by their status as a student worker, which usually implies having less time available for project development outside of classes when compared to regular (full-time) students. Regardless of the shift in which students are enrolled, regular students stated they felt more motivated by this approach, which helped them to better understand how the diverse contents were inter-related and have considered this approach as being positive or even very positive. As strengths points of this approach, students often mention (i) the existence of a single context/focus of work, i.e.: the project; (ii) the project realism given by the fact of knowing that there is a company supporting it; (iii) the similarity with the way of working in companies; (iv) the need to interact with the software-client. As weak points students often mention (i) the team formation issue described before; (ii) lack of faculty support on some classes and/or courses; and (iii) their afraid of being failing to one course, being failing to all, which obviously there is no reason for that, but they felt it anyway.

The latter criterion is of special interest since the courses' learning objectives have not changed, but the assessment method has undergone some/a lot of changes (depending on the course). Using the effective approval rate of students in 2015-16 as reference, Table 2 shows the percentual variation observed to the reference value throughout the further years.

Table 2. Variation on students' approval rate per course using 2015-16 as reference (%).

School Year	4th Semester						5th Semester					
	Cov. 19	EAPLI	LAPR4	RCOMP	LPROG	SCOMP	Cov. 19	ARQSI	LAPR5	SGRAI	ALGAV	ASIST
15-16	N	ref.	ref.	ref.	ref.	ref.	N	ref.	ref.	ref.	ref.	ref.
16-17	N	5.50	-4.04	1.65	-5.01	-9.81	N	22.96	31.37	28.79	2.20	-2.39
17-18	N	-6.67	6.27	-2.12	-12.97	5.71	N	9.21	28.43	47.10	7.77	-5.00
18-19	N	-7.95	-1.59	9.29	-5.46	-6.79	N	3.47	28.43	40.53	5.05	-1.93
19-20	Y	-1.29	2.98	1.76	-4.78	1.19	N	13.35	34.31	53.05	19.04	2.39
20-21	Y	-10.41	-0.96	-0.71	-12.17	-7.44	Y	8.28	26.61	53.83	20.73	3.86

Accordingly, there is no abrupt change and/or one that deserves any particular attention between the approval rates obtained within the 12+4 weeks model (2015-2019) and within the integrated approach (2019-2021). As so, the registered positive/negative variations are seen either by the courses' coordinators as by LEI management as being inside the usual and acceptable range. At this respect, it is important to stress out that due to Covid-19 pandemic only the 5th semester of 2019-20 results were not affected by changes (e.g.: switching from face-to-face classes to online classes) motivated to properly respond to this new reality (cf. "Cov.19" yes/no column). Thus, comparing the 5th semester results of 2019-20 with 2020-21 suggests that the integrated approach was quite resilient to measures taken due to Covid-19. This resilience is somehow also supported by the results achieved on same years by the 4th semester courses. Despite that, in the last two years, it has been noticed an increase (>12%) on the approval rates of SGRAI and ALGAV courses when compared to the previous editions. Comparing the last two years results of the 4th semester courses, a decrease (>7%) on the approval rates has been observed in LPROG and EAPLI courses. This variation cannot be endorsed to the integrative approach as both results were obtained adopting the same approach. Moreover, currently, the 4th semester is also a time of adaptation for students that come from the first three semesters used to the 12+4 weeks model and now, get in contact, for the first time, with this integrative approach. This fact might somehow partially justify this variation. However, this situation will deserve our future attention.

Faculty Dimension

When the decision to proceed with the implementation of this approach was made, the reality is that there was a non-negligible number of professors who, in a more or less clear/direct way, showed that they were facing this change with some/very concern and caution for diverse reasons such as (i) considering that they would not be prepared; and/or (ii) that it would require a greater effort from them; and/or even (iii) natural human-being resistance to change. However, after 2 years of being applying SI-PBL approach, most of these professors no longer manifest or manifest on a much lesser degree these initial concerns, and many of them are even quite satisfied and are recognizing the added value of the approach to students training.

Among the professors that are courses' coordinators, they have been quite satisfied with the change and are rejecting the hypothetical idea of going back to the previous model. As evidence of this greater acceptance by faculty in general and, namely, by courses' coordinators, it has been suggested to apply on a trial basis this approach also to the 2nd and 3rd semesters.

Companies Dimension

Through direct interaction with companies, typically, while assessing the capstone project, it is quite noticeable that companies are extremely satisfied with the overall quality and technical competence of our students. However, through this interaction is less noticeable their satisfaction regarding aspects of human, societal, and environmental nature. As so, to objectively measure this perception, companies usually offering internships to our students were asked to fill in a survey regarding our freshly graduated students who have been recently employed by their company. The survey consisted of 4 questions to be answered on a Likert scale, from 0 (bad/not at all) to 5 (very/excellent). The survey questions are:
A. Do they demonstrate lifelong learning ability?
B. Do they demonstrate high-level professional computer engineering skills?
C. Do they reveal appropriate human, social and environmental attitudes?
D. Do you have the ambition of professional achievement?

By the time of writing, from the 16 answers obtained, the average of the results is: A-4.50; B-4.25; C-4.25; D-4.00. These results clearly support the initial perception regarding their technical competencies (cf. answers to question B) as well as suggests that their training process is promoting soft-skills and other relevant competencies (cf. answer to question A, C and D) that are hard to assess at courses' level.

CONCLUSION AND FUTURE WORK

Overall, we are strongly convinced the SI-PBL approach has shown to be adequate to increase/improve the students' soft skills to the high levels currently required in the practice of informatics engineering. Simultaneously, this approach has also allowed to solve/minimize all the identified limitations, namely, through (i) a general reduction in the effort load of students in carrying out practical assignments while increasing their motivation (cf. limitations 1 and 2); (ii) the continuous promotion and enhancement, consistently across all courses, of the acquisition and application of the best engineering practices (cf. limitations 3 to 5); and (iii) a greater students' exposure to real software development scenarios (cf. limitation 6).

In addition to operationalization issues, this approach implied and still implies significant changes (i) in the students, regarding their level of commitment to the programme and to the teaching-learning process, in which they are required to have a more active attitude (Standard 8); and (ii) of faculty, regarding the courses' preparation and the required time synchronization between courses, as well as in improving the alignment between learning assessment and outcomes (Standard 11). Yet, in respect to faculty, it is also worth highlighting that this change lead, in some cases, to enhance some faculty teaching competences (Standard 10) as well as showing the need for it and, in other cases, to increase motivation for teaching.

Furthermore, on one hand, this approach has significantly contributed to increasing the quality of the design-implement experiences (Standard 5) and of the integrated learning experiences (Standard 7) provided to LEI-ISEP graduates. On the other hand, despite it has attested that LEI-ISEP curriculum is designed with multiple complementary and mutually supporting disciplinary courses on the 4th and 5th semester (Standard 3), it has also shown there is some room for improvement (e.g.: to foster courses' adherence to SIP earlier).

At last, we aim to consolidate the SI-PBL approach (e.g.: to better accommodate the diversity of students' enrollment situations that naturally exists when there is ~400 students/semester) and incrementally expand its adoption to the 2nd and 3rd semesters of the LEI programme, which has started on the 2021-22 school year and, thus, can be seen as success evidence.

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