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Deploying Serious Games for Management in Higher Education: lessons learned and good practices

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Abstract

Deployment of serious games (SGs) and their insertion in higher education (HE) curricula is still low. The literature lacks papers describing deployment of SGs in HE critically showing educational benefits and providing guidelines and good practices for their use. With the present work, we intend to make a first step in this direction, by reporting our experience in using state of the art managerial SGs in MSc engineering/business courses in four different European universities. In order to describe and analyse the educational characteristics and effectiveness of each game, we propose to use two models that we have straightforwardly extracted from two major pedagogical paradigms: the Bloom's revised cognitive learning goals taxonomy and the Kolb's experiential learning cycle. Based on our experience, we also propose a set of lessons and good practices to incentivize and better support deployment of SGs in HE courses

Keywords: Serious games, deployment in higher education, Bloom's taxonomy, Kolb's learning cycle,

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1. Introduction

In the last decades European economies tend towards being knowledge-driven, and in the globalized world, the success and competitiveness of European companies are ever more bound to their ability to be innovative and competitive. This process leads to the need for changes in educational requirements. In particular, it is necessary to prepare students for work in a dynamic, global and highly competitive environment. Given the clear difficulties in delivering and developing knowledge in normal class room settings [1], other teaching methods and tools are being explored that target more active participation of students [2-3]. Game-based learning (GBL) [4-5] - in particular through Serious Games (SGs), games ad-hoc designed for joining fun and instruction [6-11] – has been established as a significant tool in this regard, in particular for primary and secondary education. Teachers can exploit well designed games to motivate children, contextualize teaching and/or offer opportunities to exercise and verify knowledge and skills. Educational simulations that can be enhanced with gaming features, in particular do enable the learners to cope with real problems and authentic situations that are close to reality [3], [7], [8]

While there is a certain consensus about the educational potential of SGs in higher education (HE), the deployment rate of SG in HE and their proper insertion in meaningful curricula are still quite low. This is generally attributed to an undefined teacher's reluctance towards the use of games. However, there is also a lack of papers in the literature describing deployment of SGs for HE in detail, critically showing their educational benefits and providing guidelines and practices on their use, in comparison with other educational tools/techniques (e.g., [12-13]). With the present information, we intend to make a first step in the direction of better characterization of the effectiveness and the use of SGs in HE, by reporting our experience in using managerial SGs at different European universities, namely: Genoa (Italy), Bremen (Germany), Nottingham (UK) and Open University of the Netherlands.

In particular we describe the deployment of four games, selected because of their quality and ability to cover the course's managerial topics that are being used in MSc courses in different engineering areas (civil, electronic and industrial). In order to describe and analyse the educational characteristics and effectiveness of each game, we propose to use two models that we have straightforwardly extracted from two major pedagogical paradigms (that we briefly describe in the next section): the Bloom's revised cognitive learning goals taxonomy and the Kolb's experiential learning cycle.

2. Background

2.1. Pedagogical models for characterizing learning with SGs

Several pedagogical theories and learning models have been employed to inspire SG design and to assess validity of SGs. Among the knowledge models, we highlight the Nonaka SECI model [14] which is mentioned as a theoretical basis for the use of SG-based workshops, at least in the fields of business, management and manufacturing [15], and Kirkpatrick's "The Four Levels of Learning Evaluation" that is a popular learning impact assessment model, involving the following levels: reaction, learning, behaviour, results [16]. A fifth level of evaluation has been added in new versions of the model by [17], considering also return on investment and impact on clients and society, respectively.

In our work we have focused in particular on describing SGs through two models that we consider complementary, simple and particularly useful to analyse SGs: the Revised Bloom Taxonomy, which is the most popular cognitive approach to SG evaluation [15]; and the Kolb's Experiential Learning model, which systemizes the work rooted on Piaget's cognitive developmental genetic epistemology [18], on Dewey's philosophical pragmatism [19], and on Lewin's social psychology, putting the experience at the centre of the learning process.

Bloom taxonomy

Bloom created a taxonomy for categorizing levels of abstraction that commonly occur in educational settings, so that learning outcomes can be easier compared and assessed [20]. He defined three domains in which educational objectives are divided:

- Cognitive
- Affective and
- Psychomotor

Cognitive learning refers to the intellectual capabilities that are most relevant for educational applications, as well as the affective capabilities that refer to the players' feelings, motivation and behaviour relevant in serious games applications. For each of the above-mentioned domains, the model defines a set of competence categories. Schulman [21] and others have criticized the lack of theoretical foundations. Based on this criticism, Anderson and Krathwhol [22- 23] created a new model by reinterpreting the set of verbs, replacing the nouns related to the learning categories in the cognitive domain with verbs, and by inverting the two highest order levels, Creating and Evaluating, on the assumption that evaluation is less challenging than Synthesis / Creating, thus reflecting the process of solving problems better" [15, p.19]. In our work we use this revised version, which is shown in Table 1.

.**Table 1:** Original and revised Bloom taxonomies

Cognitive competences in the Bloom taxonomy ([24])	Learning goals in the Revised Bloom taxonomy ([27])
Knowledge	Remembering
Comprehension	Understanding
Application	Applying
Analysis	Analysing
Synthesis	Evaluating
Evaluation	Creating

Kolb experiential learning circle

SG foundations typically rely on an experiential learning model, in which active experience (action) plays a key role. This is in the tradition of Kolb [24] and Revans [25]. By thinking and reflecting on his experience and by relating it to former experiences, the learner makes generalizations and fits the results into his personal view of reality. Based on this, he is then able to modify his approach for future experiences. This approach is often associated with constructivist approaches that mostly consider learning as a construction of knowledge [24]. Even when the learning task is simple, constructive processes operate, so that mental structures are formed, elaborated on, and tested, until a satisfactory structure emerges [26]. This learning process requires the building up of conceptual structures through reflection and abstraction, which is reflected within Kolb's learning cycle.

Kolb's [24] four-stage learning cycle suggests how experience is translated through reflection into concepts, which in turn are used as guides for active experimentation and the choosing of new experiences (Figure 1). Within the first stage, concrete experience, the learner actively experiences an activity. In the second stage, reflective observation, the learner consciously reflects back on that experience. In the third stage, abstract conceptualization, the learner attempts to conceptualize a theory or model of what was observed. In the fourth stage, active experimentation, the learner attempts to create a plan on how to test a model or theory or plan for a forthcoming experience.

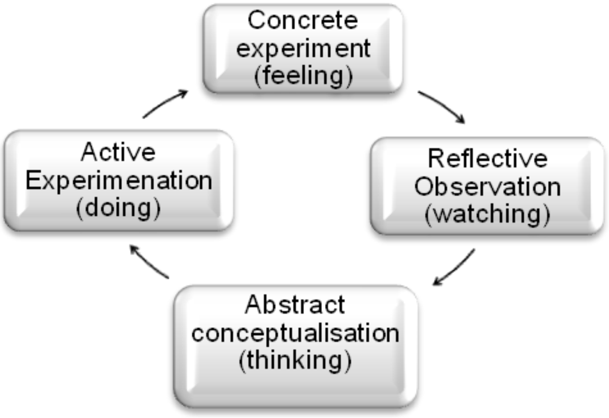

Figure 1: Kolb's learning cycle

2.2. Managerial Serious Games

SGs and simulations have been used in the business and management area for a long time [15]. The first simulations were based on papers and pencil, spreadsheets were then used to automate and standardize the process, which finally evolved into complex, digital business simulations, some of which feature appealing game mechanics and smoother aesthetics. Faria et al. [27] show the progressive adoption of cutting edge technologies (e.g. virtual reality, artificial intelligence) and an increasing use of such tools within US Universities. The European situation, however, is less investigated and appears more fragmented, although interesting business school initiatives should be considered. Examples include [3, 15].

The effectiveness of the used games must be considered within the literature reports on effectiveness of using games. Blunt [28] reports his experience at the US Department of Defense, where three different, Commercial-Off-The-Shelf (COTS), management simulation videogames were added to three courses. The study states that "students in classes using the game scored significantly higher means than classes that did not". Gamlath [29] reports that user performance in simulations is largely the result of the players' skills rather than luck, that that learning through "trial-and-error" led to better simulation performance, and that skills employed in the simulation are not the same as those being assessed in conventional academic evaluation. King and Newman [30] report of a project that evaluates the business simulation software for mechanical engineering students through analyzing various open source and COTS tools. When speaking of requirements for potential classroom games, Bellotti et al. [31] discuss the requirements for SG applications on getting students from technology-oriented subjects familiar with concepts of entrepreneurship and company management. Concerning deployment, [3] report their working experience on how games can be used for teaching concepts and practices related to the field of logistics.

For increasing deployment, the effectiveness of business games is highly relevant. This is often questioned and Stainton et al [32] stress the current unavailability of specific evaluation tools and methods, due to the high variability (dimension, content, structure…) of the educational actions. The lack of a common framework for describing/classifying the educational interventions in a SG is a limitation that is being addressed.

3. Case studies

This section describes three case studies of serious games that the authors deployed in higher education contexts in four countries, namely The Netherlands, Italy, UK and Germany.

3.1 Estuarine systems: the *Scheldt*

The Scheldt is a web-based, role-playing, single-user game developed via the *EMERGO* methodology and toolkit [33]. The user-interface is consistent with other *EMERGO*-games and is continuously improved. *EMERGO*-games are developed in such a way that the user-interface, created as a separate skin, can be easily replaced without changing game-structure or game-content. Content resources are also separated from the game-structure. This enables easy maintenance and supports sustainability. The learning objective is to analyze, understand and explain the problem of the soil-water systems in the *Scheldt* (see Figure 2). This concerns a natural science approach towards the threats to our society, and complex spatial and temporal interactions between soil and water.

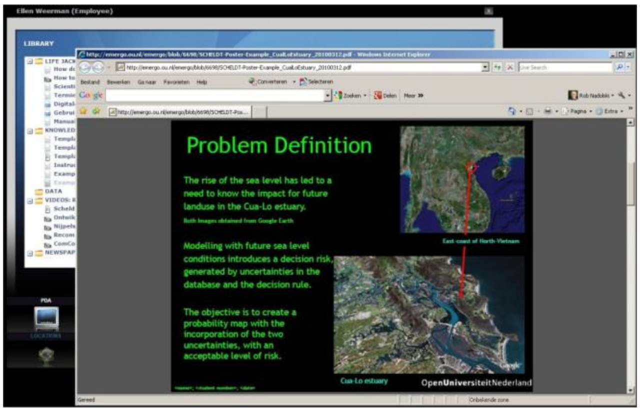

Figure 2: Consulting resources during carrying out a task.

During gameplay, the student takes the role of a junior researcher-trainee at a virtual company. He receives tasks and feedback from a senior researcher (embedded NPC) during the analysis of increasingly more complex problems and must propose/find workable solutions. He may use web-based tools / GIS sites, multi-various data and models to work towards his solution. This occurs by watching the phenomena and visually inspecting the area (e.g., video, satellite images, GIS sites) in order to solve the question on "Why is land reclamation or loss necessary from a scientific point of view?"

Tasks and feedback are given via company-mail, or via video (see Figure 3). Feedback can consist of completed examples and discussion. Students need to compare their own solution to these as such tasks don't have unequivocal solutions. Then, based on examples, a consecutive task will be given. In other tasks, feedback is given in a very natural way (for example, reactions from NPC's when consulted during task execution).

Figure 3. Senior researcher (NPC) at the virtual company while giving feedback to a task. The feedback is given in video.

The Scheldt (0,7 ECTS) has been embedded in an online distance learning course on soil and water (4.3 ECTS) since 2010 at the Open University Netherlands (OUNL).

Up to this point, (end 2012), there has been no needed revision of the game. *The Scheldt* is meant for independent self-study, so there are hardly any restrictions concerning the number of enrolled students. However, normally 30-50 students are enrolled every year. The central theme for the game case is "a field study focused on research and exploration of the *Scheldt* estuary towards relevance for naturalness, accessibility and security." This case concerns a step-wise approach towards the solution of the question "Why is land reclamation or loss necessary from a scientific point of view?" The case is highly realistic and centres on authentic tasks.

Support for Bloom's cognitive learning goals

Analyzing *the Scheldt* game, we can see that it supports several learning goals, as reported in Table 2.

Table 2: Bloom's cognitive learning goals covered by the *Scheldt*

Learning goal	Modality/mechanics
Remembering	Not explicitly addressed, but is expected during mastery of higher level learning goals.
Understanding	Understanding of the processes associated with the interaction between groundwater and surface water and between soil and water
Applying	To intervene and to propose appropriate measures for the *Scheldt* estuary towards relevance for naturalness, accessibility and security.
Analysing	The main goal of the game is that students learn to analyze, understand and explain the problem of the soil-water systems in the *Scheldt*. Analysis subsumes all underlying levels (i.e., remember, understand, apply)
Evaluating	Students need to evaluate and contrast their own solutions with completed examples, need to evaluate their approach towards solving problems, and need to evaluate their learning (i.e., learning to learn).
Creating	Although the problem space is set by the game there is ample room for students to propose alternative solutions considering new, creative points of view.

Support for Kolb's learning stages

Although Kolb was not explicitly used in the design phase of the game, the Scheldt targets thinking and doing (e.g., reading literature resources, conducting expert interviews, using models), which leads to concrete outcomes (e.g., reports, written presentations) and as such conforms to the Kolb cycle (see Table 3).

Table 3: Kolb's learning cycle the *Scheldt*

Learning stage	Modality/mechanics
Concrete experience (feeling)	The student systematically analyzes concrete problems using different tools. The student has the role of a junior researcher-trainee at a virtual company and receives tasks and feedback from a senior researcher (embedded NPC) during the analysis of increasingly more complex problems and proposing/finding workable solutions.
Reflective observation (watching)	As the game play succeeds, the students can observe how their own processes evolve. Based upon this information as well as the indicators delivered by the game, they can observe how they are getting along meeting the overall target of the collaboration as well as that of their own strategy
Abstract conceptualization (thinking)	An NPC provides feedback either via email or videos, and thereby supports conceptualization of new knowledge. Feedback is given via company-mail, or via video, and may consist of worked out examples as well.
Active experimentation (doing)	Based upon the outcome of the previous phase, the player may change the scenario according to the analysis and observation carried out so far.

Support for soft skills

As anticipated, the game supports several soft-skills aspects such as problem solving, strategic thinking, meta-learning.

3.2. *Any Business*: a highly configurable online multiplayer business simulation

GoVenture *Any Business* (http://goventureany business.com), developed by GoVenture educational games and simulations, is an instructor-customizable business simulation platform that can be used to simulate virtually any type of business, within any industry and any market. It is playable both individually and in teams. The game objective is to successfully manage a business while competing with other companies, managed by other players or by the computer. The Simulation Manager (usually an instructor) has a lot of freedom to configure the simulation, creating scenarios that can range from very simple to very complex/difficult; The Simulation Manager is also able to model specific events or situations to target specific learning goals

Figure 4: The *Any Business*' main control panel

The gameplay consists of making business decisions, which in practical terms translates to using the interface to set several parameters – price, product features, marketing, human resources, and business' ethics, among others –before the deadline of each period of the simulation. After the deadline, the simulation advances to the next period and the game presents the results of the previous decisions in terms of sales and profits. A performance score is provided as a weighted sum of different dimensions, and the instructor receives a detailed report with all the activities performed by the students. Every simulation is different (e.g., economic and market conditions), which makes performance not perfectly comparable, but allows for more engaging challenges. Teams compete against each other in the same settings, as in a strategy game, and computer-driven competitors are also generated, creating a good model of the market.

GoVenture Any Business is one of the serious games being used in the second edition of the course on "Entrepreneurship through Serious Games" (eSG) at the University of Genoa, Italy, for the Electronic Engineering M.Sc. degree. The course - which is presently in progress - aims to stimulate entrepreneurship in university students, especially future information technology engineers with little previous academic instruction in economics.

The 3 ECTS course includes a series of lectures/workshops that introduce the theoretical foundations of entrepreneurship, discuss case studies and present the main features of the serious games that are used in the course. The games are played in teams as part of each week assignments, and in addition students are required to fill in questionnaires about the game and the concepts presented in the lectures. By the end of the course, students will have played a total of seven different simulations in *GoVenture Any Business*. The students' actual performance in the games is counted into the final course grade.

Support for Bloom's cognitive learning goals

Any Business shows a good capability for covering all the levels of the Bloom's taxonomy, as described in the following table.

Table 4: Bloom's cognitive learning goals covered by *Any Business*

Learning goal	Modality/mechanics
Remembering	Does not emphasis on remembering, as there is contextual help available, where the player can revise the main concepts whenever needed. However, practice helps remembering.
Understanding	The game requires the player to understand business concepts, which are important when reading the reports available inside the game to make their own successful decisions for the next period.
Applying	Closely related to understanding the business concepts, the player is also required to apply the concepts when making decisions inside the simulation.
Analysing	The concepts of entrepreneurship are used to support the analysis of the results and the data (reports), so that the player is able to make informed decisions in the business, taking into account also the competitors' behavior.
Evaluating	The evaluating learning goal can also be explored by the game, as there is a space for the player to write a decision journal, explaining their business decisions and making also medium-long-term planning.
Creating	The game, if played as intended by the game designers, does not support the creation of new content, as all the decisions must be made within the parameters specified by the simulation manager. It is possible to let the students setting up their own simulations, in which case the learning goal of creating original content could be targeted.

Support for Kolb's learning stages

The authors do not know whether the game was designed on accordance with Kolb's cycle. However, it is quite well supported, as shown in the following table.

Table 5: Kolb's learning cycle *Any Business*

Learning stage	Modality/mechanics
Concrete experience (feeling)	In *Any Business*, the cyclical nature of the game play can be directly mapped to the sequential steps as described by Kolb. Especially in the first period of a simulation, the player needs to set a series of parameters based mostly in his "feeling" of how the decisions will affect the simulation. Even if he does know the business concepts, there is the need to experiment with the many settings in the simulation, which gives a "concrete" experience in the game.
Reflective observation (watching)	As the simulation advances, the player observes the results of the decisions and is able to compare his own performance with the performance of the other companies.
Abstract conceptualization (thinking)	By analysing the several reports provided by the simulation, the player may formulate a mental model of how his decisions affected the results.
Active experimentation (doing)	Finally, using the concepts that were generated by the observation of the results, the player is able to apply the concepts in setting his company's parameters for the next period of the simulation.

Support for soft skills

The game supports mainly strategic thinking and decision making. In cases where the game is played in teams, it also supports interpersonal relations, as the decisions made must first be negotiated among all team members, who may also specialize and consider different aspects of company management (e.g., human resources, finance, etc.).

3.3 *Seconds*: a role playing game to improve decision making skills

The game *Seconds*, developed at the University of Bremen, is used to train students in decision making on supply chains (SC) and in distributed production environment. It is a facilitated multi-player online game. The game creates a safe learning environment in which the students can apply different approaches for improving the flexibility and efficiency of manufacturing and analyse the impact on the SC. The main rule is as follows:

finished goods are not allowed to be produced without collaboration. The game limits the number of parallel running processes (facilitator decides the number). It is configurable, and the level depends on the knowledge level of the player (pre-configured). The goal is adaptable (depending on course setting), but is mostly used to produce a specific product in cooperation with other players in order to meet the customer's demand and deliver the goods in the right quality and quantity punctually and correctly, while, taking all costs and expenditures into account. A simplified accounting system is implemented, i.e. the game delivers several performance indicators that are used for the analysis and calculation. The students receive a role and a starting scenario including necessary business information, so that they are able to develop a strategy for their company and establish new sites.

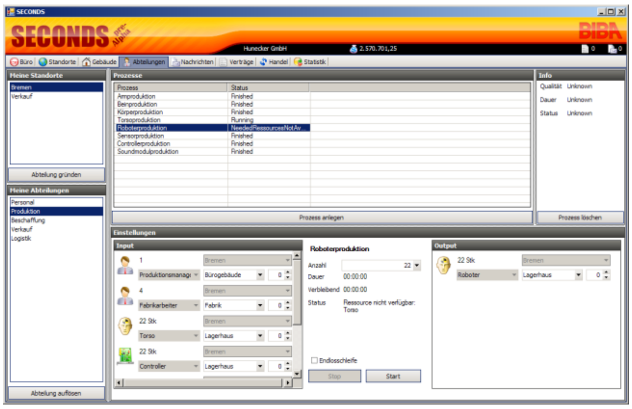

Figure 5: GUI shows the input needed for producing robots

The gaming scenario evolves as the players play the game. They have to establish they processes and make decision (Figure 5). Depending on production volume and time, the player can gain experience and skills needed for producing higher quality.Target users are master students from industrial, production and system engineering and MSc logistics and operational management.

The game is used at the University of Bremen as part of a 3 ECTS lab course on "Decision making in distributed production environment", which uses a blended learning concept. This part is comprised of 6 units- one for introduction to the basics of SCM and a tutorial on the gaming environment and five for playing. Methods for strategic decision making are successively introduced into the course. Each session lasts 5 hours. On average, the play time is 3-3,5 hours for each session and at least 30-45' for debriefing and reflection.

For two years, *Seconds* has also been used at the University of Nottingham. There, it is used as a supplement to a post graduate course on Supply Chain Management. Therefore, there is no introduction to strategic decision making in supply chain or in the basics of SCM, since this is knowledge already known to the students, i.e. the students come solely to play the game. So far, the students had have played twice. The sessions have taken around 2,5 hours with an additional 30 minutes for debriefing. In this case, the students received predefined scenarios with all company processes already implemented; i.e. the degree of freedom for taking decision on production sites etc. was lower than in the German case

Support for Bloom's cognitive learning goals

In the design phase of *Seconds*, Blooms taxonomy was hardly considered. Only the higher levels are supported. This is typical for this type of game; it emphasizes on the two highest levels of evaluating and creating.

Table 6: Bloom's cognitive learning goals covered by *Seconds*

Learning goal	Modality/mechanics
Remembering	The simulation model in *Seconds* hardly supports remembering. The player needs to recall the pre-requisite knowledge without any support from the game, except to some extent information gathering from the game.
Understanding	Understanding is only partially supported. The system delivers the information. It supports the player to understand the decision process and how the supply chain and the production plan work. The debriefing phase is important
Applying	*Seconds* is designed to support the users in applying their strategic SCM and to make their decisions accordingly. The players can apply strategic decision making methods, change the operational processes or modify the scenario
Analysing	With the information delivered by the system the player is able to analyse and compare his results to the played strategy and whether they are compliant to SCM theories and also compare the result with others.
Evaluating	The game delivers enough information to evaluate the learning outcome. This is normally carried out in the de-briefing session and in the analysis carried out by the students after each class.
Creating	The game supports creation of new content, because it helps the player to identify specific structures and pattern. It encourages the players to combine different information and to construct new knowledge based on these experiences. This is possible due to a high degree of freedom in the gaming environment and few boundaries.

Support for Kolb's learning cycle

The use of Seconds uses an extension of Kolb's learning cycle: it uses the BIG (beyond the information given) defined by Perkins [26, p.20] BIG constructivism. Following the BIG approach, a facilitator directly introduces the concepts, provides examples to the students with concrete experience in activities that challenge them to apply, generalise and refine their initial understanding in multiple activities. This approach presents information to the learners but stresses the need to go beyond the information given.

Table 7: Support of Kolb's learning cycle due to the BIG approach

Learning stage	Modality/mechanics
Concrete experience (feeling)	The concept foresees the use of BIG constructivism, i.e. the students receive a starting scenario and a role for which they must choose a strategy to follow throughout the game play. At the beginning, the students do not have enough information to make their decisions based upon what is happening in the game, but rather of what they think may happen. Every time the students change the strategy (normally after the debriefing phase), they will again make their feeling-based decision, but as the game proceeds, these are more and more related to what has happened in the game in the past.
Reflective observation (watching)	As the game play succeed, the student can observe both how their own processes evolves depending on his/her own decisions but also how the decisions affect the collaboration with the other players. Based upon this information as well as the indicators delivered by the game; he can observe how close the overall target of the collaboration is being met, as well as that of his own strategy.
Abstract conceptualization (thinking)	Is supported in two ways- during game play, the student can draw his conclusion based on how his indicators (financial, stock level, use of material, material flow etc.) emerge. This process is supported in the common debriefing session and by the facilitation of the game.
Active experimentation (doing)	Based upon the outcome of the previous phase, the player changes the scenario according to the analysis and observation carried out so far.

4. Lessons learned and good practices

Quantitative results from the deployment of the games are not yet available from each game. However, the experience gained from the field allow us to make some considerations that we believe could be useful for educators in order to better understand the serious game deployment process and for researchers to better identify points where more research should be done, in order to improve the state of the art educational tools and practices.

The different case studies show that there is a **difference between customised games designed for meeting specific "technical skills"** (The *Scheldt* and *Seconds*), and commercial of-the-shelf games mostly designed for more generic use. For the first type, fulfilment of learning objectives of the course is given the highest priority, while the second ones are usually more attractive, as they feature high level graphics and multimedia look. Secondly, the development of first type of games mostly ensures a co-creative development process between teachers, designers and software developers, where as for the latter, the game designer is paying less attention to the learning objective and more to the game-related considerations. Consequently, the latter type of game may attract a broader audience, improving the embedment and deployment in formal HE education. Thirdly, assessing existing games from a curriculum point of view sometimes requires an adjustment of the curriculum towards embedding the game for the purpose of transfer of learning, supplemented with other blended learning possibilities or lead to functional requirements for modding such a game towards evidence-based transfer of learning within the game. If resources and content are separated, the latter change is favourable, since it reduces the cost and time of modding the game. Some new games are appearing on the market, such as GoVenture *Any Business*, is delivered to be easily customised by the teacher.

The experience shows that in both cases, it is important to carefully align gaming goals with course goals and course assessment (i.e. constructive alignment) in order to ensure successful employment.

A fourth main finding is that deploying a new game is a complex and time-consuming activity that requires the development of an ad-hoc deployment plan, specifying goals (educational and in-game) and context of use. Also feedback from the students has to be carefully considered, in order to tune the game in terms of contents, difficulty levels, pace, and in addition, the fine tuning requires long term evaluation and iterative changes.

The quality level of a game match largely depends on the quality of the player/teams that should thus feature similar levels, in order to create compelling situations (where the students are challenged to perform even better) and didactically useful market conditions. For competitive games, the teacher should thus more support the weaker teams, in order to enhance the overall competitiveness, whereas for a collaborative game setting, it is more important that the game environment is able to support different competence levels within the same gaming scenario.

The three case studies presented here shows that in facilitated games, the facilitator's experience and competence is essential..

Game playing is time consuming and the overall educational effectiveness and efficacy - in particular with respect to other educational tools and approaches – has to be better understood and verified through specific experiments, also to precisely devise the actual benefits and shortcomings of the serious games.

The number and duration of the sessions is relevant to the manner of interaction between students, especially regarding collaboration. For example, in the game *Seconds*, it was observed that the students' willingness to make compromises/trade-offs and to make strategic collaborations is higher, on average, in the groups having five sessions than those having two (thus showing a collaboration learning effect). The vast majority also indicated that the gaming experience did help them to recognise their own strengths and weaknesses (e.g. on issues like price bargaining), and that it did help them to enhance their learning on SC cooperation, as they did feel part of a cooperation.

An observed barrier for the use of SG in HE is the lack of documentation. This should be easily accessible online, in particular during the game. For the phases of course design and early deployment, the availability of game developer support is essential.

Our experience with both facilitated and un-facilitated games shows that in addition to using Kolb's experiential learning cycle in a blended learning concept including debriefing sessions, it is important to collect precise feedback from each game session, either through questionnaire or through data collected during game play and discussed in the debriefing. This supports the construction of new knowledge among all participants and leads to a deeper understanding of systems' dynamics. Secondly, also rewarding mechanisms and consideration of the game score as an important element for the overall students' assessment ensures a higher motivation among the players.

While the term SG is appealing, in particular for students, state of the art SGs has generally limited entertainment features, especially if compared with the bestselling videogames. Tools like *AnyBusiness* are frequently referred to as a business simulations, without specific serious games mechanics (i.e., able to join fun and instruction). However, inter-team competition even through the simple mechanics of score and other performance indicators (e.g., cash flow, profit and loss, etc.) are an excellent motivator.

Like *Seconds* some SGs have been used for several years and have undergone an incremental process of changes, directly related to the feedback given by the students as well as on assessment of their learning outcome. Both games are based on simulation of business processes. A main lessons learned in both cases, is that it is very important to not overload the games, making the simulations too precise, thus giving the students too many variable and too high complexity to handle at once. In the case of *Seconds*, which actually replace a far too complex game, prime, we had to design a complete new game, since the simulation behind was too complex.

Moving from theory to practice signifies an important step in one's mind-set, and this was indicated in our results.

Our experience shows that SGs should typically be used in blended learning settings, with briefing and debriefing sessions in order to complement and reflect on the experience, possibly also with questionnaires. Facilitated games like *Seconds* should not be played in single mode or without facilitator, since intra-team relationships are very useful and the overview of an expert is very important both for the contents and for the game procedures themselves.

The duration of the session is critical, as it should not be too short, since the students have more time to observe, reflect and construct before taking actions.

A critical factor concerns the instructions given to the students before and during the game (both concerning the contents and the game itself). It is possible to allow the students to freely manage their roles. However – this is a common rule in education - freedom should be limited for students having less knowledge about the target domain, in order to make the learning process more efficient and to help them overcome hurdles, concerning both the playability and the contents. Moreover, in-game knowledge (typically procedural and intuitive) should be complemented with other type of information, typically verbal and objective.

The facilitator or the teacher should pay attention at the students' learning outcomes after (and possibly also during) the game, in order to detect misconceptions, that are likely to appear, according to our experience, given the students' procedural and empirical approach.

The introduction part has to be carefully adapted to the level of knowledge of the users and decision making management strategies (we use pre-questionnaires for defining the level of the course). A hands-on session before the start of the actual game competition is strongly suggested, as it helps the students to concentrate on the game play, and reduces the stress level.

A crucial step when preparing a course exploiting SGs is the actual choice of the games. The first step involves the collection of requirements related to the course and the curriculum. Addressed items include: target group, credits, learning objectives, which skills and competences should be trained, connection to the overall curriculum, underlying technical infrastructure, course setting, embedding with other learning material, use of blended learning concepts or not, number and length of units, feedback and assessment needs, pre-requisites.

The candidate games' features will need to be analysed in the light of the above mentioned requirements. Typical criteria for selection include various factors, such as: coverage of the needed educational topics; matching between the course's learning objectives and the game's features; costs (both in terms of software and of deployment and of maintenance); usability; quality of user assessment and provision of feedback; game adaptability; knowledge transferability; in house competencies and time availability in case development of a new serious game was considered; degree of freedom for players and teachers; support to collaboration; SG's learning curve, difficulty level and long-term playability; competences and effort needed on the teacher's side; availability of additional educational material related to the game. A main challenge in the selection process is the difficulty in having a critical and complete overview of existing games.

Depending on the weight of each one of the above criteria, existing games can be matched, and a make or buy decision may also be done. In the second case some of the collected requirements may need to be adapted. In the case studies presented in this paper, different needs led to different choices. In the first case (the *Scheldt*), the game had perfectly to comply with distance education and should partly serve as a replacement of fieldwork. Consequently, an ad-hoc development was deemed as necessary. The second case study (*Any Business*), a comparative analysis of several state of the art games was carried out, based on the main criteria of entrepreneurship topic coverage and per-license costs lower than €30. For the third case study (*Seconds*), a review was performed of the few available games on supply chain management and of several simulation environments as well. Since simulations were considered very good for mapping the real world processes, excessively difficult for the students, and the games not complex enough, in-house development was decided, allowing also the implementation of collaborative features, mirroring the work carried out in the production network.

5. Conclusions and Future Work

Observing the three games through the revised Bloom's taxonomy, it is apparent that none of them specifically targets the lowest cognitive levels, but focus more on supporting the cognitive level of analysing, evaluating and creating. Even though all three games support these three levels, they do this in different ways and to different extents. The *Scheldt* emphasises the analysing level, whereas *Any Business* the evaluating level. *Seconds* focuses on supporting students to learn to create new knowledge. These differences substantially reflect the targets of the games and the corresponding courses.

Our observations (though still qualitative) highlight that this has a strong relationship with the role of the teacher/instructor/facilitator. The higher level to be achieved according to Bloom, the more emphasis has to be put on supporting the abstraction process, which typically requires the teacher's intervention. This process is only partly supported in the three games and related documentation, so it is very important that the teacher designs a proper pedagogical plan to make the game experience profitable from a real learning point of view. Also during the lectures, the presence of a teacher is very important, introducing and explaining topics and giving indications and discussing the experience with students. In *Seconds*, furthermore, the gameplay itself is accompanied by a teacher, while *Any Business* has been played at home by the competing teams and feedback has been provided by the teachers during the debriefing discussion. In The *Scheldt*, in-game feedback is provided by an NPC player, which aims at nurturing the thinking process, even if with a lower quality than through a human teacher. However, in *the Scheldt* the NPC-Player can be monitored by a teacher and the teacher can circumvent (as the same NPC-player) without students' knowledge of this circumvention.

For example: a student needs to send a report to the NPC-player (a specific mail-facility is used in the game, but this mail is forwarded to the teacher. The teacher decided whether the 'in game feedback' will be given (this is a predefined mail in 'The Scheldt'), or that a more specific feedback is needed. In case of the latter, the teacher can use the mail-facility in 'The Scheldt' to reply.

In this example, the teacher is always in charge, but it is possible to work with a specific rule in 'The Scheldt' that states that there is no teacher-circumvention during the game. Furthermore, it is also possible to indicate that if the teacher does not circumvent within a specific time-frame, the predefined mail will be automatically given.

This game is made for an online university course, and thus it is also only offered in single user mode.

We do not agree that new education practices should turn the teacher into a consultant nor a simple facilitator. We believe that SGs can only be powerful learning tools if they are well balanced with other learning materials and a well-designed educational discourse between the teacher and the students, possibly supported by better practice-supporting materials. Overall, the adult's presence is necessary for the educational role of leading students to knowledge and understanding of/access to reality. A proper use of SGs, instead of limiting the teacher's role, requires even better prepared teachers, and able to introduce students to aspects of reality by using a potentially powerful, yet complex, simulation tool. In the *Any Business* course, lectures involved the presence of two other researchers for supporting the official teacher by monitoring the teams' behaviours during the de-briefing (probably one would have been enough, but we preferred two given the experimental case).

Our analysis has shown that all the three games seem to correspond to the Kolb's learning model. Whereas The *Scheldt* emphasises concrete experience and reflective observation, the other two games, at least in the multi-player settings with debriefing, seem to be more focused on an abstract conceptualisation.

Regarding the effectiveness of the games, it can be reported that the students who had used The *Scheldt* received high grades on the final exam that was conducted after completing the game (average score 8.9 (maximum 10)). For *Any Business*, the preliminary results after four game sessions of one week each show that the game supports strategic thinking and requires and stimulates a deep understanding of the simulation environment. It can also be seen that the different reports generated by the game help in analysing and taking decision. Moreover, competition is really compelling for the majority of the players. The market conditions are determined by the abilities of the competing teams. Thus, it is important that the teacher supports the weaker teams, so to make the overall competition more challenging.

Seconds has been used for decision making for more than 6 years. The available results mainly show that the game is useful as it helps the students in applying methods and constructing new knowledge, and there is still room for improvement, in particular on abstraction and conceptualization.

Our experience in deploying the targeted games suggests possible reasons for the current low penetration rate of GBL in HE. The game that seems to be most easily to integrate is The *Scheldt*, for which only few adjustments were necessary to well connect the game topic and the online course plan. For the other courses that involved the presence of one or more teachers, it can be concluded that it is difficult to set up a course integrating the use of a SG, since the playing time, the length and plan of the sessions, the modalities for keeping the motivation etc. are difficult to estimate in advance. Thus, these courses often have to undergo an iterative design process, adapting the course set-up depending on the evaluation of the learning outcomes. This requires a continuously monitoring and a proper working experience. Taken into account the cost of this work, the experimental design, and the low number of students in each class it is still a question if the resources used for implementing GBL are efficiently used.

The results reported here are still qualitative and preliminary, thus more work should be done before providing reliable conclusions about the impact and effectiveness of the selected SGs in HE settings, considering also transferability of results. However, we argue that our current achievements should support use of managerial SGs in HE. To the best of our knowledge, this is the first paper showing a SG effectiveness analysis based on cognitive and experiential learning models, also in a certain geographically significant scale.

Despite the consensus on their potential (in particular due to the technological/graphic appeal, interactivity and the huge data processing/storing capabilities), the deployment rate of SG in HE is still quite low. We argue that this is due to the fact that games are more naturally suited to children than to adults. Moreover, educational effectiveness of games is easier to achieve with simpler contents, while more complex and costly games are necessary in order to efficiently and effectively achieve the needed educational targets. Finally, integration in existing curricula is not straightforward and requires a careful pedagogical planning and a smart usage of games. So, we think that a lot of work is still to be done, in particular to understand how to use it and how to design its insertion in the course so that it is really effective for students. Our results and conclusions are based on our working experience on managerial SGs and courses. We believe that they may be generalized to other types of curricular domains as well, but more research should be done on this as well.

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