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Design and Implementation of a Business Simulation Game Tool for Services and Digital Economy Courses in Engineering Degrees*

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Engineering education is increasingly introducing business administration and management courses in order to adapt engineering curricula to the needs of the labor market and 21st century competencies. Traditionally, business simulation games have proved their efficacy in enhancing learning of business-related subjects in graduate and post-graduate courses. However, business simulation games focus on training on operation of traditional markets, characterized by a strong emphasis on manufacturing, promotion and distribution of physical goods, and thereby they might not be suitable to apply concepts specific to the digital and services economy. This research covers this gap by presenting a new business game simulation tool adapted to this new economy. The paper outlines the design and implementation of such a tool, and it proposes an instructional plan that uses the tool in order to fulfill the new training needs of engineers in business and management courses.

Keywords: business simulation games; engineering teaching; business administration; digital economy; SCRUM

1. Introduction

After the introduction of business simulation games (BSGs) in the 1950s, their use has constantly increased, up to the point that they are one of the most used tools for teaching and training in management and business administration studies in the last decades [1, 2]. Business simulation games aim to facilitate the transition between formal academic contexts and real-world management experience by giving students means to act and take decisions based on the knowledge they have acquired about strategic and organizational concepts. Thus, they become a bridging step to connect theory, practice and reality through the simulated experience [3], positively affecting learning and performance [4].

BSGs are suitable for problem-based learning and role based learning methodologies, which emphasize action learning. In general, BSGs try to imitate complex real-world contexts and problems. BSGs introduce some constraints as restrictions in order to achieve pre-defined learning goals—too trivial or too complex simulations have a reduced pedagogical effectiveness [5]—, with students playing different organizational roles and making business decisions. The most known example among BSGs is the Top Management Decision Game, the first business simulation game known. The Top Management Decision Game simulated an environment where 5 teams competed with each other in a fictitious market of one product [6]. The teams could make decisions about product, price, production volume, financial budgets, marketing and research, and development campaigns, and they could even request studies for further market analysis and prospection in greater detail. The next generations of BSGs have for the most part followed the main lines drawn by the *Top Management Decision Game*, updating its principles to adapt them to new social and economic theories and realities—e.g., new technological products, specific functional area simulations, globalization or innovation processes—, and they have also benefited from the expansion of information technologies in terms of distributed online access, advanced interfaces, data processing capabilities, and complexity. Some examples of this new wave of business simulation games are listed in ABSEL[1] (Association for Business Simulation and Experiential Learning).

These social changes have also had consequences in job positions and the skills demanded by the labor market, with an increasing number of IT professionals incorporating to management tasks, a situation that has raised interest in the inclusion of soft-

[1] http://absel.org/gaming-packages-by-abselites

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skill training and basic and advanced business management courses in the programs of most computer engineering degrees. Nevertheless, the concepts included in these courses generally have little to no affinity with the rest of the courses included in the curriculum, in terms of concepts and required competences. BSGs facilitate engineering students' adaptation to business courses by providing a direct transference of the theoretical concepts learnt in class through situated learning, or problem-based learning in a specific context.

In this context of this study, the Engineering Schools of Universidad Politécnica de Madrid have been actively promoting the use of BSGs in business administration courses. More specifically, the Telecommunication Engineering School has been offering a course on ''Business Simulation'' as a complement to theoretical courses on Economics, Business Organization, and Management and Business Administration. This course used an ad-hoc business simulation game, known as EASE (Entorno Avanzado de Simulación Empresarial, Advanced Environment for Business Simulation). EASE was developed by the Grupo de Tecnologías para la Gestión Empresarial (Group for Business Management Technologies) at the Universidad Politécnica de Madrid. The introduction of EASE also aimed to comply with the Bologna Process and the transition to the European Higher Education Area (EHEA) [7] in regards to instructional design, by incorporating new learning methodologies based on active learning tools as an integral part of learning. This meant that the design of EASE sought to ensure the effective application and learning of all the concepts taught in the theoretical courses, in both graduate and postgraduate courses. The resulting experience with EASE was considered a great success, both in terms of student satisfaction and academic performance [8].

EASE, like most of current BSGs—e.g. Marketplace's *The Global Business Game*[2], markStrat[3]—has a strong focus on manufacturing and distribution of physical goods. However, this approach lacks application in contexts more suitable for computer and IT engineers because most of them will likely develop their professional careers in service-oriented organizations or ''digital economy'' companies—be it as employees or entrepreneurs. Physical and digital goods markets have radical and substantial differences, in terms of product development and provision, and how demand and supply work; therefore, EASE might not fully meet the requisites to satisfy learning needs of IT engineering students. Furthermore, an initial search for free or open source BSGs, adapted to the specific conditions of services and digital economy, reported no available programs, which suggested the need to develop a new BSG adapted to the digital and services economy. A necessary requisite for this new BSG is flexibility; that is, it should be easily adaptable to different application scenarios, allowing easy configuration based on parameters and activation or deactivation of specific functionalities [9]. For educational purposes, the first phase of development would cover a specific context that students are familiar with: the mobile apps market. An additional requisite is web access, seeking to give answer to the mobility requirements fostered by the EHEA, and to facilitate student-centred and self-regulated learning. Web access guarantees that the business simulation game may be used in both face-to-face—in labs and/or mobile devices—and online virtual learning environments.

The structure of this paper is as follows: Section 2 details the methodology for design and implementation of the BSG, as well as the system architecture and modelling, covering functional, data and interface levels. Section 3 presents an instructional plan for the application and use of the BSG in business administration courses in the context of a Master's Degree in Telecommunication Engineering. Finally, Section 4 summarizes the main conclusions from the research.

2. Development of the BSG tool

This section presents the design and implementation of the BSG tool, covering different aspects of the BSG development plan: methodology, problem definition and detail of the final implementation solution.

2.1 Design and development methodology

A new software solution to a problem requires the application of different approaches and methodologies. How to decide on what is necessary to address the problem depends on many diverse issues. In the particular case of the new BSG tool adapted to digital and service economy, some additional constraints apply: (1) the size of the development team, that includes two designers and two developers; (2) the requirements are subject to possible changes in the future; and (3) there is a limited temporal development horizon available because the first version should be available in no more than six months, in order for it to be ready for use in the following academic year. Given these constraints, agile design methodologies appear as the best

[2] http://www.onlinegbg.com. A list of scholarly articles on Marketplace's BSG applications is available at: http://www.marketplace-simulation.com/instructor-resources/scholarly-articles
[3] http://web.stratxsimulations.com. A list of research papers using markStrat is available at: http://www.stratxsimulations.com/webinars/Markstrat_References_Articles_July%202014.pdf

option for this project. More specifically, among the different agile design methodologies the most suitable choice is SCRUM.

SCRUM cannot be considered a methodology for analysis or design, such as The Unified Software Development Process [10]. Unlike the latter, SCRUM is a methodology for work planning and management; it is an agile development framework that defines the process, rules, practices, roles and artifacts necessary in order to increase productivity of development teams, based on an iterative and incremental cycle of software creation and development [11].

Thus, the application of SCRUM implies a continuous process of testing and learning, where rules and practices can be dynamically adapted in order to ensure an optimal use of available resources in order to increase efficiency. SCRUM is therefore an appropriate approach to achieve a successful implementation of the new BSG tool, since it builds upon the existing version of EASE, and it is subject to future changes and evolution (therefore the knowledge generated during the design of the new tool can be reused and applied in future developments). This adaptability guarantees a correct and optimal use of resources.

In this project, the application of SCRUM requires the identification of a series of fundamental tasks to ensure the effective implementation and integration of the development. These tasks are included in what is known as Product Backlog. Some examples of these tasks are: work team configuration, definition of the product development model, definition of the human resources and labor market models, definition of the finance and capital risk investments models, definition of a demand engine based on infection models, development of the graphical interface for the human resources direction module, development of the interactions in the graphical interface for the human resources model, etc.

The final product backlog includes 16 tasks, each of which has an assigned priority level. Each task is then decomposed by the project team in discrete elements that allow for easier task management and that are implemented in each sprint. The sprints have an estimated dedication time of between 7 and 14 days, with an allocated time of 8 hours per day in the case of developers and 4 hours per day in the case of designers; on each sprint there is a software increment. The total number of sprints for the project was 17, with some of the tasks consisting of 2 sprints. Fig. 1 shows the process steps, and Table 1 depicts each of the different tasks and their distribution in terms of sprints.

From Table 1, after the definition of the main system models, the next two sprints cover the more differential and specific aspect of the project: building the simulation engine. In order to undertake these two sprints, the design of the demand engine used infection models extracted from Social Network Analysis (SNA) theory [12], instead of using the demand curve generation engines that are typical of the economy of physical goods. As mentioned above, each task included in a sprint is divided into subtasks (the right column of the Table 1 shows the decomposition of task 15 as an example), with the effort measured in estimated hours per task.

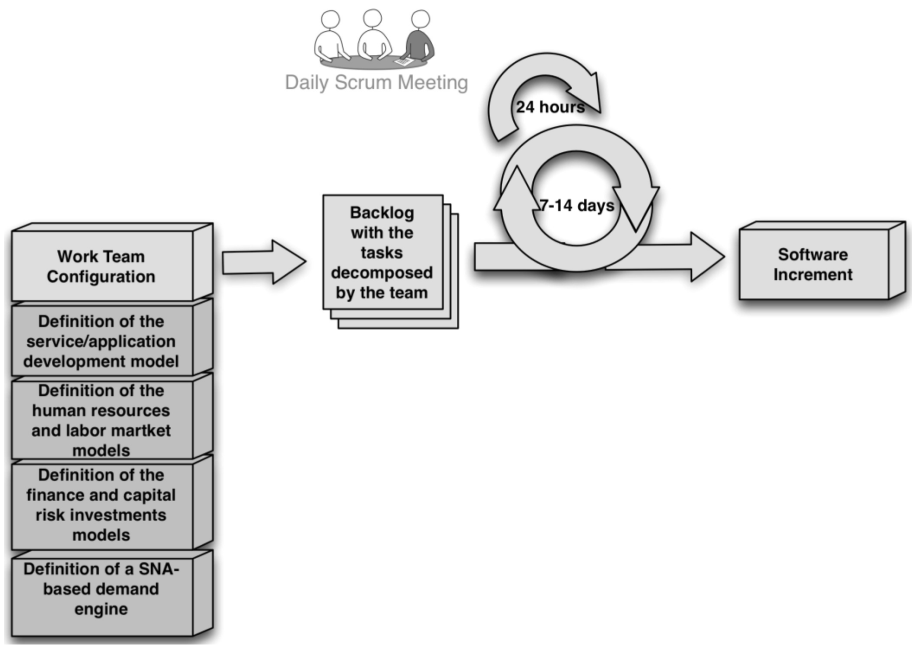

Fig. 1. SCRUM process applied to the BSG development.

Table 1. Backlog sprint table (left) and subtasks for task 15 (right)

Sprint	Task	Duration
1	Work team configuration	
2	Definition of the service/application development model	1 week
3	Definition of the human resources and labor martket models	1 week
4	Definition of the finance and capital risk investments models	1 week
5	Definition of a SNA-based demand engine	2 week
6	Definition of a SNA-based demand engine (II)	2 weeks
7	Development of the graphical interface for the Chief Human Resources Officer (CHRO)	2 weeks
8	Development of the interactions in the graphical interface for CHRO	2 weeks
9	Development of the graphical interface for the Chief Technological Officer (CTO)	2 weeks
10	Development of the interactions in the graphical interface for CTO	2 weeks
11	Development of the graphical interface for the Chief Finance Officer (CFO)	1 week
12	Development of the interactions in the graphical interface for CFO	1 week
13	Development of the graphical interface for the Chief Marketing Officer (CMO)	2 weeks
14	Development of the interactions in the graphical interface for CMO	2 weeks
15	**Development of graphical interface and graphic interactions of Administrators**	**2 weeks**
16	Development of graphical interface and graphic interactions of Administrators (II)	2 weeks
17	System integration and tests	1 week

Subtask for Task 15	Effort (hours)
Design of Administrator interfaces	**72**
Implementation of the general settings interface	**26**
DDBB for general settings storage	**12**
Implementation of HR interface	**26**
DDBB for HR information storage	**12**
Dynamic graphic generation for HR information preview	**18**
Implementation of Finance interface	**26**
DDBB for Finance information storage	**12**
Implementation of Technogogy interface	**26**
DDBB for Technology information storage	**12**
Dynamic graphic generation for Technology information preview	**18**
Implementation of Marketing interface	**26**
DDBB for Marketing information storage	**12**
Implementation of Users and Teems Interface	**26**
DDBB for Userts and Teems information storage	**12**

Considering that the sprint is developed during 14 working days, and there are 2 developers and 2 designers who work 8 hours and 4 hours per day, respectively, the total effort to carry out the task is 336 hours.

2.2 Problem definition

In order to define the BSG tool, it is necessary to understand its structure. UML class diagrams [13] graphically describe the problem. Figure 2 shows the result of the initial problem analysis.

From Fig. 2, there are some basic components:

- Class *Game*: the fundamental component of the simulation tool; it comprises one or more rounds.
- Class *Team*: it represents the group of participants in a game. They have to make different decisions based on their role. A team can have one or more participants.
- Class *Participant*: each of the members of a team (players). Each person can have one role in a game.
- Class *Role*: it characterizes the role played by each participant in a team. Depending on the role, the available decisions for each participant will vary.
- Class *Decision*: it embodies the different decisions made by each participant of a team in each turn depending on parameters that are specific to each game.
- Class *Turn*: the game is divided in one or more turns, and each turn can have different parameters which, depending on the different decisions made, may lead to different outputs. The results and parameters of each turn may have influence on the next turn.
- Class *Result*: each turn produces output results. These results affect the next turn and/or the game parameters.
- Class *Parameters*: they represent special conditions associated to the game for a given turn.

From the problem proposal, the next section describes the solution implemented for the design and development of the business simulation game tool.

2.3 Description of the final solution

This section covers the actual design and development of the business simulation tool. The solution should specially attend to three issues: the architecture of the solution and how it integrates with the

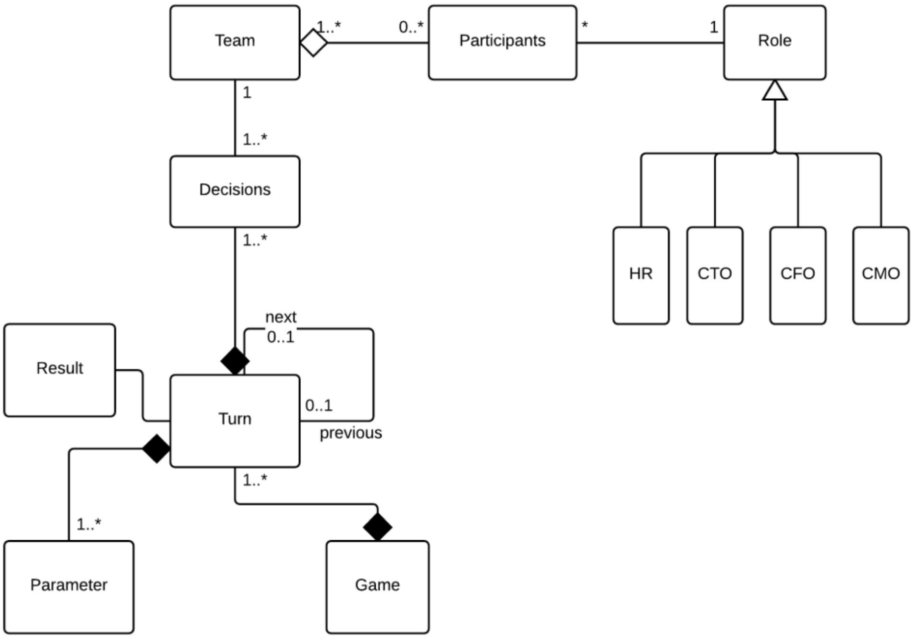

Fig. 2. Domain problem description [13].

LMS applied for engineering education, data storage, display and visualization of information, and final system implementation.

2.3.1 Solution architecture and integration with the LMS

Regarding the architecture of the solution, this work aims to provide a tool that can combine with a LMS in order to facilitate both theoretical and practical training. It should be accessible from the web, so an optimal architectural solution is a client-server approach, where the server receive the queries from the client (i.e., a web browser), processes them and returns the output results. The right side of Fig. 3 represents this part of the BSG tool, consisting of the web application packages and the runtime engine. The web application incorporates basic functionality for management and interaction with the simulator, while the runtime engine includes the business logic for the different models implemented. The second component is a database that stores information related to the application and the decisions. Although the use of the simulator as a standalone web tool can be helpful to enrich the learning process [14], students should be able to access both the LMS and the tool, and therefore it would be desirable to access the BSG using a common environment, a problem that can be solved using interoperability specifications [15].

Conde et al. [16] propose different possibilities to integrate tools from personal to institutional environments. One of their scenarios explores the integration of external educational online tools into the LMS. In this scenario, the activity is done in the external tool but integrated by using interoperability specifications. This requires the use of an Interoperability Tool Consumer in the LMS and an Interoperability Tool Provider in the external tool. Figure 3 shows the architecture of the interoperability implementation. The LMS provides an interoperability ToolConsumer that is used by the BSG to provide the information about the outcomes, and the BSG provides an interoperability ToolProvider that enables the instantiation of an activity from the LMS and students access. The BSG also includes an additional component that implements the interoperability specifications. This configuration allows the teacher to launch a BSG activity from Moodle. Students may access the activity both in Moodle and externally, by using a web browser. Once the activity is completed or the deadline to complete the activity has finished, information about students' outcomes will be returned to the LMS. This means that teachers and students would only need to access one environment, although standalone use of the BSG tool is also possible.

2.3.2 Data model

The system's data model comprises four main areas:

- The first area is comprised of all the tables with data about game configuration and parameters; these data are introduced in the application by the system administrator through the "new game creation" interface (view game/new). In general, all the tables that include the name *params* store data relative to modeling of new games that are

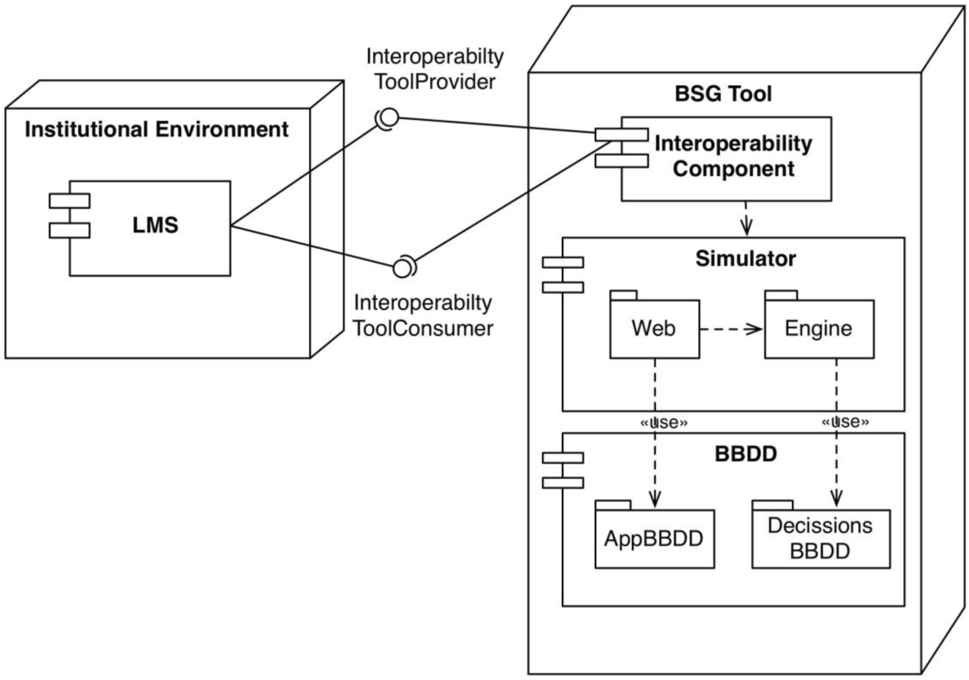

Fig. 3. System Architecture. On the left side the LMS which is connected with the BSG by using interoperability specifications.

introduced via the administration interface on game creation.

- The second area consists of tables associated to the decisions made by each of the directors (defined by the role of the participants), and identified by the prefix *decision*. Records about decisions are registered for each of the four modules: CTO (technological, Chief Technological Officer), CFO (finance, Chief Finance Officer), CHRO (human resources, Chief Human Resources Officer) and CMO (marketing, Chief Marketing Officer). In addition, auxiliary tables are required for registering of other decision-related data—these tables do not include the word decision in their name.
- The third area includes tables with data about output results, obtained after the inputs (decision values) have been processed by the simulation runtime engine. These tables include the prefix *outcomes*.
- Finally, there are 3 tables that include data that cannot be considered parameters, decision or auxiliary variables, or results: users, companies and companies_users_relations. The former two are self-explanatory, since they store information about users and companies; the latter contains a relation of the participants of each team (that is, each company's members). This design ensures that each company is unique and is defined exclusively for one game, but the different users can be assigned to different companies in different games.

2.3.3 Interface modeling

In order to increase interactivity and student engagement, the graphical user interface of the business simulation application has to be attractive, but also usable. One way to ensure proper design of the graphical interface attending to these two pre-requisites is to design a prototype of said interface in early stages of development. OOWS was used for this purpose. OOWS is a software development method that allows specification of web applications, extending an existing object-oriented (OO) method. Web applications share some characteristics with desktop software applications: system functionality and user interaction. However, web applications also incorporate new browsing characteristics that must be captured in order to offer a more precise and realistic representation of the system [17].

In particular, OOWS provides browsing and context diagrams for each user profile. Upon the browsing diagram, it is easy to explain the different contexts experienced by a user with a given profile. Context diagrams specify how users navigate through a series of views, and the nature of information exchanges occurring in each of those views.

Figure 4 shows an example of a system context diagram for a user with the role of administrator. Figure 4 must be interpreted this way: when an administrator initiates a session in the application, he or she can access two scenarios (games and users management and configuration). When game management is entered, administrators can create a new

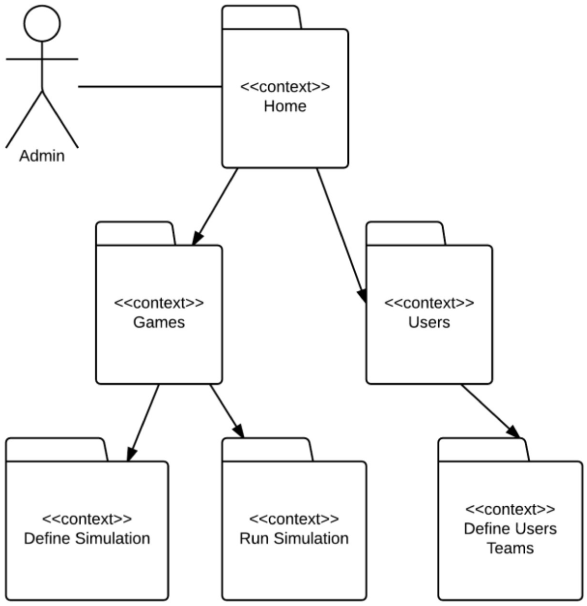

Fig. 4. User Browsing Context [13].

simulation or execute an existing one; if the administrator accesses user management and configuration, then he or she can create users and teams.

Figure 5 depicts a particular context (creation of a new simulation game). This context includes setting of the initial setup by the administrator, and the configuration parameters of a new game, for each of the four modules that have to be navigated sequentially.

2.3.4 Implementation of the tool

The final implementation takes into account two design requisites: (1) the application should be accessible trough a web browser; and (2) it should be easy to connect the BSG tool and Moodle—the LMS used by the university. In order to do so, the web application engine is programmed in PHP programming language, using a combination of HTML and PHP, as well as CSS and jQuery for interface programming, and MySQL as database server with InnoDB engine. The development framework used for implementation of the system is PHP Zend. PHP Zend facilitates application development in PHP based on a Model-View-Controller (MVC) pattern [18]. MVC guarantees independence between view and model, and this independence improves portability and scalability of the solution [19].

Regarding the integration of the tool with the LMS, it is necessary to explore Moodle's interoperability specification. Moodle supports LTI 1.1 and it is currently implementing LTI 2.0. [20]. This means that the BSG should include a LTI tool provider and

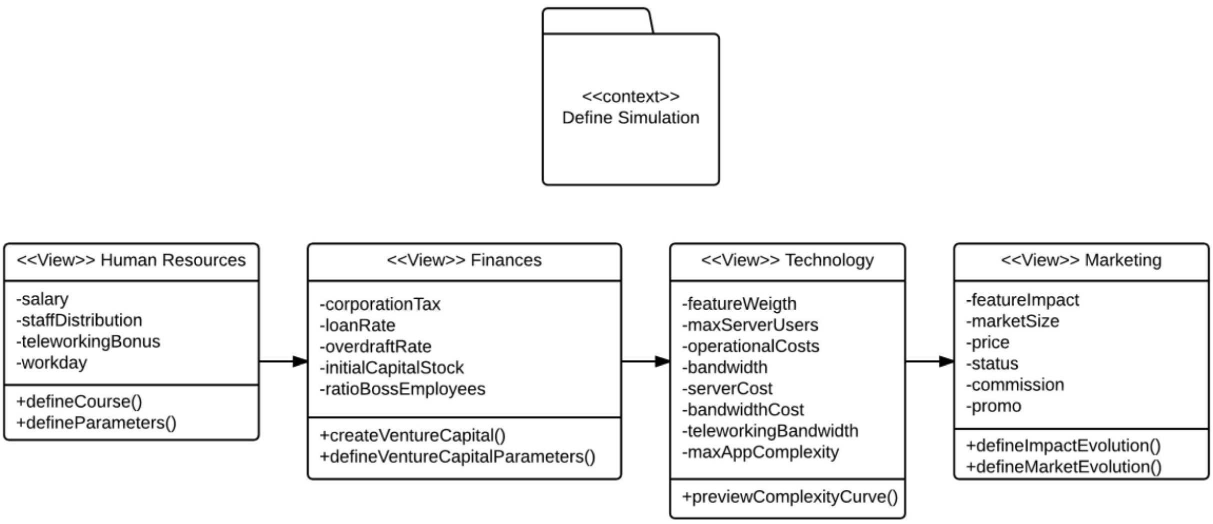

Fig. 5. Context example: creation of a simulation game.

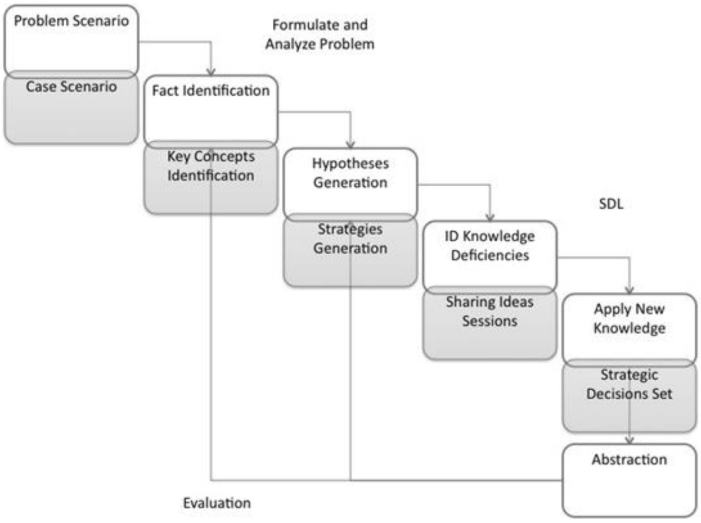

Fig. 6. Web PBL Cycle [20].

use the Tool Consumer provided by Moodle. This entails the use of web services—both Moodle's web services and interoperability specifications are well documented.

3. Proposed instructional methodology

Implementation of the BSG should also be aligned with the instructional method. That is, the final BSG tool is as useful as the instructional plan including its use. Our instructional proposal of the new BSG, adapted to the digital and services economy, has five main methodological pillars: experiential learning to provide hands-on experience on the consequences of business strategic decisions, collaborative (intra-group collaboration) and competitive (inter-group competition) learning by setting an environment where teams compete against each other, role-based learning (students have a predominant role associated to each of the management duties), and problem-based learning (students face open-ended and unclear problems with several ways to solve them), following the Web PBL cycle proposed by [21], shown in Fig. 6.

The Web PBL Cycle comprises six different stages, that are preceded by a theoretical explanation about the main topics and concepts that will be applied in the simulation: case scenario (deliverable with instructions on how to operate the system and information about the characteristics of the different mobile app markets), key concepts identification (where students analyze the information relevant to their role and as a group, and relate them to the theoretical concepts learnt), generation of strategies (where they analyze the different possible strategies and courses of action), sharing of ideas (where students put in common their ideas, identify knowledge shortcomings and then reassess the different strategies), decision making (students choose to deploy the strategy that they consider most effective), and abstraction (students receive the results of the simulation, reflect upon the consequences of their decision based on the outcomes provided by the BSG and the feedback provided by the teacher). In turn-based BSG, this stages are dynamic and cyclic; that is, after abstraction of knowledge is achieved, the teacher may use the resulting situation to introduce other concepts of interest. The flexible design of the BSG allows this by altering parameters for the next simulation turn (providing students the necessary information to start a new cycle) or introducing new functionalities (e.g., enabling or disabling decision variables for one or more roles; there are up to 10, 8, 5 and 8 decision variables for the CTO, CHRO, CFO and CMO, respectively).

The instructional plan includes an initial module on strategic management with traditional business case study solving to scaffold case scenario analysis skills. Then, there are two initial theoretical sessions about the characteristics and main topics used in digital and service economy, followed by a presentation of the initial simulation scenario and a first hands-on session with the BSG to make students get familiar with the tool. Then the Web PBL Cycle starts, and when each turn is completed the students have to provide an analysis of the current situation based on the simulation outcomes and discuss it with the teacher. After this, a new turn starts, focusing on aspects related to one specific role and the cycle begins again. A final sixth turn brings together all the concepts used in the simulation, and concludes with a team group presentation of their analysis of the simulation, with feedback from the other groups and the teacher.

4. Conclusion

This study proposes design and implementation principles for the development of a BSG tool suitable for instruction of concepts specific to the services and the digital economy in business administration and management courses for engineering graduate and postgraduate education. The BSG tool also meets the requirements of the EHEA and it is easily integrated in Moodle virtual learning environments. As a result, the final product is a functional BSG tool and an accompanying instructional plan to be used as a core element in a new business administration course for second-year students at the Master's in Telecommunication Engineering at Universidad Politécnica de Madrid. From here, the course will be used as a pilot study in a controlled environment with less than twenty students to assess its impact both in terms of students' learning enhancement, and of its convergence with the required knowledge and competencies required by the labor market. Based on the results of the pilot study, we shall determine whether any further adjustments might be required to improve learning or expand its use to larger courses at graduate and postgraduate levels.

A full scenario of application is currently under development in order to further test the BSG before its implementation in the real learning context. This scenario covers six rounds following the instructional design principles detailed in Section 3. As a by-product of this study, the design principles used in this development have allowed a different work team led by the same researchers to revise and redesign the graphical interface of EASE, the former BSG focused on traditional manufacturing and distribution markets, taking advantage of new programming techniques that enable higher degree of interactivity in web applications (HTML5, jQuery). At this point, a conjoint use of both BSG tools is not discarded, as they can be seen as complementary to explain similarities and differences between physical goods markets and services and digital economy markets. Future research will focus on acceptance and evaluation of the new BSG by students and teachers in a real learning scenario. Upon this evaluation, both functional and learning requirements must be reassessed in order to include new aspects and contexts—e.g., new market characteristics, new products—in order to extend the use of the new BSG to other engineering courses.

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