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Effect of Gamification on the Motivation of Computer Programming Students

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Abstract

Aim/Purpose	The purpose of this research is to examine the effect of computer-assisted gamification on the learning motivation of computer programming students.
Background	The teaching-learning of computer programming involves challenges that imply using learning environments in which the student is actively involved. Gamification is an innovative approach that allows the creation of environments using game-related elements in order to increase the levels of participation, engagement, and motivation of the participants. Several studies have integrated gamification in academic contexts, where generally the qualitative results show remarkable effects in different aspects analyzed; however, there is still no consensus on the quantitative results presented in different investigations. For this reason, it is necessary to conduct more empirical studies in computer programming learning environments to better understand the impact of gamification on aspects such as students' motivation to learn.
Methodology	A quasi-experimental mixed explanatory study was designed and carried out in which a gamified tool was integrated into the methodology of an Introduction to computer programming course. Through a literature review and a comparative analysis, we selected CodeGym as the computer-assisted gamified environment suitable for integration into the activities of the course. Subsequently, we proposed an educational intervention where the instruments were applied to characterize the motivational construct by means of the self-report questionnaire MSLQ-Colombia and a survey of student opinion. The

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MSLQ-Colombia questionnaire characterizes distinctive features of students' motivation to learn. This instrument was adapted and validated to Spanish based on the original MSLQ (Motivated Strategies for Learning Questionnaire). Forty-eight students participated in this study, distributed in two control groups and one experimental group selected by means of a non-probabilistic convenience sampling technique.

Contribution: The effects reported through this research provide empirical evidence related to the effect of computer-assisted gamification on students' motivation to learn. The results contribute to understanding the effects that gamification can generate in the motivation of computer programming students.

Findings: The quantitative results obtained through the MSLQ-Colombia showed that the students in the experimental group significantly increased the levels related to the motivational aspects of Task Valuation. The results obtained by the survey (quantitative and qualitative data) confirmed the quantitative effect found and, additionally, generated inputs related to other motivational aspects: the participants expressed that due to the development of the practical exercises proposed with CodeGym, they felt authentic desires to learn (Orientation of the study activities towards Intrinsic Goals), greater self-confidence to approach the learning tasks (Beliefs of Control of Learning), and better expectations to achieve their learning goals in the subject (Expectations of Self-Efficacy in Learning).

Recommendations for Practitioners: The computer-assisted gamification generated a good reception by the students of computer programming, making the teaching-learning process pleasant and favoring the interest towards the topics generally considered as challenging. It is recommended that teachers in the area of computer programming continue adopting and using gamified tools that support and facilitate the appropriation of knowledge of their students in a dynamic and innovative way.

Recommendations for Researchers: The empirical results reported in this study allow a better understanding of the real effects that gamification can have on programming students' motivation to learn. However, there are still great challenges in trying to understand and generalize these findings. It would be interesting to deepen the results obtained by integrating gamification in environments where there are more participants and longitudinal studies where the impact is analyzed over time.

Impact on Society: The results of this research showed that computer-assisted gamification generated a significant increase in the ratings related to the interest, importance, or liking towards the topics proposed in the subject of computer programming. Additionally, the participants felt authentic desires to learn (Orientation of the study activities towards Intrinsic Goals), greater self-confidence to approach the learning tasks (Beliefs of Control of Learning), and better expectations to achieve their learning goals in the subject (Expectations of Self-Efficacy in Learning). All mentioned contribute to the understanding of the real effects related to gamification in computer programming because in this way teachers and students can appropriate these methodologies in an informed way.

Future Research: It would be interesting to be able to replicate the intervention carried out in this study in longitudinal research that would allow us to know the effects of gamification over a long period of time. It is also necessary to understand, through more experimental or quasi-experimental studies, the effects of computer-assisted gamification on other aspects such as academic performance, learning, active participation of students, among others.

Keywords gamification, computer programming, computer-assisted gamified environments, learning motivation

INTRODUCTION

Currently, the area of computer programming is fundamental to the technological development of computer science and the information technology (IT) industry. This situation makes the demand for trained personnel in this area increase in order to generate progress and economic innovation (Popat & Starkey, 2019); therefore, computer programming courses in the academy are essential. In these courses, each student is required to appropriate concepts, transform the proposed problems into certain steps, and be able to code the solution to the problems by making use of a programming language (Martins et al., 2018). However, it has been found that this teaching-learning process of computer programming is challenging due to the difficulties in appropriating its concepts, and acquiring and mastering necessary skills during the formative process (S. Azmi et al., 2017). For example, students may evidence demotivation, frustration, and feelings of failure as they feel disappointed for not being able to understand the topics, increasing dropout and avoidance rates (Martins et al., 2018; Talingdan & Llanda, 2019).

Several authors have mentioned the importance of didactic tools, teaching strategies, and learning environments used in these courses due to the influence that these can generate in the perceptions of difficulty related to computer programming (Amro & Romli, 2019; Piteira et al., 2017). For example, some researchers have found that game-based learning environments provide significant benefits because they help to enhance students' motivation for learning, participation, and engagement (de Pontes et al., 2019; Sprint & Cook, 2015; Talingdan & Llanda, 2019). These types of teaching approaches, as well as their effects, are especially important in courses that require a high level of cognitive engagement such as computer programming (Ubaidullah et al., 2019). Gamification has been conceived as a game-related methodology that implements interesting, fun, and exciting mechanisms with the aim of increasing aspects related to participation, motivation, and engagement of the individuals using it (Olsson & Mozelius, 2015).

Given the above, several studies have focused their attention on integrating gamification in the learning process of computer programming. The research by de Pontes et al. (2019) investigates the effect that gamification generates in the participation of students in an introductory computer programming course. This study evidenced that badges, personal records, and leaderboards positively influence students' motivation and participation. This perception is in line with the effects found by Hoshang et al. (2018), where a link was found between the integration of gamification and the ease it generates in the understanding of the proposed topics. The students surveyed perceived that methods based on technology and game-related elements motivate them to learn and improve individual performance and productivity. However, there are other studies in which the integration of gamification has not evidenced effects on motivation, such as the case of Ortiz-Rojas et al. (2017), who analyzed the impact of gamification on intrinsic motivation and self-efficacy based solely on the implementation of the element of badges; they concluded that there was no representative effect on the aspects analyzed. For such reason, there are authors who suggest conducting more empirical studies in computer programming learning environments in order to better understand the impact of gamification on different aspects such as engagement, motivation, academic performance, among others (Çubukçu et al., 2017; Kaila et al., 2018; Piteira & Costa, 2017).

Accordingly, this research proposes to address the following research question: What is the effect of a gamified computer-assisted learning environment on the learning motivation of computer programming students? To answer this research question, we designed a quasi-experimental mixed explanatory study in which a gamified environment was selected and integrated into a computer programming course. The selected gamified environment was CodeGym© (HiTech Rush Inc, 2015).

The organization of this paper is as follows: the second section presents the conceptual framework; the third section presents the design of the study; the fourth section presents the results of the study; the fifth section discusses the results; and finally, the sixth section concludes this work and gives recommendations for future work.

CONCEPTUAL FRAMEWORK

BACKGROUND

Motivation in learning

Motivation can be defined as a tendency and intention that drives an individual's behavior towards the achievement of goals (Gopalan et al., 2020). Motivation to learn corresponds to non-cognitive components that influence students' learning and is related to psychological mechanisms that allow people to engage and persist in certain behaviors during their learning processes (Fincher & Robins, 2019). From this point of view, for example, learning is influenced by students' self-efficacy expectations, fear, and stress (Gopalan et al., 2020). It is important to emphasize that motivation is not interpreted as an individual entity but as a set of patterns related to affective determinants of behaviors, including personal goals, desires, and beliefs. According to the theory of self-regulation in learning (Pintrich & de Groot, 1990), the elements that constitute the construct of motivation in learning are: (i) the valuation of the task, which can be understood as the levels of importance, usefulness, pleasure or interest that the student attributes to the activities that he/she carries out in order to learn a subject; (ii) the orientation of his/her learning tasks towards intrinsic goals, that is, towards true desires to learn; (iii) the orientation towards extrinsic goals when studying for reasons external to the fact of learning; (iv) the expectations of self-efficacy in learning that are manifested through self-judgments about the confidence and abilities to achieve the purpose of learning; (v) self-efficacy expectations in performance, demonstrated by thoughts about the ability and confidence to succeed in the assessment process; (vi) control beliefs in learning that indicate the degree to which the student considers that his or her learning depends on his or her own control and individual effort and not on external factors; and finally, (vii) anxiety in the assessment process that indicates the degree of concern or nervousness that the student feels when facing assessments (Pintrich & de Groot, 1990).

In some studies, it has been shown that a high level of motivation in learning allows the student to remain focused on their learning processes and the achievement of their goals. For this reason, motivation in programming courses is affected by the belief that learning programming requires hard work. For example, higher motivation has been associated with students who have prior knowledge of computer programming with respect to novice students who are easily discouraged when they do not understand programming-related topics (N. A. Azmi et al., 2018).

Game-based learning

Game-based learning is a technique through which teachers can generate learning environments that seek to motivate students, keep their attention during the development of a course, and allow students to actively participate in order to achieve meaningful learning (Montero Herrera, 2017). Likewise, the game is a tool to relate to others, promoting self-knowledge, responsibility, determination, and self-realization of the student. In the teaching-learning process of computer programming, faced with the challenges in this area, game-based strategies have also been adopted to promote a higher level of engagement, participation, motivation, and encouragement that allows students to achieve their learning goals and reduce failure and avoidance of tasks (Piteira & Costa, 2017).

Game-based strategies that are prominent today include game-inspired design, gamification, serious games, and video games or digital games (Darejeh & Salim, 2016; Lindberg et al., 2018; Shahdatunnaim et al., 2015). Although these strategies are related to each other, they also have characteristics that differentiate them. For further illustration in this regard, readers can refer to Darejeh and Salim

(2016), where serious games for educational purposes and non-recreational environments oriented to simulate real-world situations are revised. Likewise, Sousa Borges et al. (2014) inquired about video games or digital games, defining them as systems in which users solve conflicts or challenges based on predetermined rules, generating emotional reactions due to the interactivity and comments that the game offers to the user. Finally, Khaleel et al. (2017) define the concept of gamification as the use of game design elements in non-game contexts to engage people, motivate action, promote learning, and solve problems. Among the above strategies, gamification stands out because it has been widely implemented in academic contexts (Khaleel et al., 2017; Shute et al., 2021; Sousa Borges et al., 2014).

Gamification in learning

Gamification in learning is conceived as an approach that uses mechanics, elements, and techniques of game design in non-game contexts (Carreño et al., 2018; Lindberg et al., 2018; Sousa Borges et al., 2014). Gamification in learning mediates student engagement and motivation to action so that they can learn and can solve problems (Khaleel et al., 2017; Sousa Borges et al., 2014). The integration of gamification in programming courses has been seen as an opportunity to maximize student engagement and positively impact learning by making use of interest, excitement, and fun mechanisms that lead to an increase in the level of student engagement and motivation (S. Azmi et al., 2017; de Pontes et al., 2019; Lindberg et al., 2018). In the study by Shahdatunnaim et al. (2015), the authors categorized gamification activities in courses related to computer programming, as follows: gamifying the learning activity, gamifying the social activity, and gamifying the assessment activity. In this same study, the authors considered the inclusion of these approaches as an effective solution to increase participation, attendance, feedback, improved performance, and skill development of students. Likewise, Thongmak (2017) conducted a study using a card game to gamify the evaluation activity in the first programming course, generating an impact on the decrease in anxiety levels of students. Another clear example of the success of gamification in the classroom is the one presented by Carreño et al. (2018) who proposed to present to students fragments of algorithms that they had to develop through the use of cards; in this way, students improved the ability to acquire knowledge and their motivation to face difficult problems.

Computer-Aided Gamified Learning Environment Selection

In the development of this research, several gamified environments were identified in order to perform a comparative analysis and select the ideal tool to be incorporated in an introductory computer programming course. Initially, a literature review allowed the identification of different gamified tools for the teaching-learning of computer programming, and a description of each of them was made with their characteristics and objectives according to the purpose of each gamified learning environment. Subsequently, we constructed a comparative matrix to contrast the identified gamified environments, as shown in Table 1. Criteria consider several aspects such as the type of platform of the environment (mobile or web), the programming languages supported, which game-related elements were implemented, and which activities outside the classroom were supported by the learning environment.

Table 1. Comparative matrix of gamified environments for computer programming

Name	Type	Programming Languages	Gamified Elements	Activities outside the classroom
SoloLearn	Mobile and web	Python, C++, Java, JavaScript, C#, PHP, Swift, Ruby, jQuery C, HTML, CSS, SQL	Points, Trophies, Levels, Peer Competition, Social Interaction Areas, Leaderboards, and Badges	Discussion Forums
CheckiO	Web	Python and JavaScript	Levels, Challenges, Leaderboards, Social Interaction Areas, Points	Blogs and forums
CodinGame	Web	Java, Python, JavaScript, Swift, Ruby, Rust, C#, C++, C, and Groovy	Challenges, Leaderboards, Social Interaction, Points, Missions, and Awards	Blogs and forums

Name	Type	Programming Languages	Gamified Elements	Activities outside the classroom
ViLLE	Mobile and web	Various	Unlimited number of attempts, Visual hints, and Tutorials for initial skill development	Blogs and forums
Stack Overflow	Web	Various	Performance Statistics, Badges, Experience Points, Help from other participants, and Communication Channels	
EasyLogic	Web	Javascript and Graphic Blocks	Points, Trophies, Unlimited attempts, Visual hints, and Feedback hints	
Funprog	Web	Code blocks and surveys	Learning Levels, Awards, Points, Game Restrictions, Leaderboards, and Score Reporting	Discussion Forums
Code Combat	Web	Python, JavaScript, HTML and CSS	Levels, Avatars, Virtual Worlds, Points, Challenges, Multiple Attempts, Leaderboards, Clans, Badges, Missions, Rewards, Progress, Coins, Customization, Social Area, and Rankings	Discussion Forums
CodeGym	Web	Java	Challenges, Game Restrictions, Ways to Earn or Lose Points, Characters, Narrative Scenarios, Unlimited Attempts, Badges, Teams, Performance Stats, Leaderboards, Social Interaction Areas, Levels, and Access to Locked Content	Job Search, Discussion Forums and Related Article Blogs
CodeHS	Web	Java, Javascript, HTML, Python, CSS, SQL, Karel, and React	Points, Badges, Progress Bars, and Levels	Lesson Plans, Problem Guides, Solution Guides, and Interactive Exercises without programming
Codecademy	Web	Java, Python, PHP, JavaScript, Ruby, HTML, CSS, C# and C++	Badges or medals for completing exercises, Record user's total score, Leaderboards, and Points	Discussion forums, Glossary by course
Code Avengers	Web	Python, Javascript, and HTML	Videos, Badges, Points, Levels, Leaderboards, and Interactive Games	Learning materials and lesson plans

Finally, we carried out a comparative analysis to select the tool that suited the needs and purposes for the development of this research. This selection was made considering aspects such as the number of gamified elements of educational environments integrated into each of the identified tools (Peixoto & Silva, 2015). CodeGym was one of the tools that integrated more gamified elements classified as essential in educational environments. Specifically, it integrates 11 primary elements listed by Peixoto and Silva (2015) among which are: challenges, reward system, sense of competition, increasing difficulty, achievements, overcoming, evolution, interaction, results, progress, and achievement of goals. Another criterion considered for the selection of the gamified environment was used in the study of Amro and Romli (2019), where it is important to consider the programming language to be used; for such reason, we determined to select only the tools that made use of Python or Java as the base language to perform the practical exercises. Additionally, Amro and Romli (2019) refer to being able to use the tool on different platforms and the availability of different techniques used for teaching programming. In this criterion, it is worth highlighting CodeGym due to the fact that it implements a technique based on the theoretical introduction to the topics related to computer programming along with practical exercises ranging from fundamental to advanced levels. It is not necessary for participants to have previous knowledge because the tool teaches from the basics of computer programming. This criterion was fundamental because, as mentioned by Astudillo et al. (2016), the selected gamified tool should represent significant support and complement in the development of the methodology of the class. From the comparative analysis, we concluded that CodeGym was the most suitable gamified environment for the implementation and integration within the methodology of the computer programming course.

CodeGym

CodeGym is a gamified platform developed by the company HiTech Rush Inc. in 2015 that allows teaching programming through the Java language (HiTech Rush Inc, 2015). Participants can register on the platform and start with learning from basic to advanced topics. This platform presents its content organized into missions. Each mission is composed of different levels that the participant overcomes as he/she solves the proposed lessons. CodeGym makes a theoretical introduction to the topics related to computer programming and then presents a series of practical exercises to apply and consolidate the theoretical concepts. CodeGym presents the contents through a narrative adapted to an outer space context, involving the participant directly with the characters. During practical exercises the tool monitors the performance of the students; this allows to assign "dark matter" or points that can be used to unlock the next levels, and the participant earns achievements, medals, among others. Figure 1 shows a screenshot of CodeGym that is displayed to the participant when he/she completes a practical exercise, showing the number of attempts made, the average number of attempts, and the "dark matter" obtained.

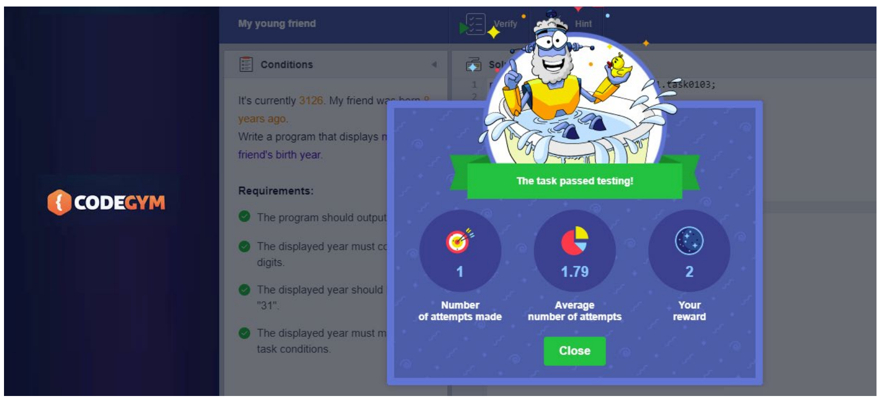

Figure 1. Screenshot of a problem solved in CodeGym

The tool allows users to monitor their individual statistics, their progress, and the progress of other participants. In addition, the tool has spaces in which participants can interact and support each other in a collaborative way. The user can make unlimited attempts for each practical exercise proposed, and, due to the concept of training-based teaching, 80% of the activities proposed in the gamified environment are practical. Table 2 describes each gamified element integrated in CodeGym.

Table 2. Gamified elements integrated in CodeGym

Element	Description
Challenges	Challenges that CodeGym proposes through practical exercises where the participant must apply the concepts learned.
Game restrictions	Limitations or restrictions imposed by the game, either for the acquisition or loss of points or unlocking of higher levels.
Ways to earn or lose points	Each participant can earn points by solving as many of the proposed practical exercises as he/she can, and points are spent as he/she unlocks lessons or higher levels.
Characters	Characters immersed in an outside world to actively involve the participant.
Narrative scenarios	Narrative scenarios carry a common thread in which the story of the extraterrestrial characters is told.
Unlimited attempts	The user is free to make mistakes, there is no penalty for sending incorrect answers.
Badges	Badges are insignias that characterize the performance of each user.
Teams	Users can belong to teams or groups, where they can interact and view the progress of each participant.
Performance stats	Statistics that provide evidence of each participant's performance, including achievements, badges and points earned.

Element	Description
Leaderboards	It allows to visualize the performance of each of the participants, either in their team or at a general level, encouraging competitiveness.
Social interaction areas	Participants can interact with their peers in the different forums or wikis where they can revise interesting information and/or clarify doubts related to the proposed challenges.
Levels	The content proposed by CodeGym is approached through levels, as the participant solves the different challenges proposed, overcomes lessons, and moves up to higher levels.
Access to locked content	Accessing or unlocking restricted content by solving previous challenges and redeeming earned points.

STUDY DESIGN

The research design in this study corresponds to a mixed sequential explanatory design, considering as independent variable the educational intervention generated from the computer-assisted gamified learning environment and, as dependent variable, the learning motivation of the students participating in the gamified learning environment. The participants in this study were not organized by random assignment, but the groups of the course were maintained; consequently, it was not possible to guarantee an initial equivalence of the groups in the dependent variable. Therefore, this is a quasi-experimental study. The analysis and interpretation of results were carried out taking into account this situation and in accordance with recommendations for this type of study (Fontes et al., 2010).

This design had an experimental group that integrated gamification into the class activities and two control groups that carried out the traditional classroom activities. Before and after the intervention, the self-report questionnaire MSLQ-Colombia (Ramirez-Echeverry et al., 2016) was used to characterize the learning motivation of students in the three groups. The MSLQ-Colombia is a statistically validated adaptation of the MSLQ (Pintrich & de Groot, 1990) for engineering students in Colombia, a study conducted by Ramírez-Echeverry et al. (2016), where the original MSLQ was translated into Spanish, and the necessary linguistic and cultural adaptations were made to obtain a valid instrument. The MSLQ-Colombia domain allows characterizing motivation at the subject level; that is, each item of the questionnaire asks the student about his or her motivation to learn the topics addressed in the subject, in this case, the motivation to learn the topics of computer programming. Thus, at the end of the study, it was possible to analyze whether the students in the experimental group and the students in the control groups modified aspects of their motivation to learn the topics of the computer programming subject. Additionally, students in the experimental group were asked to fill out an opinion survey with Likert-type questions and open-ended questions in order to identify whether the possible changes in their motivation to learn the topics of computer programming were due to participation in the gamified learning environment generated with CodeGym.

PARTICIPANTS

A total of 48 students of the course Introduction to Computer Programming participated in the experiment. This subject is of a theoretical-practical nature and has 3 academic credits. The control groups consisted of a group of 16 Industrial Engineering students (33.3% of the sample) of which 7 were women and 9 men between the ages of 20 and 28, and another control group of 15 Mechanical Engineering students (31.2% of the sample) of which 5 were women and 10 men aged between 18 and 25. The experimental group included 17 Systems Engineering students (35.5% of the sample), all of them male, aged between 18 and 20 years. The participants in this study did so voluntarily and according to the willingness of the guiding teachers to participate in the experiment. According to this situation, it can be indicated that the sampling of this study corresponds to a non-probabilistic convenience sampling technique.

Integration of the Gamified Environment

Considering the thematic contents of the subject, five levels of CodeGym were selected to be integrated into the methodology of the experimental group's class:

Level 0: Introduction.

Level 1: Introduction to Java - output, int, and String types.

Level 2: Introduction to Java, variables, methods.

Level 3: Your first program: keyboard input, working in the IDE.

Level 4: Introduction to branches and loops.

We selected these CodeGym levels because of their direct relationship with the thematic contents of the subject of the experimental group and because they cover the four initial competences proposed by the curriculum: to allow the student to interact with contents related to the initial approach to computer programming, concepts related to data types, functions and procedures in software programming, conditional structures, and loops. Table 3 shows the association between the modules of the gamified environment and the topics of the curriculum.

Table 3. Association between modules of the gamified environment and the topics of the curriculum

COMPETENCES	CONTENTS OF THE SUBJECT	CodeGym LEVELS
Fundamentals of computer programming.	Approach to computer programming.	Level 0: Introduction.
Fundamentals of computer programming.	Approach to computer programming and data types.	Level 1: Introduction to Java - output, int, and String types.
Understanding the concept of function, its use and application in problem-solving.	Functions and procedures in software programming.	Level 2: Introduction to Java, variables, methods.
Fundamentals of computer programming.	Introduction to the IDE.	Level 3: Your first program: keyboard input, working in the IDE.
Understanding of a structure that allows you to establish multiple conditions.	Simple and complex conditional structures.	Level 4: Introduction to branches and loops.
Combination of structures: basic loops, complex loops, and variable assignment.	Use of conditional structures and combination with loops.	Level 4: Introduction to branches and loops.

This table shows the correspondence between the learning objectives and topics of the course Introduction to computer programming and the levels proposed by CodeGym. It is also worth mentioning that the organization of the CodeGym lessons and modules in these levels follows a similar structure to the one established by the syllabus.

Methodology

Figure 2 presents a detailed diagram of the study methodology; it shows 5 phases and 9 stages for carrying out the quasi-experiment. Phase I "Initial Diagnosis" established the Pre-Test as stage 1 in which the students of the control and experimental groups did the initial filling out of the MSLQ-Colombia. This first characterization of motivation in learning the subject was carried out in the same week to all participants and constitutes one of the sources of quantitative data of this study. Next, phases II ("Formative" phase) and phase III ("Feedback" phase) correspond to the work sessions of the students and teachers. These sessions were held weekly, both face-to-face and non-face-to-face (extra-class work), and covered from stage 2 to stage 6. Stage 2 consisted of a theoretical introduction related to the topics proposed by the curriculum, followed by practice in CodeGym (stage 3) using the gamified elements described in Table 2 together with the clarifications and interactions between the teacher and students about the CodeGym modules (stage 4). Stages 3 and 4 were only carried out by the students in the experimental group. In stage 5, practical assignments were proposed for both the experimental group and the control group students. While the students of the experimental group carried out the practices in CodeGym, the students of the control groups solved practical exercises in the development environment (without gamification), at the same time that polls and clarifications of the topics seen in the practical assignments were established (stage 6). Phases II and III were repeated weekly for 8 weeks in both groups. In the experimental group, 50% of the sessions integrated the gamified CodeGym environment into the classroom activities. In phase IV "Final Diagnosis", two stages were established: in stage 7 or "Post-Test" all the participants of this study filled out the MSLQ-Colombia for the second time, and in stage 8 the students of the experimental group answered an opinion survey. In this survey, the students specifically expressed, through a Likert scale and by means of open text, what modifications the participation in the gamified learning environment using CodeGym produced in their motivation to learn the subject matter of the course. With the quantitative and qualitative data collected from this survey, we sought to explain and expand the meaning of the quantitative data obtained with the MSLQ-Colombia on the learning motivation of the students in the experimental group. Finally, in phase V the "Data Analysis" was done in which the quantitative and qualitative data collected were analyzed and interpreted with the objective of studying the possible effects of the gamified learning environment on the motivation levels of the computer programming students.

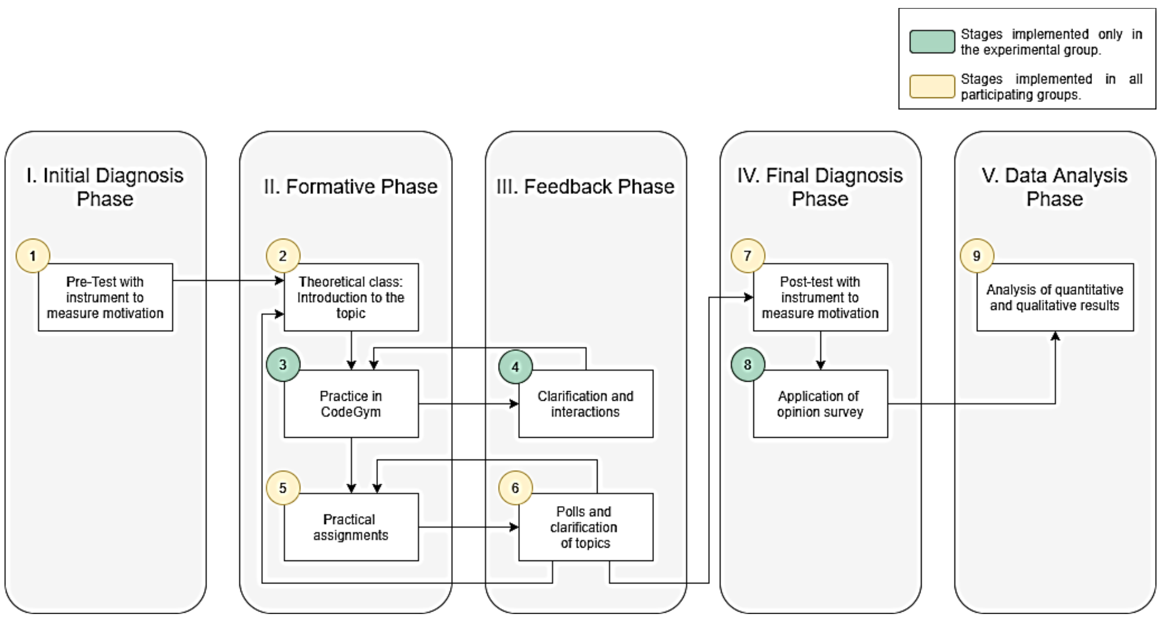

Figure 2. Study design methodology

INSTRUMENTS

Motivation in learning

One of the instruments used to characterize the dependent variable of this study, learning motivation, was the Motivated Strategies for Learning Questionnaire - Colombia (MSLQ - Colombia). The MSLQ - Colombia is an adaptation and validation in Spanish of the Motivated Strategies for Learning Questionnaire, MSLQ (Pintrich & de Groot, 1990) with students in Colombian engineering programs. This self-report questionnaire presents a set of items that allow characterizing aspects related to motivation and learning strategies used by students during the development of a subject. In this study, only the set of items of the subscale on learning motivation of the MSLQ- Colombia was used because of its direct relationship with the research question and object of investigation. The learning motivation subscale of the MSLQ-Colombia establishes 7 aspects related to the construct of learning motivation. Each aspect has a certain number of items or statements proposed by the questionnaire. The aspects related to learning motivation described by Ramirez-Echeverry et al. (2016) are task valuation, intrinsic goal orientation, intrinsic goal orientation, self-efficacy expectations in learning, self-efficacy expectations in performance, beliefs about learning control, and anxiety in evaluation processes.

In the first filling out of the questionnaire, the informed consent and confidentiality agreement were presented in which the student indicated whether or not he/she agreed to participate freely and voluntarily in the research. Subsequently, the items of the MSLQ-Colombia questionnaire were addressed, in which the student evaluated each statement, and as he/she considered that it applied to his/her reality, he/she selected one of the 7 options of the Likert scale: (1) Does not describe me at all; (2) Does not describe me; (3) Slightly does not describe me; (4) Neither does it describe me nor does it not describe me; (5) Slightly describes me; (6) It describes me; and (7) Totally describes me. For more information, a Google Forms with the MSLQ-Colombia instrument used to collect data related to learning motivation is available at the following link: https://forms.gle/9xAC5Ktsn8AvGRdG8.

Students' opinions

In order to find additional data to explain and expand the meaning of the quantitative data obtained with the MSLQ-Colombia on the learning motivation of the students who participated in the gamified learning environment, we designed a survey with 16 questions. In this survey, the students of the experimental group gave their opinions about the effects that their participation in the gamified learning environment had on their motivation to learn. The quantitative and qualitative data from this survey were collected one week after the last activity the students did with CodeGym. The survey initially stated the purpose of the survey and the confidentiality of the data collected, along with personal data questions to relate these responses to the quantitative data collected with the MSLQ-Colombia. The first 14 questions related to learning motivation: 7 questions with Likert- type answers (1 - Strongly Disagree; 2 - Disagree; 3 - Somewhat Disagree; 4 - Somewhat Agree; 5 - Agree; 6 - Strongly Agree) and 7 questions with open-ended answers justifying the choice of each of the Likert-type questions. Finally, the last 2 questions of the survey are open-ended and inquire about the general perception that students had in relation to the use of CodeGym, and in general, to the use of gamification in the course. Table 4 presents the survey.

Table 4. Survey of students' opinions about the effects on their learning motivation due to their participation in the gamified learning environment

Number	Item	Response Type
1	My work in this subject using CodeGym allowed me to discover the importance or taste for the topics of the computer programming subject.	Likert
2	Why did you select the previous answer?	Open
3	I feel that the use of CodeGym in the computer programming subject provided me with challenges that awakened in me a genuine desire to learn how to program.	Likert
4	Why did you select the previous answer?	Open
5	Using CodeGym in the computer programming course was helpful in achieving my most important goal: getting good grades in the course.	Likert
6	Why did you select the previous answer?	Open
7	Using CodeGym in the computer programming course increased my confidence in understanding the more difficult concepts and topics taught in this course.	Likert
8	Why did you select the previous answer?	Open
9	Using CodeGym in computer programming increased my confidence in getting good grades.	Likert
10	Why did you select the previous answer?	Open
11	I believe that the use of CodeGym helped me to understand that the level of understanding of the topics of this subject depends on my effort.	Likert

Number	Item	Response Type
12	Why did you select the previous answer?	Open
13	Using CodeGym in this subject helped me to have more confidence to control the worry and anxiety I feel when I take midterms examinations.	Likert
14	Why did you select the previous answer?	Open
15	What is your general perception about the use of CodeGym in the methodology of the Introduction to computer programming class?	Open
16	Regarding gamification in learning, what is your perception about the use of game elements such as badges, points, levels, rewards, leaderboards, among others, within the methodology of the Introduction to computer programming class?	Open

Data Analysis

Motivation in learning

To analyze the data collected with MSLQ-Colombia, a statistical test was selected to show whether or not there was a significant change in the motivational aspects studied. In this research, the hypotheses considered the integration of the gamified environment in the classroom methodology as an independent variable, and the effect generated on students' motivation to learn as a dependent variable. Thus, we posed the following null hypothesis:

> H_0: Computer-assisted gamification has no effect on students' motivation to learn the subject matter of computer programming.

Therefore, the alternative hypothesis corresponds to:

> H_1: The computer-assisted gamification generates an effect on the motivation of students to learn the subjects of the subject of computer programming.

The Wilcoxon statistical test is a nonparametric test applied quite successfully in the behavioral sciences (Siegel & Castellan, 1998). The significance level ($\propto$) is set to determine whether the result of the statistical test provides a probability of occurrence associated with the H0 less than or equal to the probability set as $\propto$. Generally, this probability possesses a value of 0.05 or 0.01 (Siegel & Castellan, 1998). If the particular value provided by the statistical test is less than or equal to $\propto$, the null hypothesis H0 is rejected. In this study, the selected significance level was 0.05, which is the standard for measuring whether differences are significant in educational research (Coolican, 1997).

Students' opinions

The analysis of the quantitative data collected with the survey was done through descriptive statistics, specifically, with a bar chart indicating the number of people who selected each of the options on the Likert scale. The analysis of the qualitative data collected with the survey was done through thematic analysis, starting with open coding and then axial coding that allowed the identification of implicit and explicit categories and themes about the learning motivation of the participants in the gamified learning environment. This qualitative analysis allowed the data to be divided into labeled components for the purpose of identification and thus potential theoretical meaning (Bryman, 2012). These labeled components allowed the data to be separated, compiled, and organized, which were examined and treated through indicators, categories, and themes based on the identification of motivational behavioral actions. In the open coding, each of the responses obtained was analyzed and grouped according to indicators. These indicators, in turn, were grouped into categories according to the affinity and relationship between them. Finally, themes were constructed with the identified categories that allowed us to establish a general conception of the opinions of the participants about the effects on their motivation to learn due to the use of the gamified learning environment with CodeGym. It should be noted that some students' opinions grouped fragments classified into several indicators because it was common for the student to mention different aspects in the same opinion.

RESULTS

MOTIVATION IN LEARNING

The motivation of the students in the learning of the topics of the course was analyzed by means of the Pre-Test and Post-Test applying the self-report instrument MSLQ-Colombia in each of the selected groups. The objective was to analyze if there was a significant change in any of the motivational aspects in each of the groups.

Table 5 presents the results obtained in the Pre-Test and Post-Test from the MSLQ-Colombia in each of the participating groups. The results compiled in the table showed the different behaviors presented during the experiment. For each of the motivational aspects, the table includes the average results obtained in the Pre-Test and Post-Test, the difference between these averages, the standard deviation of the data, and finally, the p-value generated by the Wilcoxon test, which indicated whether the change generated was significant or not.

Table 5. Results obtained in the Pre-Test and Post-Test from the MSLQ-Colombia

Motivational aspect	Group Type	Group	Pre-test Average	Post-test Average	Difference	Pre-test Standard Deviation	Post-test Standard Deviation	Wilcoxon p-value
Task valuation	Experimental	Systems Eng.	6.29	6.66	0.37	0.72	0.41	**0.02***
	Control	Industrial Eng.	5.33	4.33	-1.00	1.22	1.23	0.79
		Mechanical Eng.	5.22	5.20	-0.02	1.14	1.16	0.87
Intrinsic goal orientation	Experimental	Systems Eng.	5.76	5.68	-0.08	0.72	0.65	0.69
	Control	Industrial Eng.	5.41	4.91	-0.50	0.98	0.86	0.08
		Mechanical Eng.	4.97	4.82	-0.15	1.07	0.99	0.65
Extrinsic goal orientation	Experimental	Systems Eng.	5.11	5.31	0.20	1.42	1.35	0.54
	Control	Industrial Eng.	5.62	4.92	-0.70	1.05	1.11	**0.03 ***
		Mechanical Eng.	5.81	5.68	-0.13	0.71	1.12	0.50
Self-efficacy expectations in learning	Experimental	Systems Eng.	5.79	5.91	0.12	1.00	0.84	0.62
	Control	Industrial Eng.	5.51	5.47	-0.04	1.35	0.72	0.32
		Mechanical Eng.	5.10	5.05	-0.05	0.97	1.47	0.79
Self-efficacy expectations in performance	Experimental	Systems Eng.	5.98	6.21	0.23	1.09	0.70	0.33
	Control	Industrial Eng.	6.25	6.05	-0.20	0.74	0.58	0.27
		Mechanical Eng.	5.76	5.66	-0.10	0.49	0.71	0.59
Beliefs about learning control	Experimental	Systems Eng.	5.97	6.05	0.08	0.85	0.95	0.41
	Control	Industrial Eng.	6.09	6.06	-0.03	0.68	0.81	0.86
		Mechanical Eng.	5.60	5.4	-0.20	0.92	1.01	0.67
Anxiety in evaluation processes	Experimental	Systems Eng.	3.96	4.38	0.42	1.00	1.56	0.35
	Control	Industrial Eng.	3.47	3.81	0.34	1.48	1.52	0.33
		Mechanical Eng.	4.50	4.92	0.42	1.21	1.06	0.34

* *p-value < 0.05: Statistically significant result.*

In general, the results obtained in the Pre-Test showed that in the first 6 motivational aspects students generally identified with the highest ratings on the Likert scale. That is, the students' levels of learning motivation corresponded to the statements that described them from slightly to completely. In subscale 7, related to anxiety in the evaluative processes, it was found that the responses were divided between feeling identified with high levels of anxiety or concern in the evaluative processes and not feeling described or slightly identified with feelings of anxiety in front of exams or evaluative processes.

With respect to the Post-test, in the experimental group of Systems Engineering, there was a significant statistical difference in the subscale related to the assessment made by the students to the learning tasks proposed in the subject. That is to say, the students who participated in the gamified learning environment increased their evaluations regarding the usefulness they see in being able to apply what they learned in other areas, the importance of appropriating the related concepts, and the interest or liking of the topics addressed in the subject. In this motivational aspect, the Wilcoxon test found an increase between the Pre-Test and Post-Test with statistical significance (p-value: 0.027), that is, it is sufficiently improbable that the variations exposed in this subscale are due to chance factors. In the Pre-Test, 100% of the answers given by the students were positive evaluations, that is, all the answers were located in the Likert options in which the students felt slightly to completely identified with an average of 6.29 (standard deviation: 0.72). In the Post-Test it was evident that 100% of the responses were located in the two most positive Likert options with an average of 6.66 (difference of 0.37 with respect to the Pre-Test). The standard deviation of the data in this measurement was 0.41, indicating that they present a low dispersion.

Regarding the other motivational aspects, no significant effects were found between the Pre-Test and Post-Test. The p-values generated by the Wilcoxon test indicate that it is likely that the differences in the other aspects might be due to chance effects.

Results obtained in the control group of Industrial Engineering showed a significant difference only in the subscale related to extrinsic goal orientation. The results show that in the Post-test there was a significant decrease in the valuation that students gave to goals other than the true desire to learn during their study processes in the subject of computer programming such as grades, scholarships, social recognition, or, in general, causes other than the desire to learn. In the Pre-Test it was evidenced that this aspect presented an average valuation of 5.62 (standard deviation: 1.05), which could indicate that the students felt highly identified with being involved in the process of learning as a means and not as an end. A 93.75% of the responses were positive, demonstrating the importance students placed on factors external to the act of learning. On the other hand, the data collected in the Post-Test presented an average of 4.92 (standard deviation: 1.11), which indicates that the evaluations made by the students decreased in comparison to the Pre-Test. In the Post-Test compared to the Pre-Test, the ratings of the neutral or negative scales increased by 25% indicating that the students with the passage of time may have decreased their interest in achieving purposes other than learning. The p-value of the Wilcoxon test in this subscale (0.030), suggests that there was a real significant difference between the Pre-Test and Post-Test in relation to the evaluations linked to the extrinsic goal orientations of the students of the control group of Industrial Engineering. With respect to the other motivational aspects, the null hypothesis could not be rejected from the results; that is, during the time of the experiment the students of the Industrial Engineering group did not present significant variations in the other motivational aspects studied.

Finally, in the control group of Mechanical Engineering, the results of the MSLQ-Colombia in the Post-Test presented a similar behavior to those found in the Pre-Test. The data collected in the Mechanical Engineering control group did not show significant differences in any of the motivational aspects. The Wilcoxon test established that none of the variations presented was statistically significant.

Students' Opinions

The students' opinions collected from the survey applied only to the experimental group at the end of the educational intervention. The objective was to collect data to obtain a more detailed perspective about the effects that participation in the gamified learning environment could have on the motivation to learn the topics of computer programming. The 7 questions in the student opinion survey (see Table 4) that had a Likert scale response provided quantitative data related to the same motivational aspects evaluated with the MSLQ-Colombia, but this time, they specifically asked if participation in the gamified learning environment had produced any effect on their motivation to learn. Figure 3 relates each of the questions and the number and percentage of associated responses according to the Likert scale option presented.

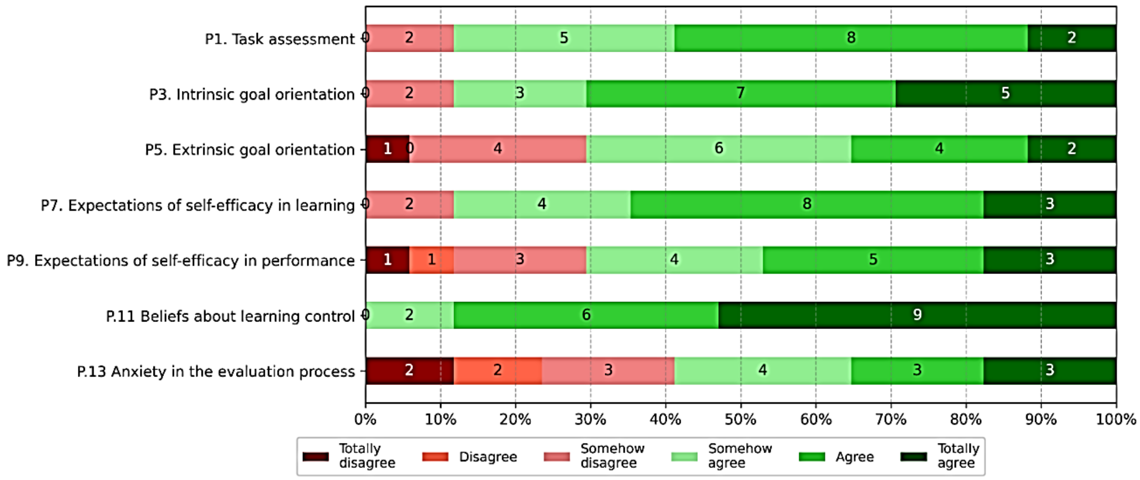

Figure 3. Quantitative results obtained in the opinion survey

Regarding the first 6 motivational aspects, there were responses oriented towards being slightly to completely identified with the statements presented in the survey (see Table 4). In general, students recognized the favorable impact of the gamified learning environment generated with CodeGym on their motivation to learn. Specifically, it stands out that 100% of the students considered that the use of CodeGym helped them to recognize that the level of understanding of the subject matter of the course depended on their effort; that is, to consolidate the idea that the control of their learning depends on themselves and not on external factors. Also, 88% of the students expressed some degree of agreement with the statements related to the motivational aspects of task valuation, intrinsic goal orientation, and self-efficacy expectations in learning, 70% of the students agreed to some degree with the statements related to extrinsic goal orientation and self-efficacy expectations in performance. Finally, in the aspects of anxiety in the evaluation processes, 41% of the students did not feel identified with the opinion that CodeGym allowed them to control their feelings of anxiety and worry about the evaluation processes.

These results allowed us to complement and contrast the information collected with the MSLQ- Colombia. In the experimental group, the only aspect in which significant differences were found between the pre-test and the post-test was the Task Valuation. However, in this opinion survey, it was possible to identify that most of the students who participated in the gamified learning environment with CodeGym recognize that these activities contributed to increasing several aspects of their motivation in learning computer programming, not only the Task Valuation. The aspect of Beliefs of Control of Learning stands out in which 100% of the students gave the use of CodeGym an important role in improving these beliefs. Additionally, students indicated that the activities in the gamified learning environment allowed them to increase their Task Valuation, their learning orientation towards Intrinsic Goals, and their Expectations for Self-Efficacy in Learning. On the other hand, almost half of the participants indicated that CodeGym did not help them in the management of Anxiety towards the evaluation processes in the subject.

In addition to the quantitative data from this opinion survey, the qualitative data obtained from the open-ended questions were analyzed. Students gave their opinions about the use of CodeGym and the integration of gamification in course activities. After giving structure to these qualitative data from their analysis, we identified two general themes: Motivation in learning and Gamification.

Theme: Motivation in learning

This theme arose based on the opinions given by the students of the experimental group (exclusively) directly related to aspects of their motivation in learning. Table 6 presents this thematic with the categories obtained, some textual examples of the opinions given by the students, and the count with the number of opinions grouped in each category. In general, Table 6 shows that all aspects of learning motivation were commented on, some to a greater extent than others. This result, initially, indicates that the participants found that CodeGym contributed to varying degrees to increase their motivation in learning computer programming.

Table 6. Theme: Motivation in learning

Category	Description	Example of opinions	Number of opinions
Task valuation	Opinions of the students who participated in the gamified learning environment that indicate the importance, usefulness, liking and interest attributed to the tasks or topics proposed in the subject of computer programming.	"...thanks to CodeGym I learned about topics that caught my attention and the importance of them". "...CodeGym made me see the importance of the themes and increased my taste for them somewhat."	24
Intrinsic goal orientation	Students' opinions that the learning environment allowed them to make learning or becoming an expert in the subject matter their main objective in their study tasks, no matter how challenging or difficult the subjects were.	"...the exercises posed problems I didn't think I'd have, and they awakened real desires to learn their code and how to complete it, as well as ending my difficulties."	24
Beliefs about learning control	Opinions where it is evident that the learning environment allowed students to be more aware that the level of learning of the subjects of the course depended on themselves, their individual effort and the time of dedication in the tasks and activities of the area.	"...Codegym is a very useful help to understand programming topics, however, it all depends on the time and effort the student puts into it."	14
Anxiety in evaluation processes	Responses from students who participated in the gamified learning environment that alluded to concerns about the assessment processes in the subject.	"...Even with Codegym, in midterms I tend to worry quite a bit when I encounter a challenging problem, which often causes me to block, and in turn I end up giving up when it comes time to take the test." "...The greater the mastery of a subject, the less anxiety or worry experienced when taking a midterm".	13
Self-efficacy expectations in learning	Opinions of the participants in the gamified learning environment related to the increase of their sense of confidence to acquire new learning and increasing their security in the capacity of understanding the proposed topics.	"Codegym increased my confidence and ease in learning...".	11
Self-efficacy expectations in performance	Opinions associated with the confidence of being successful in the evaluative process of the subject due to the constant practice in the gamified learning environment.	"... it increased my confidence to have better grades. Because it gave me confidence in many subjects, and that makes that, with every exercise, I could do it without any problem."	7
Extrinsic goal orientation	Opinions oriented to perform the activities in the gamified learning environment with the aim of obtaining good grades.	"because it motivated me to learn more and get good grades."	4

One of the categories that had more indicators refers to the valuation of the task, it is worth remembering that in the data collected with the MSLQ-Colombia this was the only motivational aspect that had a significant positive difference between the post-test and the pre-test in the experimental group. The open opinions of the students indicate that the use of CodeGym helped them to identify the importance of the topics of the course as well as to increase their enjoyment of learning these topics.

Additionally, Intrinsic Goal Orientation and Control Beliefs in Learning were categories widely commented on by participants. For example, students noted that the programming problems posed in CodeGym made them really want to learn and finish the task. They also noted that because of the CodeGym activities they were able to recognize that their learning depends to a large extent on the positive results in the quantitative data of this survey (see Figure 3).

Finally, it is worth noting that the qualitative results of this survey regarding the motivational aspect of Anxiety were not in the same direction: some students indicated that they felt more confident in while for other students it was not enough because they continued to present high levels of anxiety distribution of the quantitative data presented for this aspect in Figure 3 in which 59% of the opinions were favorable while the remaining 41% were not.

Theme: Gamification in learning

In this thematic, the categories and indicators were grouped with the opinions about the integration of the computer-assisted gamification learning environment in the course. Table 7 presents this thematic with the categories obtained, some textual examples of the opinions given by the students, and the count of the number of opinions grouped in each category. The categories grouped in this thematic can be considered as emergent given that they do not have a direct relationship with the research question addressed in this study. It stands out that the students considered that CodeGym became a tool that complemented the class activities because it helped them to understand the topics, strengthened their computer programming skills through practice, offered them feedback on the programming problems they were trying to solve, generated a playful learning environment that encouraged their interest in the class activities (innovations in the class methods) and expectations regarding the possibility of finding this same type of environment in future subjects in order to take advantage of the benefits of gamification. Additionally, students indicated that it is convenient to generate in gamified environments a principle of healthy competition that leads to taking advantage of these environments in terms of learning and not as an end to create rankings among students based on the performance they achieve in the game activities.

Table 7. Theme: Gamification in learning

Category	Description	Example of opinions	Number of opinions
Tool as a complement	Opinions that indicated that the gamified learning environment was an important complement to reinforce the knowledge acquired and strengthen the concepts presented in the oral explanations by the teacher. CodeGym was conceived as a good complement to feedback the activities seen in class and to learn.	"Because with the CodeGym tool I was able to reinforce even more the knowledge I have on the subject of programming, it also helped me to fill or feedback my classes."	55
Aspects to improve and recommendations	Suggestions related to gamification, recommendations to consider a healthy competition and in some cases express their neutral position against the use of game elements in class.	"It is a useful tool and very well structured to learn new concepts. I think the problem is the accumulation of exercises along with the main ones in the class."	20
Innovations in classroom educational methods	Opinions that highlighted that the learning environment offered them the possibility of obtaining a recreational and playful learning in the acquisition of new knowledge, making the classes not a monotonous process, but on the contrary, it was perceived as a good initiative, dynamic and entertaining through the integration of elements of the game in class.	"Because, as many people emphasize, it's like a game. It's a good complement to the typical programming classes that universities teach; it's dynamic and entertaining, it tries to teach the subjects in a simpler way".	17
Advantages of gamification	Responses related to the good acceptance of using game elements in class because it generated interest and incentive in students during the learning process. Additionally, it was mentioned the interest in continuing with the use of gamified tools even in subsequent courses, due to the good acceptance that CodeGym had.	"It's a good initiative, it makes the classes not monotonous. More tools like this should be implemented. The more there are, the more interest they will awaken in the students."	12

DISCUSSION

In order to answer the research question "What is the effect of a computer-assisted gamified learning environment on the motivation of computer programming students?" and based on the results obtained, it became observable that the integration of computer-assisted gamification, through the use of CodeGym within the class activities, had a differentiated effect on the learning motivation of the participants of this study:

Task Valuation was the motivational aspect for which the greatest amount of evidence was found with a positive increase. The quantitative data collected with the MSLQ-Colombia (Pre-test and Post-test) and with the opinion survey, as well as the opinions in the open-ended questions reflect that the participants in this study found that the gamified learning environment helped them to significantly increase their attributions given to the importance, usefulness, liking or interest in the subject matter. Specifically, students indicated that the activities carried out through CodeGym were the cause of the increase in this motivational aspect.

Secondly, the participants expressed quantitatively and qualitatively that due to the development of the practical exercises proposed with CodeGym they felt authentic desires to learn (Orientation of the study activities towards Intrinsic Goals), greater self-confidence to approach the learning tasks (Beliefs of Control of Learning) and better expectations to achieve their learning goals in the subject (Expectations of Self-Efficacy in Learning). The students stated that the exercises presented in this gamified learning environment were challenging and provided them with additional elements to those given in the lectures. These characteristics of the exercises aroused their interest in the topics, led them to study on their own the topics they did not know, even if they were difficult, and allowed them to better understand the subject matter.

On the other hand, with respect to anxiety in the evaluation processes, it is worth mentioning that the students participating in the gamified learning environment indicated different points of view through the survey. Some of the students indicated that CodeGym allowed them to feel calmer to solve the exams and to feel less worried about the different evaluation processes. However, there were also students who indicated that the use of CodeGym did not help them reduce their anxiety levels when taking exams. This situation is similar to that found in studies such as Johnson et al. (2016), in which it is indicated that gamification can have positive effects on the stress and anxiety of the participants; however, they emphasized that it is not clear to what extent the gamified elements fit in contexts of anxiety in the evaluation processes.

In addition to the previous results, another point that is important to highlight was the high level of motivation to learn computer programming topics that the students had at the beginning of the course. These high motivational levels were indicated by the students (control and experimental groups) in the quantitative results of the Pre-test with the MSLQ-Colombia. This result would be showing that before starting the course the students are aware of the importance of computer programming for their professional training, they consider that they could obtain good results in their learning and evaluation processes, they were aware that learning would depend on their own effort and they considered that the course would be useful to learn the topics and to obtain good academic performance. The reasons for this high degree of motivation to learn computer programming are consistent with (Ortiz-Rojas et al., 2017) when they show that at the beginning of an introductory programming course, motivation levels tend to be high.

Another important result has to do with the significant decrease in the evaluations made by the students of one of the control groups in the motivational subscale of orientation towards Extrinsic Goals or factors external to the fact of learning. This significant difference between the Pre-test and Post-test of the MSLQ-Colombia, in this motivational aspect for the students of this control group, is not possible to explain from the design of the research carried out in this work. However, this result allows inferring that as time went by, the students of this group lost interest in getting involved in the study tasks due to objectives such as obtaining high grades, obtaining scholarships, achieving social recognition, among others.

Another aspect worth highlighting is the similarity found between the results of this study and those found in the study by Ortiz-Rojas et al. (2017). In both studies, from the analysis of quantitative data, no significant effects were found in students' orientation towards Intrinsic Motivation in learning after participating in a gamified learning environment. However, despite the fact of agreeing in not finding quantitatively significant effects, both works did find a high number of opinions (qualitative data) related to the increase of their motivation towards setting Intrinsic Goals to the real desire to learn thanks to the activities carried out in the gamified learning environment. Likewise, in the research of Facey-Shaw et al. (2019) in which an implementation of learning activities was done by awarding badges the qualitative results indicated that thanks to such incentive (badges) students were motivated to engage in the subject tasks with the aim of learning the subjects (Intrinsic Goals) and not for extrinsic objectives to the fact of learning. According to the above, results show that students participating in gamified learning environments can be influenced in the appropriation of true desires to learn; however, empirical research is still needed to provide a greater external validity to confirm this result, as mentioned by Prieto Andreu (2020). Finally, another important result in this study has to do with the theme and emerging categories found from the qualitative data: Gamification in Learning. Two important results are worth discussing in this theme:

- A considerable amount of the students' opinions has to do with a perception of the gamified tool as a complement during their learning process. Students indicated that the use of CodeGym allowed them to practice what they had seen in class, receive feedback on their level of learning thanks to the exercises proposed by the tool and reinforce the subject matter through practice. The study by Agapito and Rodrigo (2018) obtained opinions along the same lines, in which it was found that for each practical exercise posed in the gamified environment, participants could obtain immediate feedback, allowing them to demonstrate whether their answer was correct or incorrect, generating greater interest in the student to solve the exercises and improve their scores.
- Another representative category in this thematic relates to students' appreciations that perceived gamification as an innovative teaching strategy in their formative process. Students were pleased to find game activities in their learning processes in the subject and found in CodeGym a playful and recreational learning process, positively influencing the perceived attitudes and the intention to use the gamified environment. In this same sense, Aguiar-Castillo et al. (2020) affirm that the use of novel and innovative methodologies provides new forms of interaction between teachers and students, encouraging the active participation of the different actors in the learning process.

CONCLUSIONS

This research addressed the integration of the gamified environment of CodeGym in the activities of the Introduction to computer programming class with the purpose of analyzing the effects that a gamified learning environment generates in the motivation of students to learn.

The design of the proposed study, through the quantitative and qualitative data obtained with the MSLQ-Colombia and the opinion survey, allowed us to find inputs to answer the research question posed in this paper: What is the effect of a gamified computer-assisted learning environment on the motivation of computer programming students? The students participating in the gamified learning environment presented an increase, with statistical significance, in their evaluations given to the learning activities proposed in the subject. Specifically, the participants indicated that their valuation about the importance, usefulness, liking, or interest towards the topics of computer programming increased thanks to the activities that they developed in the gamified tool. Additionally, participants indicated through quantitative and qualitative data responses that their Intrinsic Motivation to learn, their Expectations of Self-Efficacy in Learning, and their Beliefs of Control in Learning also increased thanks to the practical computer programming exercises they performed in the gamified learning environment. Additionally, students considered that the CodeGym tool complemented their learning process in the subject because the learning environment generated with this tool was innovative and interesting thanks to the use of game elements in class (playful environment) and because it allowed them to achieve higher levels of understanding of the topics. The data collected in this research allowed contrasting and complementing the findings found in previous studies in which participants in computer programming learning activities carried out in gamified learning environments increased some aspects of their learning motivation. The results provide empirical evidence to better understand the effects that gamification can have on the learning motivation of computer programming students.

On the other hand, some limitations of this research are pointed out: firstly, the sample size was small. This situation, due to the convenience sampling used, generates limitations in the external validity of the study. Also, the participants in this research belonged to only one educational institution, so it is advisable to carry out the same study with participants from different universities in order to explore the possible influences of the institutional context on the findings presented in this research.

As future work, it is necessary to understand, through more experimental or quasi-experimental studies, the effects of computer-assisted gamification on other aspects such as academic performance, participation, learning, among others. In addition, it would be interesting to replicate the intervention carried out in this study in longitudinal research that would allow us to know the effects of gamification over a prolonged period of time. Finally, the sample size could be expanded and the intervention could be carried out in different scenarios to deepen the understanding of the effects generated by computer-assisted gamification in the teaching-learning process of computer programming.

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