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PAPER

Games and Arts as Tools for Developing Generic Skills in Engineering Students

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ABSTRACT

In today's educational landscape, the integration of innovative pedagogical approaches is essential for improving student learning. In this respect, game-based learning appears to be a strategy that not only actively engages students—who often struggle to understand scientific concepts, leading to negative emotions and discouragement—but also helps them acquire transferable skills. Particularly in the field of telecommunications engineering, where the practical application of knowledge is essential, the use of educational games offers a unique opportunity to explore and reinforce specific and general skills. In this study, a cross-sectional quantitative methodology was implemented using a representative sample of 64 undergraduate students in the sixth semester of the telecommunications engineering program at a public university. In general, educational games are primarily intended to evoke emotions in participants, such as enjoyment, to help them cultivate a "receptive learning mindset" and to effectively teach a specific subject. In contrast to these approaches, the game proposed in this study incorporates humanistic skills and artistic tools to construct antennas within a specific context. This enabled students to engage in a practical, applied learning experience in their field of study, focusing on three key aspects: appropriating knowledge, building values, and learning about life, as well as recognizing others in society and interacting with the environment. The results obtained using the proposed game-based strategy were compared with those obtained using conventional teaching tools. The results showed that play not only imparted knowledge but also contributed to students' overall development by fostering the values and skills essential to their personal and professional success. The results underscore the significance of developing games that authentically simulate project processes and activities. This emphasizes the importance of aligning game dynamics with real-world challenges and situations in the field of telecommunications engineering. This simulation-based approach may be the key to maximizing the impact of game-based learning on the training of future professionals in this field. This comparative study helps fill a gap in knowledge about game-based learning in engineering education by providing valuable insights. It is also important to comprehend the impact of game-based learning on an antenna course and the students' willingness to engage with this innovative teaching style in the classroom.

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KEYWORDS
arts, artistic tools, game-based learning, generic skills, higher education, teaching strategies

1 INTRODUCTION

Globalization, the Fourth Industrial Revolution, and other contemporary changes in society have accelerated modernity in the 21st century. This has resulted in numerous technological innovations, a world instantly connected to technology, and the pervasive presence of technology in our daily lives [1]. Consequently, various international organizations have set out to gather the skills, aptitudes, values, and attitudes that enable today's professionals to adapt to this complex world. The literature on this subject suggests that the professional training of higher education students should include the development of tools for understanding this uncertain and complex world [2].

The Colombian Ministry of National Education (abbreviated MEN in Spanish) has utilized the above definition to outline the skills necessary for professionals to thrive in the knowledge society. This society is marked by rapid and exponential growth in patents, specialties, and scientific advancements within a post-industrial context. These elements are part of disciplines that focus on solving society's problems, understanding reality, and building a set of criteria for acting autonomously and responsibly within the organization, the local community, the country, and global society in general [3].

In 1999, during the Bologna Process and as part of the European Higher Education Area (EHEA), the competencies that universities should develop in the 21st century were defined. These competencies include learning to learn, learning to be, learning to live, learning to coexist, and learning to do. The Tuning Educational Structures in Europe project subsequently proposed working on general competencies similar to those declared by the US National Academy of Engineering [4], [5]. Today, the OECD Learning Framework 2030 proposes a vision and some fundamental principles for education. It emphasizes that to prepare for 2030, people should be able to think creatively, develop new products and services, create new jobs, innovate new processes and methods, adopt new ways of thinking and living, establish new companies, explore new sectors, devise new business models, and create new social models [2]. In addition, as engineering evolves, it is important to have an overview of what the national education system should consider to produce employable engineers and ensure that they meet the demands and expectations of the technological world in which they interact and work [6]. With regard to the challenges that universities face today, [7] proposes the importance of contextualizing subject teaching to align with students' educational objectives. This can be accomplished through interactive and collaborative curriculum models.

A common issue with current curricula is their uneven distribution, with an overabundance of subjects emphasizing discipline-specific skills and a noticeable absence of humanities courses, which are crucial for fostering soft skill development [8], [9]. Particularly in engineering education, the imbalance between these two fundamental dimensions has posed a significant challenge to the comprehensive training of students. Clearly, existing curricula lack a structure that holistically addresses both the ontological (or "being") and practical (or "doing") aspects of the subject being taught [10], [11]. Without this holistic perspective, students, even if they possess sound technical knowledge, are less well-equipped to use it in a way that is morally and socially conscious and appropriate to the situation.

According to reference [12], the absence of integration of generic skills in engineering curricula is directly linked to curriculum fragmentation. As a result, courses are taught in isolation, with each professor focusing on the technical content specific to his or her discipline. This fragmented approach sidelines the common skills and competencies essential for the professional and personal development of engineers.

In this research, the antenna course in a telecommunication engineering program that we used as a case study has a strong emphasis on mathematics and physics, so it is structured around domain-specific elements. Consequently, we were motivated to develop a learning strategy aimed at fostering skills beyond those directly associated with the course. In particular, we aimed to assess various aspects of students enrolled in this course, including knowledge acquisition, value formation, lifelong learning, recognition of others in society, and interaction with the environment. To achieve this goal, we implemented an innovative active learning strategy that involved a card game. In this game, students utilized artistic tools to design an antenna and apply it in a specific context. To delve deeper into the impact and effectiveness of the proposed strategy in fostering generic skills within the field of telecommunications engineering, we conducted a comparative analysis with conventional and traditional teaching methods.

The importance of this study lies in the pressing need to equip engineers not only with solid technical skills but also with the generic skills they need to face the multifaceted and ever-changing challenges of today's professional landscape. As the field of telecommunications engineering is constantly evolving, practitioners in this sector must master specific technical knowledge and possess generic skills such as critical thinking, problem-solving, effective communication, and teamwork. These generic skills, often referred to as essential "soft" skills, are vital for successfully adapting to a changing work environment and developing innovative solutions. While technical skills ensure effective infrastructure design, generic skills are essential for understanding customer needs, collaborating with multidisciplinary teams, effectively communicating proposed solutions, and adapting to sudden changes in project requirements.

Taking all these elements into account, our aim is to demonstrate that the implementation of a game-based learning strategy, which includes the use of artistic tools, will offer students a useful and entertaining experience while fostering the development of generic skills. By comparing the proposed strategy with traditional pedagogical approaches, we will be able to assess more precisely how these skills are addressed and reinforced. This will contribute to enhancing the training of future telecommunications engineers.

The remainder of this paper is structured as follows: First, we present a theoretical framework covering topics such as generic engineering skills, game-based learning strategies, and art as a gateway to engineering. Next, we will provide a detailed description of the methodology used in this research. This includes key elements such as the game used, the procedures for selecting and recruiting participants, the instrument chosen, and the overall approach to data collection. We then analyze the descriptive statistics, factor scores, and Pearson correlation coefficients obtained. We also examine the statistical differences observed in engineers' evaluations of various course strategies after acquiring generic skills. Finally, we will discuss the results and draw conclusions.

2 THEORETICAL FRAMEWORK

2.1 Generic skills in engineering education

Generic skills are the knowledge, abilities, and attitudes that students acquire upon completion of their degree [13]. These skills enable individuals to perform effectively and responsibly in different contexts when conceptualizing, designing, implementing, and operating products, processes, or systems [14]. Context plays a crucial role in the training of students as they process new knowledge. It is essential for the information to make sense within their own frame of reference. Therefore, skill development depends on the context [15]. Developing generic skills is crucial in preparing students for their roles in society, whether as professionals or citizens [13], [11], [16].

In recent years, governments and organizations around the world have started to emphasize the strategic importance of generic skills. Engineering education accreditation bodies, such as the Accreditation Board for Engineering and Technology (ABET) and the International Engineering Alliance (IEA), now recognize generic skills as essential graduate attributes [17]. In 1996, ABET adopted the Engineering 2020 criteria, which consist of eleven skills that all engineering graduates should possess. These skills are divided into two categories: hard skills and soft skills. However, ABET also emphasizes the importance of students being able to develop new skills to meet the requirements of their organizational structures and participate in any project at their workplaces [18].

Universities provide the best environment for acquiring generic skills, especially through group activities that require interaction and collaboration with peers. Therefore, the constructivist learning environment plays a vital role in fostering these skills [19]. In this regard, Ausubel (1983) proposed the meaningful learning theory, which states that learning is meaningful when it can be related in a non-arbitrary and substantial way to what the learner already knows. Similarly, in this type of learning, there must be a connection between prior and new learning, thus enhancing students' cognitive structure while modifying their behavioral patterns. This fosters a self-critical and reflective mindset in learners, encouraging them to take responsibility for exploring the foundations of their learning, understanding how to approach them, and achieving their learning objectives.

As a result, many modern engineering degree programs incorporate active learning methods that often include game-based learning strategies. Most didactic games are designed to help students understand technical subjects, such as mathematics, computer science, and language, by simulating real-life experiences or, as our goal, developing social skills [20]. As various authors have suggested, games offer the opportunity to integrate cognitive, affective, and social aspects, which are linked to generic skills [21]. Thus, engineering professors and employers agree that university graduates need to master their field of study as well as acquire skills and competencies that enable them to actively engage in various work environments. Such skills include problem-solving, communication, leadership, and collaboration [22]. The integration of these elements into formal education can provide students with better tools for their professional lives.

Importantly, recent research suggests that there is not enough solid evidence to support the long-term advantages of using games in learning environments [23]. Therefore, it becomes imperative to explore novel teaching strategies, such as game-based learning, that foster meaningful learning experiences through new didactic scenarios. To achieve this, aspects such as the adaptability of these strategies to diverse disciplines and educational levels must be addressed. Moreover, an in-depth analysis of empirical data and real-world experiences is necessary. This analysis will enable a more thorough understanding of how these strategies integrate into and enhance the educational environment, thereby providing a more robust foundation for decision-making regarding pedagogical practices.

2.2 Games as a strategy for learning and developing generic skills

Studies on the use of games in engineering classrooms have shown that, regardless of the various assessment techniques currently employed, there is a general trend towards enhancing learning outcomes and student attitudes through game-based activities [24]. There are a wide variety of games designed to engage and motivate higher education students during their learning process [25]. According to research, some of the main advantages include enhanced academic performance, motivation, engagement, and attitude [26]. Game-based learning, as an innovative learning strategy, is increasingly being used in the classroom because it promotes the acquisition of specific skills, competencies, and content, making it appealing to both professors and students [27].

Johan Huizinga, the philosopher and historian, was a pioneer in the study of play. He stated that play is older than culture and that, such as animals, humans have always played. Throughout history, play has evolved from providing only amusement and interaction to also providing learning. Play allows participants to express themselves differently from their everyday lives. It is accompanied by feelings of tension and joy and rules that are different from social standards. The sense of autonomy, the power of decision, and the risk of error encourage players to explore all the possibilities. Physical or imaginary spaces exist throughout the duration of the play experience. According to [28], play has certain basic characteristics, such as freedom to participate, space and time different from daily life, uncertainty, no need for wealth, rules, and imaginary realities.

These characteristics, however, may vary significantly depending on the educational environment and the specific subject matter. For instance, based on the nature of the educational content, the freedom to participate can be interpreted and experienced differently by students. Similarly, the use of rules and imaginary realities might prove more effective in certain fields of study than in others. As demonstrated in [29], a game-based environment that is founded on self-determination and problem-based learning and incorporates a comprehensive learning process has promising effects on learning outcomes, motivation, and student engagement. This was observed in students' perceptions of the motivational aspects of the game elements and in their willingness to continue learning in similar environments. Likewise, [30] other aspects such as joy, empowerment, and the element of fun were introduced. Indeed, the experimental findings support the effectiveness of games, revealing that students enjoy this type of learning.

Numerous publications have demonstrated the advantages of incorporating game-based learning into education. It has proven to be useful in engaging students of the new generation, who require a more dynamic learning model. Consequently, higher education institutions (HEIs) have begun utilizing game-based learning as part of their pedagogical tools to teach various areas of knowledge [31]. These strategies are helpful in addressing complex situations, thus favoring the development of generic skills necessary for ambiguous or uncertain situations. In addition, they can improve interactions with others and job performance since games provide the freedom to fail without serious consequences [32]. Professors may want to use these learning strategies because they've been shown to have successful practical implications for promoting student-centered learning through behavioral and cognitive engagement, learning achievement, and higher-order thinking skills such as problem-solving, critical thinking, and creativity [33].

Nonetheless, it becomes necessary to address any issues that may arise, such as potential distractions from learning objectives, a lack of alignment with certain teaching styles, or variability in students' perceived effectiveness of gamification. Professors play a crucial and vital role, even though students are the primary focus of instruction. They are responsible for attending to and understanding the needs of each student individually, providing appropriate learning materials, and evaluating the entire educational process [34].

Reuter et al. [20] conducted a study in which they analyzed 56 publications on gaming experiences across various contexts within the past six years, all focusing on the benefits of implementing them to develop generic skills in different scientific fields. The study's findings revealed a surge in game-based learning strategies in higher education institutions (HEIs) and an increased interest in disseminating them. The authors also found that engineering fields, especially computer science, account for the highest number of published studies. Among the skills identified in the analyzed studies, the most important ones are collaboration, communication, creativity, critical thinking, decision-making, motivation, problem-solving, and teamwork. Engaging with participants of varying levels of expertise improves communication and time-management skills. Moreover, adults can enhance their communication, adaptability, and problem-solving skills in a short time through serious games. It is also crucial for individuals to develop the ability to manage emotions and perform well under pressure in both school and professional settings.

2.3 What is the contribution of art to engineering and the development of generic skills?

Despite being excluded from science, technology, engineering, and mathematics (STEM) education, the arts are vital for maintaining a balance in the technical landscape by promoting innovation and diversity. In other words, the arts and sciences are complementary because they shape the way individuals experience the real world [35]. Following reference [36], there are three distinct and autonomous elements that define art as a part of play. The first element is arts/aesthetics, which involves artistic concepts such as style, color, composition, and proportion. The second element is contextual understanding, which involves empathy and reflection on the socio-cultural context. It focuses on real problems experienced by the population, giving meaning to the integration of technology as a solution to local and community concerns. Lastly, the third element is creativity, which refers to the ability to create novel, unique, and appropriate things.

One of the most significant factors in arts education, unlike other disciplines, is the emotional impact that works of art have on students. This emotional resonance helps students comprehend the depicted realities and develop interpretations during the learning process. However, few studies have developed strategies for integrating art and practical STEM activities. Therefore, the OECD advocates for transdisciplinary collaboration to enable students to address complex societal challenges [37].

Some researchers argue that teaching and learning the arts are crucial to human culture [38] and can enhance students' 21st-century generic skills. For example, [39] suggests that integrating the arts could stimulate creativity in groups of engineering students, while [40] recommends integrating the arts into graduate courses to promote reflective thinking. This reflective thinking can lead to substantial changes in the learning process of engineering students. Thus, incorporating the arts into technical education prepares future leaders to actively and creatively contribute to overcoming barriers encountered by a sustainable society [41].

In [42], information and communication technologies (ICT) were employed to provide extracurricular art education during the COVID-19 pandemic. Through mobile positioning technology and information platforms, students completed 32 art appreciation activities in their respective cities. The assessment of learning outcomes relied on mobile positioning data, feedback questionnaires, and other indicators. This study confirms that satisfaction with artistic activities directly influences students' interest in art, fostering the sustainable development of aesthetic education in schools.

Hence, this study aims to validate the benefits of game-based learning strategies, which foster different perspectives and enhance creative skills at the academic level. These skills are directly linked to everyday life and offer real possibilities for implementation. The objective is to creatively overcome mental, budgetary, and contextual challenges through collaboration among professionals, sectors, and projects.

3 METHODOLOGY

This study employed a mixed methodological approach that integrated both qualitative and quantitative techniques. The qualitative analysis emphasizes important methodological aspects that enhance the understanding of the context and provides a unique interpretative approach to the students' perception of the methodology used, thereby aiding in characterizing the specificities of the context. Regarding the specifics of this study, one of the primary tasks performed was the content analysis of the responses to the following open-ended question asked to the students: *"Please share your opinions or comments on the card game activity this semester."* Content analysis is a research tool used to determine the presence of specific words or concepts within a text or set of texts. In this case, the critical texts analyzed were the participants' reflections on the activities and the development of the skills used throughout the game's phases. The content analysis process involved identifying and quantifying words and concepts, as well as analyzing their meanings and relationships. Finally, inferences were made about the messages in the participants' texts and publications.

We used a questionnaire to find out which generic skills and learning goals students in the Antenna course developed and achieved through a game-based strategy (experimental group) and through lectures and traditional methods (control group). The three dependent variables employed in this study were: (i) appropriation of knowledge; (ii) construction of values and learning for life; and (iii) recognition of others in society and interaction with the environment.

3.1 Experimental procedure: The game

"I + A" is a card game that enables students to engage in interdisciplinary creation and collaboration around the topic of Antennas in Context. The text explores various approaches, contexts, tools, materials, and information applied on different scales and in various territories regarding the topic of antennas. People with diverse disciplinary, social, and contextual backgrounds will collaborate in simulated games to develop methods for creating designs, projects, and strategies in real-world situations. The purpose of this game-based method is to identify alternative ways of analyzing, contextualizing, designing, adapting, planning, and implementing realistic and feasible projects in a didactic, collective, and relational manner. The game involves taking turns and utilizing cards based on the available options.

The card game consists of five categories of cards, each with its own subgroup. The first category is materials, which pertains to antenna materials and coatings for indoor and outdoor use, tailored to specific applications. The second category is applications, which is crucial for achieving project solutions. This category empowers students to find global solutions to worldwide problems and work towards a common good. Additionally, it allows them to assess a project's economic, social, and environmental impact, considering its applicability in context. The third category, contexts, refers to the spaces where the project is implemented, which must align with the type of wireless communication systems being designed. Complementary is the fourth category that either benefits or disadvantages students by drawing the crisis, benefit, or blank cards. The fifth category, design, allows students to create antennas that are not only functional but also visually attractive. The design concept refers to any creative activity that serves a purpose to fulfill a human need, whether it is personal or social in nature. This category enables students to think critically, creatively, connectively, and flexibly by integrating technical, symbolic, and aesthetic aspects within a specific cultural context. It also involves considering uses or advantages beyond the original purpose for which antennas are created. This could involve adding more features to the initial design to significantly enhance its value in terms of utility, symbolism, emotion, and/or profitability.

The objective is to progressively construct the desired project, which will take shape throughout the game. Projects that share conceptual, structural, or contextual similarities can collaborate and rely on each other. However, they can also be carried out independently if necessary to achieve their goals. The project is considered successful if it can produce and obtain resources, surpassing its original purpose as a construction and service provision exercise. To achieve this goal, the project must integrate additional elements, explore better opportunities, and create more favorable conditions, aiming to closely replicate real-life scenarios.

To set up a project, the available cards must be placed on the playing field at level 3. Available cards are those that, when combined with others, give meaning to the project and have potential based on the initially played cards. Thus, it is important to assess the compatibility and associative potential of each card before combining them. Each project is created through logical combinations of cards of different colors. The project idea of each player or team is free, as long as it can be logically and rationally justified, either by the simplest card combination or by achieving specific goals. A project is consolidated through the combination of various types of antennas, materials, supports, and contexts (see Figure 1). The addition of supplementary elements is necessary to strengthen and reinforce the project. Certain cards can increase the complexity of the game. To incorporate them effectively, it may be necessary to introduce additional cards to maintain optimal conditions and create a coherent combination of elements. After creating their project, each player or team must provide a reasoned explanation of their card choices, combinations, configurations, and the scope of the project to the other participants. The professor will act as a negotiator, promoter of ideas and possibilities, and facilitator of each project. Figure 1 illustrates the process of creating, implementing, disseminating, and producing the final product or formulating the proposal.

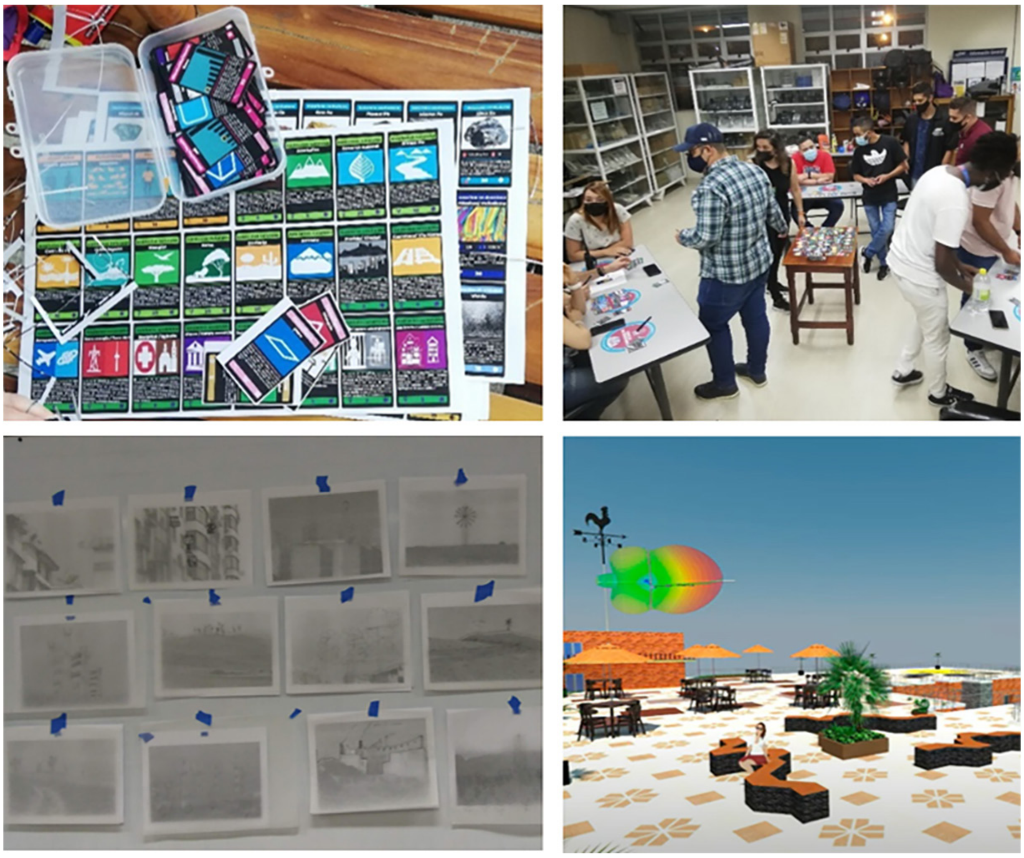

Fig. 1. Game design and implementation (a) Creation of a game card. (b) Game session. (c) Projection of the antenna in different environments. (d) Broadcasting educational content to remote, open spaces via digital terrestrial television

3.2 Participants and recruitment

The study involved undergraduate students in the sixth semester of the Telecommunications Engineering program at a public university. Two groups were surveyed for quantitative data: (a) students who participated in the Antenna course game during the two semesters of 2021, and (b) a control group from the same semester and program during the same period. Recruitment did not consider any socio-demographic restrictions (e.g., age, sex, ethnicity, and language).

Two types of non-probability sampling were used in the study. The experimental group was selected through purposive sampling; specifically, all the Antenna course students were chosen to participate in the research. The control group was selected using voluntary response sampling. As shown in Table 1, the target sample consisted of 63 students in total: 34 students in the experimental group and 29 students in the control group.

Table 1. Demographic characteristics of the experimental and control groups

Socio-Demographic Variables		Control Group	Experimental Group
Age	16–25 years	11	12
	26–35 years	17	22
	36–45 years	0	0
	Over 45 years	1	0
Sex	Male	25	29
	Female	4	5

3.3 Instrument and data collection

Participants were asked to complete a questionnaire consisting of 40 items, divided into four sections. The first section addressed various aspects of the classroom strategies and activities (CSA) developed by the professor, including aesthetics, ease of learning, enjoyment, focused attention, relevance, and perception of learning. This scale comprised 13 items taken and adapted from sources [43] and [44], with a Cronbach's alpha of 0.973. For the Antenna course students, the questions were specifically focused on the game strategy, whereas for the control group, they were formulated for any type of strategy implemented by the professor. The other three sections consisted of statements on the perception of the development of the following generic skills—taken and adapted from [45]: appropriation of knowledge (AK), with 10 items and a Cronbach's alpha of 0.969; construction of values and learning for life (CVLL), with nine items and a Cronbach's alpha of 0.955; and Recognition of Others in Society and Interaction with the Environment (RSIE), with eight items and a Cronbach's alpha of 0.944. The standardized Cronbach's alpha of the four sections was 0.932.

Participants rated each statement using a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. The questionnaire was designed online and could be accessed through a link sent to the students via their institutional email. Demographic information, including age and gender, was collected to investigate potential relationships with other variables. Finally, an open-ended question was included for students to express their appreciation of the game strategy as a learning resource in the Antenna course.

3.4 Data analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS®), version 26. A one-way analysis of variance (ANOVA) was conducted to determine if there was a difference between the means of the experimental and control groups for the four variables under analysis. Furthermore, the homogeneity of variances was assessed using Levene's test: CSA ($F = 2.717$, $p = 0.104$), AK ($F = 0.241$, $p = 0.242$), CVLL ($F = 0.212$, $p = 0.647$), and RSIE ($F = 1.216$, $p = 0.275$).

4 RESULTS

A descriptive analysis was conducted to determine the characteristics of the study population in relation to the variables under investigation. Women accounted for 14% of the population, while men accounted for 86%. Moreover, 44% of the sample was between 26 and 35 years of age. The population's characteristics were used to study the mean of the variables. Table 2 shows that the most highly valued variables were CSA and RSIE. In addition, male participants and individuals aged 26 to 35 obtained higher valuations in all variables.

Table 2. Descriptive statistics for the experimental and control groups

Factors			n	CSA		AK		CVLL		RSIE	
Group	Sex	Age		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	Male	16–25 years	10	3.58	0.40	3.47	0.43	3.46	0.38	3.58	0.42
		26–35 years	14	3.60	0.35	3.64	0.39	3.67	0.35	3.61	0.35
		36–45 years	0	–	–	–	–	–	–	–	–
		Over 45 years	1	4.00	–	3.50	–	3.33	–	4.00	–
	Female	16–25 years	1	3.23	–	3.00	–	3.11	–	3.13	–
		26–35 years	3	3.67	0.58	3.43	0.51	3.59	0.53	3.67	0.58
		36–45 years	0	–	–	–	–	–	–	–	–
		Over 45 years	0	–	–	–	–	–	–	–	–
Experimental	Male	16–25 years	12	4.65	0.42	4.43	0.42	4.52	0.38	4.63	0.41
		26–35 years	17	4.58	0.44	4.54	0.48	4.52	0.42	4.59	0.43
		36–45 years	0	–	–	–	–	–	–	–	–
		Over 45 years	0	–	–	–	–	–	–	–	–
	Female	16–25 years	0	–	–	–	–	–	–	–	–
		26–35 years	5	4.51	0.57	4.44	0.48	4.42	0.48	4.45	0.68
		36–45 years	0	–	–	–	–	–	–	–	–
		Over 45 years	0	–	–	–	–	–	–	–	–

Notes: (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly agree.

Table 3 shows that the students in the Antenna course perceived a higher level of learning and relevance of the CSA and RSIE skills that involve the use of the cards, with a mean of 4.59 and 4.58, respectively. Meanwhile, the control group achieved a mean score of 3.6 in the same factors evaluated. Hence, the mean score is 0.9 points higher for the experimental group compared to the control group. Furthermore, in terms of validity, the values of Pearson's correlation coefficients indicate significant and high linear correlations.

Table 3. Factor scores and Pearson correlation

Variables	Experimental Group (n = 34)		Control Group (n = 29)		CSA	AK	CVLL	RSIE
	Mean	SD	Mean	SD				
CSA	4.59	0.44	3.60	0.38	1			
AK	4.49	0.45	3.53	0.41	.871**	1		
CVLL	4.50	0.40	3.56	0.38	.915**	.940**	1	
RSIE	4.58	0.45	3.60	0.39	.992**	.853**	.904**	1

Note: **Correlation is significant at the 0.01 level (two-tailed).

The descriptive results of the one-way ANOVA tests are presented in Table 4. It is evident that there was a significant difference in the four variables under analysis between the experimental and control groups. Regarding the CSA variable ($F = 88.695$, $p < 0.05$, where $p < 0.05$ indicates a significant difference between the results obtained for the two groups), the mean in the experimental group ($M = 4.59$, $SD = 0.44$) was significantly higher than that in the control group ($M = 3.60$, $SD = 0.38$) (refer to Table 3). As for the AK variable ($F = 75.921$, $p < 0.05$), the mean in the experimental group ($M = 4.49$, $SD = 0.45$) was also significantly higher than that in the control group ($M = 3.53$, $SD = 0.41$) (refer to Table 3). Likewise, for the CVLL variable ($F = 91.199$, $p < 0.05$), the mean in the experimental group ($M = 4.50$, $SD = 0.40$) was significantly higher than that in the control group ($M = 3.56$, $SD = 0.38$) (refer to Table 3). Finally, concerning the RSIE variable ($F = 83.827$, $p < 0.05$), the mean in the experimental group ($M = 4.58$, $SD = 0.45$) was also significantly higher than that in the control group ($M = 3.60$, $SD = 0.39$) (refer to Table 3). These results suggest that, when compared to the control group, playing the "I + A" card game led to better outcomes in all four variables.

Table 4. ANOVA results for the assessment of classroom strategies

Variable	SS	df	Mean Square	F	p
Aspects of the classroom strategies and activities (CSA)	15.359	1	15.359	88.695	.000*
Appropriation of knowledge (AK)	14.149	1	14.149	75.921	.000*
Construction of values and learning for life (CVLL)	13.943	1	13.943	91.199	.000*
Recognition of others in society and interaction with the environment (RSIE)	15.085	1	15.085	83.827	.000*

Note: *p < .05.

Thirteen responses to the open-ended question included in the questionnaire were selected and analyzed using MAXQDA 20 to gain insights into participants' perceptions of the card game. With this software, data from open-ended questions can be transformed into numerical data (percentages) and displayed in graphs for easier interpretation. The most frequently mentioned responses described the activity as innovative, providing context for mathematics, and increasing motivation for learning. Figure 2 displays the results concerning participants' opinions or comments on the card game. As evidenced, students found the game engaging and helpful throughout the learning process.

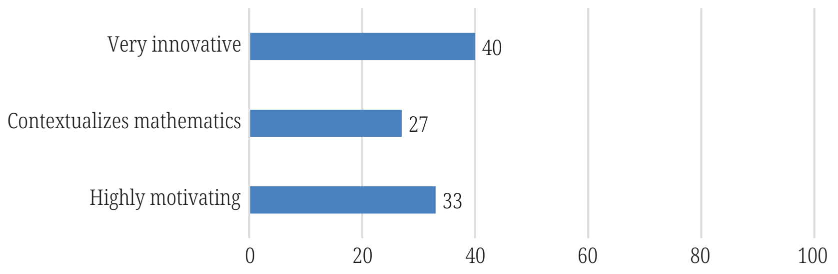

Fig. 2. Participants' perceptions of the card game

5 DISCUSSION

Based on the results, the factor that received the highest rating in the control group was related to the effectiveness of the implemented strategy. This factor is associated with its structure, motivational capacity, contribution to learning, and ease of implementation. The questions designed for this factor focused on determining whether the strategies and activities employed by the professor differentiate the class from others, foster motivation for project development, cultivate interest in the subject, enable the search for information to overcome challenges, contribute to learning, prove beneficial for expanding knowledge, facilitate unique learning experiences, and are simple and easy to implement. According to research, integrating innovative teaching and learning strategies in the classroom improves engagement among higher education students. Multiple studies have demonstrated the benefits of game-based learning in the classroom [20], [46], [47]. Similarly, several authors have argued that game-based learning promotes the attainment of learning outcomes, particularly in the cognitive domain [48]. Others have characterized it as an effective instructional tool [49].

Additionally, the RSIE variable was found to influence students' motivation to learn about social issues. The questions related to this variable were designed to evaluate the capacity to cultivate the following RSIE skills through the game: teamwork; collaborating in different contexts and with various disciplines; demonstrating social responsibility and civic engagement; advocating for environmental and sociocultural conservation; valuing and honoring diversity and multiculturalism; and comprehending cultures, traditions, and challenges from various local, national, or international contexts. In line with previous research [50], [51], game-based learning strategies have been shown to enhance the knowledge, attitudes, and behavior of the participants. This study supports those findings because students found the methodology helpful in enhancing teaching and learning processes. Furthermore, reported benefits had a significant impact on students' perceptions of them.

Our findings indicate that game-based learning solutions can motivate students and prepare them to handle uncertainty in real-world projects. We found that students connected their projects to real-life issues by using a set of cards containing the Sustainable Development Goals (SDGs). Moreover, students expressed a sense of learning, indicating their grasp of real-world issues, through their responses to the following question within the AK variable: *"I am able to propose innovative solutions that can influence different areas using the tools specific to the discipline."* In essence, the game empowered students to participate in real-life problem-solving through practical and realistic assignments [33]. Therefore, games should simulate processes and events in a sufficiently realistic manner [52].

Some of the learning solutions developed include home electricity control, a physician locator for health facilities, antenna camouflage in indigenous communities, transmission of academic content through digital terrestrial television in open classrooms in rural areas, a mobile application for sustainable transportation, and a mobile application for food banks.

6 CONCLUSIONS

In this study, we utilized a classroom card game to examine the influence of strategies on student engagement and the cultivation of three essential generic skills: (i) knowledge acquisition, (ii) value construction and lifelong learning, and (iii) awareness of others in society and interaction with the environment. The recent systematic review by [48] revealed that most studies were associated with cognitive (19), affective (19), and behavioral (8) learning outcomes. In the field of cognitive learning, commonly researched effects include enhanced knowledge acquisition (15), content comprehension (5), critical thinking and clinical reasoning (4), knowledge retention (2), and learning performance (1).

Our results provide strong evidence in favor of using the proposed card game to simultaneously enhance the three generic skills mentioned above. Students were able to enhance these skills due to the synergistic collaboration between the game environment, which fosters learning through play, and the integration of independent and classroom activities. This collaborative approach actually encouraged students to actively engage in the learning process. They were able to understand complex mathematical and physical theories in a real-life context.

In light of the above, game-based learning facilitated students' active engagement throughout the course, resulting in significant progress in all three generic competencies. In addition, student-centered activities transformed courses into more interactive experiences, significantly improving student participation, skills, and outcomes.

We are aware, however, that this study may have certain limitations. Only 63 students participated in the analysis, which may have impacted the robustness of the statistical analysis. To enhance the reliability of the results, future studies should include larger sample sizes and participants who have completed relevant courses. One potential solution to this limitation is to develop an online or virtual reality version of the proposed card game. This would not only enable the game to be applied to other antenna courses but also broaden the scope of solutions proposed by students.

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