EDUSCRUM – THE EMPOWERMENT OF STUDENTS IN ENGINEERING EDUCATION?

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ABSTRACT

The students are not all alike. It is one of the characteristics of the human species that makes it especially adaptable to the formation of communities: people complement each other. So, if students have different characteristics, a rigid "one-size-fits-all" approach will not be successful. It may be achievable, if you try to find a lowest common denominator, but we all know what that means: wasting most of the students' potential.
In this paper we describe the application of a Scrum based pedagogical approach to several courses of the Informatics Engineering bachelor program of ISEP (LEI-ISEP). eduScrum is a framework where much of the responsibility for the learning process management is delegated from teachers to students, both in terms of time and effort management. This flexibility allows for multiple student profiles to actively participate in the learning process.
eduScrum builds on top of the Scrum project management methodology and active learning best practices, such as peer learning and embrace correction.

KEYWORDS

eduScrum, Active learning, Learning Assessment, Standards 8, 11

INTRODUCTION

Instituto Superior de Engenharia do Porto (ISEP, School of Engineering - Polytechnic of Porto) is the largest polytechnic engineering school in Portugal with more than 6500 students and over 400 teachers. It is located in Porto and lectures 12 first cycle and 10 second cycle Bologna programs. 11 of this programs are EUR-ACE accredited.

Licenciatura Engenharia Informática (LEI-ISEP) is a Bologna1st cycle Informatics Engineering program (3 years – 180 credits) created in ISEP in 1985, but extensively improved in 2006/07 with the adoption of Bologna declaration in Portugal. The new structure is based on ACM Computing Curricula (2005), namely a combination of the Computer Science and the Software Engineering curricula, and structured along the CDIO principles.

The program is structured in 6 semesters:

- Semesters 1 to 5 have 12 weeks of ordinary classes (4 or 5 courses per semester) followed by a 4-week long design-build course.

- The last semester has some 3 semester-long courses, but it is mainly devoted to an internship/capstone project (18 ECTS).

In all, in the 2015/16 school year, there were 1323 students enrolled in LEI-ISEP, 415 in the 1st year, 421 in the 2nd and 487 in the 3rd. These numbers are not enough to characterize LEI-ISEP, as the student population is far from being homogeneous. For example, most students attend daytime classes, but there are 346 students enrolled in nighttime classes (18:00 to 23:30), usually because they have full-time jobs. Also, most students are enrolled as ordinary students (5 or 6 courses per semester), but there are 304 students enrolled as partial students, which have half the number of courses per semester of an ordinary student (maximum of 3 courses), thus taking at least 6 years to graduate. Most of these students attend nighttime classes.

Such a heterogeneous environment is the direct result of the massification of higher education and is not by any means exclusive of LEI-ISEP. Governments are a driving force in this process, using higher education as a fast paced social engineering tool, especially in southern Europe countries, which trail northern Europe countries in most education indicators. LEI-ISEP has a key role in this process of upward mobility, as roughly 25% of the students need to have a full time job to pay for their studies.

As students are not all alike and have different expectations regarding their higher education experience, the school should provide different learning processes somehow adapted the students' profiles. Nevertheless, there are several constraints:

1. School's internal pedagogical regulations, which strongly limit the existence of different assessment paths in a course.
2. Outcomes-based program accreditation processes, which require that a minimum set of outcomes must be the same for every student. Thus, different learning processes must have the same outcomes.
3. Working students class attendance is not mandatory by Portuguese law, though most regularly attend classes. Nevertheless, many working students have sometimes to skip some classes due to their jobs.
4. Not all students are enrolled at the beginning of the 1st semester, especially 1st year students. There are several different national application processes for 1st year students, so it's possible for a student to be enrolled one month after the beginning of the semester.
5. Lecture attendance is quite low (on average), as it is not mandatory. Still, some courses' lectures do have a high attendance (e.g. over 70%), which shows that students value lecture quality.
6. Students usually prioritize their effort, so coursework that does not contribute to the course's grade is usually given a very low priority or left undone.

Active learning (standard 8) must be dominant in a CDIO program. Active learning means different things to different people, so that it would be useful to have a reference/catalog for active learning methods. The Pedagogical Patterns Project (PPP) has the produced the book "Pedagogical Patterns Advice for Educators" (PPP, 2012), to try to capture the expertise of teaching practice/learning in a compact form that can be easily communicated to those who need the knowledge. Many of the pedagogical patterns in the book are focused on active learning. Figure 1 provides a mind map of the active learning patterns on the book.

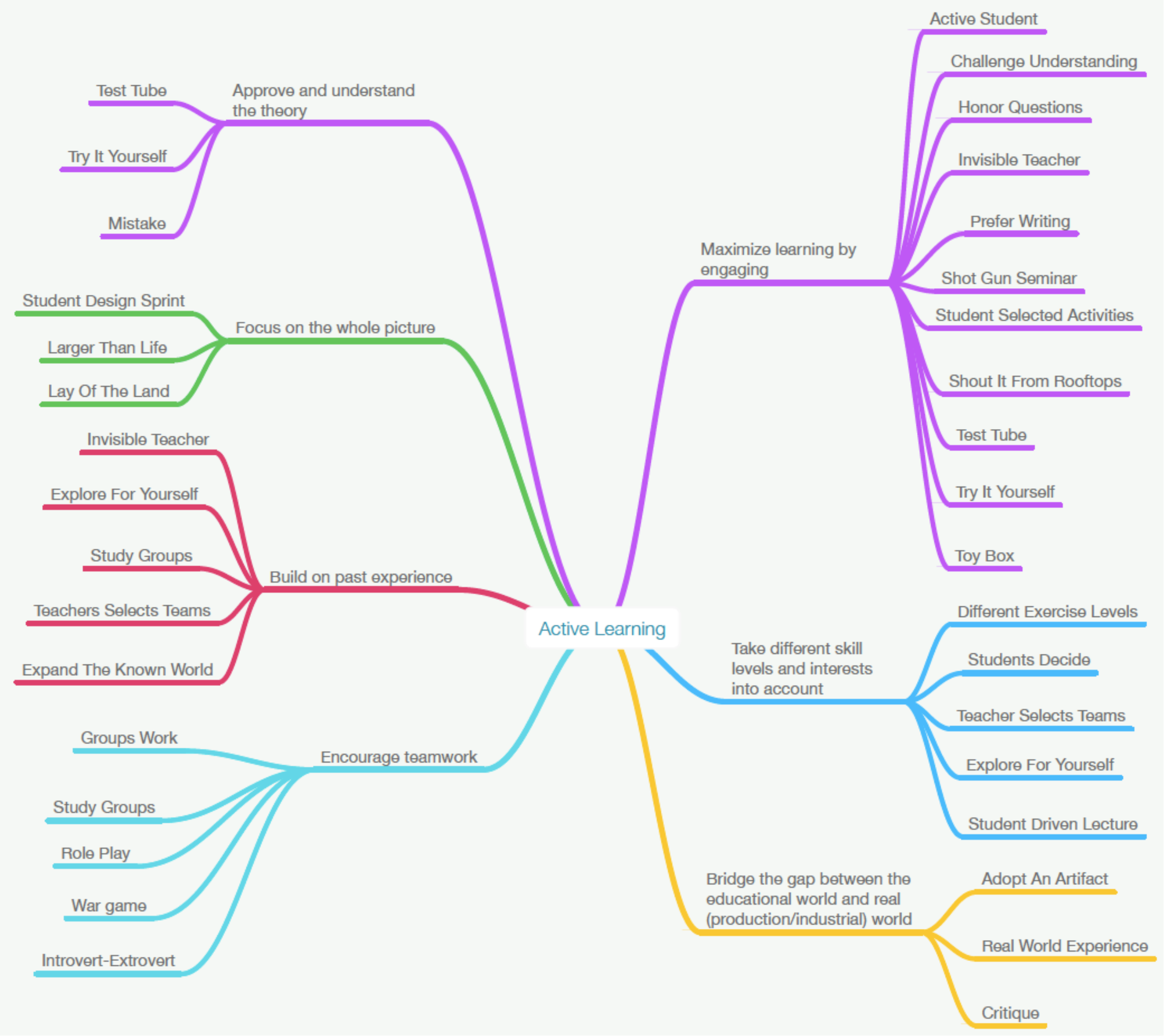

Figure 1 Active learning pedagogical patterns

ACTIVE LEARNING IN LARGE PROGRAM

One important aspect of active learning is student engagement and this can hardly be achieved by applying a standard “recipe” to all students. Flexibility is paramount. The teacher must continuously adapt its approach and select the appropriate methods in order maximize the effectiveness of the learning process. This is quite achievable in a course with one or two teachers and a small number of students, but quite hard in a course with 400 students and 10 teachers. It is quite difficult o providing a consistent learning experience to all students with a large teaching staff team, especially in courses with a strong practical component, lab classes and group work.

Lab classes are especially challenging, as students have different learning and working speeds. Groups help mask some differences, but they will hardly work at the same rhythm. A “forced march” approach may be used to achieve intra and between class synchronization, but it will hardly result a productive learning process for the students. Worse, experience shows that students will organize themselves in order to ease their march, creating two types of groups: the best students and the left behinds. This is the recipe for disaster.

To force the creation of heterogeneous groups may look to be a solution, but in a “forced march” scenario it will move the rupture forces inside the group. Working in a heterogeneous group is not easy, because of different working and learning speeds, background knowledge, work ethics, individual objectives, etc. (Martins et al., 2013). But this is what happens in real life, in the workplace, where heterogeneous teams are the norm, not the exception. The program should prepare students for real life, so its learning processes should encourage good teamwork practices. That’s, where eduScrum can be very helpful.

TEAMWORK USING SCRUM

Scrum (Sutherland, 2014) is an agile project management methodology widely used by software companies worldwide, but applicable to any area. The main concepts behind Scrum are:

- Team empowerment – the team manages its own work (task allocation) and periodically reviews its internal processes in order to continuously improve.
- Sprint based scheduling and planning – at the beginning of each sprint, a set of tasks are chosen form the project’s backlog, i.e. work to be done, and a work plan is defined for the sprint. Fixed length sprint are used (e.g. 2 weeks) and the tasks not finished at the end of the sprint go back to the backlog.
- Periodic client feedback – the project has a client, be it internal or external to the organization, which provides feedback at the end of the sprint. Work not accepted by the client it is not finished and goes back to the backlog.

eduScrum (http://eduscrum.nl/) is an adaptation of Scrum to education. It was created and first applied in secondary education (forms 7 to 12) in the Netherlands, but it can easily be applied in higher education and professional training. It can be used in any class context where teamwork is dominant.

Engineers work in teams. In the context of LEI-ISEP, a software engineering program, teamwork and interaction with a client are paramount. Thus, the application of Scrum to the classroom of one of the most widely used agile software development methodologies looked quite natural. There is no single educational approach that can be successfully applied to all courses, but the approach proposed by eduScrum (with minor customization) seems to applicable to most LEI-ISEP courses’ practical and lab classes. Until now, the exceptions are mostly courses where a major overall of the course’s classes are required, thus resulting in stiff resistance from the teaching staff. Change does not come easily…

Scrum’s flexibility and team empowerment make it especially useful in an active learning environment and we have found it to answer to all 6 constrains presented before. For example, a group of students beginning classes a few weeks later in the semester can be easily solved by shortening the duration of the first sprints, until they reach the level of peers. Regarding working students, a multi-week sprint gives (e.g. 2 or 3 weeks) gives them the ability to manage their work, even if they have to skip a class during the sprint.

Heterogeneous teams pose a special challenge in a teamwork classroom environment, but not when a Scrum based approach is used, as it naturally encourages peer-learning and peer-assessment. Better yet, scrum also allows for students to negotiate with their teammates their tasks and workloads, thus allowing for both over and under achieving students to fit in the same group. Scrum provides simple, yet robust tools for activity planning and monitoring.

And it has an essential aspect: it does not grade incomplete/wrong work. It is better that a student provides half of the tasks/work well done than most of them with defects! It promotes work quality in a natural way and the students are also stimulated to develop themselves into valuable team member (Linders, 2013).

eduScrum

eduScrum is based in the Scrum framework, but especially tailored for the education environment. A brief explanation is provided below, but more information can be obtained from the eduScrum website.

Roles

The main roles are (Figure 2):

- Product owner – teacher who manages and defines the product backlog.
- Scrum Master – teacher or team member who coaches the teams in order to correctly follow eduScrum rules.
- Development team – group of students who delivers the product.

Groups can be formed by students at the beginning of the semester and for the whole semester, unless unfortunate events (e.g. element quitting) or poor teamwork performance require changes. It is also possible to be teachers to form the groups, but they must be aware that it is a significant overhead and a responsibility. It is always better for the students to organize themselves. It is also possible to have temporary groups (e.g. for a single assignment), but one must be aware that team needs some time to start being productive.

It is a good practice to create balanced teams, at least in number of elements. 4 or 5 elements are common choices, but it can go up to 7 in large projects. Bigger teams are not productive, even in a professional environment.

Sprint

A sprint is a period of work in which the group has to develop or solve a set of tasks or user stories related to the course's objectives (Figure 3). It ends with a sprint review, where the sprint results are assessed. At the end of the sprint there may also be an integrative individual or group assessment activity. Sprint duration is the same for all sprints and it should be 2 or 3 weeks, maximum. A module can be composed of several sprints, so there is no need for longer sprints, which are quite ineffective.

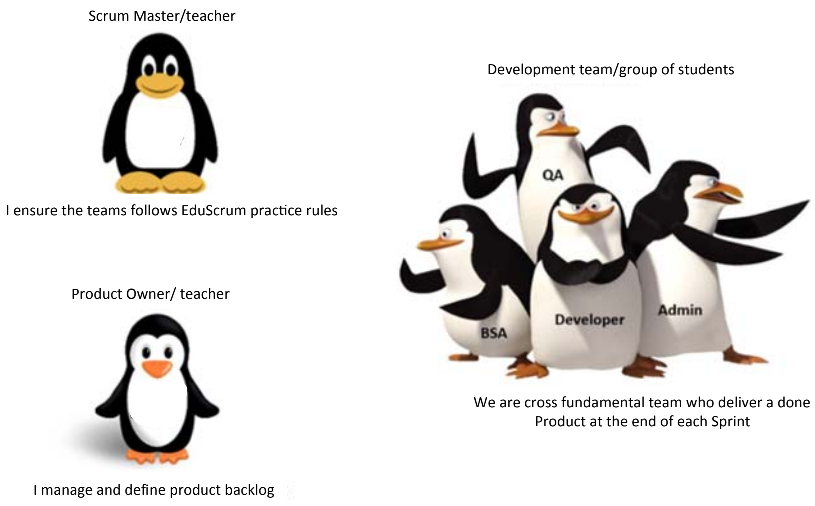
Scrum Master/teacher
I ensure the teams follows EduScrum practice rules
Product Owner/ teacher
I manage and define product backlog
Development team/group of students
QA
BSA
Developer
Admin
We are cross fundamental team who deliver a done Product at the end of each Sprint

Figure 2 Scrum team (adapted from http://www.123sfdc.com/2015/03/scrum-framework.html)

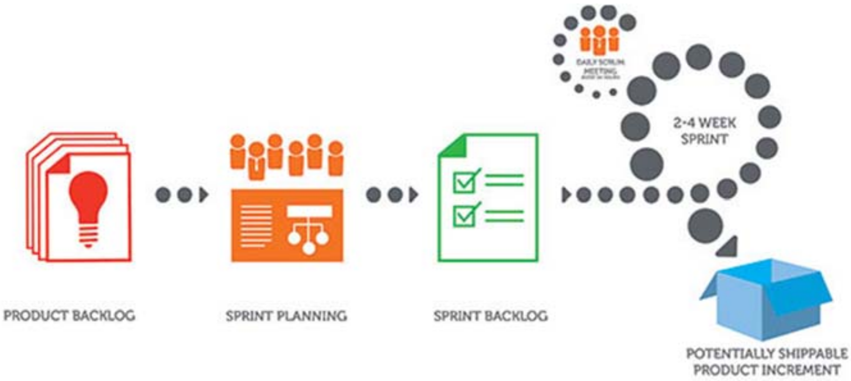

Figure 3 Sprint

Each sprint must have:

- Objectives – subset of the course outcomes
- To-do list – could be exercises, problems, user stories, monographs, etc.
- Acceptance criteria – for each activity there must be a set of criteria for accepting and assessing the activity.

During the sprint students develop their activities, dividing responsibilities among the team members. Activity can be further decomposed into more than one task. The task allocation mechanism requires an estimation of the effort of each task. A common solution is using the Fibonacci series (1, 2, 3, 5, 8, 13, 21, ...) to assign weights (complexity and time to implement) to each task. The students then choose the tasks accordingly. In the team's first sprints, while students are not used to this process, teachers may suggest weights for the activities/tasks. The team decides when and how they execute the activities/tasks during the sprint.

Task management is achieved is a Scrum board, i.e. a simple board with 4 columns:

1. Not started
2. In progress
3. Finished
4. Accepted

At the beginning of the sprint, all tasks are on the “Not started” column. The distinction between “Finished” and “Accepted” is quite important for the methodology, as only work accepted by the product owner should be graded. There is also the possibility to include mandatory peer review tasks, so that only tasks reviewed can be declared “Finished”. This is especially advantageous because it encourages work reviewing and peer learning by the students and also alleviates some work on the teaching staff. A task that fails the peer reviewing process or is reject by the product owner/teacher returns to 2nd stage, “in progress”. The acceptance process by the teacher may include asking some questions to the team related to the task/activity.

Sprint review

The sprint assessment usually has 3 components:

- Assessment of tasks performed - usually calculating the weighted average of accepted activities. Activities not accepted have a 0.
- Assessing students’ individual contribution by analyzing the team’s scrum board (photo submitted in moodle).
- Integrative sprint review (optional) – the students have to answer a quiz or solve and exercise/practical problem related to the sprint, individually or in groups. A simplified grading mechanism scale (e.g. 1-5 scale) should be used.

The sprint assessment corresponds to the weighted average of the two components.

Sprint retrospective

The group should write a brief analysis (e.g. paragraph) on 3 questions related to the team performance during the sprint:

- what went well;
- what went wrong;
- what should be improved in the next sprint.

APPLICATION AND FEEDBACK

The eduScrum methodology has been applied in in two Math, one Physics and four Programming courses of LEI-ISEP. There was some initial reluctance from the teaching staff regarding its “by the book” application, so that some courses used a customized version of eduScrum. This was a mistake one had to endure in order to bring faculty onboard.

Math courses used variable duration sprints (2 to 4 weeks) aligned with the course syllabus’ sections. These courses have 4 hours/week of practical classes and sprint related activities were only included in half of the classes. The remaining followed the traditional approach: teacher provides a list of exercises, the students solve them and the teacher helps the students individually or by solving the exercises on the board. There was an integrative sprint review at the end of each sprint in the form of a quiz. Teams of 4 or 5 students were used. Due to school regulations, the sprint assessment was only formative on Math courses. The courses’ assessment was by a final exam. In the following semester, sprint assessment was both formative and summative..

The Physics course used the methodology only on lab classes. The students have to plan, implement and report the results of an experience; and that was the scope of application. There were 3 sprints with increasing weight on the lab grade. Only the last sprint had an integrative sprint review in the form of presentation and discussion of the experience's results. Teams of 4 or 5 students were used.

The programming courses have several group assignments, so that would be fairly easy to apply the eduScrum approach to those. The objective was to apply the process "by the book", using teams of 4 students. Unfortunately, not all courses followed the standard approach and several questionable "customizations" were introduced. One course used groups of 2 students, which is not a team. This resulted in an increased workload for the teaching staff, which had to provide feedback to about 8 or 9 groups in each class, instead of 4. Teaching staff feedback on the pseudo-eduScrum application on this course was overwhelming negative.

It is always very difficult and dangerous assess the application of a new methodology in terms of the students' academic results/grades. Also, one school year is not enough to have a solid assessment, especially because students change every year. Nevertheless, there is strong evidence that the students were more engaged in practical and lab classes, even on Math courses where the sprint assessment was only formative. Overall results were also better in most courses, but not in all. We were not able to derive a strong correlation between the improvement in the programming courses lab classes results and the final exam grade.

CONCLUSIONS

In this paper we describe the application of the eduScrum methodology in several courses of a large Informatics/Software Engineering program (over 1300 students). We believe there is a strong correlation between the Scrum project development process and CDIO, as depicted in Figure 3. Thus its adoption as the reference methodology to foster active learning adoption in the program.

The first conclusion is that students were more interested and engaged in lab classes, though there is not enough evidence to assert that this had a positive impact on final exam grades. But exams' grades were not the prime objective for eduScrum adoption, anyway.

On the other hand, there is strong evidence that some teaching staff is still reluctant to use active learning and to allow the students some freedom in choosing their own learning path. Some teachers also seem to focused on student individual grading by the teacher, ignoring the positive effects of peer learning and peer reviewing by the students. Nevertheless, the application of eduScrum is being expanded to more courses. A special effort is being taken on training teaching staff on the methodology.

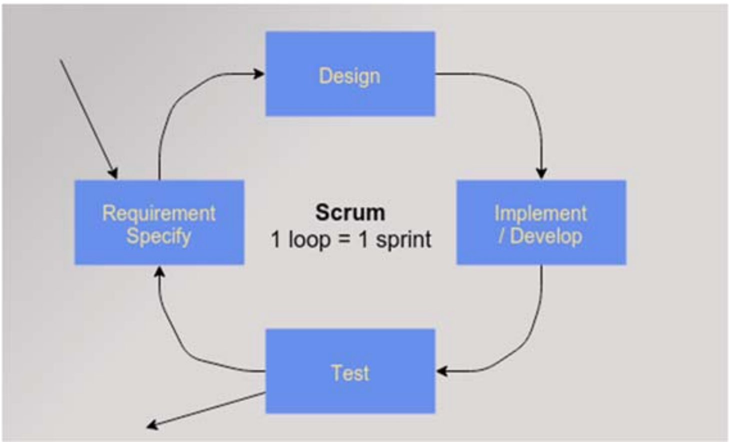

Figure 3 Workflow during the sprint (Marler, 2015)

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BIOGRAPHICAL INFORMATION

Eduarda Pinto Ferreira, is an Auxiliary Professor of Mathematic at ISEP - Instituto Superior de Engenharia do Porto, Portugal. PhD in Science Engineering. Chairman of 1st CDIO Iberian Workshop (ISEP), March 2011. Chairman of the 3rd ESICUP Meeting (EURO Special Interest Group on Cutting and Packing), international conference in Porto (ISEP), March 2006. Member of the Scientific Committee of JBLE-09 (Jornadas Luso-brasileiras de Engenharia), Porto (ISEP), February 2009. Attended almost all CDIO conferences since 2008. President of Pedagogical Council between 2010 and 2014. President of the NGO IPP Solidário since January 2016.

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