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Pedagogical and technological replanning: a successful case study on integration and transversal skills for engineering freshmen

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Abstract Replanning is often used to optimize results of an activity in an ever changing world. To address the challenge of preparing future engineers for success, a special course was created for all engineering freshmen of the Faculty of Engineering of the University of Porto, in Portugal. Presented as a case study, this special course underwent a careful replanning as a result of several years of experience in teaching practice alongside with a theoretical deepening in pedagogical and technological issues, under the aegis of the action-research methodology. Within the context of the case study course, the mentioned replanning was also based on a theoretical approach that clearly identifies teaching–learning-assessment methodologies that promote regulation from those that foster emancipation, using a specific instrument: a taxonomy of educational processes. The replanning was designed to globally boost results regarding the educational aims of the course such as furthering freshmen's integration into work environment and preparing them for success by fostering transversal skills (needed for study and work). Technology is seen as a mean of education enrichment as well as a productivity tool. The introduced innovations include fun-but-educational activities, several types of assessment over time and specific technological tools which were critical for the educational impact/achievement of this course. Success is demonstrated by encouraging feedback from the stakeholders, high students' classifications and a steady reduction in retention. It is advocated that large portions of the reasoning behind the replanning can be extrapolated to other courses.

Keywords Integration · Transversal skills · Engineering · Pedagogical–technological innovations · E-learning · Active learning

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Introduction

In a world where technology plays a central role and economy many times writes the script, Higher Education (HE) has been vital and, also, subject to several challenges which could be seen as opportunities to pursue academic excellence and prepare future engineers to thrive in the labour market, as well as citizens in a global society.

Such challenges include adjustment to international standards, common policies and harmonization procedures that help universities adjust to contemporary phenomena such as globalization, mobility, technology or economy. Another complex situation that HE institutions face today is the successful integration of many heterogeneous students with diverse knowledge, attitudes and behaviours into high standards of academic performance. As Confucius once said "success depends upon previous preparation, and without such preparation there is sure to be failure", the focus upon integration of freshmen is embodied by scientific evidence, which reports that.

> the importance of doing well as a first year student creates tension: students need to have time to adapt to their new surroundings and at the same time there is the pressure to achieve. If an institution for higher education wants to influence its student success rate, the first year is an obvious starting point. It is therefore of paramount importance to institutions to determine which first year student experiences matter to a student's success and how the institution could influence these experiences (Van den Bogaard 2015: 14).

The scientific community also agrees that students' work should be steered to become an active learning process, in accordance to a new learning paradigm (Torres 2013) that implies the promotion of students' autonomy and teamwork, using individual heterogeneity as an advantage (Commission of the European Communities 2005). Although a high number of students isn't the most favourable scenario to nurture active learning, "in many universities, the courses in the first years of different engineering degrees share program and objectives, having a large number of students and teachers. These common courses are expected to provide students with meaningful learning experiences" (Estévez-Ayres et al. 2015: 387), facing the challenge of motivating and managing active learning processes of many diverse students at the same time.

Current day's job market demand professionals with Transversal Skills (TrS) able to adapt and evolve according to the needs faced in the workplace, as well as in everyday life. Actually, "the eligibility of applicants on the job market highly depends on the range of Soft Skills (SS) possessed, as companies prefer hiring graduates who do not need further training in this respect" (Urs 2013: 138), pressuring HE institutions to foster TrS alongside with technical skills. Although it is intrinsically complex to promote and evaluate SS improvement, it is a task that should be accomplished in the long run and right from the beginning, in order to provide the time and experience needed for the personal development of these skills (Sousa and Mouraz 2014). Engineering courses are not exceptions as "it has become clear that engineers cannot do a good job without taking into account the human and social aspects. Every technological problem is a socio-technological problem, and therefore needs to be approached as such. This has caused important changes in the education of engineers" (De Vries 2009: 2), bringing TrS into the spotlight.

It appears difficult to find a consensual definition for TrS, often confused with soft or transferable skills. Hence, this paper adopts the structure of skills profiles (Fig. 1) presented in "Transferability of skills across economic sectors: role and importance for

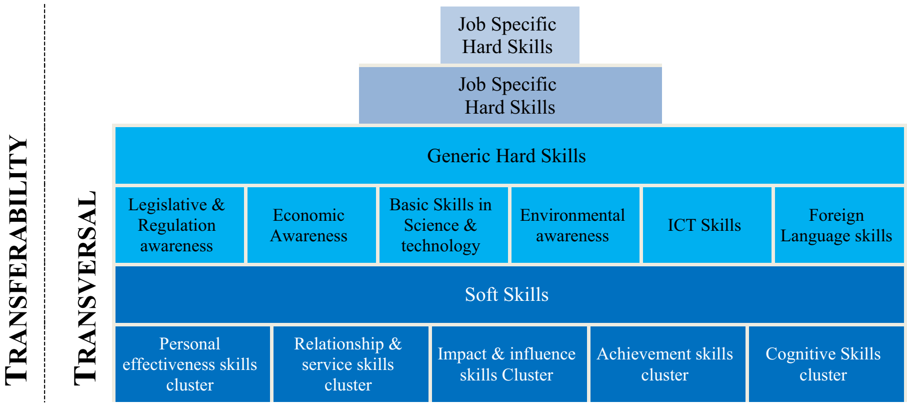


Fig. 1 Structure of skills profiles (adapted from European Commission 2011)

employment at European Level" report, supported by the European Commission in 2011, which categorizes skills by their transferability capacity, providing a taxonomy that catalogues and relates different groups of skills.

According to this classification, TrS include SS "that are related to individual ability to operate effectively in the workplace" (European Commission 2011: 10), comprising: (1) personal effectiveness skills such as stress resistance, self-confidence, flexibility, creativity and lifelong learning; (2) relationship and service skills like cooperation, costumer orientation and communication; (3) impact and influence skills as organizational awareness, leadership and development of others; (4) achievement skills involving efficiency, proactivity, organization, autonomy and accuracy; and, finally, (5) cognitive skills such as analytical and conceptual thinking. The same source also describes TrS as covering some of the presented generic hard skills, namely basic skills in science and technology as well as ICT skills/E-skills,[1] fostering a new approach to scientific and technological education since the start of the students' academic journey. Indeed, beside SS, scientific and technological basic skills are unavoidable to become fully integrated in the university's context and thrive academically: the scientific approach is the root of knowledge production disseminated within universities, while technology is the source where knowledge is applied but also the channel through which knowledge is distributed. In this sense, it became clear that learning and practicing science and technology should be an integral part of the student integration process. The remainder of this article will present a pedagogical replanning that takes into consideration the presented TrS that include SS and generic hard skills.

The current section introduced context and nomenclature. The following sections will bring the research methodology and theoretical approach for the replanning. The case study is presented next, together with challenges, reasoning and innovations introduced to the case study. The results section demonstrates the success of the replanning and the conclusions section include lessons learnt and advocate that the strategies used in this case study are likely to be used in other situations.

[1] As stated in the European Commission reports ICT-skills include Information & Communication Technology Skills and E-Skills, covering three main categories: ICT practitioner skills, ICT user skills and e-Leadership skills.

Action research methodology

An alert teacher (and researcher) will always keep a sharp eye for opportunities to improve teaching practice. "When the practitioner-researcher asks, 'How can I improve what I am doing?' (Whitehead 1999)" (Cain and Milovic 2010: 20)—that is the start of the Action Research (AR) methodology.

AR is a widespread methodology pioneered by Kurt Lewin (1890–1947) and John Collier (1884–1968) that has as major goals the creation of changes in practice and the development of new or existing theory (Neilsen 2006). Additionally, Lewin described AR as a series of cycles that include: problem identification, planning and acting (implementing an intervention), observing and interpreting the findings, problem redefinition, replanning and so on successively (Maruyama 1996; Kemmis and McTaggart 2005; Cain and Milovic 2010; Edwards and Burns 2016). This sequential cycle allows practitioners to investigate their work and create new knowledge while at the same time improving practice. Indeed, the positive impacts of AR amongst the practice of teaching are scientifically well documented since.

> action research has been lauded as a way for teachers to improve their practice (Dana and Yendel-Hoppey 2009; Mertler 2009; Stark 2006), to engage in on-going, in-depth, critical dialog with colleagues (Anderson et al. 2007; Mohr et al. 2004), to share knowledge across, and outside of, the profession (Chiseri-Strater and Sunstein 2006; Hatch et al. 2005; Meyers and Rust 2003), to generate theory from classroom practice (Nias 1991; Whitehead and McNiff 2006; Zeichner 2003), and to address issues of inequity in schools and in society (Benson and Christian 2002; Cammarota and Fine 2008; Caro-Bruce et al. 2007) (Flessner and Stuckey 2014: 36).

Borg (2010) even endorses the transformative potential of teachers' engagement through AR and Vallenga et al. (2009) supports, following the ideas of Carr and Kemmis (1986), that "besides the improvement of practice, action research is directed at improvement of understanding of the practice by its practitioners, and the improvement of the situation in which the practice takes place" (p. 81).

As "action research has been shown to empower educators, create lasting changes in schools, and have an impact on student learning outcomes" (Flessner and Stuckey 2014: 36) it has become a methodological drive to push for replanning. AR is a methodology that allows for full participation, entailing "a social process of collaborative learning realized by groups of people who join together in changing the practices through which they interact in a shared social world" (Kemmis and McTaggart 2005: 277). In general, the implementation of participatory AR will most likely involve technological instruments for all stakeholders to express their feedback about the activity being replanned. The participation of the students in the replanning is very interesting because it fosters even further their own self-assessment.

The following sections will show that the above considerations are particularly well suited to the case study course with many challenges in a partially adverse context.

Teaching–learning–assessment processes

The replanning was based on the findings of Torres (2013) which confirmed the existence of strong correlations between pedagogical work modes (PWM)[2] (which comprises teaching methods), learning strategies and assessment types. These correlations imply an

[2] Pedagogical work modes are introduced and developed by Marcel Lesne (1977).

adequate conceptual framework on educational practices that covers the interdependency of Teaching–Learning-Assessment (TLA) processes in HE. The current section will briefly introduce this conceptual framework.

In academic practice, as in scientific literature, references to teaching–learning processes are easily found, acknowledging their tacit interdependency. In addition, it's also recognized that assessment can assume distinct purposes, ranging from the comparison and classification of students' achieved results until the promotion of self-management of their learning, constituting itself as an integral part of teaching–learning processes. Indeed, "we also assume that there is a strong relationship between the way teachers assess learning and the way students organize themselves, get involved in their training and finally learn" (Torres and Leite 2014: 14). This means it is widely accepted that "the interdependence [… of these] concepts is fundamental to understand what happens under those names. Their perception and understanding are crucial to the development of any work of learning, education or teaching" (Kubo and Botomé 2001: 1).

From a conceptual perspective, literature shows that there is a close relation between the concepts of constructivist learning (Von Glasersfeld 1989) student centred teaching (Lea et al. 2003) and active learning (Ljungman and Silén 2008), in the sense that the responsibility for learning must belong mainly to the student. This presupposes that the learners build knowledge from their experiences, being active, discovering and learning independently. In this particularly case, we adopted a theoretical framework that considers a strong link between student-centred teaching, active learning and formative assessment. In fact, "internationally over the past two decades, HE institutions and educators have become increasingly committed to making assessment and grading more effective in promoting student learning (that is, in fulfilling a significant formative function)" (Sadler 2005: 193). To us "formative assessment (and self-assessment) is an inseparable part of more emancipatory teaching–learning processes and indispensable for an effective active learning. The desirable autonomy of students to manage their own learning is strongly conditioned by the possibility of being able to use self-regulation in HE" (Torres 2014).

In the process of planning an educational activity and even more so in the process of replanning (where additional information is available) the pedagogical work should be guided to reinforce the congruence of the educational processes through the alignment of the TLA dimensions, which results in a "consistent use of teaching methods and modes of assessment appropriate to the sought level of learning (Aviles 2000; Hall 2002; Biggs 2003b; Kennedy 2008)" (Torres 2013: 225). The analytical instrument developed by Torres (2013), a TLA taxonomy, is summarized in Fig. 2.

Besides allowing to implement educational processes with regard to the necessary calibration between teaching methods, learning strategies and assessment procedures, this taxonomy is a guiding tool for the design, analysis and reflection of teaching, learning and assessment practices, being these introduced throughout the various axes that aim to characterize their intrinsic heterogeneity. Regarding Fig. 2, for example:

- the teaching axis at top left presents transmissive techniques such as lectures and goes to bottom right to project based methods of teaching;
- the learning axis characterizes strategies that go from knowledge reproduction to active learning;
- the assessment axis embodies summative procedures of classification (top right) up to alternative formative procedures that aid students to self-manage their learning (bottom left).

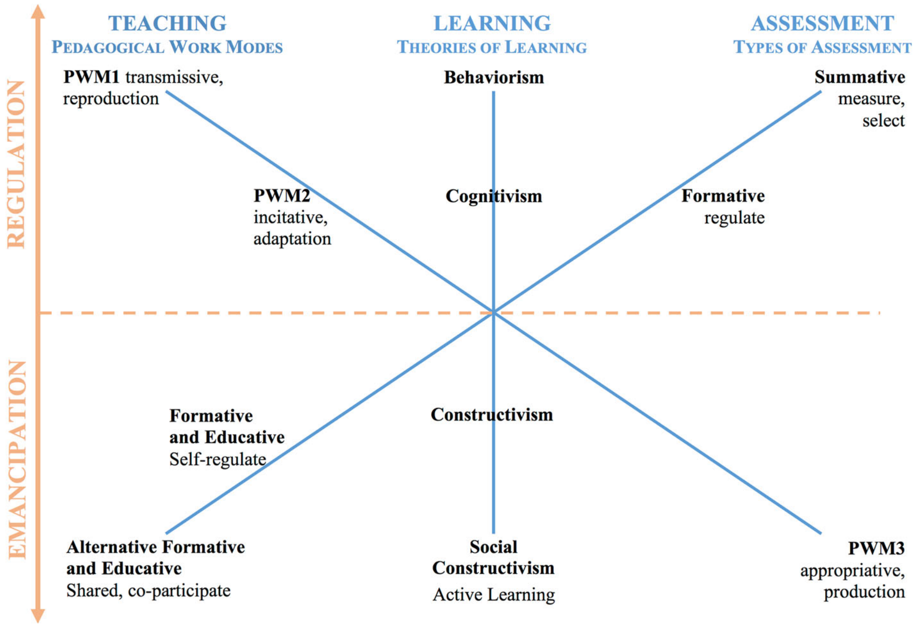


Fig. 2 Taxonomy of teaching–learning-assessment processes (adapted from Torres 2013)

This taxonomy presents an upper level where the adopted teaching methods are usually supported by a transmissive/normative pedagogical work mode and knowledge reproduction, promoting behaviourist learning strategies and resorting to summative assessment procedures. Conversely, the lower level starts with focus upon the learning outcomes through the implementation of a formative and educative assessment, fostering socio-constructivist learning strategies and requiring an appropriative pedagogical work mode, sponsoring knowledge production. These levels presuppose different educational outcomes, represented in this taxonomy on the vertical axis (of Fig. 2) by the concepts of regulation and emancipation. Paulo Freire (1987, 1997) explored these concepts concerning the possible impacts of education: on one side regulation and knowledge reproduction; on the other, emancipation and (self-)knowledge construction.

Additionally, scientific research (Torres 2013) showed that in the first academic years of HE, often with a large number of students and where basic skills are promoted, usually lectures are adopted, instigating passive learning and using summative assessment in a regulation perspective. Otherwise, in the last years of HE, often associated with a Master of Science (MsC.) degree, having less students and focusing on more complex and professional skills, teaching is more student centred, stimulating active learning and resorting to formative assessment to promote emancipatory learning outcomes. Through the alignment of TLA methods, pedagogical (re)planning can be directed to regulate or emancipate students' knowledge, according to the targeted learning outcomes. However, it is important to note that both educational impacts (regulation and emancipation) are essential to students' development, since we assume reproducing existing knowledge should be as much important as producing new knowledge in HE.

Replanning an independent learning activity should take advantage of both, the AR methodology and the TLA taxonomy. Replanning an on-going teaching activity such as a

HE course is bound to be much more complex because of the interrelations and additional information available. Such replanning also seems coherent with AR methodology and the mentioned research by Torres (2013) where not only each course module should be analysed separately but also the sequence of modules should be scrutinized, both during the course (if possible) as well as before the next occurrence to promote more efficient educational processes and more success in reaching the desired learning outcomes.

Birth and starting point of the "Projeto FEUP" initiative

The Faculty of Engineering of the University of Porto (FEUP) is a large faculty with more than 5600 (FEUP 2014, 2016) students in MsC. programs related to engineering and has grown to frequently accept enrolments nation-wide, with the background of the students becoming more and more diverse. The foundations for the Projeto FEUP (PF) initiative were laid in the curricular year of 2004/5, as mentioned by one of the initial responsibles, Francisco Restivo: "the initiative was an answer to common complaints that the starting point for students at FEUP was not that good" (FEUP 2005). The idea of the "Projeto FEUP" initiative was endorsed by the at-the-time director of FEUP, Prof. Carlos Costa who started a trial run in about half of the programmes at FEUP. The very first run included refreshing basic issues from Mathematics and Physics and transversally the programs involved in an effort centrally organized by the direction of FEUP. Simultaneously, students were grouped across all programs to perform a teamwork leading to a written report and an oral presentation. To foster adequate integration with healthy institutional speech older students ("monitor students") were selected from each program, trained and formally contracted by FEUP. Monitors help integration with a healthy proximity discourse, facilitate teaching the course and coach the teamwork (Mouraz and Sousa 2015).

At the end of the first run, despite some negative feedback of some stakeholders, the majority of the opinions were in favour of continuing the initiative and the decision to push forward was made. The next year, 2005/6, the initiative was transformed into a mandatory course for all nine of the engineering programs given at FEUP. This decision had partial support of the departments but was imposed through changes made in the programs curricula. This initial "all-in" run included refreshing Mathematics, Physics and Chemistry as well as the previously mentioned teamwork that now should deliver: (1) a written report, (2) a poster and (3) an oral presentation. The report is graded by the professor, the poster is exposed in busy corridors and graded by professors and the presentation is in a conference-like environment, given to professors. The objectives of the course were consolidated as: (1) integration into FEUP work environment, (2) TrS regarding technical topics common to all the engineering programmes involved and (3) TrS related to SS and communicational issues, seen as enabling for study and work. The course had 2 ECTS and used avidly shared resources managed centrally in a manner not supported by the information system. Usage of e-learning was limited to repository, at this initial time.

The PF initiative was always supported by the direction of FEUP but faced some undermining from some departments and some professors centred in their own technological core (Sousa and Mouraz 2014). Additionally, there were huge pragmatic difficulties related to the logistical challenge of organizing the 1000 students involved in the course: as an example, errors in room reservation were not uncommon. Another huge difficulty is defining an adequate work schedule common for all students involved from the different programs, finding motivated professors for first year non-technical issues and student evaluation. Mainly due to in satisfaction on the student part but also due to logistical issues, the Mathematics, Physics and Chemistry part of the course was abandoned, whilst the soft skills were understood as important business.

The evolution of the course at year 2009/2010 changed largely the implementation strategy and implicated the creation of a first initial week for students to dedicate solely to the "Projet FEUP" course. At the end of the initial week, devoted to integration and TrS, there is a short summative quiz called "Mini Test". After the initial week, the students engage normally in the program' classes, alongside with a second part of the PF course that, as previously, makes students produce research and write a report, create a poster and give an oral presentation to an audience. Also, as a pragmatic change, the new teams were mainly constituted of colleagues from classmates that shared weekly scheduled, thus improving the quality of schedules. This change also allowed the classes for the PF course to appear in the information system schedules for professors and students. At this point, many small implementation changes were made to foster internal acceptance on the course, mainly on the behalf of professors and the course became "natural" and generally well accepted by students and staff (Sousa and Mouraz 2014). Albeit this much needed stabilization, logistics was still heavy and relied on many lecturers and classical or computer rooms as well as the grand auditorium.

In year 2011/2012 a central decision by the University ordered all courses to be transformed into an ECTS multiple of 1.5 and, as such, internal discussions led to the PF course being downsized into a 1.5 ECTS course. The initial week was changed and became mainly based on lectures at the grand auditorium of 500 people. Many of the limitations remained, new problems arose and a dire need for yet another large (coordinated) reformulation/replanning was recognized.

General issues on replanning

On year 2014/15, without substantially changing the objectives of the PF course (integration into academic/work environment and promotion of TrS), the implementation modified drastically. This was the product of the replanning, which was done under the aegis of the AR methodology while resorting to the TLA taxonomy.

In rather simple terms, the AR methodology encompasses a sequence of steps including: (1) problem redefinition, (2) replanning, (3) acting, (4) observing and (5) reflecting upon its current configuration. Considering the PF initiative, a number of problems were identified (observed, in the nomenclature of AR): excessive lecturing, lack of active learning, reduced engagement, poor motivation of stakeholders, etc. As an example, a student wrote in an anonymous survey: "small course that provides large amounts of information but delivered limited learning". Upon the reflection and problem redefinition steps of the AR methodology, the problems were summarized as: students' learning was not targeted and had a limited impact. The replanning part of the AR methodology takes advantage of the TLA taxonomy that allowed for an exceptionally clear view of the modules of the course: the initial week of the course that should be focused on knowledge reproduction and regulation (top half of Fig. 2) and thereafter on autonomous work that will promote (some) emancipation (bottom half of Fig. 2) and foster TrS.

Many changes were made in initial week in order to really deliver high quality interactive lectures at the grand auditorium and a large number of fun-but-educational activities were arranged. These activities are run by the older students in less used rooms of variable size. Careful coordination between lectures, practical activities and e-learning activities (with various types of assessment) was also addressed to maximize learning outcomes during the initial week. Like in previous editions, the "Mini Test", (small moodle quiz, summative assessment) was run to validate learning over the initial week and provide feedback to learners. Clearly, this course module hopes to have a regulatory impact.

In the second part of PF course, students are invited to create a small engineering research "project" that requires active learning, research methods and teamwork. This project base method gives students an opportunity to develop their TrS, as well as acquire more learning autonomy and responsibility while fostering a permanent assessment culture (mainly through self and peer assessment, with formative but also summative dimensions) which were crucial to achieve a more emancipatory impact.

The replanning decisions made in PF tried to avoid the mistake of teaching everyone as if they were one, a particularly relevant issue to HE teachers who face the difficulty of working with large groups of students, and on the other hand, to overcome the inaccuracy of assessing all students as if they learn at the same rhythm. For the first aspect (teaching all as one), it was considered that an active learning strategy, promoting the students' autonomy and encouraging the use of assessment as a learning opportunity (Hand et al. 1996; Gibbs and Simpson 2004; Cullen 2007; Levia and Quiring 2008), could be an effective alternative. Whilst exploring the possible interconnections between summative and formative assessment, using proper ways of assessment with regard to different students' profiles, styles and learning needs, seems to be an answer for the second aspect (differences in learning rhythm).

Technological tools in education play a central role in allowing students to be integrated while progressing in the educational process accordingly with their own individual learning rhythms. Technology itself is also an important aspect for students, even more so for future engineers: it is a tool for productivity and success. Similarly, technological resources are a very important tool for replanners to optimize the localization of a given activity, module or course in the TLA taxonomy. Within the AR methodology, technology can also be seen as an important method to gather and analyse data in large amounts of information as well as, of course, a mean for action. The mentioned issues lead to the consideration that technological issues should be considered as pedagogical aids.

Although there is an "unresolved debate over whether ICT should be conceived of as supporting delivery of a traditional or a radically different vision of pedagogy based on soft skills and new digital literacies" (Livingstone 2011: 9), we believe that it is very important to consider that "technology is also shifting students' learning experience from simple knowledge acquisition to knowledge construction through working together, problem solving and getting solutions they did not know in advance" (Leon 2004: 9). Consequently, we chose to adopt the concept of "second generation" e-learning as a new paradigm for thinking about online learning to develop soft skills, highlighting the need of taking a pedagogical, rather than a technology-driven approach (Adams and Morgan 2007), as presented in Table 1.

It appears "obvious that the dramatic development of technology can easily support active learning in e-learning" (Pundak et al. 2010: 3), while some authors claim yet that "information literacy education […] must underpin [and anticipate] any pedagogical initiative especially in the area of e-learning which requires the learners' active engagement with a wide range of information sources and formats" (Andretta 2005: 181). The goal is to articulate pedagogical and technical aspects to create conditions for a learning by doing (Dewey 1916) approach. Consequently, students are meant to achieve better learning outcomes using e-learning as a complementary learning tool to develop Information Technology (IT) skills, while they are simultaneously developing their e-learning competences. For this, they benefit from an active learning approach with the continuous

Table 1 Key characteristics and design principles of "first" and "second generation" e-learning—adapted from Adams and Morgan (2007, p. 162)

First generation	Second generation
Technology driven	Pedagogy driven
Linear-sequential logic	Self-organizing
Instructor-in-control	Learner-in-control
Content memorization "Passing the Test" assessment	Self-assessment, reflective practice, successful application
"Eye catching"	Engagement through provocation/hooks/ideas
Separate theory and practice	Integrates theory/practice/work/learning in real time
Separate learning, knowledge capture/dissemination	Integrated learning knowledge creation and knowledge sharing

Online Collaboration can be fitted onto both "First" and "Second" generation approaches

support of formative assessment, allowing them to use immediate feedback to regulate themselves in the while at the same time learn IT and Information Literacy (IL) skills.

As examples of how much the technology and the TLA taxonomy are relevant in the replanning process, the initial week uses lectures with formative assessment as a teaching tool and e-learning as a tool for students to learn at their own rhythm (with formative and summative assessment). The "Mini Test" is a small test that serves as multi-purpose tool to allow for "assessment as a learning opportunity", making clear the most important issues and giving timely feedback to students, thus inciting students to rethink study approach, if necessary. As mentioned earlier, in the second part of the PF course, students gather in teams for research work to produce a poster, a report and an oral presentation. As another example of the relevancy of the TLA taxonomy, it must be noted that assessment strategies must be well tuned with teaching and learning. During this team work, self-assessment and peer rating are used to promote healthy team working in a push for emancipation. Later, after submission, the final communicational deliverables are also a motive to learn from colleagues. Deliverables are given constructive feedback orally and of course descriptive classifications from professors. As shown in these examples, assessment is a key element of the strategy of a course and the TLA taxonomy makes this much clearer. TLA placement should thus be optimized to better guide students into the learning objectives of the course.

In summary, with a unique design, the replanning of PF implemented a pedagogical and technological compound that allowed to create better conditions to accomplish targeted objectives and, at the same time, to implement an articulated variety of TLA processes. Generally, such pedagogical and technological replanning can, most likely, be extrapolated to optimize other courses and learning activities.

Replanning details of the case study

This pedagogical and technological compound has been implemented in PF since 2013/2014, involving all FEUP's freshmen of the mentioned school year and the following. As mentioned earlier, the PF logistics involve teaching about a thousand newcomer students a year, distributed by 150 teams, which mobilized 50 monitors, 50 supervisors, 10 trainers, courses coordinators, FEUP student's association, some technical and administrative staff, as well as several FEUP services. This heavy logistic presented challenges that were overcome by the introduction of several innovations in the pedagogic strategy of PF, namely:

Audience response system (ARS)

The lectures performed in the initial week of intensive training involved about 500 students at a time in an auditorium. Interacting with many of them at the same time was made possible through the implementation of an ARS technological device. This device allowed lecturers to: stimulate peer education; interact with "all" students in real time; instigate their interest with initial questions; maintain their focus; receive real time information (diagnostic assessment); self-test progressively (formative assessment) and might have been used to verify knowledge acquisition (summative assessment). As shown in Fig. 3, students of school year 2014/2015 perceived the introduction of this innovation as an instrument that increased the interest of auditorium lectures.

The auditorium is not equipped with clickers so, instead of this, students are challenged to use their own cellular phones as answering devices. Answers are collected in real time and shown in a web page, projected onto the large screen.

Pedagogical activities

To foster integration and skills development in the initial week of the PF course, a set of practical exercises, group dynamics and computer games were engineered. These fun-but-educational activities were implemented in an active learning context and institutional integration environment, intending to create assignments that eased the acquisition of knowledge exposed in lectures and generated ludic situations that encouraged informal interaction between students.

Some pedagogical activities were specifically designed while others were adopted and adapted, setting up a programmed sequence of challenges that could be presented as practical exercises, group dynamics or computer games. Examples would be the "Pitch yourself" practical exercise, the classical "NASA Game" for team building (group dynamics) and "FEUP Paintball", a networked PC based real time paintball game played on the virtual campus of FEUP playable team versus team.

This great offer of fun-but-educational activities aimed to further a variety of skills:

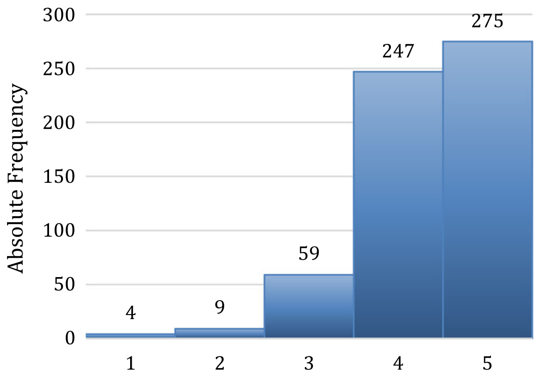


Fig. 3 Histogram of responses to the question *Does the ARS promote more interesting sessions at the auditorium?* Answers range from 1 meaning "Total Disagreement" up to 5 meaning "Total Agreement"

- Interpersonal communication and presentation skills;
- Formative assessment with auto and hetero-assessment procedures;
- Scientific information management (e.g. good practices, ethics, plagiarism);
- Technical and scientific reports;
- Problem resolution with interpretation and calculation;
- Ethic problems and required behaviours;
- Individual and group decision-making;
- Questioning and argumentation;
- Giving and receiving feedback;
- Teamwork (e.g. processing complex information, empathy, cooperation and competition);
- Technology as an instrument for active learning.

Making the mentioned activities accessible and viable for so many students in such short time is possible by using technology as a mean for accomplish learning, recognizing its dual function of simplifying students' interaction and integration. Additionally, promotes students' autonomy by giving them the chance to individually complete the given tasks.

In order to run all the mentioned fun-but-educational activities, older students contracted as monitors for these activities were specifically trained to support students in their learning journey. These monitors were submitted to an intensive training on the worked skills but also upon integration and identity construction, coaching and teamwork stages with the purpose of effectively prepare them to the posterior phase of teamwork project.

Mega-activity

The innovation, introduced in 2013/2014, that finished the initial week of intensive training, was an outdoor mega-activity which granted the opportunity to the new students to collectively accomplish a task that represents FEUP community and, at the same time, present them to their new community. This integrative and memorable activity entails a strong interaction between freshmen, intended to consolidate their integration while, at the same time, they can train their teamwork skills. Figure 4 shows one of the results of the actual activity where students arranged themselves to draw the letters FEUP and the photographs can latter on be searched with an interactive "lens".

This outdoor mega-activity had as specific objectives:

- Feeling well integrated in the FEUP academic/institutional context;
- Being part of a human system that should work as a whole;
- Contributing with individual work that understands the collective dynamic;
- Being part of a collective construction that searches for joint efficacy;
- Contributing for FEUP visibility (internal/external marketing);
- Developing a positive attitude towards a complex situation providing a constructive environment between colleagues.

The ludic dimension of this activity features an interesting motivational factor that stimulates learning. Plus, the sense of belonging in a big human system is instigated by the drive to accomplish this mega-activity, involving all freshmen of PF in a general cooperation that used every individual contribution.

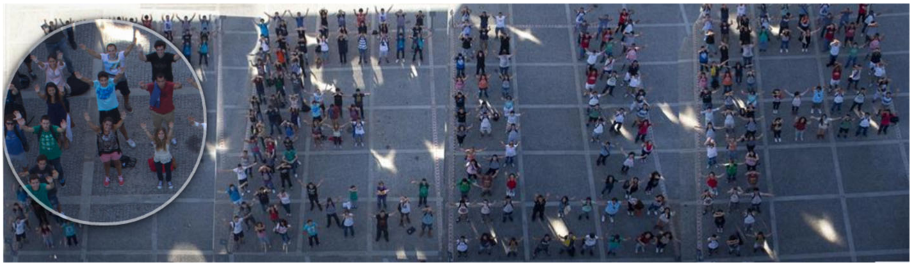


Fig. 4 Example of one of the results of the Mega-Activity 2013/2014: interactive lens over picture of students arranged as letters "FEUP" using ground tiles

Technological resources

Facing the already mentioned problem of how to address the lack of practical training for TrS development and especially in the Information Literacy (IL) area/domain, with approximately 1000 students, decision was made to replan the course as a B-Learning solution to improve learning effectiveness. In this context, we advocate that (in addition to traditional lectures) a complementary e-learning approach providing formative and summative assessment, together with practical activities, will lead to active learning as a powerful strategy to enhance skills development, in this case, IL skills within the PF course, now clearly identified as one of the most important modules of the PF course (Sousa et al. 2015). Technology can thus be seen as a powerful tool for active learning. Hence, to further students' autonomy (see Table 2), it became necessary to redesign the use of technology within PF, aligning with the sought learning outcomes.

The presented technological tools allow students to autonomously build their learning path, improves cooperative work and knowledge production, provides self-regulation/assessment mechanisms and boosts creative and critical thought.

After the replanning process, the mentioned pedagogical and technological innovations were introduced to boost PF to achieve better results, that is, the replanning allowed the implementation of TLA processes capable of reaching the targeted educational goals.

Results

From the previous presentations, it can be seen that the PF case study is somewhat different from the most common courses in an engineering program. It has been subjected to some studies (Sousa and Mouraz 2014) and the present chapter shows relevant information, mostly quantitative, gathered throughout the years, demonstrating that replanning improved the achieved results. The very initial years suffered from infancy problems and the instruments were not tuned nor stable and as such, results pertain to years 2010/11 and after.

The instruments used to gather the data are: (I1) students' surveys after the initial week; (I2) students' surveys at the end of the course; (I3) classifications of the summative quiz after the initial week and (I4) official final classifications for the course (including small test, report, poster and presentation). Naturally, although the course has around 1000 students per occurrence, response rates to the surveys vary a lot: I1 is given in a situation the students are totally focused in the single course and responses are very high, above

Table 2 Synthesis of outputs for learning of each technological tool utilised in PF

Technological tool	Outputs for learning
ARS	Stimulate peer education, interact with "all" students in real time, instigate their interest with initial questions, maintain their focus, receive real time information (diagnostic assessment), self-test progressively (formative assessment) and might have been used to verify knowledge acquisition (summative assessment)
B-Learning	Closely coordinated lectures, e-learning and fun-but-educational activities allows for partially autonomous training of skills
Learning Management System (*Moodle*)	Supports active learning and formative/summative assessments aside from being a repository of lectures, contents, training exercises and evaluation tests
Collaborative applications	Tools that increase teamwork effectiveness (e.g. *Google Apps* and *Microsoft Office 365*, etc.)
Web and social networking	Other communication channels that are *en vogue* and allow for interaction and social engagement

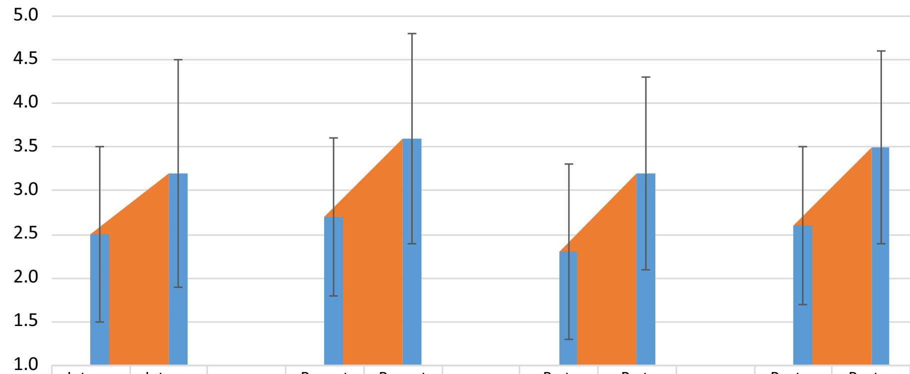
90%. I2 has response rates that showed inconstant rates over the years, typically above 50%. Statistical analysis was done using SPSS and Excel tools, as explained in the charts. Instruments I1 and I2 use a Lickert scale (Lickert 1932) where 1 means total disagreement and 5 means agreeing totally (as shown in Figs. 3, 5).

Figure 3 is taken from Instrument I1 and clearly shows that using the ARS is very important to make auditorium lectures more interesting. The effort to push this technological tool to make lectures effective is very clear and learners recognize the importance of the tool.

Figure 5 shows a global approach to the data gathered from Instrument I2. The figure shows average and a standard deviation above and below regarding students' answers of the following questions, respectively shown in trapezoids from left to right: (Q1) Did PF help find good work colleagues that spread to other courses? (Q2) Did PF help you improve report writing skills? (Q3) Did PF help you improve oral presentation skills? (Q4) Did PF help you improve poster making skills?

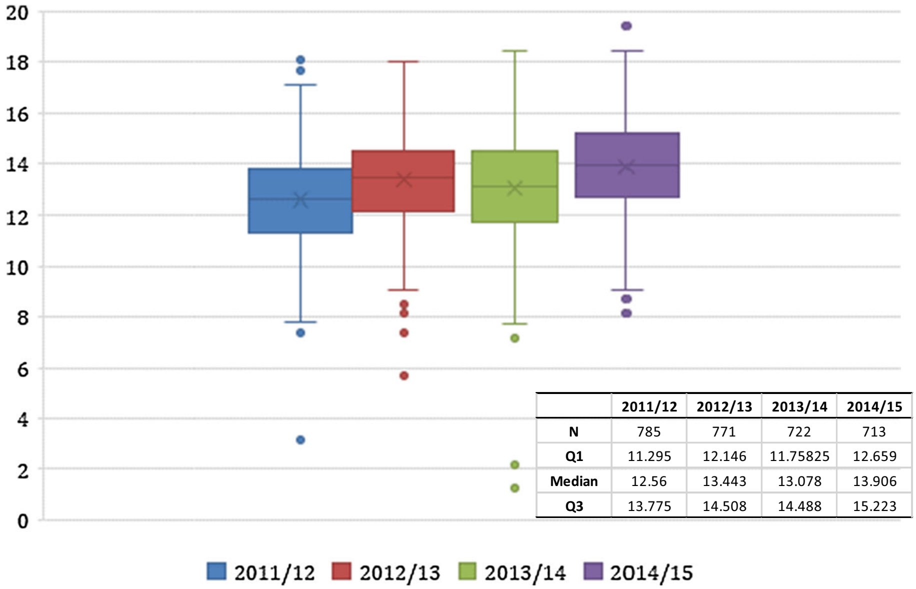
One objective of the course is student integration into FEUP's work environment and Q1 evaluates this issue. Figure 5 shows that the average of the responses change from 2.5 to 3.2, clearly showing improvement after the recent course replanning. It must be recognized that integration is much larger than finding workmates and that the answer allows partial credit to the course as positive answers. The other questions focus on the perceived improvement of the skills regarding things that are addressed in the course: Q2 relates to healthy report writing, Q3 to the ability to perform oral presentations and Q4 to poster design (and chart making). These 3 indicators show large improvements: Q2 changes from 2.7 to 3.6, Q3 from 2.3 to 3.2 and Q4 from 2.6 to 3.5. The standard deviations increase because in year 2010/11 nobody agreed totally with any of the statements.

Other interesting data is the global results of the summative quiz after the initial week (instrument I3), as presented in Fig. 6. The figure shows data from 2011/2012 beyond because the previous years are not comparable as they have very different structures. The mentioned figure is a classic boxplot showing quartiles and reveals that in year 2014/2015 the results are slightly better, particularly the median raises to 13.9 which is unprecedented and a very welcomed change. The same figure also hints that fewer students were left



	Integr. 2010/11	Integr. 2014/15		Report 2010/11	Report 2014/15		Prst. 2010/11	Prst. 2014/15		Poster 2010/11	Poster 2014/15
Avg	2.5	3.2		2.7	3.6		2.3	3.2		2.6	3.5
StDev	1.0	1.3		0.9	1.2		1.0	1.1		0.9	1.1

Fig. 5 Summary of questions on Instrument I2, survey at the end of the course. Questions regard improvement of each of the shown topics; *bar* is average value and *error bars* show one standard deviation in each direction (shading is only to aggregate the same parameter)



	2011/12	2012/13	2013/14	2014/15
N	785	771	722	713
Q1	11.295	12.146	11.75825	12.659
Median	12.56	13.443	13.078	13.906
Q3	13.775	14.508	14.488	15.223

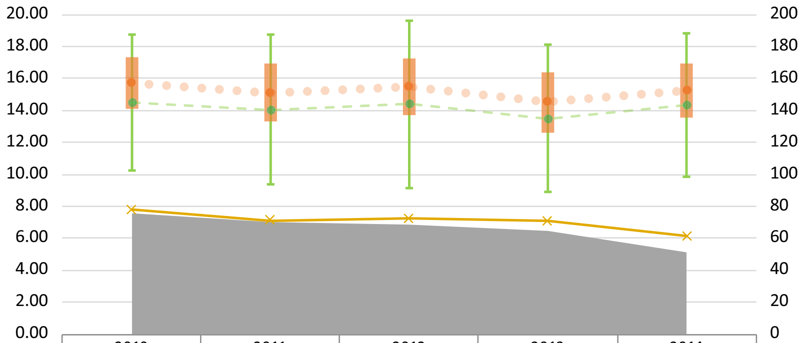
Fig. 6 *Box-plot* of the global classifications of the students that entered FEUP in time to take the “Mini Test” (summative quiz) after the first initial week, years from 2001/2012 to 2014/2015; all grades are out of 20; “N” is the number of students involved is shown in associated table as well as quartiles and median for the years at stake

behind as the lower quartile (Q1) also rises to 12.6 out of 20, always involving over 700 students.

Figure 7 shows statistical dispersion of the final classifications of the course over the years. The dashed line shows the average evolution of students’ classification and error bars above and below one standard deviation are also shown. The number of students involved is shown in the associated table in the “#(All)” line. There appears to have been a somewhat steady decrease in the number of students involved in the PF course (from 900 to the 800 s) due to lower retention rates. This is an interesting indicator that the course is running smoothly and students are reaching the expected outcomes. The year 2010/11 had somewhat high grades in some programs that produced a sense of injustice among the students. In the following year, a set of examples of evaluations was used to calibrate the achieved grade, inspired by rubrics assessment (Reddy and Andrade 2010). The subsequent years show the classifications recovering to 14.33 (with the new, more demanding, set of standards). Another statistical indicator is that the number and percentage of students not at all involved has decreased steadily from 7.8 to 6.2 and gathered statements hint this is due to the social engagement that the course now has. The burden of the students that are not present is clear when comparing the averages of the classifications with and without taking into consideration grades above 4 out of 20 (the grading formula of the course makes it very unlikely to get a grade of 4 or 5 (PF 2015) and in fact during these years this never happened). Taking year 2014/15, average for all students is 14.33 (in 829 students) and above grade four out of twenty is 15.27 (in 778 students) that are very interesting scores much more so in newcomer students just arrived at HE.

Conclusions and future work

Throughout this article, it was advocated that AR is an adequate methodology and that the researcher can be at the same time a practitioner of the studied teaching activity. This methodology enables pedagogical replannings that, coordinated with technology, allow to manage TLA processes more efficiently and, therefore, to pursue ambitious learning outcomes.



	2010	2011	2012	2013	2014
#(Classif<4)	76	70	69	65	51
#(All)	978	983	953	920	829
Avg (all)	14.51	14.06	14.39	13.50	14.33
StdDev(All)	4.48	4.13	4.26	4.00	3.96
Avg (Classif.>4)	15.72	15.13	15.49	14.51	15.27
StdDev (Class>4)	1.69	1.53	1.67	1.74	1.55
%(Classif<4)	7.8	7.1	7.2	7.1	6.2

Fig. 7 Classifications over the years. The *chart* shows: (1) the average classification of all students; (2) the number of students that did not engage at all in the course and (3) average of classifications not considering students that did not engage at all. The *error bars* are one standard deviation *above* and one *below*

Replanning a HE course such as PF initiative is particularly ambitious in the drive to go beyond simple knowledge reproduction all the way to autonomous knowledge production, empowering students to actively improve their TrS. Still considering the case study, the presented replanning emerged from the need to improve a set of TLA processes excessively focused on regulatory pedagogical practices, mostly done through transmissive methods, behaviourist learning and summative assessment. Although one of the main drives of the replanning was the introduction of a more emancipatory pedagogy, the regulatory components of PF were also enhanced, e.g. by the adoption of ARS that revitalized the classical transmissive method of teaching. The TLA taxonomy was used to guide the replanning of several pedagogical and technological innovations of the PF ensuring the development of both the regulatory and the emancipatory learning outcomes.

Technology is of paramount importance as a tool to foster students' autonomy and collaboration, and can, most interestingly, be used to promote active learning and possibly emancipation. The replanning of the PF case study resulted in a pedagogical and technological compound that includes interactive lectures coordinated with fun-but-educational practical activities run by older students and also with "second generation" e-learning practices. This newer e-learning concept is focused on pedagogical concerns allowing the learner to be in control even if under provocation to learn. Careful replanning of the educational processes in each part of the course activity is used to shift students from passive to active learning and from regulation to emancipation outcomes, as clearly seen in the TLA taxonomy.

PF educational aims are mainly integration and TrS. Results after replanning demonstrate success in both accounts: students' answers show large improvements on integration and skills such as report writing, poster creation and oral presentation. The steady reduction of retention over the years is also very interesting, also showing a certain amount of success in integration. Technology is also, itself, an objective of the PF course as it is a future engineer's tool for integration, productivity and success.

Lessons learnt include keeping away from common errors such as an excessive passive learning, a learning management system used only as a repository of content and a single summative test at the end of the activity. Trying to make students change to active learning, giving them formative assessment opportunities with feedback and promoting engagement through careful coordination of pedagogical activities seem to be ideas to foster a successful replanning, especially in HE. Keeping in mind that assessment is a learning opportunity also seems to be interesting in order to pinpoint important issues and maybe provoke students into learning and all this can be done in e-learning environment. Such considerations are generic and can be extrapolated to other teaching activities where the shown concerns make sense.

After being presented and awarded nationally with the Pedagogic Excellency Award from the University of Porto in 2015 still with provisional results, it is hoped that this international dissemination of final results can become a good contribution to enhance teaching practices elsewhere and to foster theoretical debates upon several important issues such as active learning, technology and education, action research.

Future research work includes not only the study and development of this big learning system, perfecting its design and management, but also to further investigate the link between students' integration and the improvement of transversal skills, mainly through active learning and also by resorting to e-learning and/or B-Learning.

It is also advocated that replanning must be seriously considered in HE as an effective strategy for continuous quality improvement, which should be applied on ongoing courses in order to promote better learning processes and outcomes. This case study can additionally become an example of successful articulations between technology and pedagogy, thus inspiring other educators and researchers to follow and explore similar ideas.

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