IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed / Refereed journal ⁙ Vol. 11, Issue 10, October 2024

DOI: 10.17148/IARJSET.2024.111018

Computational Thinking through a Multidisciplinary Escape Room with University Students

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Abstract: This paper presents a strategy to foster computational thinking through an unplugged approach with university students at a tutoring fair. Forty-eight students from the bachelor's programs in Software Engineering, Education, Nursing, and Public Accounting participated. The activity, named Multidisciplinary Escape Room, was structured around the four pillars of computational thinking: decomposition, abstraction, pattern recognition, and algorithms. The dynamic also promoted skills such as problem-solving, collaborative work, time management, and logical reasoning in a playful environment. The multidisciplinary approach facilitated the application of computational thinking principles in contexts beyond computer science, demonstrating its transversality. The results indicate that these activities strengthen these competencies and promote skills across multiple disciplines, contributing to the comprehensive development of students..

Keywords: Higher Education, Escape Room, Gamification, Multidisciplinary, Computational Thinking.

I. INTRODUCTION

Currently, computational thinking has been established as an essential competency in higher education, not only in technological disciplines but also across other fields such as social sciences, education, health, and finance, among others (Méndez Hernández and Fernando Bermúdez, 2023; Vásquez Acevedo et al., 2023). However, a persistent challenge is the lack of pedagogical strategies that promote these skills in a practical and interdisciplinary manner for students not exclusively in computer science programs. The absence of these competencies limits the development of key cognitive skills, such as problem-solving, logical reasoning, and critical thinking, which are essential for facing contemporary global challenges.

To address this issue, this study describes the implementation of an escape room as an unplugged pedagogical strategy to strengthen computational thinking among university students from various academic programs. This playful and collaborative methodology aims to facilitate the understanding of the four pillars of computational thinking: decomposition, algorithms, abstraction, and pattern recognition, as well as to promote teamwork, time management, and the application of these competencies in diverse contexts. The Escape Room activity was developed within the framework of Tutoring Week in a multidisciplinary academic unit, aiming to demonstrate how computational thinking can be integrated transversally across different areas of knowledge, thereby contributing to the comprehensive development of students.

II. THEORETICAL FRAMEWORK

Computational thinking (CT) is a fundamental skill in the 21st century, as it enables complex problem-solving in a logical and structured manner. Wing (2006) defines computational thinking as a mental process that involves formulating problems in ways that allow solutions to be executed by a computational agent, whether human or machine. Although it originated in computer science, its application has extended to other fields of knowledge, highlighting its usefulness in education, social sciences, and business (Corrales Álvarez et al., 2024; Sánchez et al., 2023). The four pillars of CT—decomposition, pattern recognition, algorithms, and abstraction—provide essential tools for addressing problems across various contexts, promoting creativity and logical reasoning (Rosas et al., 2017).

Unplugged strategies have proven effective for teaching computational concepts without the use of technological devices, facilitating the integration of CT into diverse educational settings (Iglesias and Bordignon, 2021; Lopez Pinzon and Pineda Paredes, 2022). This accessible, playful methodology fosters active student participation, developing cognitive and social skills through collaborative work. In this regard, escape room activities have gained relevance as educational

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tools (Lathwesen and Belova, 2021), as they combine problem-solving with team-based gameplay dynamics, promoting meaningful learning (Alonso Pobes, 2018; Calderón et al., 2023; Rodellar Suárez, 2023).

In multidisciplinary environments, the integration of computational thinking represents both a challenge and an opportunity, making it essential to foster these competencies not only in computer science fields but also in areas such as education, health, and accounting, where data-driven decision-making and structured problem-solving become essential (Méndez Hernández and Fernando Bermúdez, 2023). This research responds to this need by designing an activity that, through collaborative work and an interdisciplinary approach, demonstrates the transversality of computational thinking across various fields of knowledge.

III. METHODOLOGY

A mixed-method research design was employed, focusing on an escape room as a pedagogical strategy to promote computational thinking (CT) among students from a certain multidisciplinary academic unit with various educational programs.
The activity involved four stations, each presenting a challenge based on one of the four main pillars of computational thinking. Participants were organized into preferably multidisciplinary teams to progress through the stations and solve the challenges, thereby earning the maximum points available at each station. The order of progression through the stations was unrestricted, requiring students to decide how to optimize their problem-solving time.
The invitation to participate was open to the entire university student community, comprising 488 students. However, as the tutoring week, which framed the activity, was held during regular class hours, 48 students registered, forming 12 teams of 4 members enrolled across the four educational programs of the multidisciplinary unit: Software Engineering, Education, Nursing, and Public Accounting. Teams were formed freely, allowing students to select teammates without restrictions, which encouraged integration among different programs, fostering collaboration and interdisciplinary learning.
The registration sheet recorded each team's name and members, as well as their degree program, semester, and start time. Each team received a record key, where points earned from completing each station's challenges were noted, allowing for detailed tracking of participants' performance.
At each station, teams could earn up to four points depending on their performance in the corresponding challenge. An additional point was awarded for each educational program represented within the team, promoting interdisciplinary diversity. Thus, the maximum achievable score was 20 points. Figure 1 presents the design of the key used for the activity, on which teams' progress and results throughout the escape room were recorded.

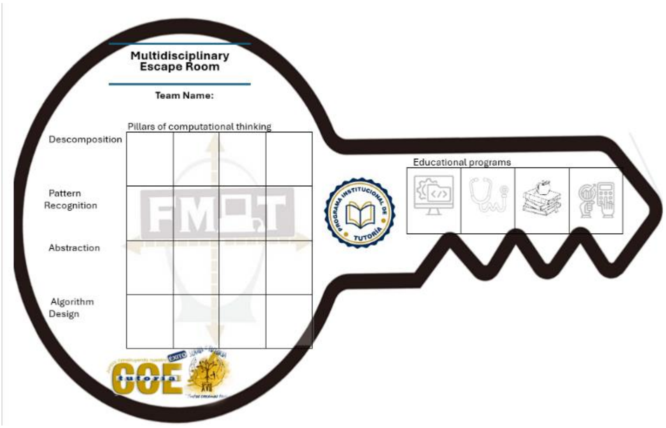

Fig. 1 Key designed to record completed challenges

The escape room was structured around the four pillars of computational thinking, with the dynamics described in Table 1.

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TABLE I ESCAPE ROOM ACTIVITIES BY CT PILLAR

Pillar	Activity	Description
Decomposition	Spell the Word	Each team member randomly selected a word from a container to spell, either forwards or backwards, as indicated randomly. One point was awarded for each correctly spelled word. If a participant failed, no point was given, but another team member could attempt it. In that case, the team could choose to keep the same word or pick a new one to continue the challenge.
Pattern Recognition	Guess the Song	Each team member listened to the first few seconds of a song and, with the help of their teammates, had to guess its name within a time limit. The 30 available songs were randomly selected to ensure variety in each attempt.
Algorithms	Physical Maze	A team member, blindfolded, had to navigate a grid drawn on the floor following precise instructions from teammates to move correctly and avoid obstacles, from the starting point to the finish.
Abstraction	Faces and Gestures	Each team member used miming, gestures, and movements to represent the most distinctive traits of a randomly selected animal, without making any sounds. The other team members had to guess the animal's name within a 30-second time limit. All team members had to perform the representation, and if the others guessed correctly, the corresponding point was awarded.

At the end of the activity, the teams answered a questionnaire with five open-ended questions to assess their understanding of CT. The questions asked students to describe in their own words what computational thinking is and each of the four pillars covered in the dynamics: abstraction, decomposition, algorithms, and patterns. These responses were not scored but were useful in gauging comprehension of these concepts.

The top three teams were determined based on the points earned, with resolution time used as a tiebreaker. The collected data were analyzed both qualitatively and quantitatively, allowing for the identification of learning patterns, skills developed, and students' perceptions of CT's application in diverse contexts.

IV. RESULTS

Forty-eight university students enrolled in the August-December 2024 semester participated, of which 34 were Software Engineering students, six were Education students, six were Nursing students, and two were Public Accounting students, as shown in Figure 2.

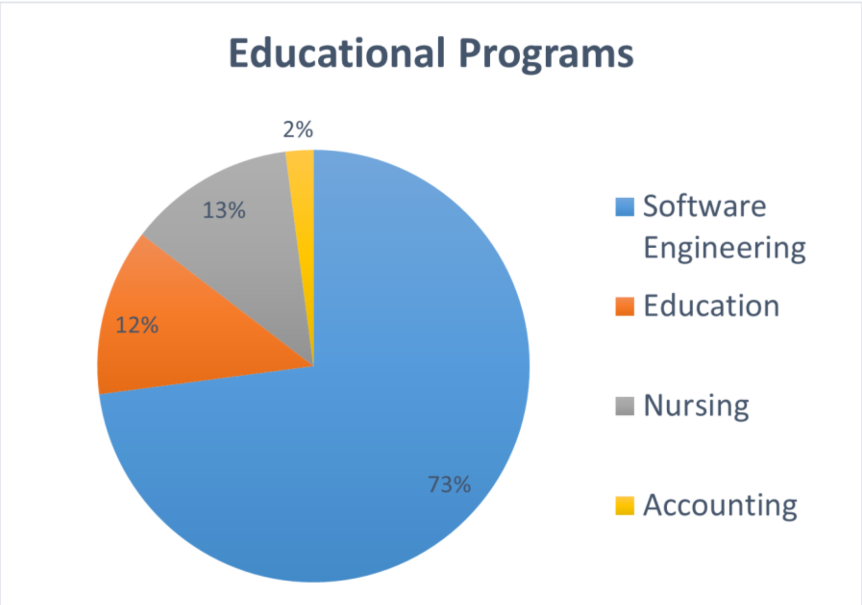

Fig. 2 Participants by Educational Program (EP)

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Quantitative Analysis

The descriptive analysis of the times and scores obtained overall by the 12 participating teams is shown in Table 2.

TABLE 2 DESCRIPTIVE ANALYSIS OF TIME AND SCORES OBTAINED BY PARTICIPATING TEAMS

	Time (minutes)	**Points**
Average	29.1	13.6
Max	35	17
Min	20	9
Std. Dev	4.5	2.1

Table 3 shows the represented educational programs: Software Engineering (LIS), Education (EDU), Public Accounting (CP), and Nursing (ENF). The number in parentheses indicates the academic level (semester) of the participants from each program. The table also shows the number of points obtained by each team and the total time taken to complete the escape room challenges (in minutes). This information enabled the analysis of individual and group performance, as well as the identification of potential relationships between team composition, score, and efficiency in solving the escape room.

TABLE 3 COMPOSITION AND PERFORMANCE OF PARTICIPATING TEAMS

TEAM	LIS	EDU	CP	ENF	POINTS	TIME
1	5º (2)	1º	1º		17	24
2	1º (4)				16	29
3	5º (4)				15	20
4	1º (3)			5º	15	32
5	1º (2) y 5º (1)			5º	15	35
6	1º (4)				14	28
7				3º (4)	13	28
8	1º(2) y 7º(2)				13	30
9		1º (4)			12	24
10	5º (3) y 9º				12	30
11	7º (3)	7º			12	35
12	5º (2) y 1º (1)				9	34

Figure 3 displays the performance of the teams in the four pillars of computational thinking: Abstraction (blue), Patterns (orange), Algorithm (gray), and Decomposition (yellow). Each boxplot summarizes the distribution of scores obtained at the different escape room stations.

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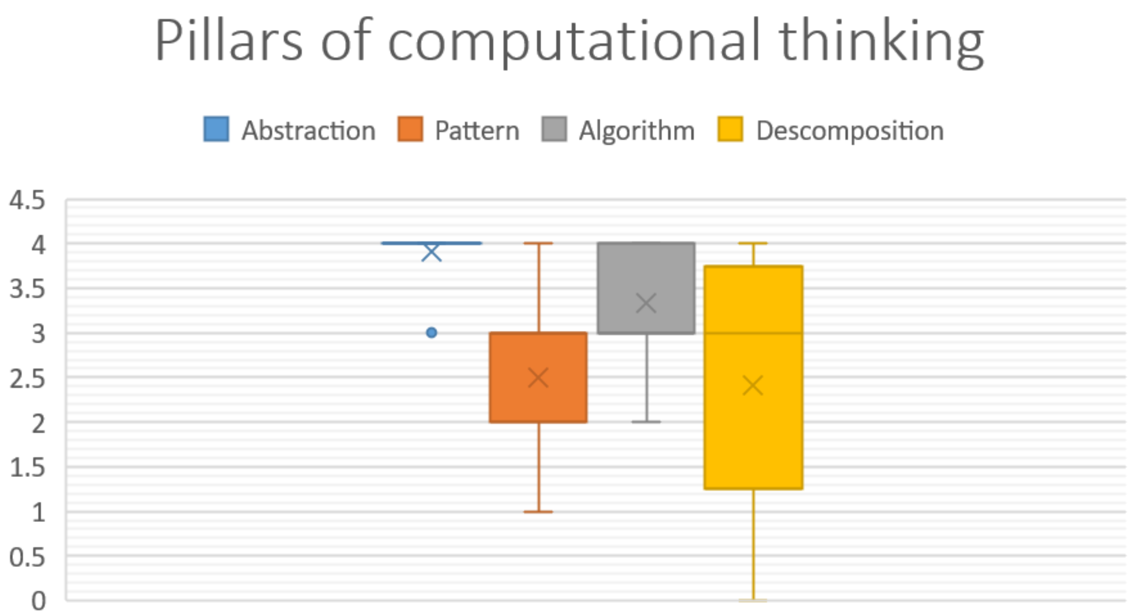

Fig. 3 Team Performance in the Four Pillars

In Figure 3, the abstraction pillar (blue) has a high mean and median, close to 4 points. The data are concentrated in the upper range (between 3.5 and 4 points), with minimal dispersion, although the outlier near 2 points indicates that at least one team encountered difficulties with this pillar.
Pattern recognition (orange) shows greater dispersion compared to the other pillars, with values ranging from 1 to 4 points. The median is around 2.5 points, indicating that half of the teams achieved relatively low scores. The box's width suggests significant variability in performance.
The algorithmic thinking pillar (gray) has more consistent scores, with most data between 3 and 4 points. The mean and median are close to 3.5 points, indicating that most teams performed well in this activity.
Decomposition (yellow) has a wide distribution, with scores ranging from 1 to 4 points. The median is near 3 points, suggesting that teams had an average performance in this station. An extended lower range suggests that some teams faced significant difficulties with this challenge.

Qualitative Analysis
For the qualitative aspect, word clouds were constructed for each set of definitions based on participants' responses, using the online tool Wordart.com. The following analysis was conducted.

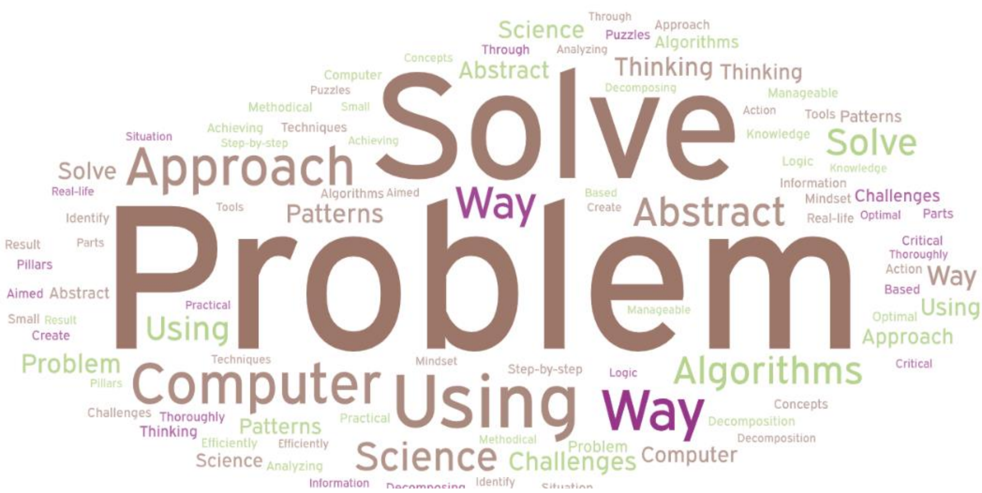

Fig. 4 Word Cloud on Computational Thinking

In Figure 4, the word cloud was generated from the definitions of Computational Thinking provided by the 12 teams. The most prominent words are "problem," "solve," "form," "informatics," and "algorithms." This indicates that the idea of solving problems in a structured way using informatics principles is central to the definitions. Concepts such as

DOI: 10.17148/IARJSET.2024.111018

abstraction, patterns, decomposition, and approach also appear, suggesting that the pillars of computational thinking are present in the participants' ideas. The focus on efficiency, logic, and detailed analysis reinforces the notion that computational thinking is not exclusive to programming but a way of logically and practically addressing problems. This analysis reaffirms the importance of computational thinking as a transversal methodology useful in various contexts.

Decomposition

In Figure 5, corresponding to the decomposition pillar, the most prominent words are "Divide" and "problem." This indicates that, for participants, the core of decomposition is the structured division of problems. "Parts," "small," and "manageable" frequently appear, emphasizing the key approach of breaking down large problems into accessible fractions. Complementary concepts, such as "easy," "complex," "subproblems," and "simplicity," suggest that the decomposition process aims to simplify complexity for easier resolution. The use of synonyms like "tiny" and the repetition of "large" reinforce the intention to break problems into more manageable levels.

This word cloud reflects that the decomposition pillar involves breaking down large or complex problems into smaller parts, making them easier to handle and solve. This strategy is essential for tackling situations with a more systematic approach, highlighting its applicability not only in computing but also in other fields.

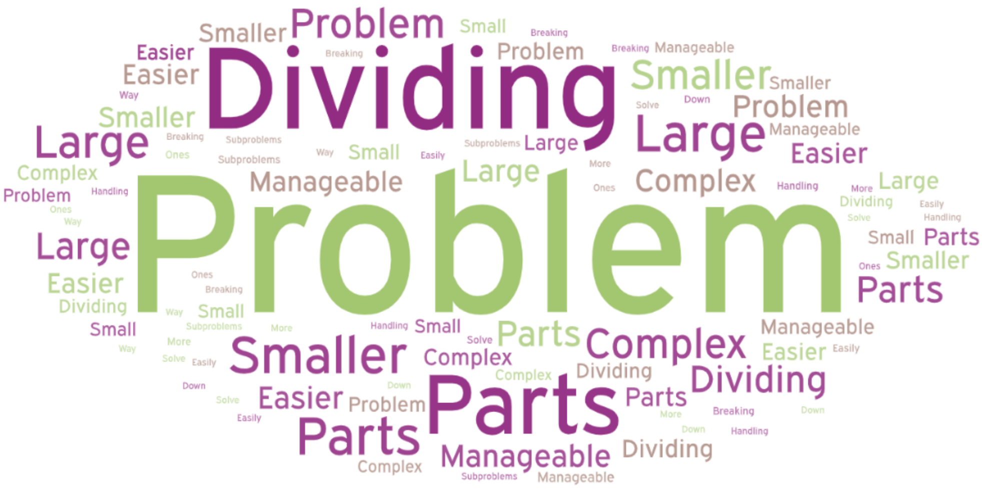

Fig. 5 Word Cloud on Decomposition

Abstraction

In Figure 6, the word cloud corresponds to the Abstraction pillar. The most prominent words were "Identify," "important," and "details," highlighting that abstraction involves recognizing the essential aspects of a problem. The repetition of terms like "ignore," "irrelevant," and "less relevant" shows that the process includes filtering out distractions or secondary information. Phrases related to "focus" and "essential" suggest the intention to maintain attention on the fundamentals to solve the problem efficiently. Frequent combinations with "problem" reflect that abstraction is not just about identifying key information but doing so with the purpose of addressing specific challenges.

This word cloud reflects that the abstraction pillar focuses on identifying and concentrating on the essential elements of a problem while omitting irrelevant details. This skill allows participants to simplify complexity, aiding them in finding practical and efficient solutions.

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Fig. 6 Abstraction Pillar

Pattern Recognition

In Figure 7, the word cloud displays the definitions of the pattern recognition pillar. The words "Identify" and "similar" are the most repeated, highlighting that pattern recognition involves finding correspondences among elements. "Data" and "set" suggest that students associate this pillar with the organization and analysis of structured information. Similarity is the central concept, reflecting that students understand this pillar as identifying repetitive patterns or common characteristics. The mention of "problem" and "concepts" indicates that it is perceived as a tool applicable to both technical data and more abstract or conceptual situations. In this regard, the students' general approach shows an accurate understanding of pattern recognition as a process of detecting shared elements that facilitates problem-solving and efficient decision-making.

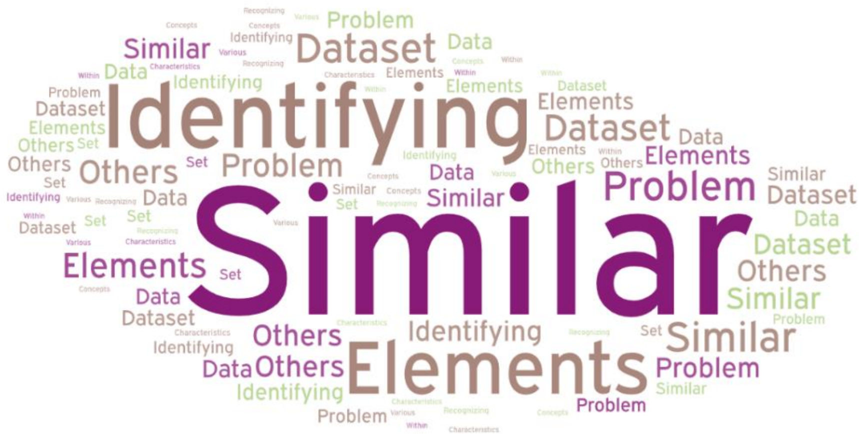

Fig. 7 Pattern Recognition

Algorithmic Thinking

In Figure 8, the words "Sequence" and "steps" are the most prominent, reflecting that students associate algorithmic thinking with following a clear set of instructions. The frequent mention of "solve a problem" underscores that students understand the practical objective of algorithms. The importance of having an organized sequence is central in their responses. Students view instructions and patterns as fundamental to the process of constructing an algorithm. Practical application is also highlighted, as many phrases refer to completing tasks or solving problems, indicating that they perceive algorithmic thinking as something pragmatic and goal-oriented. In other words, students grasp the essence of algorithmic thinking as a structured sequence of steps to achieve a goal, emphasizing both the importance of order and its application in problem-solving.

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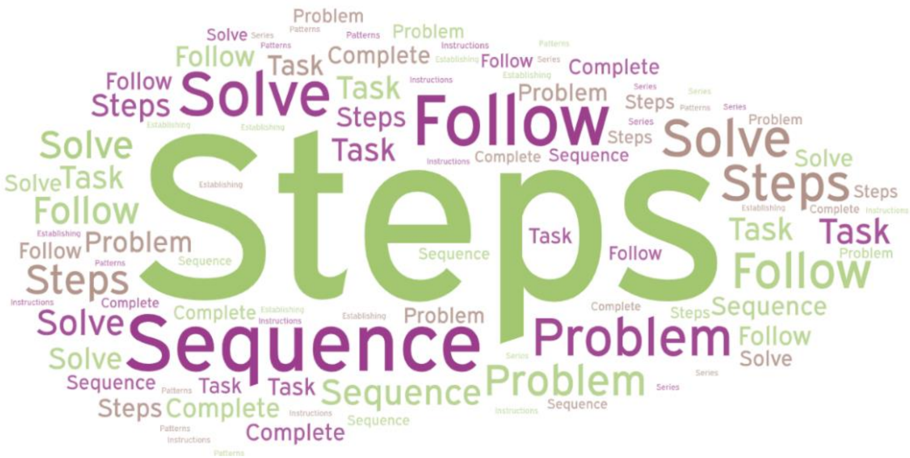

Fig. 8 Algorithmic Thinking

V. DISCUSSION

According to the data presented in Table 2, more diverse teams tend to achieve better results. For example, Team 1, which included students from Software Engineering (LIS) and Education (EDU), scored 17 points, the highest score. In contrast, teams representing only one educational program tended to perform lower (Teams 2, 3, 6, 7, and 9).

Regarding academic level, teams with participants from advanced levels (e.g., 5th and 7th semesters) scored relatively high. Team 8, with 7th-semester Software Engineering students, scored 13 points. However, teams with a broader combination of levels, such as Team 5 (comprising students from the 1st and 5th semesters), did not show significant performance improvement, scoring 15 points.

High-scoring teams also completed the challenges faster. For example, Team 3 achieved 15 points in 20 minutes, standing out for its efficiency. In contrast, teams like Team 11 scored only 12 points in 35 minutes, indicating lower efficiency in solving the challenges. Team 1 was the top performer, with 17 points in 24 minutes, demonstrating both effectiveness and speed. This suggests that interdisciplinarity and a mix of academic levels can positively influence performance.

In summary, the analysis suggests that interdisciplinary diversity and a combination of academic levels may favor better performance in terms of points and time. Teams with greater diversity and efficient communication demonstrated greater success in the escape room challenges. However, some homogeneous teams (e.g., with all members from the same educational program) also achieved competitive scores, indicating that other factors, such as internal coordination and level of preparation, also play a significant role.

Moreover, the detailed pillar-by-pillar analysis shown in Figure 3 indicates that teams performed well in abstraction and algorithms, but more pronounced difficulties emerged with the pattern recognition and decomposition challenges, suggesting a need to reinforce these concepts in future activities. Abstraction was the pillar with the most consistent and highest performance, though one team encountered difficulties. Pattern recognition showed the most variability in results, indicating notable differences in teams' ability to recognize patterns. Algorithmic thinking had uniformly high results, suggesting that teams felt comfortable with sequential challenges. Decomposition displayed wide dispersion, showing that some teams found this pillar more challenging.

VI. CONCLUSION

The results indicate that the escape room proved to be an effective strategy for promoting computational thinking (CT) in a multidisciplinary context.

Implementing this strategy strengthened computational thinking skills in an interdisciplinary and playful environment, showing that this methodology effectively develops key competencies such as problem-solving, collaborative work, and logical reasoning. Moreover, the challenge format aligned with the four pillars of CT facilitates understanding and application of these concepts in contexts beyond computer science. However, the observed difficulties in the abstraction and decomposition pillars suggest a need to reinforce these areas through complementary activities.

This experience demonstrates that CT is not exclusive to computer science but can be applied across various disciplines, contributing to students' comprehensive development. Additionally, the escape room encourages active and collaborative participation, consolidating cognitive and social skills that will be valuable in their academic and professional lives. It is recommended to continue exploring such strategies in different educational contexts, adjusting challenges to deepen understanding of the less comprehended pillars.

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Thus, the escape room activity enabled students from different disciplines to understand and apply the four pillars of CT: decomposition, abstraction, pattern recognition, and algorithms, demonstrating that these competencies are useful beyond the realm of computer science. The game-based approach, without the need for technological devices, promoted active participation and meaningful learning. It also facilitated the integration of computational thinking into fields such as education, health, and accounting, confirming its transversality. The escape room dynamics fostered additional competencies such as teamwork, problem-solving, and time management, contributing to students' holistic development. Regarding the impact of interdisciplinary collaboration, more diverse teams (from different educational programs) achieved higher scores and resolved challenges more efficiently. This demonstrates that interdisciplinarity facilitates problem-solving and enhances communication and coordination skills.

The analysis of challenges by each escape room pillar indicated that teams faced greater difficulties with the pattern recognition and decomposition pillars, suggesting the need to reinforce these concepts in future pedagogical activities. Meanwhile, the combination of different academic levels (semesters) did not always yield the highest scores, but teams with good internal coordination and diverse composition demonstrated outstanding performance in terms of both time and results.

Finally, this study highlights the effectiveness of a playful and multidisciplinary approach for developing computational thinking skills, suggesting that this type of activity can be a valuable pedagogical tool in higher education. However, a limitation is the sample size; therefore, it would be desirable to include a larger number of students and university programs, especially from areas not represented in this research, to obtain more robust and generalizable results.

As future work, longitudinal studies are planned to analyze how computational thinking skills develop in university students after participating in these activities and to examine whether their impact persists in future academic or professional challenges. Additionally, evaluating qualitative aspects such as motivation, team cohesion, and perceived learning will enrich understanding of the impact of these dynamics. In this way, further research will seek to consolidate the integration of computational thinking as a transversal skill in higher education and to enhance the effectiveness of gamification-based methodologies.

ACKNOWLEDGMENT

We thank the Universidad Autónoma de Yucatán for the support provided to carry out this work.

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