Project LEAP: Lean and Agile Practices linking Engineering Higher Education to Industry

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O5. Good practice recommendations on the collaborative, active learning design for integrating agile and lean industrial process experience in higher education

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Table of Contents

INTRODUCTION

According to general consensus, Serious games have a significant potential as an educational tool but, admittedly, their effectiveness in terms of learning outcomes depends on many factors thus a systematic approach, based on established methods, principles and guidelines is absolutely necessary in order to enhance the design of appropriate tools and methods. Given that Serious games are normally designed with a specific target audience in mind and with the purpose of being educational through fun and entertainment, their design has to be carefully implemented and should meet specific educational goals as well. Therefore, apart from considering entertainment and engagement, developers must indeed consider how to design more effective and trouble-free applications, involving the mechanics that are most suited for a given goal, the user interface that best suits the target audience's needs, the typology of tasks that are best suited for specific skills and so forth.

Project LEAP's vision is to help higher education students build experience and knowledge on emerging lean and agile industry practices in order for them to pursue effective transition into the professional world, focusing on engineering disciplines. Through their familiarization with lean and agile practices, students will either be substantially encouraged to design cost effective solutions that meet needs or they will be exposed to industry cycles in which design is integrated throughout production processes, as opposed to only in the early stages of production, ensuring that the final product effectively addresses consumer needs.

The project pursues the aforementioned objectives through the design and development of Serious games that encourage learners to adopt industry roles, to think critically for addressing community and societal needs through agile engineering solutions, to practice on the application of industrial process management in the context of their higher education curricula,

and to take into account environmental responsibility issues in service design and implementation. However, such serious games and methodology need to be validated through a solid evaluation plan that will focus on the key challenges (as set in the project proposal), the specific action strategy that will be deployed throughout the project and the goals that need to be achieved.

Usually, when a game is under development, what is needed is the systematic application of a set of early assessment practices that refer to the process of using data to demonstrate that stated learning goals and objectives are actually being met or that the game is efficient technically-wise. Usually, when it comes to serious games assessment, formative practices that continuously monitor progress and failures, are particularly useful and should be used given that their outcomes can be incorporated into the serious game through appropriate user feedback.

In the case of LEAP Serious game, the pre-designed alpha-testing stage of the game has been the very first step to focus on how to motivate users to learn through its use and specifically to foster individual as well as group reflection on the game itself, on its flows and on the positive impact that the alpha version had on them. The data collected through evaluation activities that were carried out in an on-going manner, has been particularly useful for technical and pedagogical design issues. On top of that, the “purposive” sampling strategy that has been applied throughout the game’s design as well as the engagement of various users that are located in the countries that are represented in the project consortium, namely Greece, Spain, Portugal, Estonia, and UK, ensures a more valid overview of learning outcomes and the validity of the feedback.

1. Evaluation Methodology

In order to guarantee that LEAP outcomes meet the needs of stakeholders (learners, teachers, policy makers, industry) the project introduced early on an evaluation strategy that generated feedback internally by project partners and, most importantly, externally through the engagement of learners and teachers at several sites in Greece, Spain, Estonia, Portugal and UK. The LEAP evaluation activities were planned throughout the project implementation period in order to ensure objective feedback in an on-going manner that would enable its timely integration. It has to be noted that the LEAP evaluation process was due to be finalized in spring 2018 and the results are included in the present report (Deliverable O5, LEAP Evaluation report).

Participatory user-centred design strategy combined with formative evaluation has been applied throughout the LEAP games design so that it offered the chance as well as the right tools to researchers and game designers to develop and improve the games iteratively. In any case, participatory design offers a set of practices and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities (Muller and Kuhn, 1993). In Participatory design researchers and practitioners are brought together – but are not necessarily brought into unity – by a pervasive concern for the knowledge, voices, and/or rights of end-users, often within the context of software design and development, or of other institutional settings (Muller, 2002). In LEAP project we engaged with different stakeholders in the first place since Stage 1 so as to successfully develop the LEAP games.

LEAP evaluation strategy is established through formative, quantitative and qualitative evaluation methodologies using the focus-group discussions, observation sheets, and questionnaires in data collection. The qualitative data has been used and analysed under the perspective of securing objective

feedback for LEAP games' functionalities and quality, relevance, acceptance and effectiveness of games in the higher education learning courses.

The observation, documentation and elaboration of such feedback and data, are based on the following evaluation criteria that also helped significantly for further developing and improving the game in itself before it reached the final version:

- **Usability** of the game mainly in relation to the design, functionality, and interactivity aspects as well as any possible technical difficulties encountered by learners during use
- **Level of engagement** in the situated learning process
- **Perceptions** of the game testers regarding **relevance** of the game towards building experience and knowledge on emerging lean and agile industry practices in order for them to pursue effective transition into the professional world, **value added** by the game to the learning process and **overall quality** of the game
- **Acceptance** of the game as a complementary digital tool

1.1 Qualitative and Quantitative research

Collecting information for research purposes is an important tool either in the field of natural sciences, from which it actually stemmed, or in social sciences such as education, psychology, sociology and so forth. The purpose of collecting data is mainly to observe, investigate and measure phenomena in a way that future research is helped to advance and produce newer evidence and information. The two main approaches in collecting data, either used independently or in a mixed way when and if needed, are:

- **Qualitative research** has its roots basically in the field of social sciences but it is often deployed independently or in a mixed way in natural sciences related research since the need to understand the type(s) of attitudes and interaction(s) between people and their social

context and environment is considered of universal value. Qualitative research is by definition exploratory and is preferably deployed when a problem is still under definition, when a solution for a problem needs yet to be developed or when research needs to further study and analyse issues of specific interest. In other words, the purpose of qualitative research is to try to understand and interpret social interactions and look at the "why" and "how" things happen contrary to quantitative research that is oriented towards "when, where, and how". Usually, qualitative researcher opts for small and randomly selected groups that are put into focus in order to generate data through interviews, participant observations, field notes and reflection, ethnographic analysis. No statistical tests are present because typically descriptive data is preferred to any kind of numerical form information. The final outcome of a qualitative research is a narrative report with contextual description and specifically selected quotations that come from the interaction(s) with research participants.

- **Quantitative research** can assume a rather "conclusive" role since its purpose is to quantify the problem and understand its prevalence by searching for results that can possibly be projectable to a larger population. Usually, the purpose of Quantitative research is to test hypotheses, measure and quantify potential connection between cause and effect and make predictions based on the objectivity of the researcher. Quantitative research typically generates data, which is gathered through various types of surveys, audits, questionnaires, controlled experiments or even observation that set the basis for statistical and numerical form which can be classified, measured and analysed.

The choice between quantitative and qualitative research methods should be determined by the research question and not by the preference of the researcher while sometimes, mixed research methods can help gather comprehensive evidence or give a more complete overview of what is being

studied but again it's a matter of choice under certain circumstances.

1.2 Leap evaluation key aspects

Objective feedback from the deployment of the LEAP games *(*5S Transformation, Technical Debt, and SCRUM Game) and methodologies in real-life educational contexts in Greece, Spain, Portugal, and Estonia in diverse educational, cultural, and economic environments helped the consortium to generate the evaluation outcomes. The strategy provided insight to external interested parties, including teachers and policy makers, on how to evaluate the proposed learning frameworks and software tools in relation to desired and expected learning outcomes on employability. The evaluation results are compiled into a publicly accessible report through which interested parties should be able to get practical feedback on how to best integrate the LEAP proposed methodologies and tools into their own instructional practices.

As previously stated, LEAP evaluation strategy provided a comprehensive guide on the:

- **Overall quality and usability** of the LEAP game through the feedback and reactions of the game testers as well as by game design, functionality, and interactivity aspects.
- **Relevance** of the game to **a) active teaching scenarios and different fields and contexts** (the purpose is to assess the educational added value introduced by the proposed serious games methodology for simulating industry practices in blended learning activities within which games can be used effectively and how teachers use the games in the teaching process in terms of promoting active learning, hands-on experiences and knowledge transferability and abstraction), **b) industry processes** (the purpose is to assess whether the game is inspired by real world work practices and if it promotes user-centred entrepreneurial mind sets), **c) teachers' current knowledge**

and competences (existing skills of educators will be taken into account and it will be documented how such skills can be upgraded and enhanced in order to facilitate integration of innovative technology into their instructional practices), **d) students' current knowledge and competences** (learning outcomes).

- **Acceptance** of the LEAP games in terms of willingness of teachers to use them and of students/end users long-term engagement, attraction and interest
- **Instructional support**
- **Effectiveness** of the LEAP games to the learning process considering learning outcomes. This can be documented and measured by considering the development of experience among higher education students on emerging industrial processes, including agile and lean product design as well as their capacity to understand agile product design and lean product design which promotes the responsible use of resources thus being friendly to the environment and so forth.

More specifically, the effectiveness of the LEAP game and methodologies can be traced in the:

- **Effectiveness of educational outcomes since students exposed to agile and lean industrial practices**: a) were able to explain how LEAP games simulate lean and agile processes thereby demonstrating that they fully understood what agile was about and why and how it was applied, b) learned from lean and agile approaches how to build new knowledge on their own and be responsive to challenges.
- **Alignment of educational activities to industry requirements in a way that this helps students:** a) apply critical thinking in deciding-thinking cycles, b) learn how to deconstruct a problem into smaller components and solve each of them separately, c) estimate the duration and feasibility of tasks, considering the needed changes in timeline and efficiency, d) learn how to make dynamic time-manage-

ment plans for the agile design process, e) prioritize tasks and allocate competences, have readiness to respect and take over various roles in the development process as well as develop holistic understanding of the importance of every role in the agile design process, f) make critical decisions and propose future steps of actions based on the assessment of the feedback from former stages, g) plan and analyse trials and handle errors without giving up, h) adjust initial designs to current requirements reusing the previous work and upgrading it by using the feedback and the previous prototype, i) be flexible and adaptive to changes in occasions when requirements come up unexpectedly, including strategic prioritization of the requirements

- **Effective transfer of the experience generated by the deployment of LEAP serious game into future real-world professional activities in a way that students should finally reflect entrepreneurial mindsets and would develop capacities that help them:** a) cooperate with others within the team, be open-minded and receptive to others' ideas to coexist with others so as to complete a specific goal, b) build relationships with their customers in order to keep up with their needs, c) adopt flexible and adaptive attitudes, d) develop self-confidence and self-control in case of changing challenges, e) develop openness regarding the adoption of new ideas and the deployment of new tools, f) weight every decision when it comes to business and engineering
- **Effective linking of learning outcomes with employability and transitioning into the world of work in a way that will help students develop the capacity to:** a) apply agile and lean product design in the context of new projects, b) think out-of-the-box in an entrepreneurial manner for introducing viable solutions that are environmentally friendly and respectful of users / consumers, c) adopt user-centred approaches in the design of solutions that address real-world needs of consumers.

2. EVALUATION PROCESS OVERVIEW

The following sections introduce a description of the evaluation activities that took place during the LEAP project with the objective of establishing good practice guidelines on how the project outcomes may be best deployed in higher education towards building agile and lean production skills among students.

2.1 Process overview

Evaluation took place in an on-going manner throughout the implementation period. Outcomes are being widely disseminated to the lifelong learning community and stakeholders and will be used towards the development of a post project adoption strategy. The process consists of various stages as explained below.

Stage 1 was related with **participatory design and formative evaluation of LEAP games prototypes** namely **alpha testing** during which:

- The experts and teachers were engaged to participatory design sessions in order to help the development of the games. This phase was conducted in face-to-face and online meetings throughout the project and is documented in the meeting minutes as well as with descriptions and reports on the design.
- Project partners, researchers-educators and small student samples play-tested the LEAP serious game in its alpha and beta stage in order to report bugs and inconsistencies as well as to validate the functionalities of the game, using specific evaluation sheets.

During the participatory design and testing of the first versions of the serious game, users/testers (teachers, students, experts) had the chance to put their hands on early but completed scenarios of the game in design sessions and evaluation activities. Validation through an external expert in the field of learning design was also pursued aiming to further improve project outputs and ensure that they meet the needs of students and educators.

Stage 2 refers to **beta testing and summative evaluation of the LEAP games prototype.** During this process the consortium pursued beta-testing of LEAP game in its actual (not yet finalized) version within real-life educational contexts in Greece, Spain, Portugal, Estonia, and the UK with final sample sizes that will be described further on. The evaluation tools included observation sheets of LEAP games for teachers (who were already trained regarding the educational use and technical aspects of the LEAP serious game by local researchers of the consortium in each country) and the quantitative LEAP game evaluation questionnaire for students. The initially planned sample, which has been superseded by far, included:

- In Greece (1 site): 70 higher education students
- In Estonia (1 site): 50 higher education students
- In Portugal (1 site): 50 higher education students
- In Spain (1 site): 50 higher education students
- In the UK (1 site): 50 higher education students

The LEAP games and methodologies were introduced in various courses and subject contexts (where applicable) in the partnering countries. Validation took place in classrooms through the organization of “learning experiments” and during such validation sessions students had to:

- Use the serious games scenarios/exercises off-line at the design stage and before their digital integration into the game for evaluating the game content itself.
- Use the virtual game for building experience on agile and lean industrial production design.
- Be engaged in collaborative contexts through end-to-end learning activities build around the serious game.
- Be encouraged to discuss their experiences with peers.
- Fill in the evaluation questionnaire

During evaluation sessions trainers / instructors:

- Used observational assessment methods and document the reaction of students and their progress in building experience on agile and lean industrial production design.
- Documented their findings in short reports to be communicated to consortium partners

2.2 Description of evaluation sites

As previously mentioned evaluation took place in various sites, namely higher education institutions in the countries from which the consortium members come from. More specifically:

- **Greece.** In the University of Thessaly, the LEAP project was presented to a specific number of scholars, approximately 200 of them, since it was incorporated, due to the requirements of this project, in specific courses offered during the 5th and 7th semester (fall) in the context of the undergraduate programme of the Department of Electrical and Computer Engineering in the University of Thessaly. The students were expected to provide feedback on the methodologies and applications developed within the LEAP project from the point of view of emerging engineers that had the qualification of understanding the value of the project. During the evaluation the implementation of the LEAP applications was heavily underway. This was an advantage for the evaluation process as the input was received in good time to inform later versions of the software. The contribution of the students has been crucial for the development and the optimization of LEAP project since they could contribute “fresh” ideas about the design and the implementation and they could actively contribute to this project by expressing what exactly their needs were, what made them opt for new knowledge and apply it without

being tired, bored or even unwilling. In addition, apart from the aforementioned course, the plan was to introduce the LEAP game and methodologies to as many students of the Polytechnic Faculty of the University of Thessaly as possible, during the academic year 2017-2018.

- **Spain:** The validation of the LEAP project in Spain was be based on the School of Telecommunication Engineering at the University of Vigo. The project was presented to approximately 100 students of the “Projects Lab” course that is offered during the second semester of the fourth year of the Degree in Telecommunications Technologies Engineering. This is a graduate program course, available to undergraduate students with instructor’s permission and also available for Erasmus students. This subject involves the development of interdisciplinary projects that must be addressed by a team of students who must represent at least two of the four technologies of the Telecommunication Technologies Engineering Degree. The teams are supervised by two faculty members from different Departments to enrich and facilitate the cross-fertilization between different areas of work. One of the main issues involved in this subject is the teamwork performed by students and the development of an engineering project of product. In this context, the application of Lean and Agile methodologies seems very appropriate in order to support team communication, coordination and management as well as the different stages involved in the development of new innovative products towards the provision of value to final users.
- **Estonia:** The evaluation of LEAP games in Estonia took place in Tallinn University (TLU). TLU is a relatively new university with a special focus on interdisciplinary activities and a lot of ongoing projects that emphasise such approaches. Being the third largest university of Estonia, TLU is considered to be innovative especially

when it comes to teaching methods. The LEAP games were evaluated in three sessions: first Educational Technology Master students and two groups of informatics students of Bachelor level. The expert involved was Kadri-Liis Kusmin who is a software developer at Proekspert and a PhD student in Tallinn University. Her work is focused on the social paradigm shift brought about by Industry 4.0. She is passionate about any topic that concerns improving human life through the application of IT.

- **Portugal:** The evaluation site took place at the Instituto Superior de Engenharia do Porto (ISEP), the Engineering School of the Porto Polytechnic. With more than 6000 students in total, ISEP offers a wide range of programmes in different fields of Engineering at the Bachelors and MSc levels. The evaluation was done with students from the MSc programmes in Computer Engineering (courses on Serious Games and Multimedia Authoring) and Electrical Engineering (courses on Programming and Management). Approximately 20 students per course were involved.
- **UK:** The first evaluation was conducted with students on first year Interactive Applications module (delivered to Computing, Forensic Computing and Networking courses). Students had covered some aspects of agile techniques in their course. 10% of the students agreed to participate in the study (signed consent was obtained after reading an information sheet in line with standard ethical procedures). This was performed within their usual lab classes.

  A follow-up evaluation was conducted with students from the MSc Computing, MSc Information Security and MSc Interaction Design groups. Following from the findings with the fist cohort of students and appreciating that to get good scores, or to ensure a good gameplay experience, the students needed to have some instruction, this evaluation took on a different form from the first evaluation. In this

case the students were given a fifteen-minute demonstration of the three games and then were given 45 minutes to play the three games in a lab session. 28 students took part.

3. EVALUATION ACTIVITIES IN GREECE

3.1 Evaluation Context

Throughout the LEAP games design, participatory user-centred design strategy combined with formative evaluation was applied in order to ensure that the game developers would design, implement and improve the game iteratively. In LEAP project the team engaged with different stakeholders during the development stage of the games and evaluation took place in an on-going manner throughout the implementation period and its outcomes have been used towards the improvement of the actual game before its final release. During the participatory design and testing of the alpha versions of the serious game, beta-testers had the chance to put their hands on early but completed scenarios of the game in evaluation sessions.

In Greece the LEAP project engaged in an active way a total of approximately 200 students of the University of Thessaly in the context of two different evaluation activities:

- The first one, during Fall 2017, involved approximately 130 students of the University of Thessaly, since it was introduced in the elective course named “HY310 Educational Technologies”. This course is available in the 5th semester (fall) of the studies of the Department of Electrical and Computer Engineering in the University of Thessaly and it focuses on the deployment of technology as an educational tool in lifelong learning contexts as well as on emerging learning methodologies (e.g. collaborative learning, explorative learning, active learning, mobile learning, problem-based learning, project-based learning and so forth) and gamification towards the enhancement of learning processes and experiences in formal, informal, and non-formal learning. It is an undergraduate program course offered to potentially future engineers and developers that qualified for testing the LEAP game and expressing their needs as users as well as what they actually believe about its usability during the design stage thus

their contribution is considered crucial for the development and the optimization of the software.

- The second activity was based upon an evaluation activity that engaged students of the Polytechnic Faculty of the University of Thessaly. The purpose of such an activity was to help evaluate the SCRUM digital game during and after its use by small teams working in small to medium projects. Moreover, the scope of this work was also to encourage higher education students to use the game and evaluate it as to its content and design in order to ascertain how games contribute to the learning practices. For this reason, a questionnaire was set up in order for the participating students and potential stakeholders to express their opinion on the effectiveness of the game thus their answers were seriously taken into consideration during the design strategy. Two teams of students took over the role of "researchers" that, after getting themselves acquainted with the SCRUM game itself, set up the online questionnaire based on their own experience of the game and also under the guidance of their supervisor, Dr H. Tsalapatas and afterwards they shared it with others. Actually, the questionnaire was answered by a sample of 65 people who had previously installed, played and evaluated the LEAP games.

3.2 Activity 1: Students' Feedback & Suggestions

In the context of the first evaluation activity and for better evaluating the game in a collaborative and objective way, small groups were formed and had to thoroughly test the game and provide a brief report on it based on the following pre-set questions:

1. *Please evaluate the content of the game and how it contributes to understanding (a) the concept of technical debt and (b) the 5S.*
2. *Do you think it contributes to improving the learning process and how? Which do you think are the innovative features of each game?*

3. *Please evaluate the user interaction with the application.*
4. *Suggest ways in which the game could be further improved.*

The feedback came from a total of 19 assignments the content of which was based on the previously mentioned questions. Regarding the first question about how the game contributes to understanding the concepts of technical debt and 5S (Figure 1), the students seemed to mostly agree on the fact that the game really introduces someone to both concepts and processes. All of the participants made a brief and clear analysis of what Technical debt and 5S are, which means that the game helped them grasp the main ideas behind the concepts that the LEAP game aims to introduce especially to those that aren't familiar with. According to the students that played with the application, Technical Debt simulates a process of investing in five different options (Reduced Complexity, Continuous integration, Increased Test Coverage, Code Review, No Investment), giving insight into how progress can be made. Through this process and having a certain number of investments, the user, testing how to invest in the implementation of his/her project can get results on how to evolve over time. Subsequently, the LEAP game puts the player in the process of thinking about which is the best way to invest and exactly when in order to pursue the best results while at the same time avoiding the risk to increase the cost of implementation later. In essence, the students unanimously agreed that the game indeed gives the user a complete understanding of the concept of Technical Debt through multiple trial-error processes.

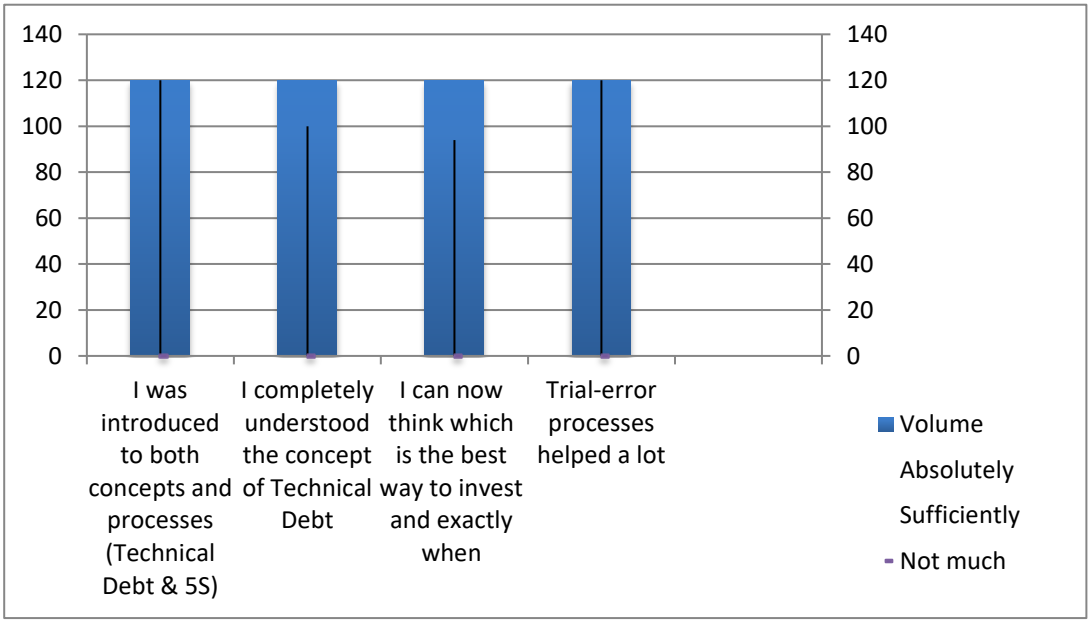

Figure 1. Game content evaluation and how it contributes to understanding the concepts of Technical Debt and 5S

Regarding 5S (Sort, Set in order, Shine, Standardize, Sustain) model, after testing the LEAP game, most of the students (96%) expressed the belief that they could fully understand the advantages it offers in terms of reducing production costs and implementation time (Figure 2). Through the simulated pharmacy operation during the game, according to the testers (students) a user can be introduced in detail to each of the steps of the 5S model while it is rather clear that the their absence would lead to a very time consuming process, resulting to significantly increased high production costs in terms of funds and implementation time.

According to many others (94%), the LEAP game absolutely helps the user to familiarize himself/herself with the concept of organizing the business and his/her workplace in a graphical environment and to understand the benefits of the process in order to successfully face real working conditions in the future as well as the value of a very well structured inventory (Figure 3). In addition, a high percentage of the students that tested the game, admitted that in any case it contributed to a better understanding of how customer

satisfaction is directly related with excellent internal work and iteration planning.

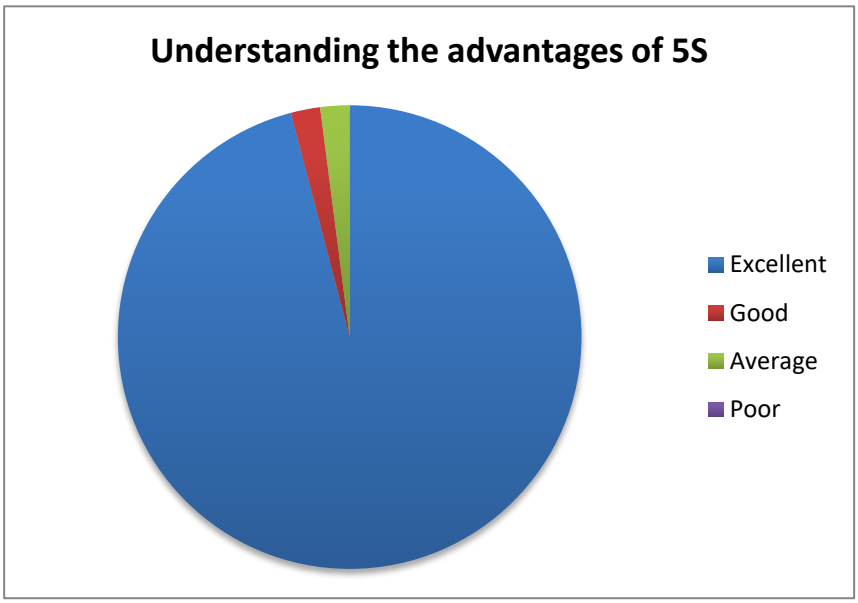

Figure 2. Reducing production costs and implementation time through the understanding of the advantages of 5S

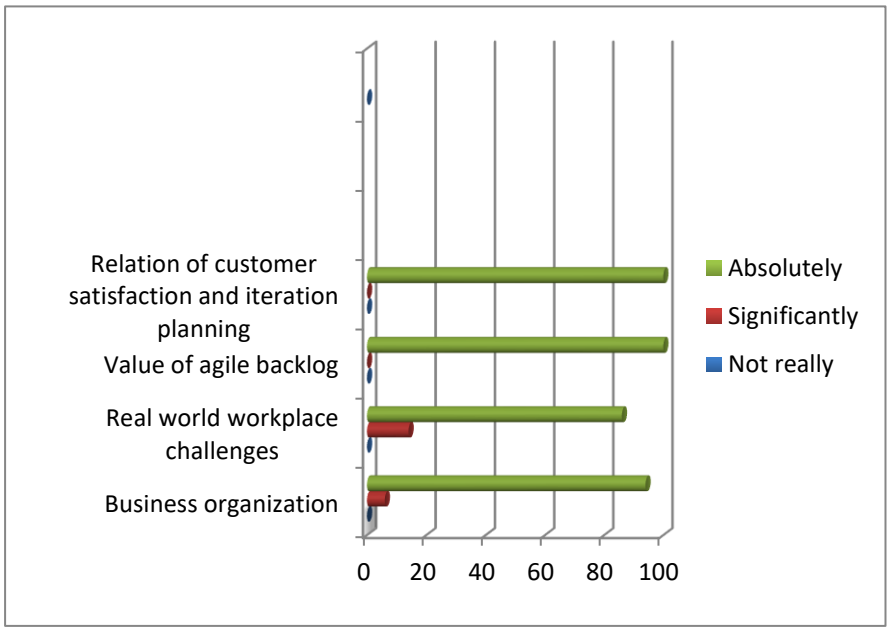

Figure 3. Does the game help the user understand the concept of agile iteration, business organization and challenges in the real world workplace?

Regarding the second question about how/if the game enhances the learning process and which are its innovative features (Figure 4), students mostly agreed on the fact that LEAP certainly contributes positively to the learning process mostly regarding its use as a «mental tool» in the context of economic literacy and entrepreneurship specifically in the respective undergraduate courses or in lifelong learning programs. Almost all the groups of students mentioned the advantage of LEAP being a free downloadable app, which in fact could increase the potential user/stakeholders base. Another common belief was that the content and theme of the game itself are innovative, as there are no such freely available applications and games that turn the user into a virtual investor. An innovative feature of the Technical Debt game was the result chart that the game offers because it makes it easy to understand how the results are being generated and how these are linked to right or wrong decisions. Also important is the choice of application for «No investment» because it leads to understand the complete absence of benefits in such case. According to other students, an important feature of the 5S game to be mentioned is the option to clearly show in detail each step of this model because this is what makes the user quite aware of the difficulties that would arise if they were not used. Overall, the testers agreed upon the fact that the innovation of the game lies in its main scenario of transferring a business to the digital world by visualizing and virtualizing the whole process so as to allow the user to develop his / her organizational skills and get ready for real-world management.

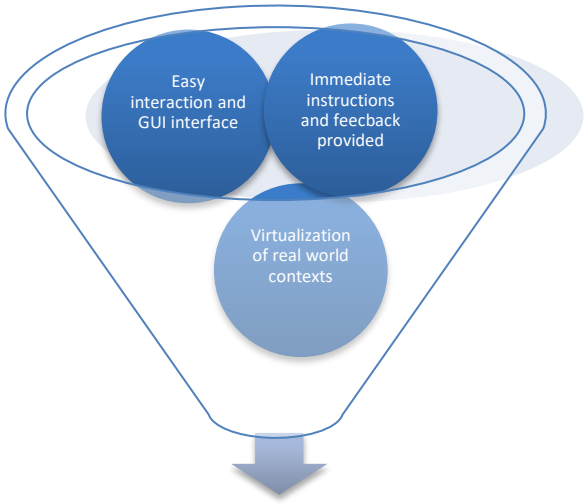

Figure 4. Students' feedback on the positive features of LEAP games

For the design team of the LEAP game, one of the most important parts of this testing session with university students was the evaluation of the user interaction with the application. Such feedback would generate useful information on which aspects should be revised and eventually change on the way to a release candidate version. First of all, most of the teams that tested LEAP thought it is rather easy to use in terms of practicality since it provides a brief analysis of each type of investment given, so within minutes the user is ready to start using it. Another positive fact is that the user is faced with immediate results on how the deployment cost varies after any investment through a handy chart showing its variation. In addition, another feature that was welcomed is that as soon as the users have already completed the specified number of investments allowed, they get to know their final score and they are informed on whether this is the highest one achieved so far, which offers additional incentive to continue to work on the application in order to further engage with the application thus improve their skills. The interface was also considered as one of the strengths of the game, being simple without burdening the user with visually unnecessary information.

Other teams commented on the fact that the interaction with the game through the exclusive use of the mouse makes it easy to play with, for people who are not familiar with such games and for people with mobility problems. Furthermore, the instructions and tutorial provided by the application were considered by the students as sufficiently informative so this seems to lead to better understanding of the game and it secures the achievement of the set learning goals and objectives.

One more crucial part of the evaluation process was the feedback regarding suggestion for potential improvement of the game (Figure 5). According to most of the participants, a feature that could be added to Technical Debt would be various proposals that would consist of investment combinations as well as suggestions on how the user could achieve a lower implementation cost. In addition, an explanation could be added as to what might have gone wrong in a case where the user did a false investment, or vice versa, whenever the user succeeded in reducing the cost. Other students suggested that it would also be very interesting if the user could change the difficulty level by varying the number of sprint numbers. Another improvement that almost all the teams commented on is the enhancement of graphics that while they are sufficient and «cute» according to the game testers, they could do with some slight improvement that would make the game even more appealing to an already wide user base. Some of the testers also found the game rather slow in its response and asked for a better implementation of the user interface (UI) but at the time the testing took place, this was clearly an expected technical issue due to the alpha version of the game. Needless to say that such feedback was absolutely useful for the project's developers that eventually fixed evert minor or major issue and bug before the final release of the LEAP game.

Other suggestions for improvement regarded the enrichment of the game's content list in order to broaden the range of topics it covers and make the process more comprehensive as well as the enhancement the scenario in

terms of continuity between stages so as to attract and maintain users' engagement.

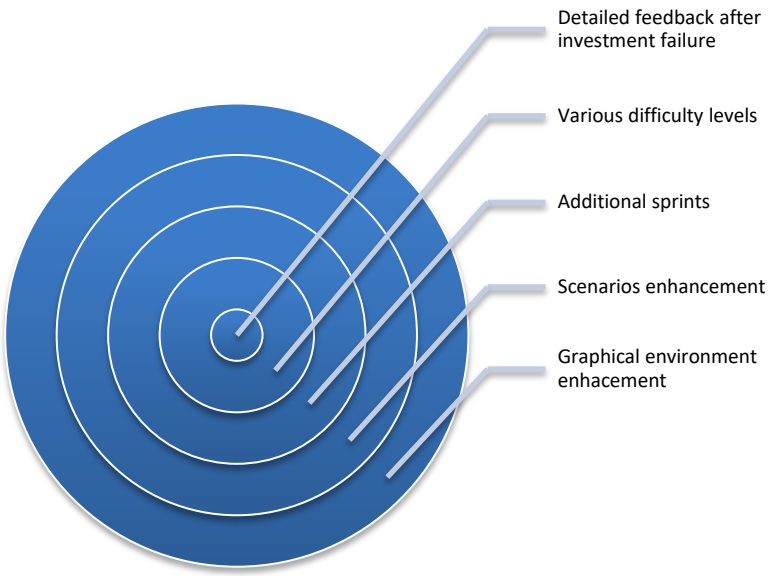

Figure 5. Suggestions on how to further improve the game

3.3 Activity 2: Students' Feedback & Suggestions

Actually, the second version of the evaluation activity that took place in Volos, Greece, didn't differ a lot from the first one since it was also based on a questionnaire that had to be answered by a sample of approximately 70 University students who installed, played and evaluated the games. The questions that the participants had to answer after play-testing were the following:

- *Is the game interesting at all?*
- *Is the game any fun?*
- *How would you rate the interactivity factor?*
- *Do you think the game helps to improve the learning process and how? Which are its strong points and its innovative features?*

- *Which of the following do you think are the innovative elements of the game (more than one): a) Digitized form of the SCRUM process, b) The user can play all roles (Product Owner, SCRUM Master, Team Member), c) The user is a student from any polytechnic school, d) Players are in different rooms as they do not have to be all in the same room (Product Owner, SCRUM Master, Team Member), e) There is feedback on how well the user went into the game, f) Other (please refer accordingly)*
- *How easy was it to understand how to perform the basic functions of the SCRUM digital game? (rate between 0-5)*
- *How balanced is the time required to complete a project in the digital game so it does not confuse (rate between 0-5)*
- *Does the game help to better understand the design and development of a product using SCRUM methodology? (rate between 0-5)*
- *Would you suggest that the SCRUM digital game is used in Higher education courses? If so, in what ways?*
- *Which are the game's weak points, if any? How could the game be further improved?*

The majority of respondents (65.5%) were aged between 21 to 25 years followed by 17.2% of users aged 26 to 30 years. Similarly, the student's education background was at a 69% of undergraduate students, followed by 31% of postgraduate students from various departments namely Agricultural Sciences, Mechanical Engineering, Urban planning, Architecture and so forth. When it came to the first two questions as if the game was any fun and appealing to the users, most of the participants (81%) responded positively (Figure 6) while even more (97%) thought that the game was rather interesting. Initially most of the participants had never used this method again in the past. However, almost all of them found the game easy and simple to handle.

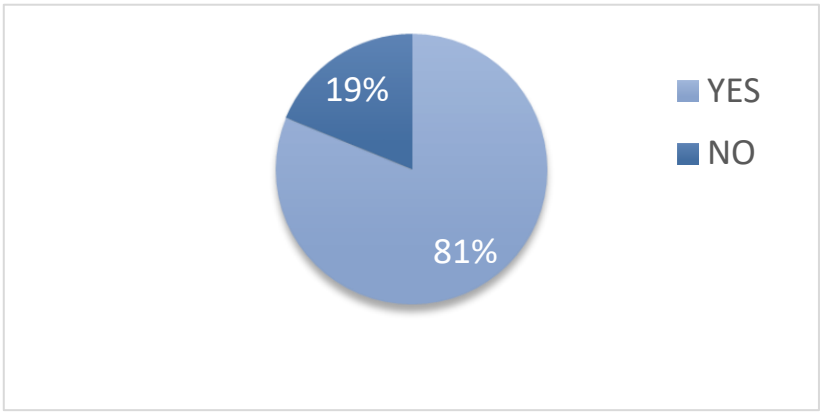

Figure 6. Is the game any fun?

The game contributed to the understanding of SCRUM concepts of users who had not been familiar with this method, but also to a better understanding of those who had once again dealt with SCRUM. Additionally, there were several persons who found that a good organization at the outset of the design contributed to a better outcome of the project. All roles have been understood by the majority of users who played one or two times each role. A 30% had to play up to three and four times. In addition, the game's interactivity factor was considered to be of a high level and was yet another winning point that could enhance the engagement of the player with the SCRUM concepts and Agile processes since a 43.8% thought that it was excellent (Figure 7).

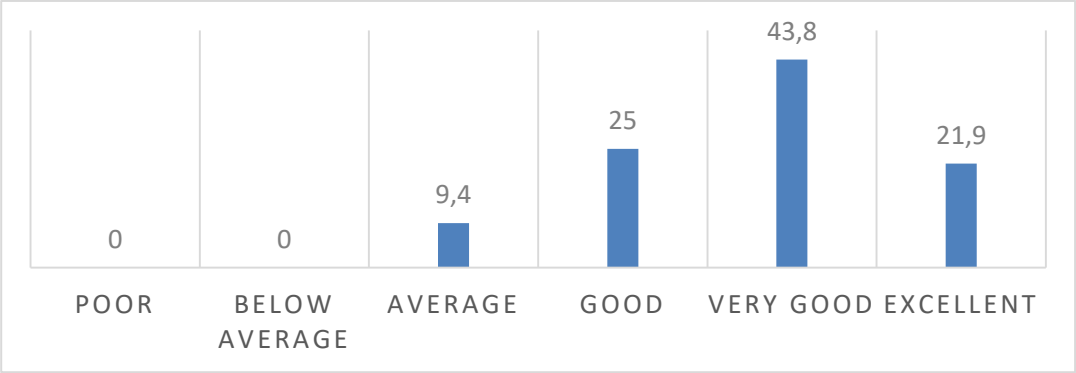

Figure 7. Please rate the interactivity factor of the game

After all, the students/beta-testers had to express their opinion on which were the innovative elements of the game as well (Figure 8). Almost 75% of the people that played the LEAP SCRUM game emphasized on the fact that the user can play different roles in the game anytime he/she wants it and this adds either to the durability of the game or to the possibility to get to know more about various competences related to the design processes etc.

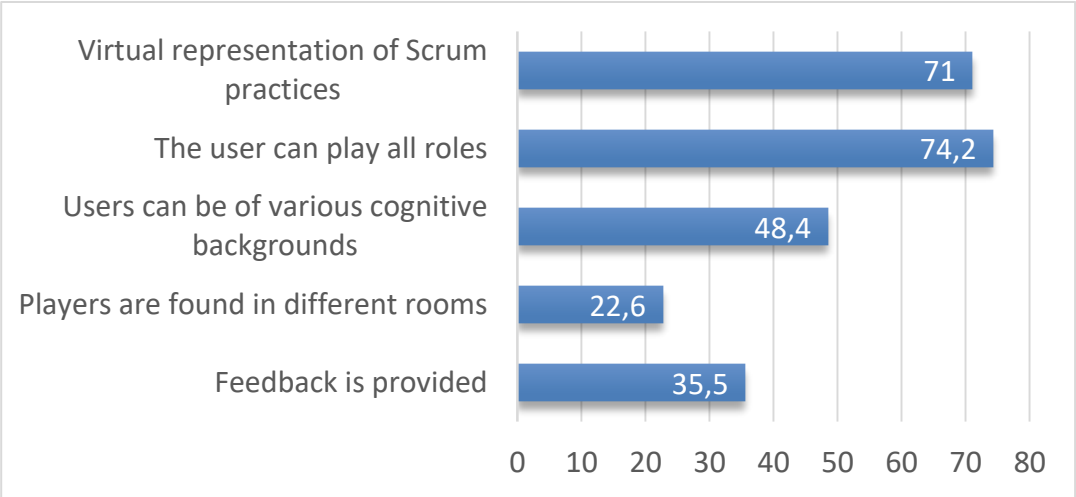

Figure 8. Which are the strong points and innovative features of the game?

Another 71% pointed out that the game offers the opportunity to delve into the SCRUM processes (Figure 9) since every single step is thoroughly presented throughout the plot, something that can be easily paired with the immediate feedback element of the game according to 35.5% of the students that tested the game

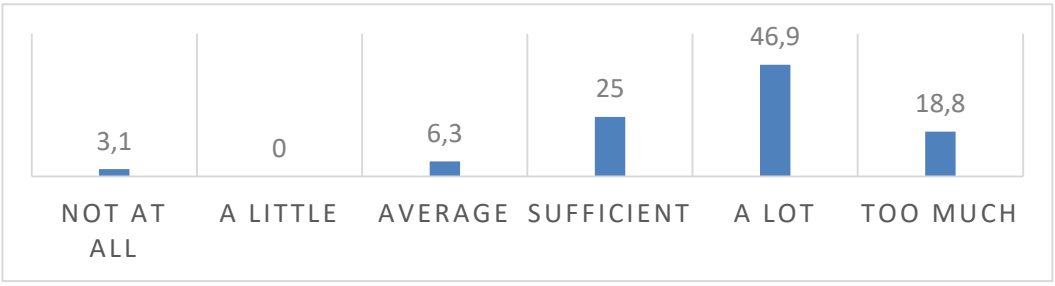

Figure 9. Does the game help the user grasp the main idea and concept of what SCRUM is?

All participants agreed that the game contributes to the learning process in a variety of ways. The first way most people have agreed to understand this method is to instantly show the results of the decisions the user is asked to take at each stage of the game and how much his actions play a role in the performance of the project but also in customer satisfaction. Also, the instant and comprehensible step-by-step presentation of the SCRUM method seemed to be an important factor that made the user fully understand the method. Moreover, many have found not only educational but also entertaining this way of learning.

In addition, the understanding and importance of priorities in the design of a project within a specific timeframe is another important innovative feature of the SCRUM Agile simulator game. The importance of collaboration and communication with other roles and with the client is also an innovative feature that is projected through the game for a better final project. The player's end-to-end performance based on performance and customer requirements is one of the elements that make an innovative learning game. Finally, some other innovative features observed by a smaller percentage of users, however, are the simulation of design processes through teamwork, the feeling of reward, the creation of prank-entanglement.

Another question attempted to document the easiness of the basic functions of the SCRUM digital game as well as whether the time it takes to complete a project in the digital game is balanced enough in order not to confuse the user (Figure 10). More than half of the users (71.9%) agreed upon the fact that the game is rather easy and straightforward to use and a mere 6.3% were not satisfied enough in this field.

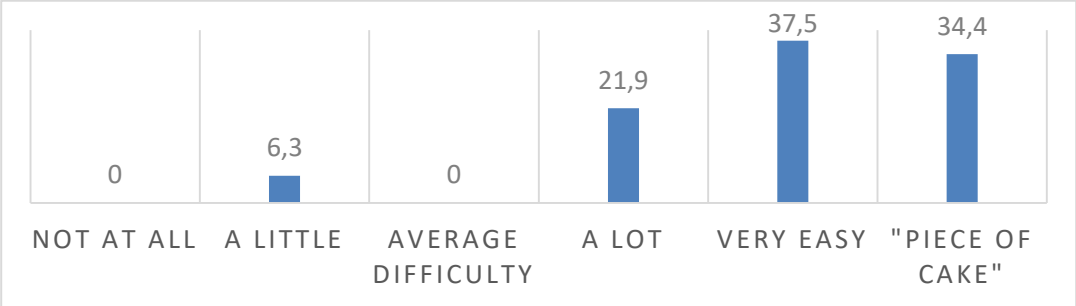

Figure 10. How easy is to use the game?

In addition a high percentage of users (62.6%) though that the rhythm of the game and the time needed to actually go through all of its stages is rather excellent while another 65.7% thinks that the game does help a lot to better understand the design and development of a product using SCRUM methodology and that is probably while almost every students that took part in the evaluation process suggests that the game could be integrated in Higher Education courses:

- In an elective course about project management and marketing
- In laboratory courses for project and time management
- In an e-learning or virtual course as a way of understanding how engineers work

When students / beta-testers were asked to contribute with their comments on whether the game lacks certain features and which were these, they came up with the following suggestions:

- more detailed instructions are necessary
- graphics and visuals should be improved
- evaluation of user performance could be added as an extra
- a more detailed description of the user's errors at the end of the game is needed in order to support understanding and meta-cognitive processes
- more open and free options for the user to take during the game
- evaluation at all stages of the game would be more than welcome

- an online version of the game could be interesting and could attract a whole new public

Last but not least, users seemed to be happy with the character of the game, but at the same time they were asking for something more, such as a more interactive (perhaps 3D) environment. Additionally, the development of the game's story, for example by adding more scenarios for different preferences, would help boost the game. Lastly, according to the students the concept of competition needs to be introduced in the game plot and scenarios as it is expected to make the game more attractive to new users in particular.

4. Evaluation Activities In Estonia

4.1 Expert feedback

As an external expert Kadri-Liis Kusmin was invited to give feedback to LEAP games and their value. She is a programmer in one of the biggest software companies in Estonia and also a PhD student. Her research topic is Industry 4.0 and she is a game enthusiast. She has had a lot of experience with real life practices in industry and engineering.

Conceptual issues

Product Owner

I was the Product Owner (PO) for two campus projects with music and science specialization (English) and one agriculture/gardening project for plants (Estonian). My scores for the projects were 69%, 59% and 79% respectively. The general logic of the game was easy to grasp: you receive a product development request from a client with an objective to complete the project iteratively in cooperation with your team and frequent communication with the client. However, there were a few things that bothered me:

- As a PO it is my responsibility that the client ends up with a project with features that s/he **needs** not features that s/he **wants**. Thus, the first phase of the game (requirements from the client) is not realistic: a true PO would never just accept the requirements and bring them to the team. It is crucial that the PO descends into the details of the client needs and helps formulate the real requirements – and understand the underlying reasoning. For me, the first phase was not transparent. I was given a set of requirements (e.g. area size, university specialization, number of students) without any background knowledge.
- Why did the SCRUM Master team decides the final set of product backlog features? This is the domain of the client & PO!

- In agile projects, the most important features are developed first. As a PO I did not understand the development team's reasoning for Sprint backlogs. Some tasks were estimated as high complexity and left for later iterations but in such cases the first action would be to try to divide them into smaller tasks (with potentially different prioritization levels). In my experience, during each iteration, the PO re-prioritizes the Product backlog multiple times and asks the client to confirm. Each Sprint backlog is also negotiated and confirmed with the client.

SCRUM Master

- SCRUM Master (SM) does not add items to the backlog! SM's responsibilities are to ensure that the processes are being followed and there are no obstacles for the dev team!
- Feature/task estimation is the responsibility of the team and PO. SM does not have a say in it.
- Sprint backlog is based on Product backlog prioritization: we take n tasks from the top of the Product backlog. Again, it's the responsibility of the PO who should first confirm Product backlog prioritization and then confirm Sprint backlog with the team.
- Agile teams are self-organized. SM does not assign tasks to individual team members – everyone picks their own task based on prioritization.

Development team

- While the dev team does have *some* say in what *could* be left out of the backlog, it's basically just their technical opinion. The client and PO agree on the final backlog.
- Dev team estimates the complexity/effort of the tasks, not SM!!

- SM does not suggest anything about the backlog. Dev team can have a say, but PO (as an extension to the client) is the boss of the backlog!
- Dev team assigning tasks based on expertise is correct ☺
- Our previous velocity was 25 but when I added two tasks with 11 and 10 estimation points to the backlog, I could not add an additional task with 4 points. Or does the -3 indicate that our velocity went down to 22?
- I played the dev team role most randomly and the end result was 100% performance and 53% project completion. What does it mean?

User Experience issues

1. Sometimes the navigation failed or I did not understand it. I resorted to clicking ‘back’ and other buttons randomly until ‘next’ button appeared. In one case the buttons disappeared entirely and I was left stuck in the initial prioritization phase.

Conclusion

The idea of the game seems viable for teaching SCRUM principles and the general mind set of agile project management. Except for a few technical / UX issues, the overall game logic is intuitive to grasp and it is easy to learn the mechanics. However, from SCRUM viewpoint there are quite a few logic errors. First, there are some issues with the roles, especially the SCRUM Master. There are two core objectives when it comes to the role of SCRUM Master: 1) to protect the team; 2) to protect SCRUM. At its current state the game portrays SCRUM Masters as some sort of project managers. The roles of Product Owner and dev team were more accurate with some minor issues, mainly as some responsibilities from both had been transferred to SCRUM Master. When teaching SCRUM, it is essential to include its artifacts and meetings. Although the artifacts were mentioned (e.g. backlogs),

they were not explained; the meetings were not mentioned by name, although the project team seemed to be holding grooming, planning and demo meetings. Retrospectives were ignored. Finally, the game lacked transparency – while the player was given two scores by the end of the game, it was not understandable what the scores indicated and how they were calculated. To improve the game, I would recommend three key actions: 1) fix the SCRUM roles portrayal; 2) add explanations to SCRUM definitions (roles, artifacts, meetings): why do they exist and what are the best practices; 3) add explanations to score calculations – what must the player achieve to improve the score?

4.2 The second evaluation

The evaluation of LEAP games was done in three sections. First group was master students of educational technology curriculum and there were two groups of first year bachelor students of informatics.

We used an online survey to answer these open questions:

- *Do you think that LEAP games will improve learning? How?*
- *What makes these games innovative?*
- *Rate the design and playability of the game*
- *Suggest, how we could improve these games.*

The survey can be found here: https://drive.google.com/open?id=1PM-LK1nbh54X-7Penpt6QHHl6ZzvofbUJTpEFpqOOp0

The first round of evaluation of LEAP games was conducted at 15.04 with 20 students of Educational Technology master programme in Tallinn University. These students have experience in developing and evaluating learning scenarios and they also are experts in facilitating learning in different educational settings.

The LEAP games were installed to the computer class and the students were provided with a short overview of LEAP project.

The students individually tested out LEAP 5S games, the game was also projected at the big screen to discuss some issues.

After testing each student was provided with LEAP evaluation survey, the students had 15 min to fill in the survey based on their formative testing experiences.

The second round took place 18th of April with the first group of informatics students and the second group was on 19th of April. The group size altogether is 69 but some of them were absent on these days. We had the evaluation aligned with the topic of the course “Software development” as they were discussing different methodology of development processes beforehand. The students heard a small introduction about the LEAP project and received instructions how to evaluate the game and how to write the feedback. The students played the games for 1,5 hours and some of them worked in pairs, so we have 45 different filled in feedback forms.

The feedback was mainly positive. They said that these games teach you how to think ahead, systematize actions, makes you think, the SCRUM basics were clearly presented, 5S also trains your memory, it also teaches you ICT skills. Studying in virtual reality makes it appealing and innovative, you can also learn other languages and terms, it enhances problem solving skills and resource planning. Some of the feedback was also critical: it is not intuitive what one has to do, it needs a learning situation to be more effective, it was too difficult, too boring to sort things in a virtual world, they get boring quickly.

The comments from the experimenter were mainly about the translation of the terms from English to Estonian.

5. Evaluation Activities In Spain

The evaluation at Uvigo was conducted with students on the Projects Lab subject. One of the main issues involved in this subject is team work performed by students and the development of an engineering project of product. In this context, the application of Lean and Agile methodologies seems very appropriate in order to support team communication, coordination and management as well as the different stages involved in the development of new innovative products towards the provision of value to final users.

To perform the validation of the LEAP project in the context of this subject we proceed as follows. First, Lean and Agile methodologies were introduced to the students and they were proposed as the reference methodologies to carry out their assigned projects. Next, students worked on their projects and experience these methodologies. Then, when the students finished their projects, we celebrated some sessions with voluntary students to test and assess the LEAP games. The subject involved 97 students from which 57 agree to participate in the evaluation. This was performed within their usual lab classes. Students were briefly introduced to the project and the games, and them they can play on their own during 2 hours. These evaluations were performed in the period April-May 2018. The software was downloaded and installed on Linux laptops (SCRUM and S5 games).

Students evaluated the games online using the short form https://goo.gl/forms/Ga2mY3ochFv75gHp1. This form in Spanish include the following questions about each game:

- *How the content of the game contributes to improve the comprehension of the concepts?*
- *Does the game improve learning? In which way?*
- *What are the innovative features of the game?*

- *What is your assessment of the user interface and of the game-player interaction? A Likert scale with 5 points was used (Very bad, bad, Average, Good and Very Good)*
- *In which way do you think the game can be improved?*

Next, the results from questionnaires for each one of the games are presented.

5.1 The 5S game

This game was tested by 31 students. 64% tried the pharmacy scenario, while 36% tried the computer desktop.

According to the players, the pharmacy scenario is a bit confusing and not very intuitive at the beginning. It takes some time to understand the game, what is required to do, how to do it, where to click or to know the action of the buttons. Some buttons seem to be hidden, such as the language or help options. Despite this, the students think the content of the game is good. They can see that in a real situation where everything is a disaster, the application of the 5S actions facilitates the performance of the work. Particularly, as the different actions are introduced step by step, this helps to understand the importance of the organization.

The computer desktop scenarios is preferred by the students, perhaps because it is more familiar for them. According to their answers, it is easier to understand, because they can see how the documents change directly and they can understand clearly the purpose of the game.

Students consider that the game improves learning (82%) because playing is a good learning method. This supports them to understand main concepts and to see from a practical point of view what the advantages of the 5S methodology are.

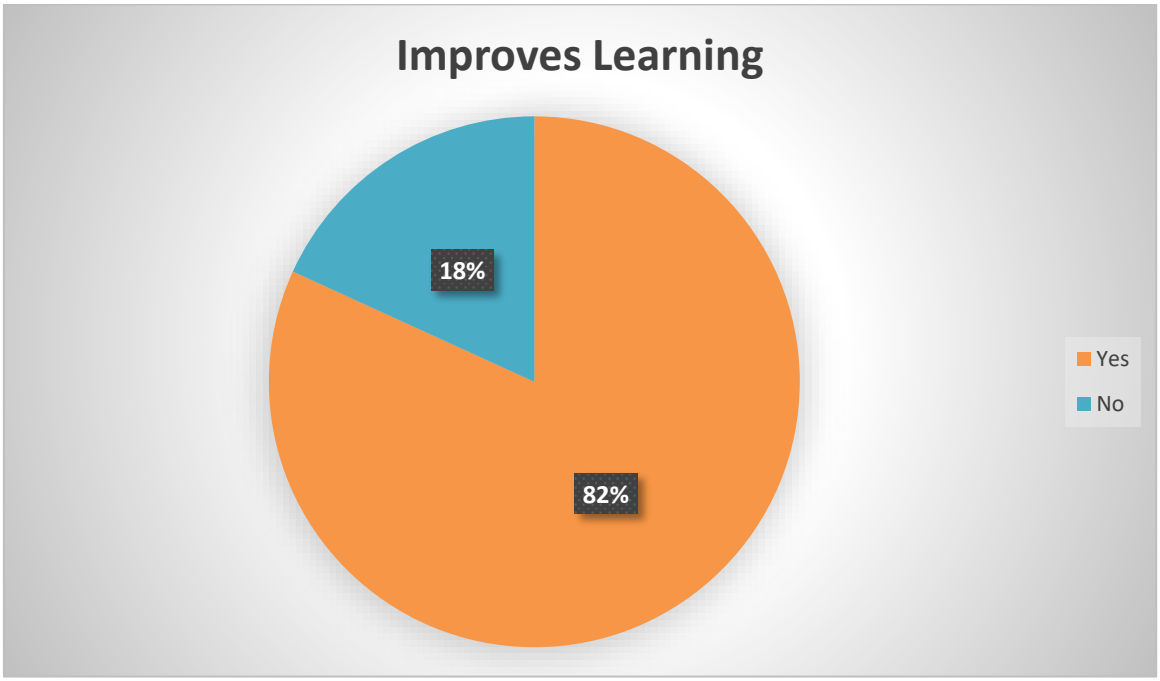

Figure 11. Answers to the question about if the 5S game improves learning

According to the students, the innovative features of the game are mainly the way in which the concepts are introduced. They appreciate the chance to see the methodology applied in an untidy computer desktop and this gave them some ideas about how they could improve their own desktops and working areas. In addition, they noticed that the amount of effort demanded by the first levels was a handicap, and this make students to reflect about how what they can do in their daily life and projects to be more productive.

Another innovative feature is the opportunity of learning by playing. Just the availability of a game is considered as a positive tool.

The representation of real scenarios and situations is also considered as a valuable feature. This enable them to see clearly the effects of a bad organisation and management in the performance.

Next diagrams, Figure 12 and Figure 13, show the answers to the question about the user interface and the game-player interaction. As it can be observed, the answers show that the results are on an average value. In the

case of the Pharmacy scenario the user interface is assessed with an average value, but the interaction of the user with the game received a worse result: 71% consider that is bad and 14% very bad. Nevertheless, in the case of the Computer Desktop scenario the results change positively, 50% consider that the user interface is good and also 50% indicate that the interaction of the user with the game is also good. It was clear that the Pharmacy game involved much more complexity and this confused some of the players and created difficulties to play properly.

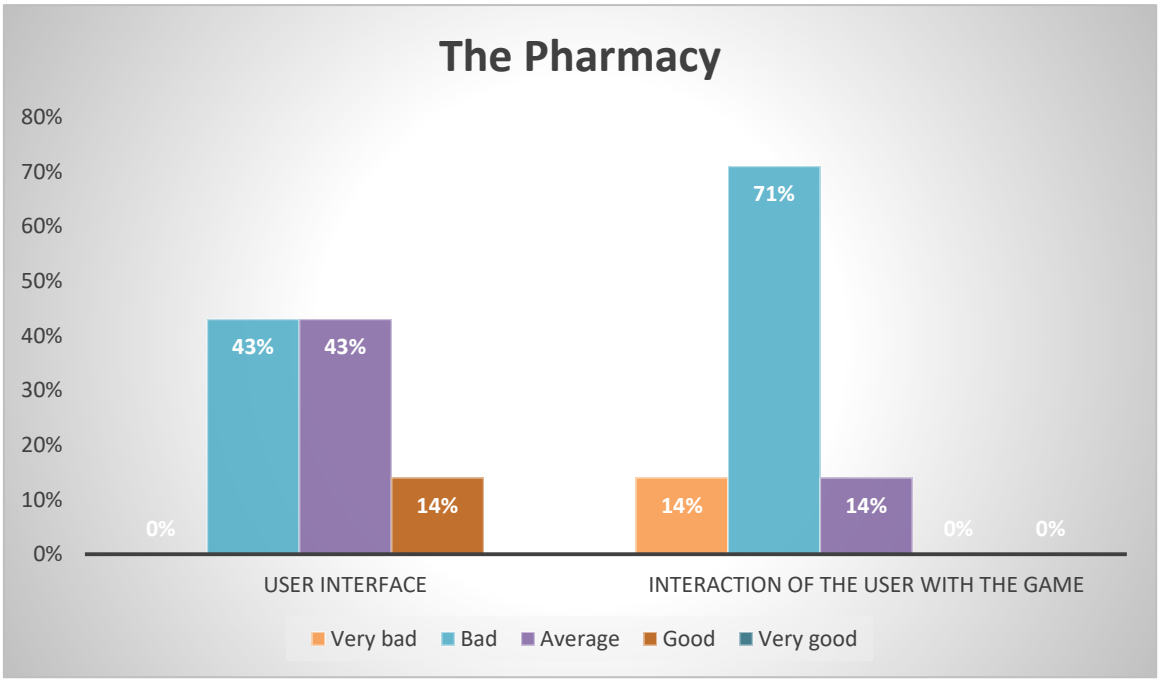

Figure 12. Answers to the questions about the user interface and game-player interaction of the 5S Pharmacy scenario

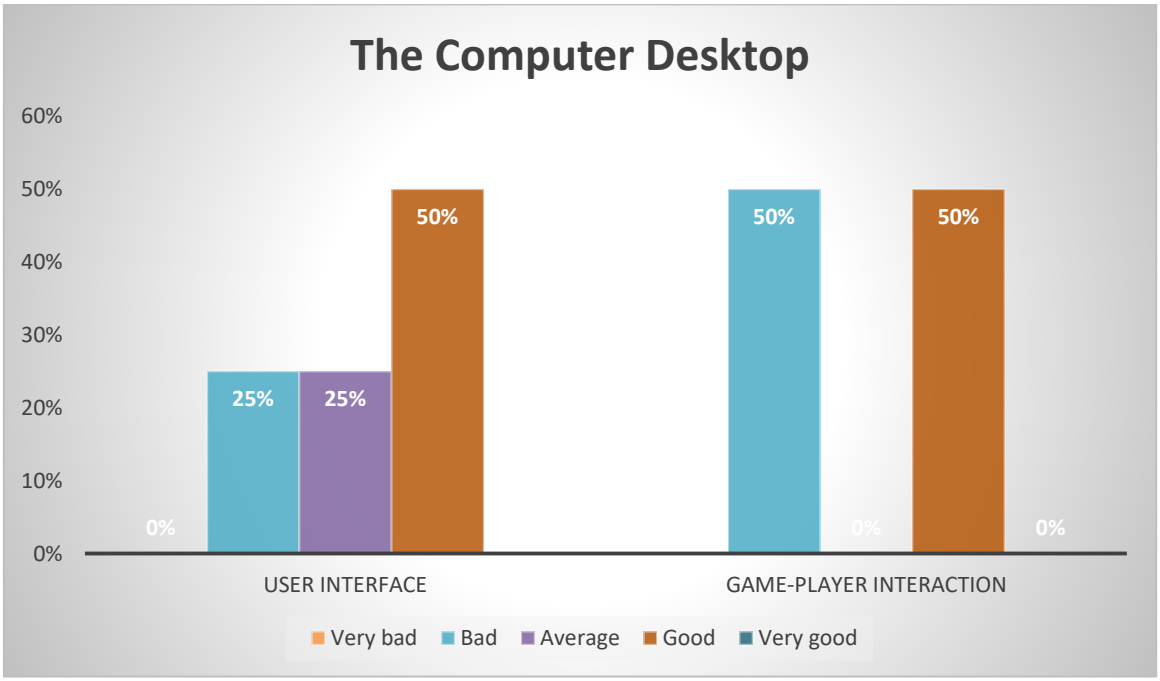

Figure 13. Answers to the questions about the user interface and game-player interaction of the 5S Computer Desktop scenario

According to the students, some improvements can be performed in the two games:

- In general, student demand more clarity in the instructions. A brief introduction explaining the purpose of the game and showing how to proceed attending to the customers is required. In addition, there are many areas where they require more clear info. For example, when the game indicates that some pills are in the first shelf but it is not indicated in which one. They also demand some text labels in the buttons, not just images, in order to know what they are intended to do. Similarly, they think that an explanation when each one of the 5S is applied would be useful to know what is happening. Another related issue: to know the medicines that you are carrying on. This creates some confusion, because the player has to remember all the medicines taken. Students also complain about the speed of the game and they demand the option to change it during the game development, not just at the beginning. Some students demand the use

of labels in addition to the colour codes. They said just the colour codes are not intuitive enough, because it takes a lot of effort to understand what they mean.

- Related to the computer desktop game some students demand a clear explanation about the purpose of the game and what the player is intended to do. Also, about how the player can interact with the game and what can do. Similar to the previous case, some students also require some explanation about what each of the 5S mean and the effect produced after their application. Furthermore, some students also demand more clear indications about the file to send, specifying name, type and mode of delivery mode.

5.2 The SCRUM game

This game was tested by 57 students. 77% tried the urban engineering scenario, while 23% tried the agricultural engineering one. Related to the role chosen by the player to play: Product Owner 46%, SCRUM Master 35% and Team Member 19%.

Almost all the students agree that the game is very well developed, with all the instructions and steps clearly explained. They highlight that it is very interesting the chance to play the game in accordance to the different roles and also to be able to reproduce the whole process.

Several students indicated that the game takes you on charge and requires to make decisions. This makes the game very useful to learn how to develop a project, supporting students to learn about sprints, task assignment, manage time, take into account task priority, etc. The game is seen as a simple and funny way to know and learn the SCRUM methodology: “when you act as ‘SCRUM Master’ you are the person in charge of the strategy definition and the main responsibility remains on you, while if you are a team member you can participate making decisions and doing work”.

For the students, the game offers a good demonstration of the SCRUM process and it supports students to learn the vocabulary and the actions that can be performed by the different roles. They have to think about the tasks, to decide what are the more important ones, to sort tasks according to the priority, to perform an effort estimation, and more. Students also find interesting the recognition of different skills and features in the members of the team and that they can have different performance. This seems as a real example. They find valuable the feedback provided during the development of the game.

For some students the concepts of the way are rather well developed, nevertheless they miss some information to focus the attention more in the game and not in the methodology. Maybe these students have a very good understanding of the methodology and they would like to be involved more deeply in the game.

As it can be seen in Figure 14 almost all the students consider that this games improves learning (95%). The game provides a practical and clear view of the theory presented in lectures. It offers a demonstration of the concepts and it makes clear and intuitive the need and rationale of the SCRUM methodology. The game seems as a practical case that is a very good complement to the theoretical introduction of the methodology.

Students find very useful the opportunity to see the methodology in a more visual way and with some gamification. This is seen as an opportunity to practice and to reinforce the concepts: strategies, on-demand changes, team organization, task assignment, etc. They saw how the decisions taken had effects and in this way, get a better understanding of the process.

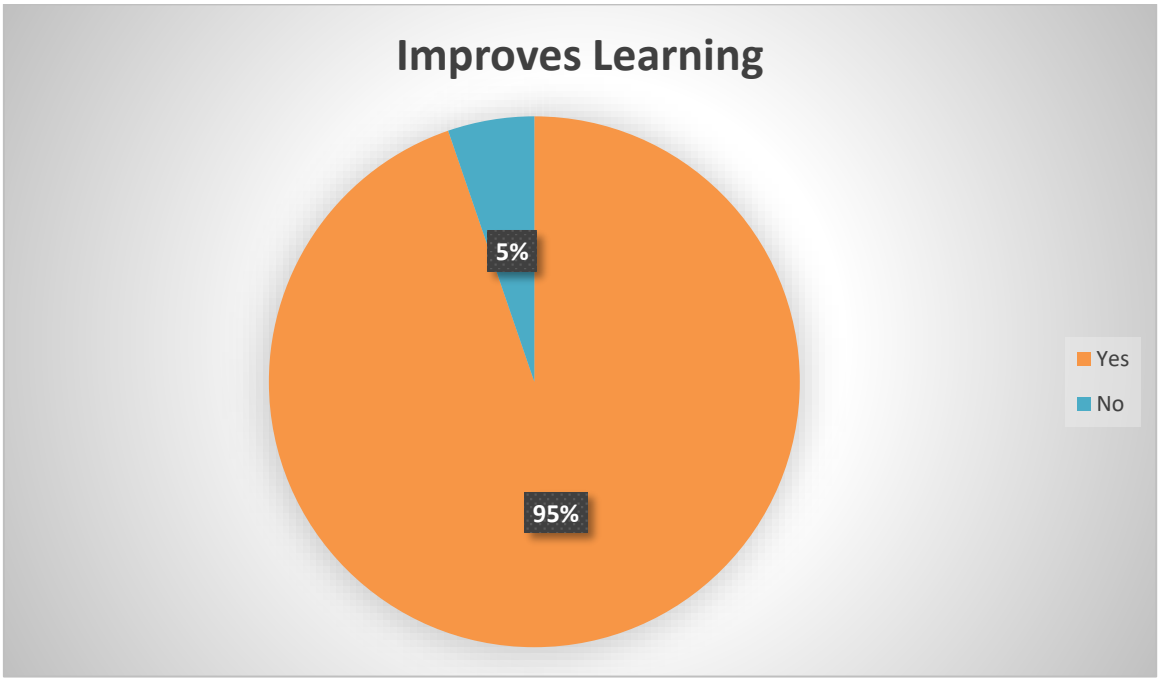

Figure 14. Answers to the question about if the SCRUM game improves learning

Students recognize several innovative features in the game: the interaction with the customer, the selection of priorities, the way in which tasks are performed, the simple management, etc. Students highlight the chance to see the project development in practice, considering the real situation and taking decisions, with freedom to manage the process and the need to change the strategy on demand because some changes are required.

Other students consider that the main innovative features of the game can be found in its simplicity. It doesn't demand a solid previous knowledge to begin to play. You can begin directly and learn from the game without any problem. You don't have the feeling of doing something that is demanding in effort. In addition, the possible of viewing the project from different points of view is also very positive. The "Product Owner" role is seen as very useful, specifically.

Some students also indicate that the learning of these concepts related to Project management is innovative by itself. Educational games is very common in small kids' education, but they can also be an interesting and very useful tool for adult learners.

Figure 15 and Figure 16 show the results to the questions about user interface and the interaction between the player and the game. In both cases the results are very positive. Related to the user interface 65% of the students think it is good and very good. In the case of the game-player interaction the percentage is even larger, 67%. Obviously there is some place for improvement, because 4% consider that the user interface is bad and 12% that the game-player interaction is bad. Nevertheless, the students have shown their satisfaction with these features.

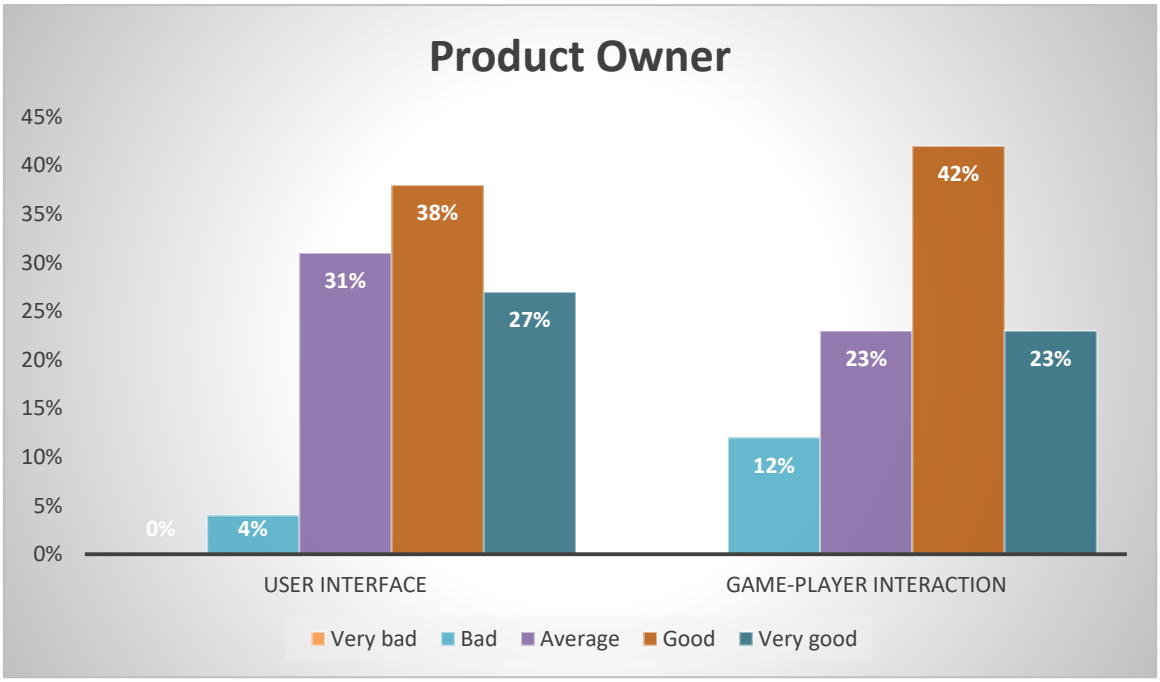

Figure 15. Answers to the questions about the user interface and game-player interaction of the SCRUM game with the Product Owner role

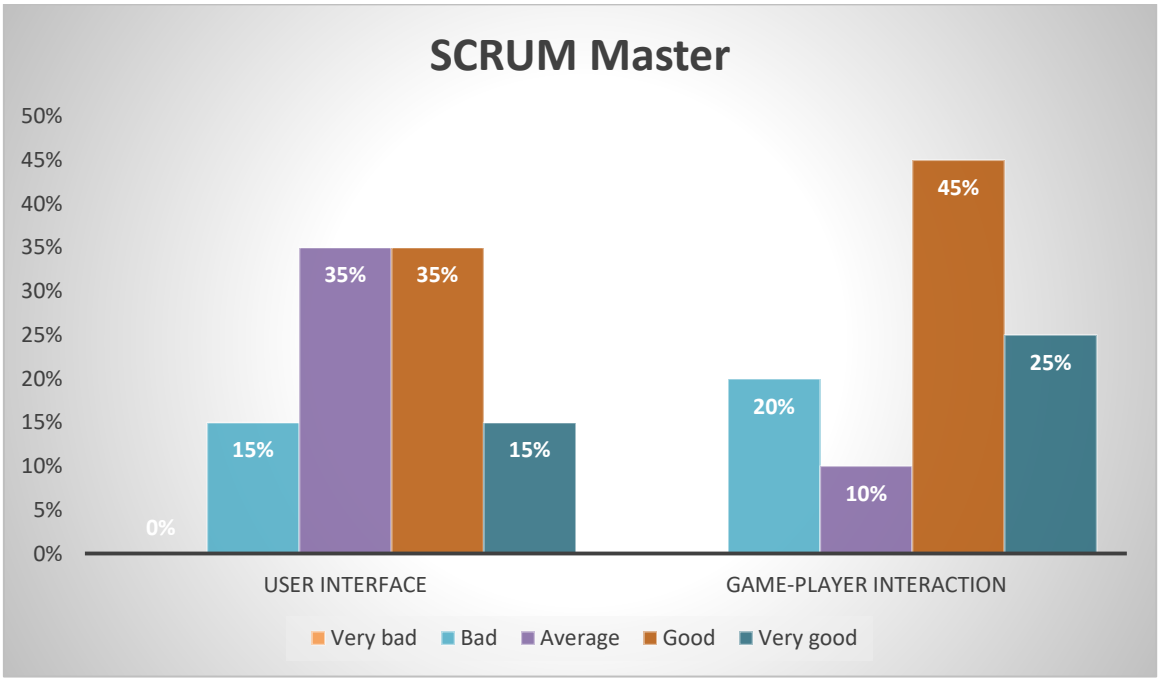

Figure 16. Answers to the questions about the user interface and game-player interaction of the SCRUM game with the SCRUM Master role

The students consider some improvements in the user interface. Some of them think it is very basic and it looks like a bit old fashioned, something that could be improved with more modern asset packs and 3D elements. Someone also requested for a return button. Other student requested some brief description about the game the first time you play providing more explanations about the purpose of the game and the task to be developed by the player, particularly related to the effort and sprints.

Other students demand more options to act on the game, more scenarios, the chance to play with other players in a multiplayer game. This can be seen as a positive feedback, because it seems students liked the game and they are aging to continue playing at an upper level.

6. EVALUATION ACTIVITIES IN PORTUGAL

6.1 Evaluation Context

In Portugal, the LEAP project was used and tested by a set of students from the Engineering College of the Porto Polytechnic, at the MSc level, in a total of 60 students, 42 from the MSc in Computer Engineering (2 groups) and 18 from the MSc in Electrical Engineering (1 group). Students had between 23 and 30 years-old with a majority of men (48).

All the students were familiar with agile development methodologies and Lean but in different scales. Computer Eng. students were quite familiar with Agile software development but had just some ideas about Lean. For the Electrical Eng. students, the situation was exactly the opposite.

For each group, in a first moment, students were shown the games in a classroom and were able to freely play with them for about one and half hour. A short (half an hour) debriefing session followed. Students were then playing the games on their own for the following week. A second debriefing session was then setup to get final feedback from them. The testing period lasted from March to April of 2018 (groups tested the games in different moments).

The two debriefing sessions for each group were setup as collective focus group sessions. The idea was to allow students to express their feelings about the game in the most open form, but, to stir the discussion, the following questions were on the table (following the project's evaluation strategy):

- *Please evaluate the content of the games and how they contributes to understanding (a) the concept of agile development and lean and, more specifically, the concepts of technical debt, 5S and SCRUM.*
- *Do you think the games contribute to improving the learning process and how? Which do you think are the innovative features of each game?*
- *Please evaluate the user interaction with the games.*

- *Suggest ways in which the games could be further improved.*

6.2 Student's Feedback

Students expressed their ideas about LEAP in an open form following the agreed structure of questions:

Please evaluate the content of the games and how they contribute to understanding (a) the concept of agile development and lean and, more specifically, the concepts of technical debt, 5S and SCRUM.

Students agreed that the game really introduces all the mentioned concepts. Based on the games, participants made a clear description of Technical debt, 5S, SCRUM, Agile and Lean. They also agreed that the LEAP games really helped them in understanding those concepts especially for those that weren't familiar with them. The LEAP game was considered to be important by requesting the player to think about which is the best way to get the best results in the longer term.

Concerning the Technical Debt game, students thought that it was too close to Software Development and it was not easy to assess its advantages on other scenarios. For the Computer Eng. students that was ok but the Electrical Eng. students asked for other potential scenarios that could better show how to apply the methodology in other industrial contexts. In any case, all the students considered that the game allowed them to experiment with different strategies and assess the best option.

Regarding the 5S LEAP game, most of the students acknowledged the advantages it offers in terms of understanding the methodology, organizing an environment, be it industrial, business or personal, and improving the working conditions.

Concerning the SCRUM game, Computer Eng. students mentioned that they were surprised to understand that the methodology could effectively be

applied outside of Software Development processes. Electrical Eng. students were only mildly familiar with the process so they considered that the game was a very interesting way to start applying the methodology. They could easily see how they could use it in their own context, be it for industrial or other purposes.

Do you think the games contribute to improving the learning process and how? Which do you think are the innovative features of each game?

Students agreed that using LEAP games (and other games) contribute to their motivation and to be active in the sense that they have to analyse what they are doing and the results they get. That leads to a better and more solid knowledge acquisition. They said that LEAP games could be used in different contexts, not only in Higher Education. For instance, they mentioned that it could be used for vocational training for people already employed.
They considered that this way of learning was quite innovative as most of them was not familiar with game-based learning or serious games. But the simulation aspects of the games and their close connection to reality were also considered as very innovative. The fact that the SCRUM games allowed to play through different roles was also considered as quite innovative. The relation between the different roles, the communication between them and the relation with the client was much clear this way. They mentioned that they would have wanted to have more disciplines using this type of tools and allowing them to understand what their professional reality would be in the future.

Please evaluate the user interaction with the games.

Students considered that the games were fun to play and easy to understand how to start to use. Nevertheless, because the game actions were very close to the methodologies, learning to play the games was very close

to learning the actual methodologies so there was a close connection between playing and learning. This rendered the games to be very interesting but at the same time quite challenging in their use. In any case the gameplay rhythm was considered as adequate.

Students asked why there were quite different graphical design approached between the games as most of them would have preferred to have a common interface and an identical graphical approach for all the games. This option would have made easier for them to learn how to play the games. The graphical design of some games (namely the pharmacy) was questioned particularly in relation to the characters.

A very positive feature was the immediate feedback provided by the games which allowed, in most cases, to assess if a decision was correct or not.

The instructions and tutorials were considered as sufficient to understand how to play the games on a first moment.

Suggest ways in which the games could be further improved.

The most common suggestion was to include new games addressing other topics and techniques from Agile development and Lean. Another common suggestion was to include different difficulty levels in the games to make them more interesting for repeated use.

Students also suggested to have a common interface and graphical design approach. This was emphasized as one of the more important aspects to improve.

Students mentioned that the games should allow the player to have more options and more freedom of operation and not being so restricted in terms of actions.

Students also mentioned that the LEAP games should continue to be free as that was a very important aspect for students.

7. EVALUATION ACTIVITIES IN U.K.

7.1 LEAP evaluation 1

The first evaluation was conducted with students on first year Interactive Applications module (delivered to Computing, Forensic Computing and Networking courses). Students had covered some aspects of agile techniques in their course. 10% of the students agreed to participate in the study (signed consent was obtained after reading an information sheet in line with standard ethical procedures). This was performed within their usual lab classes. The software was downloaded for them and installed on Windows laptops (SCRUM and S5 games) and a Google Nexus Android tablet (Technical Debt game). The order that the games was presented was balanced across participants.

Students evaluated the games using the short form of the User Engagement Scale (UES-SF: https://www.sciencedirect.com/science/article/pii/S1071581918300041), presented immediately after playing each game in an electronic format. The UES-SF consists of 12 questions, presented in a random order for each participant and answered through a 5-point rating scale (from ‘strongly disagree’ to ‘strongly agree’). The questions measure 4 dimensions of engagement: aesthetic appeal, focused attention, perceived usability and reward. The questionnaire yields scores for each of these dimensions, and an overall engagement score can be calculated from these. At the end of each questionnaire, participants were asked to give their suggestions on how the game they had just played could be improved, or any other comments. The main points from these comments are listed below.

7.1.1 Results from questionnaires:

Game	Mean score for Focused	Mean score for Perceived	Mean score for Aesthetic	Mean score for	Mean overall

	Attention subscale	Usability subscale	Appeal subscale	Reward subscale	engage-ment score
S5 Lean Processes	2	1.3	2.2	1.7	1.8
SCRUM Agile Pro-cesses	2.5	2.4	2.7	2.8	2.6
Technical Debt	2.3	2.7	2.6	2.6	2.6

Table 1. Results from questionnaires in UK evaluation

Potential order effects were not investigated due to the low number of participants.

The results show low overall scores for all games, but particularly for the S5 game, and in particular the perceived usability.

7.1.2 Comments from participants

S5 Lean Processes	SCRUM Agile Pro-cesses	Technical Debt
It was quite fun having to find the medicines for the orders, but I feel like the customers didn't wait long enough. There were so many boxes and shelves to check and I'd just seen their medicine and then	I just didn't feel that engaged by the game and choosing which parts of the campus to build first, it captured my interest in a limited manner. My role as a university builder was partially satisfying.	I did get into the game and wanted to get a higher score, but, sometimes, I felt like I was just blindly clicking random combinations of high, low, medium and no investment, to see what worked best, without really thinking

they'd gone. Surely if they need their medicine they'll wait for it! But I quite liked the idea of this game.		about the context behind them and what would be the best action in a real business. The game was somewhat addictive, but I feel like I started to get a little bored of it, limiting my desire to would replay.
Multiple times I thought I had soft locked myself (turns out you can click exit game from the top right but I didn't find this out until l after I'd alt + f4 on three occasions) you may want to make this clearer as well as having a basic tutorial on startup so people know what they are doing. I would like to have a clearer view on the purpose of the game. The click able items were not clearly	The lack of instructions complicates the experience; a set of instructions is basically necessary. It's possible to accidentally skip some important screens (when dragging notes into what you want to carry forward to the next SCRUM cycle). I like the addition of the details at the start which you have to repeat as the project lead that is actually quite clever.	I wasn't immediately sure what to do, there was a tutorial and instructions, however the instructions were more or less just explaining the concepts behind the game, which admittedly whilst interesting didn't help me enough to understand (how to play) the game. The tutorial could be improved. I found that the most efficient way to play was just to spam one button and see what the final outcome was, and in fact this method lead to

marked as of such it can be difficult trying to find what to do. In the shop, the animation for looking at the box was too vivid, even though it looked impressive. In the shop it was somehow difficult to find the items and felt tedious. Clicking a taxi ejects you from the game without any warning or confirmation message. The changes in art style that occur could be avoided.	Seems like it could be useful as a sort of training aid for the SCRUM cycle.	me attaining the highest value. Additionally the game was split into 10 rounds, however I only seemed able to pick about 4-5 times, with multiple rounds being completed with the last input that I chose.
Initially I was stuck in a crane that I was unable to control with no option to exit aside from alt+f4. More instructions would be very beneficial.	A few spelling and grammar problems with the game. At one point I encountered a game breaking bug where switching team members around stopped working and one team	

	member's portrait remained on the screen at all times. More explanation of team member characteristics such as 'plant' etc would have been useful. More explanation of what the smiley face and cogs meant.	

Table 2. Comments from the participants of the UK evaluation

7.1.3 Comments from experimenter

Given the feedback from participants, it did not seem worthwhile recruiting more at this stage without altering the tasks given. Participants were very confused. It seemed that the games needed to be presented with more explanation and instruction than was given to these participants. However, several participants suggested they ‘got into’ the games after a while, and/or wanted another go to improve their scores. One other issue identified was that in their current form, the games were not felt to be accessible by students with visual impairments, which creates difficulties when used as learning resources (see Equality Act).

7.2 LEAP evaluation 2

A follow-on evaluation was conducted with students from the MSc Computing, MSc Information Security and MSc Interaction Design groups. Following from the findings with the fist cohort of students and appreciating that to get good scores, or to ensure a good gameplay experience, the students needed to have some instruction, this evaluation took on a different form

from the first evaluation. In this case the students were given a fifteen-minute demonstration of the three games and then were given 45 minutes to play the three games in a lab session. 28 students took part. with the students eventually rating the games for 'playability', 'usability' and 'learnability' In each case they were asked to score from 0 - 4 where 0 was unplayable / unusable /no learning; 1 was just about playable/ just about usable/ minimal learning; 2 was playable/usable/learnt something new; 3 was good game experience/ good usability / good learning experience and 4 was great game play/ highly usable / great learning experience. Students were again asked to furnish comments

7.2.1 Results from survey

Game	Mean score for Playability	Mean score for Usability	Mean score for Learning
S5 Lean Processes	2.9	2.3	2.7
SCRUM Agile Processes	3.3	2.7	3.4
Technical Debt	3.1	3.2	3.1

Table 3. Results from the survey during the UK evaluation

7.2.2 Comments from participants

Comments in this case were on the overall experience of the three games and the learning experience around them. In this case very few meaningful comments were gathered – many simply write 'Good' or 'Fine'. This could have been a result of around 30% of the MSc students being from overseas and being less verbose. It did appear that home (UK) students were both more critical and more constructive. Of the 17 comments that were gathered, the main themes were as gathered here:

Engagement – almost half the comments referred to the games being engaging or being good ways to engage students to an activity in a taught class. Some referred to how agile was typically quite a 'dry' topic and how doing things on the computer made it more interesting – one wrote; 'I think it is good to be able to play a computer game about something when you have been told about it as it helps you keep that idea in mind – hopefully that would also help with remembering what it means – the S5 game seemed to make sense to me in a way that XXX (Removed to protect the teacher) didn't'

Collaboration – an unexpected finding was that 6 of the 17 comments mentioned aspects around collaboration. There was evidence in the session of students talking to one another as they were working through the games – sometimes to ask how to play but at other times asking about the purpose of the game. One wrote 'I got stuck a couple of times and had to ask XXX (removed).' Another wrote 'I wasn't sure what was going on but XXX explained it to me – then I figured it out.'

Difficulty – there were still some criticisms of the games in terms of getting stuck. 5 of the 17 comments mentioned being stuck or being uncertain what to do.

7.1.3 Comments from experimenter

The evaluators were better able to focus on the experiences once they had a starter to the games and this was useful. After the evaluation a conversation about the use of learning materials ensued and all the students thought that would be useful. The students were keen to see game-based activities becoming an embedded part of their learning in other subjects and saw the LEAP products as a good 'use case'.

8. Good Practice Guidelines on Deploying the LEAP Tools Based on Evaluation Experiences and Results

8.1 Summarizing the results of the LEAP evaluation activities

The evaluation results of LEAP games prototypes within real-life educational contexts at the various partnering countries, although varying, are generally positive and justify that these games successively support the aims of the project.

The biggest advantages of the games, according to evaluation feedback are:

- Exposing students to emerging lean and agile learning design processes that are exceedingly popular in industry.
- Helping link higher education curricula and educational content to industry practices.
- Deploying innovative learning methodologies that exploit technology, and specifically serious games, in order to enrich educational experiences for learners.
- Promoting the links between education, innovation, and research by encouraging higher education students to become engage in the design of innovative digital learning tools through their active evaluation in on-going formative evaluation activities that inform implementation.
- Introducing scenarios that demonstrate how emerging lean and agile design can be deployed widely in engineering principles contributing to process improvements. In other words, the games demonstrate how agile design can be deployed beyond the software engineering sector in which it was conceived to sectors such as agricultural and urban planning. They further demonstrate how lean design can be

deployed beyond the automotive sector in which it was first introduced to sectors such as inventory management, manufacturing, office automation, and more.

- Deploying vivid graphics, stories, and gamification features for encouraging student motivation with learning processes.
- Promoting the development of digital content for educational purposes, as all applications developed through LEAP are openly available. Notably, the source code is openly available as well in order to encourage further digital tool development by other teams that can benefit from the LEAP work by adapting it to cover additional educational needs in broad sectors.
- Promoting the modernization of higher education by introducing emerging Problem Based Learning design supported by innovative digital technologies such as serious games towards better meeting the expectations of 21st century digital natives.

Processing of the feedback and suggestions of teachers, students and expert allows the identification of possible future directions in the further development of the games. These include:

- Enrichment of the games by additional features, like proposals and suggestions to the user.
- Improvement of conceptual issues as identified by the external expert.
- Extending and improving clarity of instructions given to the user.
- Extending and improving explanations of game purpose, scenarios and plots, the game situation reached by a user, or the errors a user performed.
- Enriching the variety of user options and the difficulty levels of the games.
- Adding evaluation of user performance.

- Introduce gamification and the concept of competition in the game plot and scenarios.
- Improving game speed and performance.
- Enhancement of graphics, user interface and interaction.
- Broadening of topics and scenarios and development of extra games.
- Develop on-line game versions.
- Homogenization of the interface of the different games.

8.2 The LEAP Problem-based Learning Paradigm within Well Accepted Constructivist Learning Design

The LEAP games implement the Problem-Based Learning (PBL) paradigm, where the user (student) learns through the experience of working on an open problem. The user, through trial-error and investigation processes supported by group communication and collaboration, acquires experience and knowledge. This paradigm is based on the constructivist approach for acquisition of knowledge though collaboration and hands-on experience, where the instructor takes the role of guide who inspires and challenges the student for the active discovery of knowledge, rather than transfers previously acquired knowledge to a passive receiver.

Early applications of the constructivist approach were in children's education. Although there are differences between children and adults in their understanding abilities, their willingness for collaboration with peers, the beliefs they have developed and the experiences they possess, their ability for abstract thinking, their learning motives, and more, the processes by which learning is achieved is believed to be continuous or remain the same throughout a person's life. Therefore, constructivism has been utilized as a paradigm for the education of adults (like the young adults on which LEAP focuses), too (Groves, 2008).

However, the constructivist approach, although widely used and accepted, has also attracted criticism. This includes the view that opinions and conclusions of more active students dominate the group's conclusions and that constructivism forces students to "reinvent the wheel". Mayer (2004) in his 50-year literature review concluded that "The research in this brief review shows that the formula constructivism = hands-on activity is a formula for educational disaster." He argues that, although learners may be engaged in activities following the constructivist approach, they may not be learning. Mayer (2004) suggests the use of guided discovery, a mixture of direct instruction / knowledge transfer and hands-on activity, rather than pure knowledge discovery through hands-on experience: "In many ways, guided discovery appears to offer the best method for promoting constructivist learning." Kirchner et al. (2006) note that "the instructional consequences suggested by constructivists do not necessarily follow" and that the constructivist approach often relies on the learner to "discover or construct essential information for themselves". In essence, they agree with Mayer (2004) on the value of guided discovery.

Considering the wide acceptance of constructivism, the advanced cognitive abilities of adults who can, in an equally effective manner, discover knowledge through hands-on experience, as well as, comprehend previously acquired knowledge that is presented to them, the criticism that constructivism has attracted and the reactions and attitudes of students during the evaluation of the LEAP games, we conclude that an approach which we term as Semi-constructivism is promising. This approach builds on guided discovery (Mayer, 2004). It uses PBL where the following elements are combined: a) the discovery of knowledge through experiential learning and hands-on real-life problems experience, and b) comprehension of previously acquired knowledge which is presented to the student through b1) the game purpose declaration, game instructions, game scenarios and plots and background knowledge embedded in the game, b2) instructive introduction to the topic and repeated interventions of the teacher throughout the

learning process and b3) explanation and interpretation of the situation reached by a user within the game plot, the errors he/she performed and the evaluation of his/her performance. In the Semi-constructivism approach, playing is intermixed with short sessions of teacher lecturing. Moreover, during playing, the teacher occasionally provides knowledge material that help the student understand game status and/or errors performed and build knowledge on them. Nevertheless, the game itself incorporates previously developed knowledge material (b1) that is provided to the student in comprehensible form.

8.3 The LEAP semi-constructivist learning design

The evaluation process was very valuable for the implementation of the LEAP project. In addition to introducing real-time feedback that informed the design and implementation of the LEAP tools, thus ensuring that they address the needs and desires of students and educators, the evaluation activities generated feedback on how to best deploy the LEAP tools in educational contexts for maximizing learning benefits for students and for contributing to the fulfilment of learning objectives related to linking engineering higher education to industry.

The result of this work is the **LEAP semi-constructivist learning design**. This is an approach in learning introduced by the LEAP consortium that aims at bringing out the best benefits from the deployment of serious games in higher education. Constructivist theories (Papert et al, 1991), as described above, have as their centre core the idea of experimentation. Constructivism advocates that learners learn better by doing, by constructing, and by synthesizing solutions rather than being passive recipients of information. Constructivism advocates that knowledge is not transferred but rather synthesized. It is a learner-centred approach in which the learner leads the learning process while the educator supports it. Constructivism is based on the observation that young children learn by exploring the world around them.

This approach is applicable to adults as well, who can benefit from explorative learning environments that allow them to synthesize solutions to problems.

Constructivism has introduced the concept of “microworlds”. Microworlds are virtual environment that simulate the real world but present information in an abstract manner. They include objects and rules that govern how these objects interact. Well-designed microworlds contain only the very necessary information that a learner needs for synthesizing a solution to a problem while the remove any “noise”, namely information not necessary to the problem’s solution. Through this simplified version of the world that they provide they encourage students to focus on the problem at hand without being distracted by unnecessary content. One of the best known microworlds is the “turtle”, which was designed for introducing students to geometry and which included only a pen object and commands for moving the pen on the canvas, bringing the pen down on the canvas to write, and bringing the pen up to stop writing. This very simple form of a turtle that moved on the canvas was all that was needed for encouraging learners to write programs using the microworlds very simple set of commands for producing geometric shapes.

Serious games are a manifestation of microworlds. They simulate the real world using abstractions and a user interface that often simplifies real world conditions allowing students to focus on solving a specific problem or exercise. This is also what LEAP does. The 3 LEAP applications introduce 6 scenarios inspired by the real world that demonstrate how agile and lean design methods can be applied towards improving business processes in wide engineering principles.

The LEAP tools are versatile and may be deployed in both formal and informal educational settings. Formally, they may be deployed in the classroom

in the context of official courses. Informally, they may be deployed by anyone in their own time for building understanding and experience with lean and agile industrial design.

It is suggested that:

The LEAP tools be deployed in a **semi-constructivist approach** that **combines the free exploration of constructivism with instructor guidance**. The experience that the consortium built through evaluation activities demonstrates that the tools will provide maximum benefits if they are used in a learning context that allows exploration through the tools in order to build an understanding of the lean and agile concepts to be following by instructor led sessions in which the formal theory of lean and agile design are presented while questions are also answered. These steps may be deployed in learning cycles, each leading closer to the fulfilment of educational goals.

Similarly to what is often the case in game-based learning settings, it is suggested that a class discussion follows each learning cycle through which the learners have the opportunity to exchange ideas and findings and the instructor has the opportunity to understand what learners have learnt and what they still need to learn in order to design more effectively the next learning cycle (Garris, 2002).

The LEAP supporting content in the form of learning sheers and reference manuals should be exploited towards the most effective deployment of the tools. The reference manuals provide background information on what features the applications offer to the students and can contribute to the smooth deployment of the tools. The learning sheets provide suggested activities for classroom deployment that an instructor can use as described or can exploit as reference documents through which s/he can develop her/his own activities going beyond the suggestions of the LEAP project. Figure 17 below demonstrates graphically the LEAP semi-structured

Figure 17. The LEAP semi-constructivist learning framework for synthesizing knowledge

CONCLUSIONS

The LEAP games were evaluated on many stages and different contexts. There were a lot of valuators from a vast variety of backgrounds, from students to experts. The feedback from the evaluation events and experts was integrated into the software and support materials.

The games provide a good material for teachers to talk about emerging practices in industry such as agile and lean. The games offer many teaching scenarios such as individual learning when students play the games individually and learn about the different methodology. Flipped classroom where students play the games at home and then in class they discuss what they have learned. Also a scaffolding approach can be taken when the students play the game and the teachers act as a scaffold when the students get stuck. Or even semi-constructivism approach where the students play for a while and then stop and teacher talks what they have learned, they play again and then teacher stops and talks again.

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