Gamification as Learning Scenario in Programming Course of Higher Education

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Abstract. Gamification in higher education could be a bad strategy if you only consider creating a game environment for learning, but particularly for a programming course can represent the element of motivation to develop specific skills. This article presents a pilot learning environment using gamification, for which emotional, social, narrative and progress dynamics were applied. The mechanics consisted of challenges and opportunities, where some of components were badges and a leadership board. The educational strategy was applied during period January–April 2017 in Programming course at Technological University of Puebla-Mexico; through surveys, students' acceptance of intervention was questioned and academic results of experimental group were compared with those obtained in the last 8 years with students from previous courses. The main conclusion of the work indicates that intervention of proposal in classroom offered necessary motivation to students for achievement of challenges and can be applied to other subjects.

Keywords: Gamification · Programming · Strategy · Motivation
Teaching

1 The Gamification as an Educational Strategy

Although some people believe that gamification is recent, there is evidence that gamification has been applied in recent decades. For example, in the militia, badges and ranks have been awarded for good performance of soldiers [1]. Years later, it began to be applied in business, companies such as Starbucks or Amazon have applied it, obtaining successful results [2]. But what is gamification? The term was coined by Nick Pelling in 2002, but it was not until 2010 that it took a bigger boom in business world and later joined the educational field [3].

Gamification is characterized by taking elements of game in contexts that are not of game [4] which aims to engage and motivate students if we refer to educational scope [5]. Gamification uses elements that promote intrinsic and extrinsic motivation, for example, offering prizes (rewards) favors extrinsic while achieving a challenge favors intrinsic [6]. It also offers opportunity to experiment with rules, emotions and social roles [7].

P. Zaphiris and A. Ioannou (Eds.): LCT 2018, LNCS 10925, pp. 200–210, 2018.
https://doi.org/10.1007/978-3-319-91152-6_16

In addition, due to elements of play that are involved in design of learning activities, skills and attitudes such as collaboration, self-regulation of learning and creativity are developed [8, 9]. It can also offer to students opportunity to learn from their mistakes thanks to immediate feedback and number of previously allowed attempts [10]. In other words, gamification by involving elements of game allows cognitive, emotional and social aspects to converge in learning process [11, 12].

Cognitive aspect is given when student gets immediate feedback and he is given several attempts in such a way that he is led to a metacognitive process or when he faces a challenge [13]. Emotional aspect is given when student gets recognition for their achievement (badge, rewards, points) [14] and social aspect happens when achievements are socialized through a leadership board or when students work collaboratively to achieve a challenge or mission [15, 16].

These aspects or dimensions are related with model gamification of Werbach and Hunter [17] which started in business and now has been transferred to education [3, 18]. This model establishes three elements in gamification: dynamics, mechanics and components. Dynamics are contexts in which gamification is developed, mechanics are activities within dynamics and components are objects or resources used within mechanics and that recognize achievements [17].

For example, social dynamic happens in an environment of interrelations, here social dimension would be present. Corresponding mechanic can be challenges and opportunities (cognitive dimension) and its components, badge assignment (emotional dimension) and use of leadership board (emotional and social dimensions). Including gamification for design of an environment or learning activities also favors creative process of teacher [19].

For present proposal, model presented in Table 1 was used.

Table 1. Design of a gamified environment based on the Werbach and Hunter model in a Programming course.

Dynamics	Mechanical	Components
Emotive	Challenges	Points
Narrative	Opportunities	Badges
Progression		Avatars
Social		Leadership Board

2 Gamifying a Programming Course

Programming course, which serves as a frame of reference for definition of proposal, is offered in second quarter of career of Information and Communication Technologies (ICT) of Technological University of Puebla-Mexico at Higher Technical University level and is formed for five thematic units: I. Fundamentals of object-oriented programming, II. Development environment of OOP, III. Object oriented programming, IV. Arrays, and V. Handling exceptions. As a technological support, Moodle platform of ICT division was used, where study material for each of units was published. At beginning of course students were offered possibility of choosing a

learning modality, that is, face-to-face or semi-face-to-face; at first traditional model of theoretical-practices classes would apply and in second, a flipped class making use of online study content and hours of laboratory practice would serve to apply gamification proposal. Of 26 students, 14 participated in semi-face-to-face model. Table 1 presents didactic proposal with gamification for semi-face-to-face course, elements are described below.

2.1 Dynamics

As previously mentioned, dynamics establish context in which gamification will be applied [8, 17].

a. Emotion
   Emotional dynamics were present in sense that student received immediate feedback from teacher whose role was limited to being a guide and encouraging students, either recognizing their work or motivating them to achieve challenge.
b. Narrative
   Each challenge it is framing in a written story that would hook for development of computer program, in order to create excitement, curiosity and interest. For Example: "The year, 2017, conditions very different to the way of developing software compared to beginning of century and nothing to say about extension of devices to which you have to create programs, and not only computers now also to large amount of mobile phones and electronic devices that interact with each other or are connected to the cloud; the challenge seems greater and a few of them capitalize on a global scale. What is process to develop software? What rules must be followed? When to know if someone is ready as a programmer? What development platform to learn? The questions in students are many and insecurity to know if time is taken advantage of grows when you see everything that can be created in video games, app, virtual reality, internet of things and robotics. You have to start with first step, have a methodology to create programs and once you have passed that test grow as a programmer to overcome challenges you have to be autonomous in learning, active in teamwork and creative in software solutions; be part of a programming elite. Do you think you can belong to these elite? I invite you to demonstrate it by playing Elite programming. The first challenge of game is to demonstrate your skills to model class diagrams that allow offering a software solution, at same time that you show use of concepts of object-oriented programming, such as abstraction, encapsulation, inheritance, and polymorphism. Read carefully following problem and solve indicated activities, so you can get the POO badge and move forward with next challenge."
c. Progression
   During course, participants could visualize their achievements through a leadership board in which were found names of teams identified with their respective avatar as well as names of students, challenges overcome, badges won by student, in addition points achieved by team and individually.

d. Social
In each of challenges, teamwork was allowed to motivate the end of requested activities. Social dynamics helps strengthen collaborative work including allowing students to know their weaknesses and strengths to promote encouragement among peers.

2.2 Mechanics

Mechanics represented activities or how within dynamics [3].

a. Challenges
They were main reason for participation of students in a semi-face-to-face mode. In course, five challenges were created whose individual and collaborative work generated tangent results to students that increased confidence to achieve personal goals and expectations of course.
b. Opportunities
Immediate feedback played an important role and several opportunities were offered to achieve the challenge motivating the hitch for the achievement of activities because "failure is a learning phase".

2.3 Components

Components are physical or digital objects through which participants are rewarded [20].

a. Points
Completion of challenge makes team of 10 points creditor. Full functionality of the program indicates that challenge is completed, if no functionality is programmed the team wins 7 points, the only participation of team without delivering any program in challenge makes it win 3 points. Extra points were also offered that can be assigned to students for evidencing an extra contribution in coding, participation or collaborative work.
b. Badges
They are related to progress of stages of course, so we have the following that each team can win (see Fig. 1):
Badge POO - when team explains and exemplifies fundamentals of object-oriented programming, that is, concepts of abstraction, inheritance, encapsulation and polymorphism, as well as class and object.
Badge IDE - when team demonstrates correct use of development environment to create, open, save, compile, run and debug a programming project in chosen programming language.
Badge CLASS - when team defines a class correctly considering syntax of programming language used to define determined attributes, properties and methods of class and using the constructor method when appropriate to define it.
Badge EC - when team uses control structures to solve problem determined in challenge 3 or next of course. At least one structure of selection and repetition should be used.

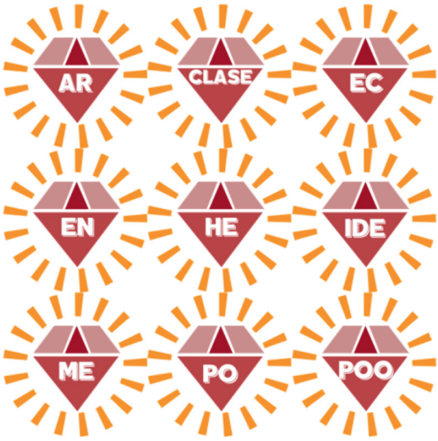

Fig. 1. Badges utilized during the Programming course.

Badge ENCAPSULATION (EN) - when team makes appropriate use of access modifiers in definition of classes that correspond to functionality needs of program developed from challenge 3.
Badge INHERITANCE (HE) - when team performs application of concept of inheritance from challenge 4, generating a base class and at least two derived classes according to problem to be solved.
Badge POLIFORFISM (PO) - when team from challenge 4 applies in definition of methods involved in classes concept of polymorphism to solve indicated problem.
Insignia ARRAY (AR) - when team from challenge 3 uses data structure array for handling of information of same type.
Badge ME - the last badge that team can win in course from challenge 3 when it adds to its coding handling of exceptions to avoid problems of execution of program.

c. Avatars
Each team designs the avatar that identifies it, as well as all the visual elements that it wants to create for members, with aim of generating an identity in each challenge session and be used in leadership board; even consider decoration of space (classroom or laboratory). It represents identity of team and it must be designed by students, was used in leadership board and all visual element that identified work done by students belonging to team.

d. Leadership Board
Board was physical object in which points and badges were publicly displayed, won by students both individually and collaboratively. Board was located in each class in front of everyone, and after feedback points and badges won were placed.

3 Observations and Findings

3.1 Challenges and Leadership Board

Figure 2 shows leadership board at the end of quarter January–April 2017, reading of results in laboratory is as follows.

First challenge. Students did not complete exercise, they indicated that due to lack of time, but it was due to fact that they did research work during class instead of doing it previously. Four teams obtained 7 points each. It was observed teamwork in organization of activities to complete challenge.

Second challenge. Although during activity most students could perform requested functionality, no team finished program; despite having received recommendation to previously study theoretical material; it was observed that they spent time in laboratory reviewing theory. Four teams obtained 3 points each, with option to report product later. Only one team subsequently submitted requested evidence so it was awarded with IDE badge.

Third challenge. Three teams finish requested product, but only one with full functionality (10 points) and won EN logo; a team won three badges (IDE, CLASS and EN) despite having limited functionality (7 points). Conformism was observed in team that only obtained 3 points. There was no teamwork during development challenge, in an isolated way students worked to program; at the end of time between them, they chose what program to present for evaluation of each of teams.

Fourth and Fifth challenge. Unfortunately, results are low because they do not have finished products, they practically attend activity without previous study trying to solve problem until time allowed them.

Fig. 2. Leadership board at the end of quarter.

During quarter, adjustments were made to the latest challenges based on evidence of student learning. At the end of quarter 13 students who finished (1 unsubscribed) and passed course carried out a Likert scale survey about their perception of gamification of course. Instrument was designed based on three dimensions: cognitive, emotional and social [11, 12, 15]. Questions and percentage are on Table 2.

Regarding cognitive dimension, it is observed that more than 90% of students who passed course considered that level of difficulty of challenges was in line with knowledge acquired, that exchange of opinions with teammates facilitated understanding of challenge and that challenge itself contributed to understanding issue involved, this coincides with what was found by [12, 21].

As for emotional dimension, most students were motivated by competitive environment and observe achievements on leaderboard, this is similar to that found by [14, 22]. Although it is important to note that a couple of students did not agree with use of board, as happened in the study of [16], so it is important to use avatars to preserve anonymity of participants.

Finally, with respect to social dimension, it is observed that more than 70% of students agree that collaborative work favored achievement of the challenges, this finding coincides with what was found in the study by [11] as well as in that [15].

4 Conclusions

Although results of didactic experience of gamification in a programming course were not entirely expected ones, it has left us a series of lessons learned. In the first place, gamification is a didactic strategy that favors student motivation [7, 8, 15, 22], however, it is very important to take care that design of the challenges is appropriate and according to students' ability, if not, results could be opposite to those planned. So, if a didactic strategy does not generate desired results the first time it is applied, it should not be a reason for discouragement but rather take opportunity to reflect on design of activities under a perspective of continuous improvement.

One of limitations of study is that there was not a reading revision assigned in flipped mode, so several of students attended classes without having read, which could have been an obstacle to solve challenges. Therefore, although this situation is more related to design of course than to gamification, these are aspects that should be considered.

On the other hand, some students may find it uncomfortable that their performance is exposed in a leaderboard and this may affect their motivation, therefore use of avatars is recommended to protect anonymity.

In general, didactic experience of gamification was gratifying because it has allowed to observe areas of opportunity both in design of same gamification and in activities of course, which leads us to a process of continuous improvement that at same time allows to validate if didactic strategy improves what is already done, that is, if it really is an innovation. On the other hand, being immersed in a process of continuous improvement will help to develop meta-evaluation models [23] of this and any other innovative didactic strategy in future.

Table 2. Results of final survey

Dimension	Question	Percentages
Cognitive	Immediate feedback from teacher in gamified activity gave me an opportunity to better analyze my response.	61,5% Strongly agree 30,8% Agree 7,7% Disagree
	Listening opinions of teammates allowed me to better understand gamified challenge.	For both questions 53,8% Strongly agree 38,5% Agree 7,7% Disagree
	Exchange of opinions with my teammates about gamified activities was done in a respectful way (for example, I listened carefully opinions of my colleagues and vice versa).	
	Solving gamified challenges helped me to better understand corresponding topics.	61,5% Agree 30,8% Strongly agree 7,7% Disagree
	Level of difficulty of challenges seemed appropriate to my previous knowledge on subject.	53,8% Agree 38,5% Strongly agree 7,7% Disagree
Emotive	Atmosphere of competition that was experienced in gamified activity motivated me to solve challenges.	For both questions 46,2% Agree 38,5% Strongly agree 15,4% Disagree
	Every time that my team managed to solve a challenge I felt happy and motivated.	
	Seeing progress of other teams on leadership board motivated me to concentrate more on gamified activity.	46,2% Strongly agree 30,8% Agree 23,1% Disagree
	Seeing progress of my team on leadership board gave us a positive emotion.	46,2% Strongly agree 38,5% Agree 15,4% Disagree
	I liked that in each partial evaluation of course there was a gamified activity.	46,2% Strongly agree 46,2% Agree 7,7% Disagree
Social	My team was motivated to move faster at each level when I saw progress board in gamified activities most of time.	53,8% Agree

(*continued*)

Table 2. (*continued*)

Dimension	Question	Percentages
		30,8% Strongly agree 15,4% Disagree
	Gamified activities based on challenges are better when they are developed as a team than individually.	53,8% Strongly agree 30,8% Agree 15,4% Disagree
	My participation would have been better in gamified activity if I had been touched by other teammates.	61,5% Disagree 15,4% Strongly agree 15,4% Agree 7,7% Strongly disagree

Notes for Gamifiers

Intervention of gamification proposal in classroom offered necessary motivation to students to achieve challenges, however, it should be strengthened with previous programming exercises in order to ensure that student is ready for challenge; to achieve above, forums can be created in Moodle platform that allow a collaborative work in addition to previous theoretical study, you can design similar challenges that students can repeat several times to learn from mistakes.

Badges can be disseminated to other cognitive or attitudinal skills within same course.

Creativity of teacher is very important to be able to create challenges that are interesting for student, that is to say, you must understand what are dynamics that your students play. Finally, this didactic proposal can be applied to other subjects, however it is recommended to take care of design and level of difficulty of challenges.

Acknowledgement. This work has been done within the PhD program Knowledge Society of the University of Salamanca, Spain.

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