Gamification-based strategy for developing computational thinking as a 21st-century skill focused on university students

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Abstract: In 21st-century education, the development of computational thinking (CT) has become established as a fundamental skill, while gamification is emerging as a pedagogical strategy to increase student motivation. However, teaching CT concepts to university students often faces challenges related to low motivation and the perception of high difficulty. Therefore, the objective of this study was to implement and validate the acceptance of a gamification-based teaching strategy to facilitate CT learning in engineering students. To this end, a quantitative methodology was employed through a pilot test with first-semester students, using a Likert scale questionnaire to assess perceptions of the usability, efficiency, and overall satisfaction with the developed platform. The main results revealed a largely positive acceptance of the tool, with high ratings for ease of use, clarity of

information, and overall satisfaction, indicating that the design was successful and did not present any learning barriers. The main conclusion is that the gamification strategy, embodied in the platform, is a viable and motivating pedagogical resource that generates a satisfactory user experience, laying the foundations for its future implementation in the formal teaching of computational thinking..
Keywords: *Computational thinking, gamification, skills, 21st century, university students*

Introduction

Computational Thinking (CT) has become established as one of the essential skills of the 21st century, fostering abilities such as problem decomposition, algorithm design, and logical reasoning. These skills are fundamental not only in the technological field but also in multiple disciplines, enabling the structured and efficient approach to complex challenges. In an increasingly technology-driven environment, promoting these skills from an early age is crucial to preparing new generations for the demands of the future (Aravena & Rojas, 2023).

Various international studies have shown that computer use can be effectively enhanced through playful, interactive, and student-centered approaches (Dahlström, 2021). In Latin America, and particularly in Colombia, programs such as "Computers for Education" and "Programming for Children" have been implemented, demonstrating the government's interest in incorporating digital skills into the early levels of the education system. However, significant challenges remain, especially regarding teacher training, technological resources, and the adoption of active learning methodologies (García-Holgado & García-Peñalvo, 2021).

In response to this need, the present research proposed to implement a gamification-based strategy that allows the development of PC as a 21st-century skill focused on university students.

The strategy was approached from two complementary perspectives: the development of the gamified educational platform aimed at strengthening PC using an agile software development methodology and the evaluation of its impact through a quantitative research methodology with a descriptive scope by applying a pilot test with first-year university students of the Systems Engineering program of a higher education institution in Medellín, Colombia.

Four phases were carried out: the identification of existing pedagogical strategies, the definition of a set of activities that would be integrated into the platform, the design of the gamified platform and, finally, its validation through a pilot test.

From this final phase, the main conclusion is that the developed platform is a robust, intuitive tool with high student acceptance. The pilot test results conclusively demonstrate that the user-centered design was successful, eliminating learning barriers and generating a satisfactory user experience.

In this context, the present article is structured in the following sections: materials and methods, results, discussion, conclusions and future work, and finally, bibliographic references.

2. Materials and methods

For the development of this study, the strategy was approached from two complementary perspectives that allowed both the construction of the technological solution and the evaluation of its impact. On the one hand, a gamified educational platform was designed and developed to strengthen computational thinking using an agile methodology. On the other hand, a quantitative research methodology with a descriptive scope was implemented to analyze the effects of the platform on students and measure its level of acceptance and usability. Each of these perspectives is described below.

Agile software development methodology

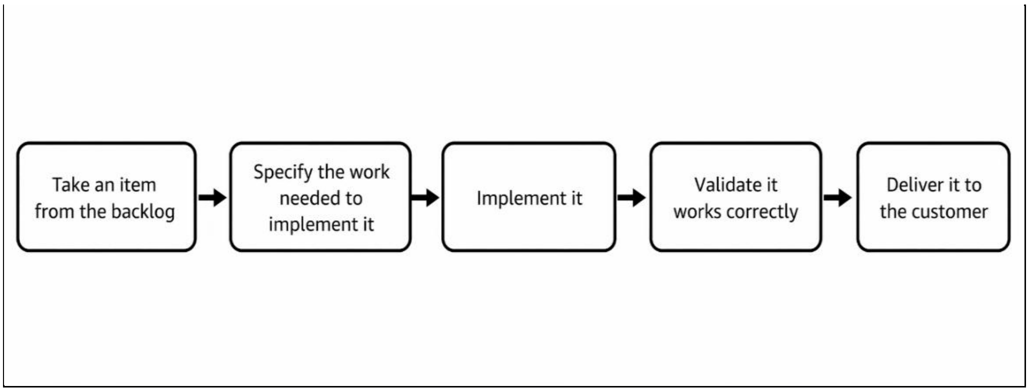
An agile software development methodology is an iterative approach to project management that uses an incremental approach to software specification, development, and delivery. It aims to deliver working versions of the software to the client quickly through iterations. Each iteration completes the phases of the software development life cycle: Analysis, Design, Development, Testing, and Deployment (Sommerville, 2011). These phases are described below:

- Analysis: This involves gathering requirements from stakeholders to create a specification document outlining the software requirements.
- Design: In this phase, the requirements are analyzed and the best solutions are identified to meet them and create the software. It is necessary to define the user experience, the system architecture, and the overall technical decisions.
- Development: This is the phase where the software product is coded by developing small tasks that are performed daily in order to achieve the final product.
- Testing: This involves analyzing the quality of the software. Automated and manual tests can be implemented to detect errors and verify compliance with customer requirements.
- Deployment: Each tested and functional version of the software is deployed in a production environment so that it can be used by the end user.

For this study, the Kanban agile software development methodology has been proposed. Kanban provides a simple approach to delivering high-quality value to the client, on time and within budget (Sommerville, 2011). It uses a board to visualize the team's work and track the workflow. This board is composed of columns, and each task is placed on a sticky note so it can be moved between them (Hammarberg & Sunden, 2014).

To move items within the Kanban board, the team follows a workflow that consists of the following steps:

Figure 1Work flow of the Kanban team (Brechner, 2015)



Kanban is based on 3 simple principles: 1. visualize, 2. limit work in progress and 3. manage flow (Hammarberg & Sunden, 2014), so the work board and the flow presented are very relevant when implementing this methodology.

Quantitative research methodology with a descriptive scope

This research employs a quantitative approach, which uses data collection to establish patterns of behavior and test theories. A quantitative study can have different scopes. For this study, a descriptive scope has been proposed, which seeks to specify important properties and characteristics of the phenomenon being analyzed, (Hernández Sampieri et al., 2014)which in this case would be the strengthening of computational thinking through the implementation of a gamified educational platform

Participants

To describe the phenomenon under study, information was collected through a pilot test with first-semester university students in the Systems Engineering program at a private higher education institution in Medellín. The pilot test consisted of the students using the platform and subsequently evaluating its usability through an instrument designed to analyze its relevance and effectiveness.

Tools

For data collection, an evaluation instrument was designed to measure the platform's usability, based on questionnaires available in Gary Perlman's usability evaluation repository (2016). The instrument consisted of structured items that allowed for the assessment of aspects related to ease of use, efficiency, convenience, and overall satisfaction. It was administered after the platform had been used, in order to obtain valid and reliable data on the tool's relevance and effectiveness in the analyzed educational context.

Table 1. Usability Survey

Section	No.	Item / Question	Response Type
Overall satisfaction	1	Overall, I'm satisfied with how easy this system is to use.	Likert scale 1–7
	18	Overall, I am satisfied with this system.	Likert scale 1–7
System utility	2	This system was easy to use.	Likert scale 1–7
	3	I can complete my work effectively using this system.	Likert scale 1–7
	4	I can complete my work quickly using this system.	Likert scale 1–7
	5	I can complete my work efficiently using this system.	Likert scale 1–7
	6	I feel comfortable using this system.	
	7	It was easy to learn how to use this system.	Likert scale 1–7
Quality of information	8	The system gives error messages that clearly tell me how to solve the problems.	Likert scale 1–7
	9	Whenever I make a mistake using	Likert scale 1–7

		the system, I recover easily and quickly.	
	10	The information (such as online help, on-screen messages, and other documentation) provided with this system is clear.	Likert scale 1–7
	11	It's easy to find the information I need.	Likert scale 1–7
	12	The information provided by the system is easy to understand.	Likert scale 1–7
	13	The information is effective in helping me complete tasks and scenarios.	Likert scale 1–7
	14	The organization of information on the system screens is clear.	Likert scale 1–7
Interface quality	15	The interface of this system is pleasant.	Likert scale 1–7
	16	I like using this system's interface.	Likert scale 1–7
	17	This system has all the functions and capabilities I expect it to have.	Likert scale 1–7
Qualitative assessment of the system	19	List the most negative aspects	Open question
	20	List the most positive aspects	Open question

3. Results

The following presents the results obtained in each phase of the development life cycle of the gamified educational platform , which are part of the agile methodology used for its construction.

Analysis

In this phase, the functional and non-functional requirements of the application were defined according to the project objectives.

Table Table 2Functional Requirementsand characteristics that the application must fulfill to ensure its correct operation.

Table 2. Functional Requirements

1.1 User Management	RF01: The system must allow registration and login of students and teachers. RF02: The teacher must be able to manage groups (create, edit, delete) and view student results. RF03: Students should be able to update their profile (name, profile picture, etc.).

1.2 Gamification	RF04: Students should be able to gain experience (XP) by completing challenges. RF05: The system should have different levels that students can reach by accumulating XP. RF06: Each challenge must have a degree of difficulty (easy, medium, difficult). RF07: Students must earn points by completing challenges. RF08: The system must assign badges to students based on their progress and achievements. RF09: There must be an individual ranking based on points and levels.
1.3 Challenge Management	RF10: Each challenge must have a description, difficulty level, points awarded, and XP. RF11: Students should be able to visualize the available challenges. RF12: Challenges must allow three types of responses: Multiple choice (one or more correct options). True or false. Writing a number as the answer. RF13: Students should be able to submit their responses to the challenges. RF14: The system must automatically validate the challenge responses according to the question type.
1.4 Monitoring and statistics	RF15: The student must be able to view their progress (XP, points, badges, level). RF16: The teacher must be able to see general student statistics.
1.5 Notifications and feedback	RF17: The system must send notifications to students when they level up or earn a badge (Pop Up). RF18: Students should receive feedback on their responses to the challenges.

Non-functional requirements complement the functional requirements by establishing the technical, performance, and quality conditions that the application must meet. Table Table 3these requirements, ensuring that the system is efficient, secure, and reliable in its operation.

Table 3Non-functional requirements

2.1 Usability	RNF-01: The interface should be intuitive and easy to navigate for both students and teachers. RNF-02: The application must provide an engaging experience with gamification visual elements.
2.2. Performance	RNF-03: The system's response to any user action must not exceed 5 seconds. RNF-04: The system must support multiple concurrent users without

	performance degradation.
2.3. Security	RNF-05: User data must be stored securely. RNF-06: Only administrators should be able to modify or delete users. RNF-07: Secure authentication must be implemented (example: JWT or OAuth).
2.4. Availability	RNF-08: The system must be available at least 99% of the time.
2.5. Compatibility and Accessibility	RNF-10: The app must be compatible with modern browsers (Chrome, Firefox, Edge).

Regarding information requirements, these specify the data that the application must handle to ensure its proper functioning. Table Table 4these requirements, organized according to the main entities and their attributes, which guarantees the availability and consistency of information within the system.

Table 4Information Requirements

Entity	Purpose	Attributes
User	Store the fundamental information of all people who interact with the system, allowing their registration, profile management and in differentiation of roles, compliance with **RF01** and **RF03** .	-User_ID Numeric/ (Primary Key, UUID) - Full Name (Text) - Email (Text, Single) -Password (Text) -Role (Enumeration: 'Student', 'Teacher') - URL_ProfilePhoto (Text) - Creation Date (Date/Time) - Update Date (Date/Time)
User	Store the fundamental information of all people who interact with the system, allowing their registration, profile management and differentiation of roles, in compliance with **RF01** and **RF03** .	- User_ID (Primary Key, Numeric/UUID) - Full Name (Text) - Email (Text, Single) - Password (Text) -Role (Enumeration: 'Student', 'Teacher')

		- URL_ProfilePhoto (Text) - Creation Date (Date/Time) - Update Date (Date/Time)
Cluster	Allow teachers to create and manage cohorts or classes of students, as specified in RF02.	- ID_Grupo (Primary Key, Numeric/UUID) - ID_Docente (Foreign Key to User) - GroupName (Text) - Registration Code (Text, Optional, Unique) - Creation Date (Date/Time)
Member Group	Establish the many-to-many relationship between users (students) and groups.	- Student_ID (Foreign Key to User) - Group_ID (Foreign Key to Group) - Union Date (Date/Time)
Student Progress	Store and manage all data related to gamification for each student, allowing tracking of their progress and their position in the ranking, according to RF04, RF05, RF07, RF09 and RF15.	- Student_ID (Primary Key, Foreign Key to User) - XP Points (Numeric) -Level (Numeric) - Ranking Points (Numeric)
Challenge	Define the structure and content of academic challenges, including their difficulty and associated rewards, as described in RF06 and RF10.	- Challenge_ID (Primary Key, Numeric/UUID) -Title (Text) - Description (Long Text) -XP_Points Awarded (Numeric) - Points Awarded (Numeric) - ResponseType (Enumeration: ' SingleMultipleSelection ', ' MultipleSelectionVaria ', ' TrueFalse ', ' Numeric ') - Solution (Text)
Option Response	"multiple choice" challenges, indicating which one(s) are correct, in compliance with RF12.	- ID_Option (Primary Key, Numeric/UUID) - ID_Reto (Foreign Key to Challenge) - TextOption (Text) - IsCorrect (Boolean)
Student Response	Record each attempt by a student to solve a challenge,	- Response_ID (Primary Key, Numeric/UUID)

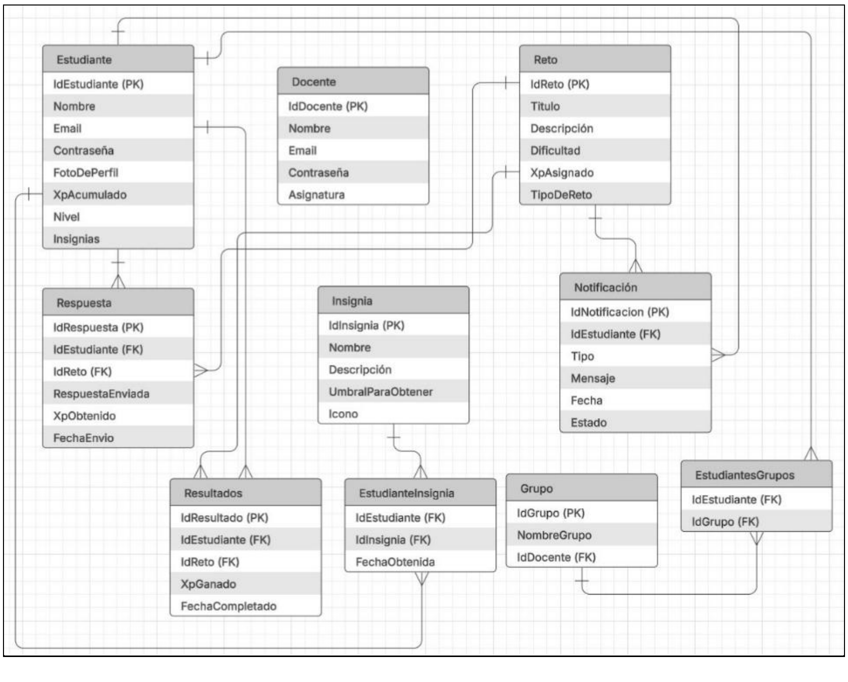
	allowing automatic validation, delivery of feedback and generation of statistics, according to RF13, RF14, RF16 and RF18.	- Student_ID (Foreign Key to User) - ID_Reto (Foreign Key to Challenge) - Response Sent (Text) - ItWasCorrect (Boolean) Submission Date (Date/Time)
Insignia	Define the catalog of badges (achievements) that students can obtain, in accordance with RF08.	- Badge_ID (Primary Key, Numeric/UUID) -Name (Text) - Description (Text) - URL_Icon (Text)
Badge Obtained	Establish the relationship between students and the badges they have earned, fulfilling RF08 and serving as the basis for RF17 notifications.	- Student_ID (Foreign Key to User) - ID_Insignia (Foreign Key to Insignia) - Date Obtained (Date/Time)

Design

In this phase, the defined requirements were analyzed, and the best solutions for addressing them and creating the software were identified. The diagrams defined for the system architecture and the general technical decisions are presented below.

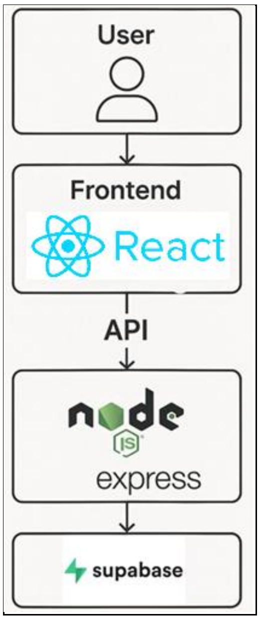
First, Figure 2 Figure 2the class diagram, which statically represents the system structure by showing the classes, their attributes, and the relationships between them, facilitating the understanding of the architecture and expected behavior .

Figure 2Class Diagram



Secondly, Figure 3, a diagram representing the basic system architecture integrating React , Node.js with Express, and Supabase . The diagram presents a layered architecture where the user is the initial point of interaction, accessing the application through the browser and sending requests to the frontend , which manages the graphical interface and presentation logic. The frontend communicates with the API to retrieve and send data to the backend server , which acts as an intermediary between the frontend and the database. Finally, the database stores persistent data and manages authentication, permissions, and storage.

Figure 3Architecture Diagram



A context diagram was developed that presents the relationship between the user and the relationships between the system components, and mockups were also created which show the different screens that make up the user's navigation flow, such as login, registration, profile, game mode selection, levels achieved, and results feedback.

Development

During the project development phase, the team organized activities using the Kanban agile methodology to distribute tasks clearly and visually. The entire coding and version control process was managed through a GitHub repository (Garcés Cabrera et al., 2025), which facilitated collaboration and continuous code integration.

Each team member assumed specific responsibilities based on their strengths, such as interface design, functionality programming, and backend development . In the latter area, the technological architecture was implemented using Supabase to manage the database connection and logic. Once development was complete and validation testing was performed, the platform was deployed on a server.

Evidence

To evaluate the functionality and level of acceptance of the developed system, a pilot test was conducted with first-semester students in the Systems Engineering program at a private university in Medellín. Subsequently, the Likert scale questionnaire described in the Instruments section of the Materials and Methods section was administered to gather user feedback on aspects such as ease of use, efficiency, convenience, and overall satisfaction.

Table 5 presents the results in detail. Additionally, a graph was created showing the average values for each item, in order to facilitate a clearer and more comprehensive visual analysis of the collected information .

This graphical representation made it possible to identify general trends and more easily compare the perception of the participants in the different aspects evaluated.

Table 5. Results of the application of the instrument

No.	**Item / Question**	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Overall, I'm satisfied with how easy this system is to use.										
2	This system was easy to use.										
3	I can complete my work effectively using this system.										
4	I can complete my work quickly using this system.										
5	I can complete										

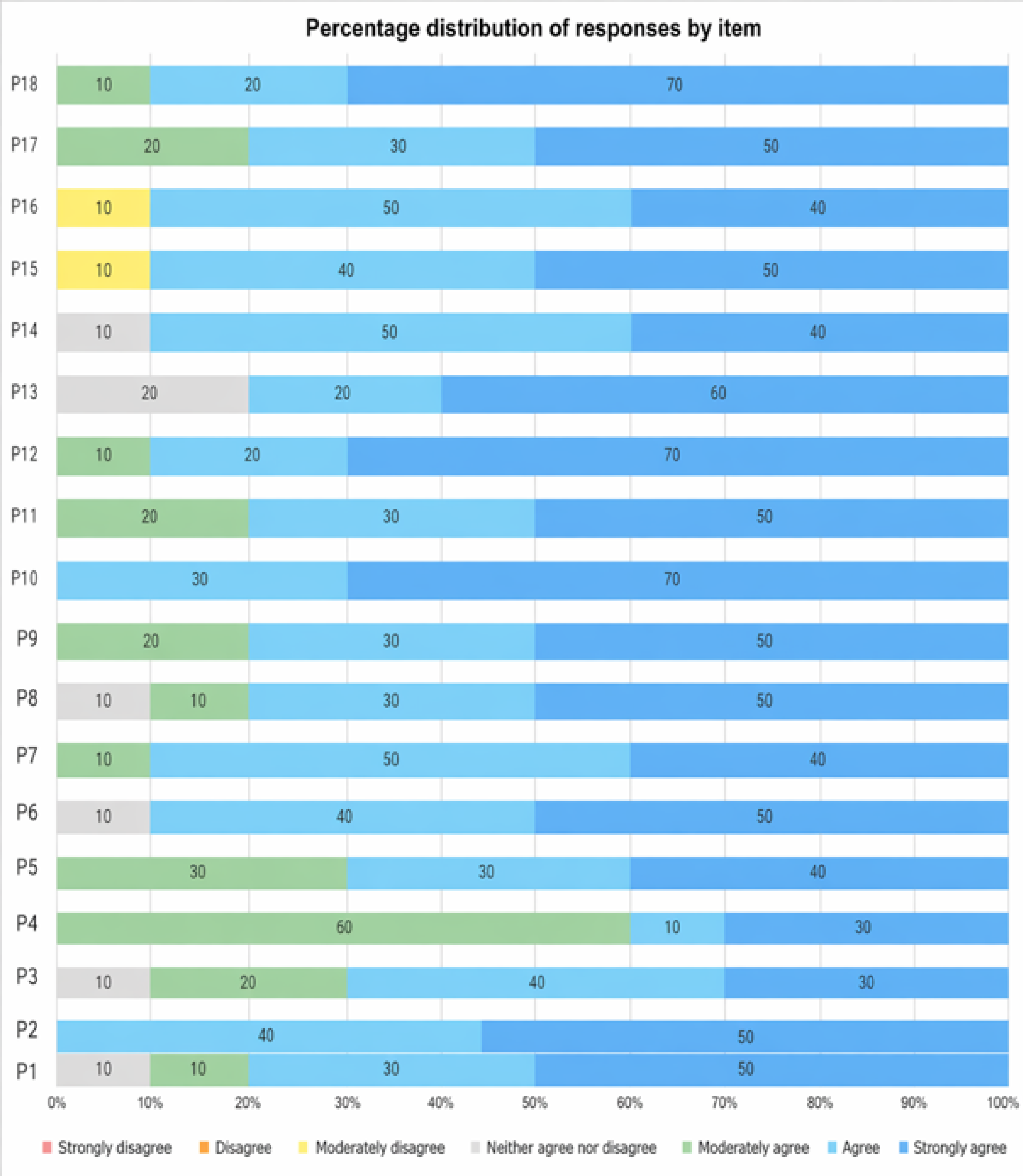
	my work efficiently using this system.										
6	I feel comfortable using this system.										
7	It was easy to learn how to use this system.										
8	The system gives error messages that clearly tell me how to solve the problems.										
9	Whenever I make a mistake using the system, I recover easily and quickly.										
10	The information (such as online help, on-										

	screen messages, and other documentation) provided with this system is clear.										
11	It's easy to find the information I need.										
12	The information provided by the system is easy to understand.										
13	The information is effective in helping me complete tasks and scenarios.										
14	The organization of information on the system screens is										

	clear.									
15	The interface of this system is pleasant.									
16	I like using this system's interface.									
17	This system has all the functions and capabilities I expect it to have.									
18	Overall, I am satisfied with this system.									

Figure 4, where 1 corresponds to strongly disagree and 7 corresponds to strongly agree. The graph shows bars stacked at 100%, allowing observation of the relative composition of each category across the 18 items evaluated.

Figure 4. Stacked bar chart at 100% of the percentage distribution of responses per item



The items related to overall satisfaction show a favorable trend. In question 1, concerning satisfaction with ease of use, 80% of responses are concentrated in the higher levels of the scale (30% agree; 50% strongly agree), with no negative responses recorded. Meanwhile, question 18, corresponding to overall satisfaction with the system, reaches 90% positive responses, positioning it as one of the most consistent indicators of general acceptance. These results reflect a broadly favorable perception of the overall user experience of the system.

The items related to the system's usefulness show a predominantly positive trend, with a high concentration of responses at the higher levels of the scale. Question 2, focused on ease of use, registers 90% of responses in the agree or strongly agree categories, demonstrating a strong perception of operational ease. Consistently, question 3, related to the effectiveness of completing work on the platform, reaches 70% at high levels, although it shows a slight dispersion toward intermediate categories, suggesting opportunities for optimization in the perceived performance.

In question 4, which assesses the system's speed, 60% of participants fall into the "moderately agree" category, while 30% select "strongly agree." Although the overall assessment is positive, the concentration at an intermediate level indicates that the perceived speed could be improved.

Question 5, which assesses system efficiency, shows 70% of responses at the highest levels, complemented by 30% at the moderate agreement level, confirming a favorable evaluation of the system's performance. Meanwhile, question 6, related to ease of use, and question 7, focused on evaluating ease of learning, each achieved 90% positive responses, reinforcing the perception of a comfortable user experience with a low learning curve.

Overall, this dimension reflects a high valuation of perceived usefulness, particularly in terms of ease and learning, with slight opportunities for improvement in speed and effectiveness.

For its part, the information quality dimension consistently shows favorable results, standing out with high percentages at the higher levels of the scale.

Regarding error management, question 8, related to the clarity of error messages, received 80% positive responses, although it showed some dispersion in intermediate categories, suggesting room for improvement in error feedback. Question 9, concerning the ease of recovery from errors, also registered 80% high levels of agreement, indicating an adequate perception of control and recovery.

Regarding the clarity and accessibility of the information, question 10 received 100% positive responses (70% strongly agree), making it one of the strongest results of the evaluation. Similarly, question 12, concerning the comprehensibility of the information, achieved 90% high levels, while question 11, related to the ease of finding information, and question 14, related to the organization of the information, registered 80% and 90% positive responses, respectively.

Finally, question 13, related to the effectiveness of information for completing tasks, shows 80% in higher categories, with 20% at a neutral level, indicating a favorable but slightly less homogeneous assessment.

In general terms, this dimension shows a highly positive perception regarding the clarity, organization, and usefulness of the information provided by the system.

Regarding items related to interface quality, a favorable trend is also observed.

Question 15 concerning the liking of the interface and question 16 concerning the preference for its use each achieve 90% of responses at higher levels of agreement, indicating consistent acceptance.

Question 17, related to the fulfillment of expected functions and capabilities, received 80% of responses in the high categories, along with 20% indicating moderate agreement. While the overall assessment is positive, this result suggests that functional improvements could be incorporated to fully meet the expectations of all users.

Overall, the interface quality dimension confirms a widely favorable perception, both in aesthetic and functional terms.

Regarding qualitative feedback, students valued the platform's clarity and effectiveness, highlighting its ease of use, user-friendliness, and ease of understanding. They also emphasized the challenging nature of the problems as a positive aspect, as it motivates learning and provides a personal challenge. Other mentions included the practicality of completing the activities, the appeal of the badges and awards, and the ease of sharing and collaborating within the environment. These elements contribute to a positive user experience that encourages participants to continue interacting with the platform.

On the other hand, among the negative comments, some students pointed out that the platform can sometimes be slow to load or exhibit minor errors during practice. It was also mentioned that, while the colors are eye-catching, they could be improved to make the interface more attractive and visually appealing. Although several participants stated that they did not find any significant negative aspects, these specific observations offer opportunities for future improvement. Overall, the qualitative feedback indicates that the platform adequately fulfills its objectives, although adjustments could be implemented to optimize the user experience.

4. Discussion

The overall objective of this research was to evaluate the effect of a gamification-mediated teaching strategy on students' motivation and perception of computer science learning. The main results indicate that the intervention was successful, as a statistically significant improvement was found in students' evaluations after using the gamified platform . This finding suggests that the strategy was very well received and had a positive impact on students' attitudinal and motivational dimensions. This is consistent with the literature, where studies such as those by [authors' names] del Olmo-Muñoz et al. (2020)and [authors' names] have shown that Pires et al. (2019)game-based learning sequences have a positive impact on learning and performance. Similarly, research by [authors' names] Kazimoglu et al. (2012)demonstrated that the use of a serious game improves students' confidence and computer science skills, which reinforces the validity of the intervention applied here.

Scopus database .

The second and third objectives, designing and implementing a gamified teaching strategy, were achieved through the use of the “Logix” platform. This tool was selected as the core of the intervention precisely because of its potential to generate an engaging and motivating learning environment, which is one of the main arguments for using gamification in education (Lee, 2019; Zhou & Tsai, 2023). A study by [author's name Kazimoglu et al. (2012)missing], which used this same game, supports this choice, having found that it increases students' intrinsic motivation and confidence in learning to program.

Finally, the fourth objective was achieved through the application of a standardized instrument to evaluate usability, which allowed for the analysis of students' perceptions of the implemented teaching strategy. Statistical analysis confirmed that students' perceptions improved significantly, demonstrating that the gamified strategy was successful in creating a positive and effective learning experience from the student's perspective. This finding is consistent with those of other studies that found a Zhou & Tsai (2023)gamified pedagogical model was perceived positively by students and improved their self-efficacy. Similarly, they reported that their Lampropoulos et al. (2023)gamified application was evaluated as an effective learning tool that enriches the educational process.

The most relevant finding of this research is the positive and statistically significant change in students' perceptions and motivation toward learning computational thinking concepts after the intervention. This indicates that the "Logix" platform was a well-received and successful tool for creating an engaging learning environment. While this study did not directly measure the increase in computational thinking skills, the literature suggests that motivation and self-efficacy are critical precursors to academic success and skill acquisition (Kazimoglu et al., 2012; Lampropoulos et al., 2023).

Therefore, the software's positive reception is not a minor finding, but rather the main evidence that a gamified strategy can create the necessary affective and motivational conditions to make learning computational thinking more accessible and less intimidating for students.

Despite the positive results, it is important to acknowledge the study's limitations. Regarding internal validity, the main limitation is the absence of a control group. As it is a single-group, pre-experimental design , the possibility that the improvement in perceptions is due to other factors, such as the novelty effect of using a new technology (Hawthorne effect) or the students' own maturation, cannot be ruled out. As for external validity, the research was conducted with a convenience sample at a single institution, which limits the generalizability of the findings to other contexts.

Finally, and crucially for the validity of the conclusions, this study did not directly measure the development of computer skills, but rather the perception of and motivation toward learning them. Therefore, it cannot be concluded that students' actual computer skills improved, only that their attitude and disposition toward learning these topics became significantly more positive thanks to the gamified strategy . Future research should include both a control group and a direct assessment of computer skills to triangulate the results and strengthen the conclusions.

5. Conclusions and future work

The overall objective of this study was to implement a gamification-based strategy for developing computer literacy in university students. To achieve this, four phases were carried out: the identification of pedagogical strategies, the definition of a set of activities, the design of the gamified platform , and finally, its validation through a pilot test. Based on this last phase, the main conclusion is that the developed platform is a robust, intuitive tool with high student acceptance. The results of the pilot test clearly demonstrate that the user-centered design was successful, eliminating learning barriers and generating a satisfactory user experience. This is evidenced by the high average ratings obtained in the perception questionnaire (between 5.7 and 6.7 out of 7), where the clarity of the information, ease of use, and overall satisfaction were the most highlighted aspects, thus validating the fulfillment of the fourth specific objective of the research.

The implications of these findings are significant for higher education in engineering and technology. In practice, this project offers a validated model that educators can adopt to introduce abstract computer science concepts in an interactive and motivating way. Positive qualitative feedback, highlighting the value of the challenge and the appeal of the gamification elements, confirms that the strategy is effective in fostering engagement and intrinsic motivation—key factors for deep learning. Theoretically, the study reinforces that the success of gamification depends on careful design that balances challenge, usability, and clear feedback.

Finally, based on the validation performed, future work is proposed. It is recommended to address the identified areas for improvement, such as optimizing loading times and refining the visual interface. The main line of research to pursue is the implementation of the strategy in a formal quasi-experimental study, with pre- and post-test measurements and a control group, to directly measure the impact on the development of computer skills. Additionally, the adaptability of the strategy to other university populations could be explored, and a longitudinal study could be conducted to evaluate the long-term retention of these skills

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