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GAMIFICATION AS A LEARNING TOOL

Rui Pedro Lopes
(rlopes@ipb.pt)
Polytechnic Institute of Bragança, Bragança, Portugal

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ABSTRACT

Higher Education Institutions have the missions of education, at a high level, research and cooperation. Regarding education, HEI must create an appropriate environment for learning, towards high-level academic performance. Students must be motivated to use the learning strategies in and out of the classes, to be able to make the best result of the learning effort.

People is motivated according to several factors, such as external in nature (earn more money, gain social status, have a higher grade, …) or internal (intrinsic), which results from the core self. The latter is associated to the satisfaction people feel when doing something appealing.

This paper describes the approach to applying gamification to a higher education subject in the course of computer science. It uses several game design mechanisms, such as adaptive challenges, rewards, curiosity and chance to increase the time students spend working, experiencing and learning in a HEI.

The sections in the curriculum are transformed into levels, awarding stars for increasingly complex achievements. There is also the concept of soft currency, which is used to increase the student autonomy and incentive the work load. Some games are also used as learning experiences, allowing collective knowledge building in the preparation and also playing the games.

Keywords: Higher Education; Intrinsic motivation; Educational Games; Gamification

INTRODUCTION

Higher Education Institutions (HEI) have three primary missions: education, research and cooperation (Kyvik & Lepori, 2010). While in different weights and strategic importance, most institutions try to cope with these missions to contribute for population education at high level, scientific and technological advances and economic and social development. In the last years, the concepts introduced by the Bologna Process followed these missions, giving to the student a central role in the learning process.

Regarding education, HEI must create an appropriate environment for learning. However, adequate student learning disposition is fundamental to achieve high-level academic performance (P. R. Pintrich & de Groot, 1990). The way they plan, monitor and modify their learning, how they manage and control their effort on academic tasks and the cognitive strategies used to learn, remember, and understand materials all contribute to the overall education process within the student.

Students must be motivated to use the strategies as well as regulate their cognition and effort (P. Pintrich, Marx, & Boyle, 1993). A motivated student is energized and available to pursue activities and tasks that appeal to him. Delivering content alone has virtually no effect on students' beliefs about the world. They can memorize data, but without active engagement and hands-on application, they do not really confront the implications of the new content.

There are several factors that determines motivation, and usually they also depend on the person characteristics. To foster motivation it is important that students understand what they can and can't do and have accurate and realistic feedback that can help them acquire the expertise needed to learn. It is also fundamental to provide tasks that should be neither too easy nor too difficult, but challenge students in appropriate ways (P. R. Pintrich, 2003).

The challenges and the overall learning experiences should provide an environment adequate to foster change. It is by accepting and reflecting in change that learning is achieved. In this context, failure is actually an option. It is easier to create the appropriate environment for change within the student beliefs and knowledge by introducing and accepting failure as part of the learning process. Failing is usually associated with reflection, since it is natural to ask what went wrong. This does not usually happen after a success.

It is not easy to accept failure, specially when related to oneself unless if the stakes are low. On the other hand, high-degree of motivation is usually achieved when the expectations are high (Weber & Chapman, 2005). Low stakes and high expectations are precisely the typical conditions of a good video game.

This paper describes the approach to applying gamification to a higher education subject in the course of computer science. It is structured in four sections, starting with this introduction. The next section describes some essential concepts. It proceeds by describing the learning structure, including an award mechanism, grading and some learning experiences. It ends with some conclusions.

GAMIFICATION CONCEPTS

Gamification may be a new term, and recently it has been receiving a considerable attention in several areas and fields. This neologism, however, describe an idea that is not exactly new: using game-thinking and game mechanics to solve problems and to engage audiences. Playing games is something that has been with humans since the dawn of civilization and, inclusively, recent research has been demonstrating that game play contributes to faster reactions as well as to increasing the brain activity, allowing people to live longer and delaying dementia (Deterding, Dixon, Khaled, & Nacke, 2011; Zicbermann & Cunningham, 2011).

In this context, we intend that students become more engaged with the learning activity, thus increasing the connection with a subject, an experience or an idea. The more engaged a student is with the learning experiences, the more effective the learning process will be.

Reward systems have always been an integral component of games. Rewards, also known as game achievement systems, allows translating the player investments into a more quantifiable, comparable and communicable form (Jakobsson & Sotamaa, 2011). The definition of a reward structure, positive reinforcement and feedback loops are key factors for any game (Lindqvist, Cranshaw, Wiese, Hong, & Zimmerman, 2011). The taxonomy and the reward structure define the base for a game design, either digital, board or, in this context, the learning experiences of a higher education subject.

MOTIVATION

The goal of this work is to try to increase the time and attention students dedicate to learning. The path to achieving this is through motivation, which psychology divide in two groups: intrinsic and extrinsic motivation. The former derive from our core self and the latter depends, or is driven by, the environment that surround us, such as the desire to earn money or to gain social status or prestige. If students are intrinsically motivated to learn something, they may spend more time and effort learning, feel better about what they learn, and use it during their life. This will naturally happen if they are involved in the learning experiences, through intrinsically motivating activities.

Most humans are motivated by the development of competences in dealing with the surrounding environment. Skills acquisition and improvement, in this context, reveal a high degree of satisfaction, motivating to further improvements.

When immersed in the environment, humans show a creative attitude, in order to make it more pleasant or more close to their ideal surroundings. This will contribute to better adapt the experiences into the existing structures of the person's mind reducing the demands of the external reality. In other words, it allows simplifying the learning process by adapting it to the mental and physical structure of the person.

Curiosity also plays an important motivational role. In fact, it represents one of the most important factors, since it drives the actor to permanently keep investigating and experimenting until he is satisfied. Curiosity can even drive people to engage activities that represent some risk, just for the sake of knowledge or in pursuit of new experiences and sensations.

In line with the above mentioned motivational factors, a successful game appeals to the player in several ways. The game structure should be sufficiently complex to attain curiosity, giving the player some expectations about what will happen. Curiosity can involve sensory stimuli, such as light, sound or other, or it can result from informative feedback, surprising, but also constructive, helping the player to perceive how to make his knowledge more complete and consistent (Malone, 1980).

The ability to make mental images, either of things (spaceships) or of social situations (ruler or emperor) can help the player to be more emotionally connected to a game or a character. It may also influence the level of difficulty, allowing him to use knowledge to achieve a goal through abstraction (cognitive fantasy). As an example, driving a spaceship in a computer game can be easier if the player knows how to drive a real car, being able to use this previous knowledge in acquiring new skills.

The implicit notion of a game implies that there is a specific objective, a goal to pursue. The goal has to be meaningful and adequate, requiring the increasing ability to challenge the player, not getting boringly simple. It also requires increasing skilled performance to overcome phases and obstacles. Usually, they also have fantasy elements, such as piloting a plane, ruling a city, becoming an emperor, and others. The game should also have a performance metric system, based on the time or on the scores the player achieve. The challenge is also dependent on an uncertain outcome, either by a variable difficulty level, by existing hidden information or by randomness.

EDUCATIONAL GAMES

As mentioned above, gamification describe the use of game design elements in non-game contexts (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011). This includes the creation of learning experiences that make use of challenges, rewards, points, levels and others, according to the goals of the game. A different way to apply games in learning contexts is to use them as educational tools. This approach will use games as learning experiences with the goal of increasing the student knowledge just by playing them, whether in context or not. In fact, the core components and patterns of game design intrinsically integrate some kind of learning with the game mechanics (Linehan, Kirman, Lawson, & Chan, 2011).

Usually, there are two approaches to using games in education. The first seek the engagement that commercial and wide available games have to foster learning outside the school environment. Games such as Sid Meier's Civilization or World of Warcraft can provide a challenging and motivating world that require analysing, planing, communication skills and others, contributing to improving the problem solving abilities of players. On the other hand, games can be specifically designed to convey traditional content in a different, untraditional, form.

Not everything can be learned through the first method, and not everything can be sufficiently motivating according to the second method. It seems obvious that an educational game is simply not a collection of content organized in an untraditional way. Educational games should follow the same principles that makes entertainment games intrinsically motivating. As mentioned above, some of these principles include the existence of medium and long term goals organized as increasingly complex levels, they should require the player to make decisions and take actions, provide immediate feedback, include a reward system for achievements, gradually teach the player new skills necessary to overcome more challenging obstacles.

LEARNING STRUCTURE

The approach described in this paper is being applied to the subject Network and System Management of the Computer Science course of the Polytechnic Institute of Bragança, Portugal. It is currently ongoing, using several game structures and design patterns.

Currently, at the end of the course, it is expected that the learner be able to: use a basic set of virtualization tools; install and configure both disconnected and networked computer systems; manage secondary storage medium, user accounts and system startup and shutdown procedures; install and configure basic network services; install and configure network file servers and authentication domains; identify and describe the role of integrated network management in modern organizations, and use some related tools.

AWARD SYSTEM

The current curriculum is structured in four sections or chapters. Each section has several subjects that should be mastered before advancing to the next section. The final assessment and the associated grade depends on the success on each of the section as well as the creativity and the level of knowledge demonstrated in every subject. Students are graded from 0 to 20, which is translated to the ECTS grading scale, demonstrating how she performed relative to other students (the best 10% are awarded an A-grade, the next 25% a B-grade, the following 30% a C-grade, the following 25% a D-grade and the final 10% an E-grade). Success is only considered if the student has a grade equal or above 10 (0-20).

The assessment and grading follows a reward structure design pattern. All the students have to fulfil the minimum requirements to succeed, meaning that he has to overcome all the sections or "levels". This will grant him the 10 grade. Within each level, the increasing number of overcame obstacles will grant the student with a higher grade.

Each level is marked by a castle. The student can additionally obtain up to 2 stars, illustrating the complexity of obstacles he successfully faced. Whenever a level is completed, BitPoints are awarded, which can be used to "buy" extra tools or help from the teacher. In other words, the reward system will have castles, stars and points (Table 1).

Table 1: Reward system and structure.

Element	Description	Grade
Castle	Awarded for each completed level. Student will need five castles to succeed in the course.	Up to 10
Star	Each level will award up to 2 stars.	Up to 10
BitPoint	Awarded when completing a level. Can be used to buy tools or information.	-

The student can, at any time, see the evolution within the awards system using a standard web browser. This will present the completed levels, the levels still to come, the number of stars awarded in each level and the total BitPoints (Figure 1).

Figure 1: Level map.

The level map also gives access to the item store, where the student can buy information or tools to be used in other tasks. The shopping list includes several items that can be valuable to overcome obstacles. The store provides information about five items, its price and the available BitPoints. It also provides the student with the number of items already bought (Figure 2).

Each time the student selects an item, the description in the figure will change, to further explain the meaning of the item. If the number of BitPoints is enough to buy the item, the "Buy" indication will also appear, allowing the student to perform the transaction.

As described above, the student can progress advancing levels and collecting stars and BitPoints. The number, length and complexity of each level is associated to the content planned in each chapter. In other words, the level design is indexed to the associated chapter. However, to provide initial increased motivation, another level is added, in a total of five (Table 2).

Figure 2: Item store.

Table 2: Level list.

Level	Length	Description
1	1	Basic Concepts (Virtualization and OS)
2	2	Disconnected systems
3	3	Networked systems
4	2	Integrated network management
5	3	Wrap up and content integration

The length of each level determines the complexity and/or the number of learning experiences the student should perform in each one of them. This also determines the amount of time required in the process. In addition, stars are awarded according to the difficulty level the student was able to complete. Several exercises and games are presented to the student, allowing him to choose according to the difficulty level (easy, normal, hard).

BitPoints are awarded as each level is completed. This soft currency may be used by the student to "buy" tools and knowledge to help him in more complex challenges. In this context, the amount depend on the number and complexity of the learning experiences, the time necessary to complete them and the overall participation in and off classes:

The student can accumulate BitPoints for each step within the level and for each learning experience fulfilled. The more he completes, the more BitPoints are awarded.

The time factor is associated to the moment the student finishes each level. It decreases until reaching the value of 0 on the deadline and becomes negative after this, following a sigmoid function. The last share of the BitPoints sum is specific of the student participation and is of the responsibility of the teacher.

LEARNING EXPERIENCES

The term learning experiences is not typically used to describe more formal learning activities, such as in classroom, transmissive methods. Centred in the student, this term describe that the learner is experiencing something that, hopefully, contributes to a change in thinking, understanding, or behaviour afterwards.

For this to happen, learning experiences should be active, meaningful, with social meaning, integrative, and diversified. We consider active learning experiences when the student has the main learning role. They should provide knowledge and skills that directly contribute to the learner's ability to perform more effectively in the context of workplace learning. Sharing and cooperation is fundamental, allowing the learner to interact with other active learners. The inherent increase in complexity demands the integration of different dimensions of knowledge, better achieved through diversified strategies. In this context, teaching and learning is more than the mere acquisition of content. It represents a process of learning by thinking-do-thinking (Dewey, 2007).

The learning experiences should be adequate to motivate the students and provide the necessary challenges for learning to take place. In this context, the concept is understood as a reinforcement of the goal of an educational interaction over its location (school, classroom) or format (course, program).

The diversity of ways in which students can learn from and interact with teachers, in addition to the level of independence they may have when learning, is considerable. We propose to include not only traditional transmissive approaches and practical work assignments but also designing and playing games. The latter is regarded as an integral part of the students' knowledge building, with the objective of being instructional with the main focus on the cognitive side of instruction.

Three types of games were selected: a Card Game, two Board Games and a Role-Playing Game (RPG). A Card Game uses playing cards as the main game support device. There are many types and styles of card games, either using traditional or specific cards. The general objective for this game is for students to describe the basic set of virtualization tools. This translates into the following learning objectives:

summarize the main virtualization concepts;

classify virtualization components;

identify advantages and disadvantages of virtualization.

According to the previous learning objectives, the student has to apply a research-develop-use workflow to complete a card game to practice classifying attributes and reinforce factual information about virtualization concepts.

Among the two board games, the first is a turn-based strategy game, of the worker placement type. Players will have to collect resources, which allows the workers to earn money or build things, and to perform other activities, such as: extend their data-center by building additional rack space; hire more system administrators; build environmental control; purchase servers; install network services.

The remaining Board Game is of the trivia type, which test students on their knowledge on the subject. It follows the design of Trivial Pursuit, although the cards contain specific questions in six different categories (virtualization, command line scripts, operating systems, disconnected systems, networked systems, network management).

The last mentioned game type is a RPG. This is a tabletop RPG, meaning that is it played by several students in a social gathering. The action is performed by the participants acting out the roles of the characters defined in a fictional setting, according to a set of rules. One participant acts as the Game Master, who is the authority on the fictional setting (or game-world), and has final say over what happens. The Game Master prepares, in advance, a set of challenges for the students. Each

character is created by the student and has a personal history and background, as well as numerical statistics. These will be used during the game to determine the outcome of events in the game.

The Game Master begins the game by introducing and describing the setting and the characters. The students describe their characters' actions, and the Game Master responds by describing the outcome of those actions. The general learning objective for this game is for students to model the necessary tools to support the persistence of data.

CONCLUSIONS

Using game-thinking and game mechanics to solve problems and engage an audience derives from the intrinsic characteristic of humans since early development stages. The gamification in education is a pedagogical and psychological approach within the mission of HEI.

A game is an interesting educational strategy because it can provide intrinsic motivation to students through curiosity, challenges with adaptive difficulty levels, some degree of chance and an award system. Moreover, it can be more pleasant by stimulating creativity. Educational games extend this by focusing the mechanics and narrative to cope with a subject curriculum, allowing the student to learn while playing.

The work described in this document applies gamification to Network and System Management subject in the Polytechnic Institute of Bragança. It requires the adaptation of content as well as the definition of learning experiences that can provide a game-like learning environment. It uses game concepts and elements to build diversified learning experiences and to improve student motivation. An award system was described that automatically translates into a final grade considering five levels and three complexity levels in each one. It also includes a soft currency approach to value autonomous work. In addition, some challenges are presented to the student with different length and complexity, allowing each of them to select the ones that motivate them. These include slide presentation by the teacher, practical assignments and several games, such as card, board and role play.

REFERENCES

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. E. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." In *MindTrek'11*. Tampere, Finland: ACM. Retrieved from http://dl.dropbox.com/u/220532/MindTrek_Gamification_PrinterReady_110806_SDE_accepted_LEN_changes_1.pdf

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. In *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems* (pp. 2425–2428). New York, New York, USA: ACM Press. Retrieved from http://portal.acm.org/citation.cfm?id=1979482.1979575

Dewey, J. (2007). *How We Think* (p. 108). Digireads.com. Retrieved from http://www.amazon.com/How-We-Think-John-Dewey/dp/1420929976

Jakobsson, M., & Sotamaa, O. (2011). Special Issue - Game Reward Systems. *Game Studies*, *11*(1), n.p. Retrieved from http://gamestudies.org/1101/articles/editorial_game_reward_systems

Kyvik, S., & Lepori, B. (2010). *The research mission of higher education institutions outside the university sector*. (S. Kyvik & B. Lepori, Eds.) (Vol. 31). Dordrecht: Springer Netherlands. doi:10.1007/978-1-4020-9244-2

Lindqvist, J., Cranshaw, J., Wiese, J., Hong, J., & Zimmerman, J. (2011). I'm the Mayor of My House: Examining Why People Use foursquare - a Social-Driven Location Sharing Application. In *CHI '11 Proceedings of the 2011 annual conference on Human factors in computing systems* (Vol. 54, pp. 2409–2418). New York: ACM Press. doi:10.1145/1978942.1979295

Linehan, C., Kirman, B., Lawson, S., & Chan, G. (2011). *Practical, appropriate, empirically-validated guidelines for designing educational games*. *Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11* (p. 1979). New York, New York, USA: ACM Press. doi:10.1145/1978942.1979229

Malone, T. W. (1980). What makes things fun to learn? heuristics for designing instructional computer games. In *Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems - SIGSMALL '80* (pp. 162–169). New York, New York, USA: ACM Press. doi:10.1145/800088.802839

Pintrich, P., Marx, R., & Boyle, R. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, *63*(2), 167–199. Retrieved from http://rer.sagepub.com/content/63/2/167.short

Pintrich, P. R. (2003). A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching Contexts. *Journal of Educational Psychology*, *95*(4), 667–686. doi:10.1037/0022-0663.95.4.667

Pintrich, P. R., & de Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33–40. doi:10.1037//0022-0663.82.1.33

Weber, B. J., & Chapman, G. B. (2005). Playing for peanuts: Why is risk seeking more common for low-stakes gambles? *Organizational Behavior and Human Decision Processes*, *97*(1), 31–46. Retrieved from http://www.sciencedirect.com/science/article/pii/S0749597805000361

Zicbermann, G., & Cunningham, C. (2011). Gamification by Design. *Oreilly & Associates Inc*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Gamification+by+Design#3

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