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Gamification in Engineering Education during COVID-19: A Systematic Review on Design Considerations and Success Factors in its Implementation

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Abstract. In pre-pandemic scenarios, various studies have indicated that gamification has turned out to contribute to improving student learning; however, in the context of the pandemic and in the face of the abrupt change to a virtual teaching modality, the need for learning innovations to overcome the limitations of social distancing was much more critical. Thus, this article aims to explore and describe the design considerations of gamification and the factors that evidenced its success in engineering education. Therefore, a systematic review of the literature was developed under a mixed approach and with an exploratory-descriptive scope. The results showed that gamification was applied to a greater extent in computer engineering and software engineering. In addition, the design considerations that prevailed in the development of gamification applications were, to a greater extent. focused on the pedagogical objective and the interaction of the simulation. It was found that the application of gamification effectively generates motivation, commitment, and permanent participation of the student. As such, it is concluded that aspects such as the area of knowledge of the student in engineering are relevant for the implementation of gamification. In addition, the design considerations that contribute to the success of the construction of student learning do not depend on the virtual, face-to-face or hybrid teaching model; however, it is necessary to build regulations that regulate and promote the continuity and sustainability of the use of gamification throughout the engineering career and not in isolation.

Keywords: gamification; engineering education; design; success factors; motivation

1. Introduction

In the context generated by COVID-19, teachers had to change their usual teaching methodologies (Salvador-García, 2021; Ng & Lo, 2022); that is, going from a traditional teaching model to virtual teaching where their adaptation to change unlocked their insecurities and inexperience to use digital tools (Villarroel et al., 2021). The use of these tools during the pandemic required teachers to change their educational practices and teaching models (Marisa et al., 2020; Rincon-Flores & Santos-Guevara, 2021; Nair, 2022), forsaking their role as an information provider, to become a counselor or guide, since the knowledge is online and no longer needs someone to provide it (Páez-Quinde et al., 2022). Thus, by abruptly moving to a non-face-to-face education model due to the pandemic, it brought with it opportunities linked to innovation in the teaching process, which allowed the diversification of forms of learning (Rincon-Flores et al., 2022; Vázquez et al., 2019), seeking effectiveness and support in the development of the educational process (Alhalafawy & Zaki, 2022). Technology-focused learning through the Internet has a broader scope than traditional learning (Cabrera & Pech, 2020), enabling to develop shared communities and with the acquisition of knowledge based on student interaction (Azar & Tan,

2020; Wardoyo et al., 2021). Therefore, the use of technology brings about reinforcing the teaching-learning process with the use of audio, video and image media, which, in many cases, are well-mastered by students (Gualda et al., 2019; Heredia-Sánchez et al., 2020).

Today's university students are digital natives, since they develop a set of habits and practices through the daily use of technologies, which are considered to be in the gamer stage (Alarcón-Diaz et al., 2020). Therefore, the application of gamification in the context of university education is propitious since it stimulates the autonomy and participation of students (Castillo et al., 2018; Manzano et al., 2022). The rise of technologies, especially in the field of videogames, has contributed to the use of components or elements of these environments in other fields, such as education (Daza & Fernández-Sánchez, 2019). The new educational demands bring with them new teaching strategies to boost the learning process, one of them being gamification (Duque et al., 2018; Fuentes, 2020; Lirola, 2022). Gamification enhances healthy competitiveness among students, which, properly managed, leads to greater interest in learning (Flores-Bueno et al., 2021; Mite & Albán, 2022). The evolution of video games and digital devices has great relevance at the didactic level, since teachers can gamble on this playful treatment as another methodology and which is implemented within educational institutions (Rodríguez et al., 2018). Likewise, the game environment favors the motivation of students to learn (Antonopoulou et al., 2022; Nivela-Cornejo et al. 2021) and helps to improve the understanding of complex concepts that require thought, space and time (Escobar et al., 2019; García-Miranda & Heras, 2019;Rodríguez-Oroz et al., 2022).

The term gamification refers to the use of game mechanisms in non-game environments (Bencsik et al., 2021; Lobo-Rueda et al., 2020; White et al., 2022) with the purpose of driving the behavior of users through participation, interaction and cooperation toward the achievement of a certain purpose (Lazarte & Gómez, 2021). In addition, gamification has the purpose of transforming activities, services and structures of different organizations to generate experiences that are gratifying, similar to what a game generates, in which there are challenges and rewards (Abreu, 2021). Oriented to the educational field, it can be defined as the process of transformation of academic elements or components of a subject into game themes (Idris et al., 2020). So, the games bring with them guidelines, with which students must comply in order to achieve the objective and win the game or move to another higher level; it is there where education takes advantage of this playful activity to turn it into a methodological alternative (Solís-Castillo & Marquina-Lujan, 2022). In the game, points are obtained by completing missions, which can be individual, as a couple, in a team, carried out in each class session or even at home (Mallén, 2019).

Some critical variables in the design of gamification tools are the game setting or decoration and the didactic technique or simulation interaction and game progression (Antonopoulou et al., 2022). It is also viable to consider as design criteria the efficient management of time for both students and the teacher and

the adaptation of the video game to the curriculum, with work thought out and designed for meaningful learning (Villalobos & Ríos Herrera, 2019). In relation to the factors that demonstrate its success, the fun and perceived utility generated in the player must be taken into account, since it will be relevant to achieve motivation and commitment to develop the ludic activity (Manzano-León et al., 2022). Likewise, when applying gamification, the impact on the motivation and degree of student satisfaction must be analyzed, which will be reflected in the degree of learning that is finally achieved (Castedo et al., 2019; Fuster-Guilló et al., 2019). There are several free tools to promote interactive learning and gamification inside and outside the classroom, such as Kahoot, Socrative or Quizizz (Muñiz-Calvente et al., 2018).

Regarding its application in engineering education, gamification aims to develop understanding and integration, as well as improve practical and critical thinking in problem solving (Hidalgo, 2021; Valencia-Rodríguez et al., 2022), in addition to developing effective communication skills in a playful context that favors the active participation of the student (Fernández et al., 2021; Ramirez-Prada et al., 2019). Taking into account that many companies make use of gamification, it is relevant for engineering students to know these methodologies, since they will also be present during their future work activities (Carnero, 2020). Gamification makes it possible to achieve pedagogical objectives in the field of engineering, by making use of strategies and dynamics typical of games, but applied to real contexts (Castán et al., 2019; Vera et al., 2020). Also, through gamification it is possible to design a motivational didactic tool that impacts engineering students by integrating transversal skills (Magino, 2019; Pulido et al., 2018;Torres-Barreto, 2018) within a positive emotional climate (Zamora-Polo et al., 2019).

In relation to what has been indicated, this research has an exploratory-descriptive scope and a mixed approach, intended to review design aspects and success factors applied in the implementation of gamification in engineering education. Although, before the pandemic, there was already an acceptance in the university academic field, during the context of the pandemic many university educational institutions had to abruptly migrate to a totally virtual teaching-learning modality, and, given the difficulties of technological infrastructure, it showed that the universities were not completely prepared for a change under these conditions. For this reason, it is relevant to develop a systematic review of the literature on closing gaps that have been generated in questions of design and contribution achieved in learning through gamification, during the pandemic and post-pandemic context. In this sense, through the systematic review of the literature, this paper aims to explore the design considerations in gamification in engineering education during the context of COVID-19 and determine factors reflecting the success in its implementation. Specifically, it seeks an answer to the following research questions:

- RQ1: In what specialties of engineering education and under what methodological approach has gamification been applied in the pandemic scenario?

- RQ2: What were the design considerations that have been used in gamification for its application in engineering education in the pandemic scenario?
- RQ3: What were the factors that showed that the application of gamification in engineering education was successful in the pandemic scenario?

The research questions are part of the initial systematic review of the literature (Valdés-González & Martín-Antón, 2023). They also represent the starting point on which the investigation will be conducted and oriented (Shen & Slater, 2021).

2. Methodology

2.1 Research design and scope

The mixed approach was used in this study to collect in-depth information on the uses of gamification in engineering education,and analyze them qualitatively and quantitatively. Mixed approach allows the researchers to integrate and synthesize relevant aspects associated with the design criteria and success factors in its implementation under the pandemic scenario. The mixed approach represents the integration between the qualitative and quantitative analysis of the study variables (Flores, 2019). On the other hand, the quantitative approach allows assigning numerical values to analyze data through statistics, and to even generalize results; however, in many cases it is necessary to go deeper and interpret the phenomenon, and that is when it is complemented with the qualitative route (Guerrero-Castañeda et al., 2016; Padilla-Avalos & Marroquín-Soto, 2021).

Likewise, the scope of the research is exploratory-descriptive because, through the systematic review of literature, it is intended to examine the results achieved by using gamification in engineering education during the pandemic scenario. It also seeks to extract similar characteristics from the studies in order to categorize them based on design criteria or considerations and success factors in their implementation. Studies with an exploratory-descriptive scope allow establishing the characteristics or general components associated with the research variables (Ramos-Galarza, 2020; Flores & Flores, 2021).

2.2 Search strategy and data extraction

In order to extract the data or scientific articles in a rigorous manner, which formed part of the systematic review, the PRISMA declaration (Preferred Reporting Items for Systematic reviews and Meta-Analyses) was used. The PRISMA statement is made up of a set of procedures that guarantees the selection of bibliographic references to be included in the systematic review, minimizing the risk of bias (Chamorro-Atalaya et al., 2023). Likewise, the PRISMA declaration allows a search for scientific articles to be carried out as adequately and ethically as possible, guaranteeing the validity and traceability of the selection process (Sánchez-Caballé & Esteve-Mon, 2022).

Table 1 shows the search equations made up of the integration of the keywords in both English and Spanish, these being: “gamification,” “gamificación,” “students,” “estudiantes.” “engineering” and “ingeniería." This integration was

carried out through the use of Boolean operators in order to achieve a high degree of specificity in the identification of scientific articles. Boolean operators allow the construction of more specific search equations that will lead to a closer identification of scientific articles in their first selection phase (Bustamante, 2021; Chamorro-Atalaya et al., 2023). The databases used for data extraction were Taylor & Francis, IEEE and Scopus. It is important to highlight that the use of too many keywords or descriptors often manages to delimit the search too much, even leading to a scenario in which the result is zero. Based on what has been indicated, the search equations were expressed as shown next.

Table 1: Search Equation

Database	Search equation
Taylor & Francis	[[All: "Gamificación"] OR [All: "Gamification"]] AND [[All: "estudiantes"] OR [All: "students"]] AND [[All: "ingenieria"] OR [All: "engineering"]]
IEEE	("Gamificación" OR "Gamification") AND ("Estudiantes" OR "students") AND ("Ingenieria" OR "engineering")
SCOPUS	(TITLE-ABS-KEY (("Ingenieria" OR "engineering"))) AND (TITLE-ABS-KEY (("Estudiantes" OR "students"))) AND (TITLE-ABS-KEY (("Gamificación" OR "Gamification")))

Likewise, in order to further increase the precision with respect to the scientific articles to be chosen and that were part of the analysis for the systematic review of the literature, the inclusion and inclusion criteria were defined as aligned to the research questions and the purpose of the study. The inclusion and exclusion criteria allow the extracted data or selected bibliographic references to align with the study framework of the systematic review (Santhanasamy & Yunus, 2022); thus, these must also be linked to the research questions, delimiting the context and scope of the study (Kehing & Yunus, 2021; Muharikah et al., 2021). Table 2 shows the inclusion and exclusion criteria defined for the systematic review to be developed.

Table 2: Inclusion and exclusion criteria

Criterion type	Criteria
Inclusion	• Publications related to engineering education • Publications whose evaluation process includes peer review. • Open access publications. • Scientific articles whose publications were made during the years 2020 to 2022.
Exclusion	• Scientific articles related to education at the initial, primary, secondary or university level that are not linked to the engineering area. • Publications related to theses or conference articles. • Publications that only show summaries and do not allow access to their full content. • Scientific articles whose publications were made before the year 2020.

Regarding the extraction of data established in the PRISMA declaration, Figure 1 shows the flow of phases that was followed to determine the final inclusion of

scientific publications from the aforementioned databases. In the first phase and through the search equation, it was possible to identify a total of 1652 publications from the three databases. Then, we proceeded to discard the repeated or duplicate publications found among the databases used, managing to reduce to 1350 publications. As a second phase, we proceeded to determine the articles in projection, for which a review of the titles and abstracts of all the articles identified in the previous phase was carried out, thus achieving a total of 1000 publications. In the third phase, the inclusion and exclusion criteria were applied, by which 28 scientific articles were chosen. Finally, an exhaustive review of the complete content of each article was carried out, based on the research questions, with which it was included for the phase of analysis and synthesis of the findings regarding gamification in engineering education.

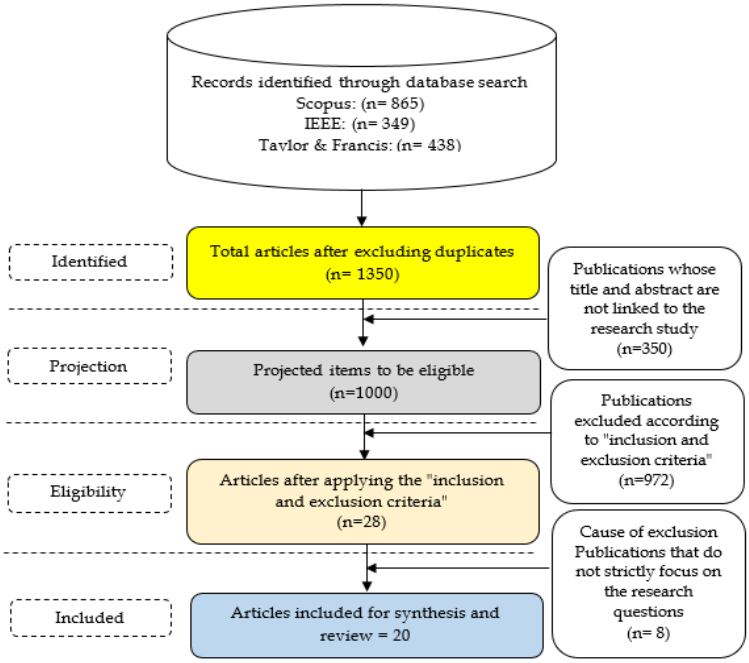

Figure 1. Data extraction through the PRISMA declaration flow

2.3 Quality analysis of the articles to be included in the systematic review

Once the data extraction process was carried out, identifying that 20 articles met the inclusion and exclusion criteria, as well as the criterion that their content is focused on the research questions, an analysis of the results was carried out. Quality was based on the adaptation of the instrument used in Ávila and Gómez (2017) in which the criteria to be considered are: application of gamification to engineering education (C1); methodological coherence (C2); clarity of the arguments (C3); and contribution to the area of knowledge (C4), the evaluation of which was carried out based on the assignment of a score of 5 when the criterion to be evaluated had a high value, 3 for a medium value and 1 for a low value. To consider an article as having quality, it must achieve at least three points in all the criteria; in the event of any having a value of 1, the publication was excluded from the systematic review. Table 3 specifies the percentages achieved for each publication, based on a maximum total of 20 points, which represents 100%.

Table 3: Quality assessment of the articles included in the systematic review

Reference	C1	C2	C3	C4	Total
(Lluch-Molins et al., 2022)	3	3	5	5	80%
(Taguas et al., 2022)	3	5	5	5	90%
(Díaz-Ramírez, 2020)	3	3	5	5	80%
(Sánchez-Martín et al., 2020)	3	3	5	5	80%
(Raju et al., 2021)	5	5	5	5	100%
(Sobrino-Duque et al., 2022)	3	3	5	5	80%
(Gasca-Hurtado et al., 2021)	5	5	5	5	100%
(Çulha, 2022)	5	5	5	5	100%
(Kho et al., 2022)	5	5	5	5	100%
(Morales et al., 2021)	3	5	5	5	90%
(Leon & Peña, 2022)	3	5	5	5	90%
(Asiksoy & Canbolat, 2021)	5	5	5	3	90%
(Alcántara et al., 2022)	5	3	5	5	90%
(Aranguren et al., 2020)	3	3	5	5	80%
(Pertegal-Felices et al., 2020)	5	5	5	5	100%
(Sarasa-Cabezuelo & Rodrigo, 2021)	3	3	5	5	80%
(Delgado-Gómez et al., 2020)	5	3	5	5	90%
(Chans & Portuguez-Castro, 2021)	3	3	5	5	90%
(Khaleel et al., 2020)	5	3	5	5	90%
(Zabala-Vargas et al., 2021)	5	5	5	5	100%

3. Results and discussion

From the evaluation of the quality of the scientific articles included for the systematic review, it was identified that all the publications reached the required quality to be analyzed and considered in the content processing stage. Likewise, when exploring the number of articles included in the systematic review by year of publication, it was possible to determine that, of the total of 20 articles, six were published in 2020, seven in 2021 and seven in 2022. Figure 2 shows the percentage distribution by year of publication, which shows that studies on the application of gamification in engineering education have followed a tendency to increase during this pandemic period.

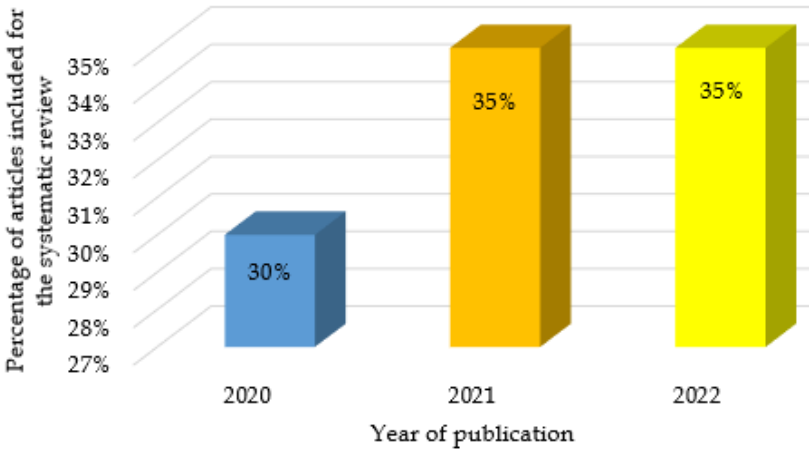

Figure 2. Percentage distribution of scientific articles by year of publication

3.1 Specialties of engineering education in which gamification was applied

From the content analysis carried out on the 20 publications, it was identified that the specialties of engineering education in which gamification was applied to a greater extent in the context of the pandemic were industrial engineering, computer engineering, mechanical engineering and engineering software. In addition, it was possible to identify that the study objectives (SO) of these investigations can be categorized into: "Analyze the efficiency in the teaching and learning process when using gamification" (SO1); "Assess student satisfaction when using gamification" (SO2); "Analyze the impact of gamification on student desertion" (SO3); and "Develop soft skills in students when using gamification" (SO4). Thus, it was also identified that publications on gamification in engineering education make use of the level and methodological design: Exploratory-Experimental or Exploratory-Descriptive. Table 4 shows the scientific articles categorized by specialty, study objective and research methodology used.

Table 4: Specialties of engineering education and methodology used

Specialty	Categorization of study objectives	Research methodology		Reference
		Level and design	Sample (students)	
Informatics Engineering	Analyze the efficiency in the gamification teaching process	Exploratory/ Experimental	56	(Raju et al., 2021)
	Evaluate student satisfaction	Descriptive/ Experimental	55	(Sobrino-Duque et al., 2022)
		Exploratory/ Experimental	54	(Pertegal-Felices et al., 2020)
Software Engineering	Analyze the efficiency in the teaching process	Exploratory/ Experimental	11	(Çulha, 2022)
	Evaluate student satisfaction		17	(Sarasa-Cabezuelo & Rodrigo, 2021)

	Analyze the impact of gamification on student dropout	Descriptive/ Experimental	60	(Khaleel et al., 2020)
Civil Engineering	Evaluate student satisfaction	Exploratory/ Experimental	10	(Lluch-Molins et al., 2022)
	Analyze the efficiency in the teaching process		18	(Gasca-Hurtado et al., 2021)
Mechanical Engineering	Analyze the efficiency in the teaching process	Exploratory/ Experimental	180	(Alcántara et al., 2022)
			153	(Aranguren et al., 2020)
Industrial Engineering	Analyze the efficiency in the teaching process	Exploratory/ Experimental	55	(Sánchez-Martín et al., 2020)
		Descriptive/ Experimental	22	(Delgado-Gómez et al., 2020)
Electric Engineering	Analyze the efficiency in the teaching process	Exploratory/ Experimental	116	(Kho et al., 2022)
Marine Engineering	Analyze the efficiency in the teaching process	Exploratory/ Experimental	70	(Leon & Peña, 2022)
Petroleum and Natural Gas Engineering	Analyze the efficiency in the teaching process	Descriptive/ Experimental	67	(Asiksoy & Canbolat, 2021)
Mathematical Engineering	Analyze the impact of gamification on student dropout	Exploratory/ Experimental	106	(Zabala-Vargas et al., 2021)
Forest Engineering and Agricultural Engineering	Develop soft skills in students	Exploratory/ Experimental	36	(Taguas et al., 2022)
Studies that apply to three or more specialties of engineering education	Analyze the efficiency in the teaching process	Descriptive/ Experimental	56	(Díaz-Ramírez, 2020)
			295	(Morales et al., 2021)
			48 by specialty	(Chans & Portuguez Castro, 2021)

Thus, the cross-tabulation analysis of the scientific articles was also carried out with respect to the "specialty in which gamification was applied" and the "category of the study objective," identifying that, of the 60.0% of articles reviewed that have as categorization of the objective SO1, the specialties that developed it to a greater extent were industrial engineering and mechanical engineering, both reaching 10.0% of the total. While of the 20.0% of articles reviewed that have the SO2 objective as categorization, the specialty that developed it to a greater extent was computer engineering, reaching 10.0% of the total. In addition, it was identified that, in a lower percentage, the reviewed

articles had SO3 and SO4 as objective categorization with percentages of 15.0% and 5.0%, respectively. Table 5 shows the results of the cross-tabulation analysis.

Table 5: Result of the cross-tabulation analysis

		Research objective category				Total
		SO1	SO2	SO3	SO4	
Engineering Education Specialties	Civil engineering	5.0%	5.0%	0.0%	0.0%	10.0%
	Electric engineering	5.0%	0.0%	0.0%	0.0%	5.0%
	Forest engineering and Agricultural engineering	5.0%	0.0%	0.0%	0.0%	5.0%
	Industrial engineering	10.0%	0.0%	0.0%	0.0%	10.0%
	Informatics engineering	5.0%	10.0%	0.0%	0.0%	15.0%
	Marine engineering	5.0%	0.0%	0.0%	0.0%	5.0%
	Mathematical engineering	0.0%	0.0%	5.0%	0.0%	5.0%
	Mechanical engineering	10.0%	0.0%	0.0%	0.0%	10.0%
	Petroleum and natural gas engineering	5.0%	0.0%	0.0%	0.0%	5.0%
	Software engineering	5.0%	5.0%	5.0%	0.0%	15.0%
	Studies that apply to three or more specialties of engineering education	5.0%	0.0%	5.0%	5.0%	15.0%
Total		60.0%	20.0%	15.0%	5.0%	100.0%

These results, although they are limited to the study of the application of gamification in education in engineering specialties in the context of COVID-19, studies prior to the timeframe established for this research, such as that of Ávila and Gómez (2015), point out that the area of knowledge in engineering registers the highest levels of application of gamification in student learning. Likewise, Arceo et al. (2019) conclude that the area of Software Engineering is where gamification strategies were implemented the most. In relation to the last mentioned, it supports what was identified in this systematic review, since one of the specialties that presents the highest frequency of gamification application is Software Engineering. One aspect that could be linked to this result is the skills and abilities that students and teachers present in this specialty, since it is relevant not only to develop the application, but also how they are adapted to the use of this type of tool. In studies carried out in the pandemic phase, such as that of Nieto-Escamez et al. (2021), conclude that most of the gamification experiences have been applied in science, technology, engineering and mathematics (STEM) disciplines. While Palomino (2021) points out that, in terms of the relationship between the concept of gamification and the engineering area, it is worth noting the proliferation of different gamification tools mediated by the use of ICT (Information and Communication Technologies), which justifies the high involvement of teachers assigned to this area of knowledge toward the

use of this type of teaching resources to improve learning. There is, therefore, agreement with what was identified, since, in this systematic review, it was identified that 60% of gamification applications are focused on "improving learning" compared to other purposes such as: evaluating student satisfaction when using gamification; analyzing the impact of gamification on student dropout and "Develop soft skills in students when using gamification."

3.2 Design considerations that have been used in gamification for its application in engineering education

Regarding the design considerations (DC) that have been used in gamification for its application in engineering education, from the systematic review it was possible to identify that not all articles contain the same criteria, as if it were a pattern or rule to follow. However, reference is taken from that indicated by Ávila and Gómez (2017), who established that, in order for gamification to meet the learning goals and purposes, it must be designed taking into account six considerations: "Pedagogical objective" (DC1): representing the scope of the knowledge domain to be reached; "Simulation" (DC2): representing the rules and game parameters that guarantee that the game does not present any scenario that requires interpretation that is not contemplated in the game; "Interaction with the simulation" (DC3): representing the aspects of how the student interacts with the game, in such a way that they can achieve the development of their learning; "Problems and progression" (DC4): representing the path that the student will follow in a progressive way to achieve the learning objectives; "Decoration" (DC5): representing the way in which the attention of the student will be achieved; and "Conditions of use" (DC6): representing where, when and who or who may develop the game. As such, it will be possible to categorize the considerations used in each article reviewed. Table 6 shows the design considerations for each bibliographic reference analyzed and their respective coding based on the six mentioned criteria.

Table 6: Categorization of design considerations

Reference	Design Considerations
(Lluch-Molins et al., 2022)	• The game must be shown as an attractive and motivating tool. (DC1) • Access to the game must be done through a QR code. (DC2) • The game must welcome and specify the instructions. (DC3) • For the start of the game, students must go through a diagnostic evaluation. (DC4) • The game must offer challenges to a student or groups of students. (DC6)
(Taguas et al., 2022)	• The game should focus on skill development. (DC1) • The game makes use of questions, written evaluations and musical dynamics from a movie. (DC2) • The game must allow you to choose a particular context. (DC3) • The game must present various conflict scenarios linked to leadership and teamwork. (DC4)

(Díaz-Ramírez, 2020)	• The game must include activities that involve mastery of the topics to be developed in class, as well as activities related to institutional aspects. (DC1) • In the game the participants carry out activities classified by categories. In addition, different types of badges can be obtained, depending on the activities carried out. (DC3) • The game provides rewards based on the degree of difficulty. Likewise, the game allows you to reach levels according to the frequency of participation. (DC4)
(Sánchez-Martín et al., 2020)	• The game must contain scientific problems and riddles related to the study topics. (DC1) • At the end of the last problem, the game will provide a key to exit the laboratory. (DC3) • The game must provide clues to start the next problem. (DC4) • In the game, time is relevant to the final classification. (DC6)
(Raju et al., 2021)	• The game should increase the confidence level of the participants and contribute to their motivation. (DC1) • The game offers "experience points" and students earn these points for participating in each activity. (DC2)
(Sobrino-Duque et al., 2022)	• The game should focus on the evaluation of usability and improvement of learning. (DC1) • The game must take into account the participant's characterizations obtained through consideration cards. Likewise, the game must take into account the characterizations of the environment through context cards. (DC2)
(Gasca-Hurtado et al., 2021)	• The game must guarantee the dynamization of the class environment. (DC1) • The game must offer the teacher the ability to recurse. (DC2)
(Çulha, 2022)	• The game should contribute to inquiry-based learning for use in the Software Engineering course (DC1). • The game must present qualification rules, the same ones that must motivate the participants to select the best pairs of questions and answers. In addition, the scoring rules are arranged with the purpose of maximizing the quality of the questions. (DC2)
(Kho et al., 2022)	• The game should increase student engagement during online class sessions. (DC1) • The game must provide an interactive map, without which students will not be able to advance to the next stage before completing the initial stage. (DC4) • The game must provide target score at the entry stage and before advancing to the initial stage. (DC2) • The game must be divided into stages and each stage must provide an informative video, which can be updated. (DC3)
(Morales et al., 2021)	• The game must represent a virtual support platform for students to improve their performance (DC1). • The game should offer scores, badges, and rewards to students who demonstrate their progress. (DC2) • The game must increase the difficulty or complexity with respect to its previous stage, as well as the game must provide a time limit for the development of the activity (DC6) • The game must allow you to pass to the next level as long as a number of tasks are completed, in addition the game will motivate

	the competition by showing a board in which the scores obtained will be specified. The game will offer a graph on the progress of what has been developed and what is pending to develop. (DC3)
(Leon & Peña, 2022)	• The game must generate a positive impact on learning, motivating attendance, participation and collaboration of students in class. (DC1) • The game must be developed using different gamification tools. (DC2) • The game bases your answers on multiple choice mode, so the game must also provide three possible outcomes: positive, negative or no score. (DC3) • The game shows different stages with different complexities. (DC6)
(Asiksoy & Canbolat, 2021)	• The game should engage students continuously in online activities linked to class sessions. (DC1) • The game should offer two types of badges, based on which student watched the most videos of the course and completed the questions correctly, and which student contributed the most to forum discussions. (DC2) • The game must offer a leaderboard that shows student achievement. (DC3) • The game offers points for posts in the forum before the start of class. (DC4)
(Alcántara et al., 2022)	• The game must present an easy-to-implement design that contributes to the learning of engineering subjects throughout three academic years. (DC1) • The game must present results that help the teacher's task, facilitating the reading of grades and adapting to the teaching methodology. (DC2) • The game must provide the player with the measurement of the results of its implementation. (DC3) • The game must show a simple interface that does not require too much expertise in technical aspects. (DC5)
(Aranguren et al., 2020)	• The game must contribute to link the theoretical and practical aspects of the subject. (DC1) • The game must offer the possibility of making comments between the members of each team. (DC3) • The game has two parts; in the first part the students develop an open question, and in the second part the students identify the parts of an image related to the topic under study. (DC4) • The game can be played from a cell phone, allowing you to join teams or groups, and the game provides a limited time for the development of the stages. (DC6)
(Pertegal-Felices et al., 2020)	• The game offers a crossword puzzle designed for reviewing thematic content. (DC1) • The game must allow peer evaluation. (DC2) • The game must show the progress of each student. (DC4) • The game must allow the evaluation through a synchronous test for the preparation of the final evaluation. (DC3) • The game must present questions with different degrees of difficulty; in addition, the game must allow the questions to be answered individually and also in a group. (DC6)

(Sarasa-Cabezuelo & Rodrigo, 2021)	• The game should contribute to improve the learning of the subject of software engineering. (DC1) • The game offers a score for achievement level reached. (DC3) • The game must be structured in phases with different levels of difficulty. In addition, the game must offer limited time for the development of each question. (DC6)
(Delgado-Gómez et al., 2020)	• The game focuses on learning the hypothesis test. (DC1) • The main screen of the game must present circular buttons that lead to a video and a square button that shows a set of questions linked to the explained concept. (DC5) • The game must provide stars that indicate the mastery acquired by the student. (DC2) • The game must provide signaling about the progress in the subject. (DC3) • The game must provide a scoring and standings table. (DC4)
(Chans & Portuguez-Castro, 2021)	• The game must be designed seeking to provide an entertaining experience to the student, under three principles: relationship, competition and autonomy. (DC1) • The game must provide interaction for students individually and in groups. (DC3)
(Khaleel et al., 2020)	• The game should contribute to the improvement of learning in programming language subjects. (DC1) • The game must provide a profile section of the participant, in which the score and level reached can be displayed. (DC2) • In this way, it should also allow visualizing the general map of the game, specifying the concept levels. (DC5) • The game must display a leaderboard, specifying scores per level, stars, badges, and evaluation time. (DC3)
(Zabala-Vargas et al., 2021)	• The game should contribute to the learning of mathematics in students of the first cycles of engineering. (DC1) • The game allows you to configure behaviors to encourage and punish attitudes that go against the rules of the game. (DC2) • The game allows you to parameterize an avatar with different attributes and characteristics. (DC5) • The game allows the formation of work teams. (DC6) • The game allows the organization of scenarios called maps, in which the first map will be composed of game introduction stages, knowledge validation stage, debate stage, collaborative workshop stage and mastery evaluation stage. (DC3)

In order to determine which design considerations have a greater predominance in gamification applications in the field of engineering education, Figure 3 shows the percentage distribution of design considerations used in the 20 reviewed scientific articles. It was possible to identify that the most used considerations were DC1, DC3 and DC2, respectively representing 100%, 80% and 75% of the total articles analyzed in this systematic review.

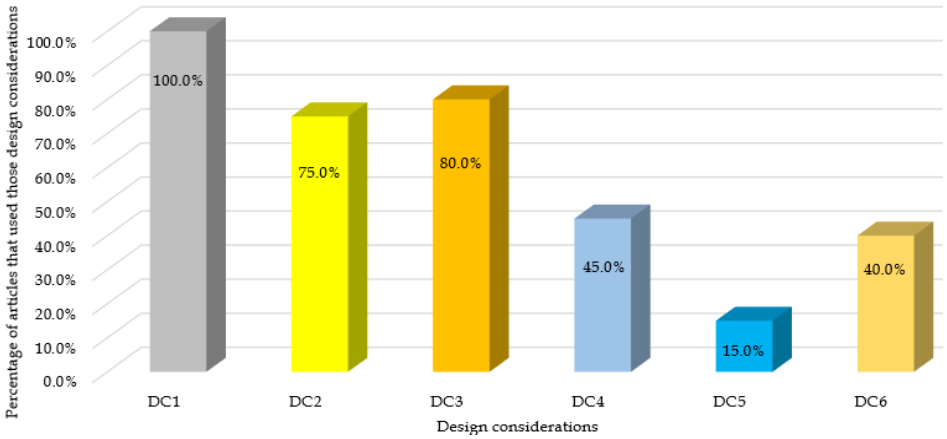

Figure 3. Percentage distribution of design considerations used

The results obtained show that a strictly necessary consideration for the design of gamification in engineering education is the "pedagogical objective," representing the support and fundamental basis for the development of the game. This point of view is also supported by Andreu (2020) who points out that one must know perfectly well what one wants to achieve, that is, the pedagogical objective, since this is relevant to the design of the game, thus achieving that gamification responds to the stated needs. In this regard, Palomino (2021) concludes that the gamification experiences proposed to the student must be previously planned and linked to specific pedagogical objectives, and must be considered for a certain content and according to the characteristics of the group of students to which it is addressed. This idea is reinforced by Rivera et al. (2020) who point out that there are several minimum methodological elements to develop an instrumental strategy based on gamification, regardless of the means used to implement it; these elements must be focused on the design process, which is structured based on the pedagogical objective. Likewise, Machuca-Villegas et al. (2019) conclude that, although elements such as points, badges, challenges, rewards, levels, leaderboards, and feedback are very prominent design considerations, it is necessary to define the pedagogical objective, since it contributes to the design of gamification strategies that allow to a greater extent to obtain results.

3.3 Factors that evidenced the success of the application of gamification in engineering education

From the analysis of the results of the articles included in the systematic review, in terms of the success factors (SF) of the application of gamification in engineering education, it was possible to identify that the positive impact fell on motivation (SF1), student commitment (SF2), participation (SF3), communication (SF4) and competitiveness (SF5). Table 7 details the success factor of each article reviewed, as well as the evidence of success. In addition, it was possible to determine that the contribution of gamification in the "Motivation" of the students represents the success factor in 80% of the reviewed articles, "Commitment" represents 50%, "Participation" 55%, "Communication" 20% and "Competitiveness" 10%.

Table 7: Success factors as a result of the application of gamification

Reference	Success factors (SF)					Evidence of success
	SF1	SF2	SF3	SF4	SF5	
(Lluch-Molins et al., 2022)	✓					The students were motivated in their learning, which led to obtaining very good grades, with an average grade of 6.6 on a scale where the maximum grade is 7.
(Taguas et al., 2022)	✓		✓	✓	✓	The students showed improvements in their soft skills from the use of gamification in their learning. Since it fostered motivation, commitment, participation and communication.
(Díaz-Ramírez, 2020)	✓	✓				As many as 83% of the students in the experimental group consider that gamification enriches and helps to improve learning in university education, based on the improvement of commitment and motivation in learning.
(Sánchez-Martín et al., 2020)	✓		✓			More than 88% of the students indicated "Yes", that gamification in education is important and that they considered it efficient in the teaching-learning process in science and technology issues.
(Raju et al., 2021)					✓	All students surveyed leaned toward gamification; this is because it highlights the competitive spirit among students.
(Sobrino-Duque et al., 2022)	✓		✓			With a confidence interval of 95%, this research indicates that the students (experimental group) have a better perception regarding their learning.
(Gasca-Hurtado et al., 2021)	✓	✓				The interviewed students felt motivated and engaged during the entire class section, since previously more than half of the students were distracted.
(Çulha, 2022)	✓		✓			Gamification improves student performance by 23% more.
(Kho et al., 2022)		✓		✓		As many as 88% of the participants commented that they liked the implementation of gamification in engineering courses and indicated that it can potentially improve the engagement and enjoyment of students toward the learning process.
(Morales et al., 2021)	✓	✓	✓			A total 90.2% of the students affirmed that the application of gamification as a new learning methodology is much better than the traditional one. Also, 87.7% of the students commented that learning programming with the new methodology was fun, while 81% of students thought that gamification

						increased their motivation.
(Leon & Peña, 2022)	✓	✓				By applying gamification, a positive impact was generated on the motivation of the students, which was reflected in their academic performance.
(Asiksoy & Canbolat, 2021)		✓	✓			Gamification in the pre-class stage has a positive effect on student performance, since it increases student engagement and participation.
(Alcántara et al., 2022)	✓		✓			The number of passes increased by 39% by applying gamification, which led to also increasing student participation by 26.7%.
(Arangure n et al., 2020)		✓	✓			A positive impact was generated on student performance, increasing by 2.7 points, with respect to the average score before applying gamification.
(Pertegal-Felices et al., 2020)	✓		✓	✓		Gamification contributed to the improvement of the participation, communication and motivation of the students, who were satisfied with their learning.
(Sarasa-Cabezuelo & Rodrigo, 2021)	✓		✓			Of the students evaluated, 66% indicated that the gamification application was easy to use, so students were satisfied with the new methodology as opposed to the traditional one.
(Delgado-Gómez et al., 2020)	✓				✓	A total 92.8% of the students responded that the application of gamification develops greater motivation, and 81.2% mentioned that it develops competitiveness.
(Chans & Portuguez-Castro, 2021)	✓	✓				Of the students who received gamification, 96% responded positively, in addition, a greater commitment and motivation was perceived during the class section.
(Khaleel et al., 2020)	✓	✓				Most of the students agree with the application of gamification (the experimental group is higher than the control group). In addition, it has a positive effect and a high acceptance in learning.
(Zabala-Vargas et al., 2021)	✓	✓	✓			It was identified that 38.5% of students were satisfied in completing the exercises; this reflects that students are more committed to the class. In addition, 46.1% mentioned that they enjoyed the applied games.

Of the articles included in the systematic review, it is determined that the improvement in student motivation represents the success of the application of

gamification in engineering education to a greater extent. Although the final purpose of gamification in education is to improve the student's academic performance, aspects such as motivation, commitment, participation, communication and competitiveness have a direct and significant influence on the construction of the student's own knowledge. In this regard, Andreu (2020) concludes that motivation is one of the factors that occur in students when applying gamification, since games generate significant experiences in them. Reaffirming what was identified in this systematic review regarding the success factors achieved when applying gamification, Zhan et al. (2022) point out that gamification in education generates a positive effect to a greater extent on motivation which, as a consequence, contributes to improving the student's academic performance. Likewise, Arceo et al. (2019) determined on the application of gamification that the majority of students reported through a survey feeling motivated by this type of initiative in the teaching-learning process.

However, other studies do not strictly focus on motivation as the only success factor that contributes to improving learning, such as Alzahrani and Alhalafawy (2022) who affirm that the success of the application of gamification is evidenced by the improvement in academic performance of the student; this is because the game is oriented to specific learning purposes, managed to "motivate" them and generated "participation" in the construction of their own knowledge. This position is supported by Nieto-Escamez et al. (2021) who affirm that the purpose for the implementation of gamification mostly responds to the need to improve student learning and that they are associated with increased motivation, commitment and competitiveness. Machuca-Villegas et al. (2019), with respect to the success factors of the application of gamification, conclude that these are related to social and human factors, among which motivation, collaboration, participation and commitment stand out. Another position is that established by Ávila and Gómez (2015) who establish that gamification can have positive and negative impacts on the motivation and interest of students, as well as on their academic performance, for which they consider that a framework of guidelines is clearly necessary for its application in the university educational environment.

4. Conclusion

Based on the research questions established in this systematic review, it is concluded that the specialties that applied gamification to a greater extent are computer engineering and software engineering, which shows that the aspect that could be linked to this result is skills. and skills that students and teachers present in that specialty, since it is relevant not only to develop the application but also how they are adapted to the management of gamification. Thus, it is also concluded that the design considerations that predominate in the development of gamification applications are to a greater extent the "pedagogical objective." This is because the basis that supports the use of gamification is the domain of knowledge that is intended to be achieved, and the "interaction with the simulation," because it represents the aspects of how the student interacts with the game, in such a way that he or she manages to achieve the development of their learning. Finally, it is concluded that the success factors

that were evidenced as the application of gamification are to a greater extent motivation, commitment, and participation; this is because all of them represent influential factors in a direct and significant way on the construction of knowledge that students own.

This systematic review of the literature limited its analysis to studies on the applications of gamification in engineering education in a timeframe in which the pandemic appeared, so factors such as the abrupt implementation of technological tools for the continuity of the process of teaching-learning, as well as teaching in completely virtual scenarios represent a limitation in the results obtained. This leads to future studies focusing on post-pandemic contexts, under face-to-face or hybrid learning models, highlighting that regulatory bases should promote and support the use of gamification in engineering education.

7. References

Abreu, M. A. F. (2021). Producción científica sobre Gamificación en educación universitaria en SciELO entre 2017- 2021: un estudio bibliométrico género. Revista Ciencias y Artes, *1*(2), 55–73. https://revistasucal.com/index.php/rca/article/view/10

Alarcón-Diaz, M. A., Alarcón-Diaz, H. H., Rodríguez-Baca, L. S., & Alcas-Zapata, N. (2020). Intervención educativa basada en la gamificación: experiencia en el contexto universitario. *Revista Iberoamericana de Desarrollo Humano y Social*, *22*(2), 117–131. https://doi.org/10.17151/eleu.2020.22.2.8

Alcántara, Ó. J. G., González, I. F., Camino, M. Á., & López. (2022). Kahoot!: Effective, simple and easy gamification in Higher Education. Practical application in an Engineering Degree. *Human Review. International Humanities Review*, *12*(3), 1–14. https://doi.org/10.37467/revhuman.v11.3949

Alhalafawy, W. S., & Zaki, M. Z. T. (2022). How has gamification within digital platforms affected self-regulated learning skills during the COVID-19 pandemic? Mixed-methods research. *International Journal of Emerging Technologies in Learning*, *17*(6), 123–151. https://doi.org/10.3991/ijet.v17i06.28885

Alzahrani, F. K. J., & Alhalafawy, W. S. (2022). Benefits and challenges of using gamification across distance learning platforms at higher education: A systematic review of research studies published during the COVID-19 pandemic. *Journal of Positive School Psychology*, *6*(10), 1948–1977. https://journalppw.com/index.php/jpsp/article/view/13543

Amaíz, A. J. A., & Flores, M. A. (2021). Exploratory-descriptive study on the attitudes of Costa Rican dentists towards the interdisciplinary application of psychological principles in oral consultation. *Vital Dentistry Journal*, *34*(1), 7–20. https://docs.bvsalud.org/biblioref/2023/01/1386442/odovn34art7.pdf

Andreu, J. M. P. (2020). Una revisión sistemática sobre gamificación, motivación y aprendizaje en universitarios. *Teoría de la Educación: Revista Interuniversitaria*, *32*(1), 73–99. https://doi.org/http://dx.doi.org/10.14201/teri.20625

Antonopoulou, H., Giannoulis, A., Theodorakopoulos, L., & Halkiopoulos, C. (2022). Socio-cognitive awareness of inmates through an encrypted innovative educational platform. *International Journal of Learning, Teaching and Educational Research*, *21*(9), 52–75. https://doi.org/https://doi.org/10.26803/ijlter.21.9.4

Antonopoulou, H., Halkiopoulos, C., Gkintoni, E., & Katsimpelis, A. (2022). Application of gamification tools for identification of neurocognitive and social function in distance learning education. *International Journal of Learning, Teaching and Educational Research*, *21*(5), 367–400. https://doi.org/10.26803/ijlter.21.5.19

Aranguren, P., Sánchez, D., Casi, Á., Araiz, M., & Catalán, L. (2020). Gamification and a low-cost laboratory equipment aimed to boost vapor compression refrigeration learning. *Journal of Technology and Science Education*, *5*(3), 184–193. https://doi.org/10.3926/jotse.1458

Arceo, E. E. B., Vera, R. A. A., Mendoza, J. C. D., & Pech, J. P. U. (2019). Gamificación para la mejora de procesos en ingeniería de software: Un estudio exploratorio. *Revista electrónica de Computación, Informática, Biomédica y Electrónica*, *8*(1), 1–19. https://doi.org/10.32870/recibe.v8i1.123

Asiksoy, G., & Canbolat, S. (2021). The effects of the gamified flipped classroom method on petroleum engineering students' pre-class online behavioural engagement and achievement. *International Journal of Engineering Pedagogy*, *11*(5), 19–36. https://doi.org/10.3991/IJEP.V11I5.21957

Ávila, C. L., & Gómez, S. B. (2017). Gamification in higher education: a systematic review. *Engineering Journal University of Medellín*, *16*(31), 97–124. https://doi.org/10.22395/rium.v16n31a5

Azar, A. S., & Tan, N. H. I. (2020). The Application of ICT Techs (Mobile-assisted Language Learning, Gamification, and Virtual Reality) in Teaching English for Secondary School Students in Malaysia during COVID-19 Pandemic. *Universal Journal of Educational Research*, *8*(11C), 55–63. https://doi.org/10.13189/ujer.2020.082307

Bencsik, A., Mezeiova, A., & Samu, B. O. (2021). Gamification in higher education (case study on a management subject). *International Journal of Learning, Teaching and Educational Research*, *20*(5), 211–231. https://doi.org/10.26803/IJLTER.20.5.12

Bustamante, M. S. (2021). *Systematic review of the literature Communities of practice as a community strategy in organizations*. B. S. Thesis, School of Management, Rosario University, Colombia. https://repository.urosario.edu.co/bitstream/handle/10336/33397/SilvaBustamante-Manuela-2021.pdf?sequence=9

Cabrera, W. R. R., & Pech, S. H. Q. (2020). Gamification in distance education: experiences in a university educational model. *Opening*, *12*(2), 6–19. https://doi.org/10.32870/ap.v12n2.1849

Carnero, M. C. (2020). Selection of application for gamification in a subject of the degrees in electrical engineering and industrial electronics and automation. *INNODOCT*, *6*(8), 821–829. https://doi.org/http://dx.doi.org/10.4995/INN2019.2019.10252

Castán, A. R., Ruano, J. A. P., Municio, Á. M. G., & Virginia San José Rodríguez, D. (2019). Gamificación en ingeniería de organización: "Cubioska" un juego de role en entorno web. *Direccion y Organizacion*, *69*, 62–81. https://doi.org/10.37610/dyo.v0i69.561

Castedo, R., Fernández-Torres, J., Lina, M. L., Chiquito, M., Anastasio, P. S., Ortiz, J. E., Pérez-Fortes, A. P., & Ortega, M. F. (2019). Gamification combined with flipped classroom, application in an engineering degree. *V International Congress on Learning, Innovation and Competitiveness (CINAIC 2019)*, Spain. https://doi.org/10.26754/cinaic.2019.0079

Castillo, V. M., González, A. H., & Ampuero, M. A. (2018). Gamification as part of the role's formation strategy in the computer engineer. *Educational Technology Journal*, *3*(1), 1–8. https://tecedu.uho.edu.cu/index.php/tecedu/article/view/82

Chamorro-Atalaya, O., Gamarra-Bustillos, C., Alejos-Ipanaque, R., Aquije-Cardenas, G., Medina-Bedón, Y., More-Sánchez, V., Farfán-Aguilar, J., & Zevallos-Vera, E. (2023). Social networks and their contribution in the university educational field: systematic review. *International Journal of Information and Education Technology*, *13*(2), 399–408. https://doi.org/10.18178/ijiet.2023.13.2.1819

Chamorro-Atalaya, O., Morales-Romero, G., Quispe-Guía, A., Auqui-Ramos, S., Guía-Altamirano, T., Auqui-Ramos, E., Linares-Sánchez, G., Sandoval-Nizama, G., & Arévalo-Tuesta, J. A. (2023). Contribution of augmented reality in teaching and learning, in the midst of COVID-19: systematic review. *International Journal of Learning, Teaching and Educational Research*, *22*(2), 302–322. https://doi.org/https://doi.org/10.26803/ijlter.22.2.17

Chans, G. M., & Portuguez Castro, M. (2021). Gamification as a strategy to increase motivation and engagement in higher education chemistry students. *Computers*, *10*(10), 1–24. https://doi.org/10.3390/computers10100132

Çulha, D. (2022). Gamification of open inquiry-based learning of blockchain technologies. *U.Porto Journal of Engineering*, *8*(1), 12–22. https://doi.org/10.24840/2183-6493_008.001_0003

Daza, M. C. S., & Fernández-Sánchez, M. R. (2019). Gamificando el aula universitaria. Análisis de una experiencia de Escape Room en educación superior. *Revista de Estudios y Experiencias en Educación*, *18*(36), 105–115. https://doi.org/10.21703/rexe.20191836sierra15

Delgado-Gómez, D., González-Landero, F., Montes-Botella, C., Sujar, A., Bayona, S., & Martino, L. (2020). Improving the teaching of hypothesis testing using a divide-and-conquer strategy and content exposure control in a gamified environment. *Mathematics*, *8*(12), 1–14. https://doi.org/10.3390/math8122244

Díaz-Ramírez, J. (2020). Gamification in engineering education – An empirical assessment on learning and game performance. *Heliyon*, *6*(9), e04972. https://doi.org/10.1016/j.heliyon.2020.e04972

Duque, A. G., Mendoza, J. P., & Castillo, N. T. (2018). Kahoot!: an innovation mechanism for university education. In R. Roig-Vila (Ed.) *Academic and social commitment through educational research and innovation in Higher* Education (first ed. pp. 633–640). Octahedron. https://rua.ua.es/dspace/bitstream/10045/87728/1/2018-El-compromiso-academico-social-63.pdf

Escobar, B. R. P., Carhautocto, G. R., Salazar, C. A. H., & Sánchez, W. A. C. (2019). Transversal competences in the university educational context: a critical thinking from the principles of gamification. *Social Prism Journal*, *3*(38), 158–178. https://n9.cl/5gfpe

Fernández, F. R., Gutiérrez, J. V. O., Roig, P. B., Mallol, V. C., Furió, M. E. C., Chornet, V. G., Guijarro, F. H., Cortina, L. O., Noguera, C. L., & Soto, A. S. (2021). Gamification in computer engineering: design of a card game to apply personal data protection legislation. *JIDINF*, 72–76. http://hdl.handle.net/10251/177481

Flores, F. A. S. (2019). Epistemic fundamentals of qualitative and quantitative research: consensus and dissensus. *Digital Journal of Research in University Teaching*, *13*(1), 102–122. https://doi.org/10.19083/ridu.2019.644

Flores-Bueno, D., Limaymanta, C. H., & Uribe-Tirado, A. (2021). The gamification in the development of information literacy from the perspective of university students. *Inter-American Journal of Library Science*, *44*(2), 1–13. https://revistas.udea.edu.co/index.php/RIB/article/view/342687

Fuentes, E. M. (2020). Breakout Edu As Key Element in Gamification Experiences Carried Out on Pre-Service Teaching Degrees. *Electronic Journal of Educational Technology*, *67*, 66–79. https://www.edutec.es/revista/index.php/edutec-e/article/view/1247

Fuster-Guilló, A., Azorin-Lopez, J., Jimeno-Morenilla, A., Saval-Calvo, M., Garcia-Rodriguez, J., Mora, H., Pujol, F. A., Sánchez-Romero, J.-L., Villena Martínez, V., Garcia-Garcia, A., & Mollá Sirvent, R. A. (2019a). Mejora de la motivación en el proceso enseñanza/aprendizaje mediante técnicas de gamificación [Improvement of motivation in the teaching/learning process through gamification techniques]. In R. Roig-Vila (Ed.). *Investigación e innovación en la*

Enseñanza Superior. Nuevos contextos, nuevas ideas. (pp. 1127–1138).Barcelona: Octaedro. http://rua.ua.es/dspace/handle/10045/98731

Fuster-Guilló, A., Azorín-López, J., Jimeno-Morenilla, A., Saval-Calvo, M., García-Rodríguez, J., Mora-Mora, H., Pujol-López, F., Sánchez-Romero, L. J., Villena-Martínez, V., García-García, A., & Mollá-Sirven, R. (2019b). Introducción de técnicas de gamificación para la mejora de la motivación y el proceso enseñanza/aprendizaje en ingeniería informática [Introduction of gamification techniques to improve motivation and the teaching/learning process in computer engineering]. In M.A. Menargues Marcilla, R. Diez Ros , & N. Pellín Buades (eds.), *Memorias de las redes-I3CE programa para la calidad, la innovación y la investigación en la docencia universitaria,* (pp. 1633–1638). Alacant: Universitat d'Alacant. https://dialnet.unirioja.es/servlet/articulo?codigo=7372142

García-Miranda I., & Heras, A. D. (2019). Uso de videojuegos de simulación empresarial como complemento de aprendizaje en el área de Ingeniería Organizacional. [Use of business simulation video games as a learning complement in the area of Organizational Engineering]. *Dirección y Organización*, 70, 19–27. https://doi.org/10.37610/dyo.v0i70.566

Gasca-Hurtado, G. P., Gomez-Alvarez, M. C., Hincapie, J. A., & Zepeda, V. V. (2021). Gamificación de un entorno educativo en Ingeniería de Software: caso de estudio para la accesibilidad digital de PcD [Gamification of an educational environment in Software Engineering: case study for the digital accessibility of PwD]. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, *16*(4), 382–392. https://riull.ull.es/xmlui/handle/915/26247

Gualda, J. E., García-Marín, A. P., Sainz, F. A., & Madueño, J. G. (2019). Gamificación y aprendizaje cooperativo para la mejora de competencias en Ingeniería de Proyectos. *Revista de innovación y buenas prácticas docentes* (*Journal of Innovation and Good Teaching Practices)*, *8*(4), 33–40. https://helvia.uco.es/xmlui/handle/10396/19677

Guerrero-Castañeda, R. F., do Prado, M. L., & Ojeda-Vargas, M. G. (2016). Reflexión epistemológica crítica sobre los métodos mixtos en la investigación en enfermería [Critical epistemological reflection on mixed methods in nursing research]. *Enfermería Universitaria*, *13*(4), 246–252. http://doi.org/10.1016/j.reu.2016.09.001

Heredia-Sánchez, B., Pérez-Cruz, D., Cocón-Juárez, J., & Zavaleta-Carrillo, P. (2020). Gamification as a technological tool for learning in higher education. *International Technological-Educational Journal Teachers 2.0*, *9*(2), 49–58. https://doi.org/10.37843/rted.v9i2.144

Hidalgo, F. V. V. (2021). Gamificación para el aprendizaje activo en ingeniería [Gamification for active learning in engineering]. *Revista de Tecnología y Ciencias Aplicadas*, 6(1), 40–43. https://retyca-tecno.unca.edu.ar/2021/12/31/gamificacion-para-el-aprendizaje-activo-en-ingenieria/

Idris, M. I., Said, N. E. M., & Tan, K. H. (2020). Game-based learning platform and its effects on present tense mastery: Evidence from an ESL classroom. *International Journal of Learning, Teaching and Educational Research*, *19*(5), 13–26. https://doi.org/10.26803/ijlter.19.5.2

Kehing, K. L., & Yunus, M. M. (2021). A systematic review on language learning strategies for speaking skills in a new learning environment. *European Journal of Educational Research*, *10*(4), 2055–2065. https://doi.org/10.12973/eu-jer.10.4.2055

Khaleel, F. L., Ashaari, N. S., & Wook, T. S. M. T. (2020). The impact of gamification on students learning engagement. *International Journal of Electrical and Computer Engineering*, *10*(5), 4965–4972. https://doi.org/10.11591/ijece.v10i5.pp4965-4972

Kho, L. C., Ngu, S. S., Joseph, A., Mat, D. A. A., Ng, L. Y., & Hau, J. L. (2022). Gamification Approach towards Engineering Students' Engagement in Online Learning. *International Journal of Information and Education Technology*, *12*(6), 485–491. https://doi.org/10.18178/ijiet.2022.12.6.1645

Lazarte, I. M., & Gómez, S. G. (2021). Application of the Quizizz tool as a gamification strategy in Higher Education. *XXIII Workshop of Researchers in Computer Science*, Spain. http://sedici.unlp.edu.ar/handle/10915/120461

Leon, A., & Peña, M. (2022). Gamification tools in the learning of shipbuilding in the undergraduate marine engineering education. *Computer Applications in Engineering Education*, *30*(2), 458–471. https://doi.org/10.1002/cae.22465

Lirola, M. M. (2022). Gamification as a methodological strategy to teach grammar in the university educational context: exploring the use of kahoot. *Educational Innovation*, *32*, 1–16. https://doi.org/10.15304/ie.32.8531

Lluch-Molins, L., Balbontin-Escorza, F. Y., & Sullivan-Campillay, N. (2022). Enhancing cooperative learning and student motivation with gamification strategies: A Case study in industrial Engineering. *Journal of Technology and Science Education*, *12*(3), 611–627. https://doi.org/10.3926/jotse.1693

Lobo-Rueda, M. A., Paba-Medina, M. C., & Torres-Barreto, M. L. (2020). Descriptive analysis of gamified experiences for teaching and learning in higher education in engineering. *Spaces Journal*, *41*(16), 21–35. https://www.revistaespacios.com/a20v41n16/20411621.html

Machuca-Villegas, L., Gasca-Hurtado, G. P., Tamayo, L. M. R., & Puente, S. M. (2020). Gamification elements in the context of software engineering. *Iberian Journal of Information Systems and Technologies*, *E27*, 718–732. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85081012435&partnerID=40&md5=622cb82fb9b0b7342b2f8b778d154a59

Magino, E. R. P. (2019). *Perception of gamification activities in collaborative learning for Civil Engineering students of a public university. Lima.2019.* MSc. Thesis, Graduate School, Cesar Vallejo University, Perú. https://hdl.handle.net/20.500.12692/41453

Mallén, Y. O. (2019). *Gamification in university education: application to programming subjects*. Faculty of Mathematical Sciences, Complutense University of Madrid, Spain. https://eprints.ucm.es/id/eprint/57429/

Manzano, R. L. M., Herreria, M. E. E., Piza, I. A. C., & Ochoa, N. V. V. (2022). Gamification of legal education. *Conrad Journal*, *18*(84), 193–201. https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders

Manzano-León, A., Rodríguez-Ferrer, J. M., Aguilar-Parra, J. M., & Herranz-Hernández, R. (2022). Gamification and family leisure to alleviate the psychological impact of confinement due to COVID-19. *Children and Society*, *36*(4), 433–449. https://doi.org/10.1111/chso.12495

Marisa, F., Syed Ahmad, S. S., Mohd Yusoh, Z. I., Maukar, A. L., Marcus, R. D., & Widodo, A. A. (2020). Evaluation of student core drives on e-learning during the Covid-19 with octalysis gamification framework. *International Journal of Advanced Computer Science and Applications*, *11*(11), 104–116. https://doi.org/10.14569/IJACSA.2020.0111114

Mite, K. D. H., & Albán, A. L. M. (2022). Gamification as a didactic resource for university Physical Education classes. *PODIUM Journal*, *17*(2), 815–828. http://podium.upr.edu.cu/index.php/podium/article/view/1315

Morales, J. B., Sánchez, H., & Rico, M. (2021). Aprendizaje divertido de programación con Gamificación [Fun programming learning with gamification]. *Revista lbérica de Sistemas y Tecnologías de Información*, 41(03), 17–33. https://doi.org/10.17013/RISTI.41.17-33

Muharikah, A., Li, M., & Roberts, J. (2021). A scoping review of teaching and learning of English as an additional language among autistic individuals. *Malaysian Journal of Learning & Instruction*, *19*(2), 1–35. https://doi.org/10.32890/mjli2022.19.2.1

Muñiz-Calvente, M., Fernández, P., López, M., & Gracia, J. (2018). Gamification in the teaching of Calculation of Structures. *26th University Congress of Educational Innovation in Technical Education*, Spain. http://journal.um-surabaya.ac.id/index.php/JKM/article/view/2203

Nair, B. B. (2022). Endorsing gamification pedagogy as a helpful strategy to offset the covid-19 induced disruptions in tourism education. *Journal of Hospitality, Leisure, Sport and Tourism Education*, *30*, 1–9. https://doi.org/10.1016/j.jhlste.2021.100362

Ng, L. K., & Lo, C. K. (2022). Online flipped and gamification classroom: risks and opportunities for the academic achievement of adult sustainable learning during COVID-19 pandemic. *Sustainability (Switzerland)*, *14*(19). https://doi.org/10.3390/su141912396

Nieto-Escamez, F. A., & Roldán-Tapia, M. D. (2021). Gamification as online teaching strategy during COVID-19: A mini-review. *Frontiers in Psychology*, *12*, 1–9. https://doi.org/10.3389/fpsyg.2021.648552

Nivela-Cornejo, M. A., Otero- Agreda, O. E., & Morales-Caguana, E. F. (2021). Gamification in higher education. *Journal Publishing*, *8*(31), 165–176. https://doi.org/10.51528/rp.vol8.id2242

Padilla-Avalos, C.-A., & Marroquín-Soto, C. (2021). Research approaches in dentistry: quantitative, qualitative and mixed. *Heredian Stomatological Journal*, *31*(4), 338–340. https://doi.org/10.20453/reh.v31i4.4104

Páez-Quinde, C., Infante-Paredes, R., Chimbo-Cáceres, M., & Barragán-Mejía, E. (2022). Educaplay: una herramienta de gamificación para el rendimiento académico en la educación virtual durante la pandemia covid-19. *Revista Cátedra*, *5*(1), 32–47. https://doi.org/10.29166/catedra.v5i1.3391

Palomino, M. del C. P. (2021). Implications of gamification in Higher Education: a systematic review of student perception. *Educational Research Journal*, *39*(1), 169–188. http://dx.doi.org/10.6018/rie.419481

Pertegal-Felices, M. L., Jimeno-Morenilla, A., Sánchez-Romero, J. L., & Mora-Mora, H. (2020). Comparison of the effects of the Kahoot tool on teacher training and computer engineering students for sustainable education. *Sustainability (Switzerland)*, *12*(11), 1–12. https://doi.org/10.3390/su12114778

Pulido, Y. F., Viejo, C. B., Vega, M. G., González, D. A., Antón, J. C. Á., & Pérez, J. C. V. (2018). Gamification techniques in electronic engineering. *26th University Congress of Educational Innovation in Technical Education*, Spain. http://journal.um-surabaya.ac.id/index.php/JKM/article/view/2203

Raju, R., Bhat, S., Bhat, S., D'Souza, R., & Singh, A. B. (2021). Effective usage of gamification techniques to boost student engagement. *Journal of Engineering Education Transformations*, *34*(Special Issue), 713–717. https://doi.org/10.16920/jeet/2021/v34i0/157171

Ramirez-Prada, P., Ortiz-Beltran, A., & Lobo-Quintero, R. (2019). Significant experiences of the implementation of gamification in computer programming courses. *Engineering Education Journal*, *15*(29), 42–51. https://educacioneningenieria.org/index.php/edi/article/view/1031

Ramos-Galarza, C. A. (2020). The scope of an investigation. *Science America*, *9*(3), 1–6. https://dx.doi.org/10.33210/ca.v9i3.336

Rincon-Flores, E. G., & Santos-Guevara, B. N. (2021). Gamification during Covid-19: promoting active learning and motivation in higher education. *Australasian Journal of Educational Technology*, *37*(5), 43–60. https://doi.org/10.14742/ajet.7157

Rincon-Flores, E. G., Mena, J., & López-Camacho, E. (2022). Gamification as a teaching method to improve performance and motivation in tertiary education during COVID-19: A research study from Mexico. *Education Sciences*, *12*(49), 1–14. https://doi.org/10.3390/educsci12010049

Rivera, M. Á. G., Escudero-Nahón, A., & Canchola-Magdaleno, S. L. (2020). "Gamification" of teaching science, technology, engineering and mathematics: Conceptual cartography. *Synetics*, *54*, 1–20. https://doi.org/10.31391/s2007-7033(2020)0054-002

Rodríguez, I. L., Martínez, R. A., Álvarez, L. M. B., & Ledo, M. V. (2018). Juegos digitales en la educación superior. *Educación Médica Superior*, *32*(1), 264–276. https://ems.sld.cu/index.php/ems/article/view/1301/654

Rodríguez-Oroz, D., Gómez-Espina, R., Pérez, M. J. B., & Truyol, M. E. (2022). Infrared thermography: An amazing resource for teaching physics and chemistry. *Eureka Journal on Teaching and Dissemination of Sciences*, *16*(2), 1–13. https://dx.doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2019.v16.i2.2202

Salvador-García, C. (2021). Gamifying in times of coronavirus: A case study. *Distance Education Journal*, *21*(65), 1–20. https://doi.org/10.6018/red.439981

Sánchez-Caballé, A., & Esteve-Mon, F. M. (2022). Analysis of teaching methodologies with digital technologies in higher education: a systematic review. *RIED*, *26*(1), 181–199. https://doi.org/10.5944/ried.26.1.33964

Sánchez-Martín, J., Corrales-Serrano, M., Luque-Sendra, A., & Zamora-Polo, F. (2020). Exit for success. Gamifying science and technology for university students using escape-room. A preliminary approach. *Heliyon*, *6*(7). https://doi.org/10.1016/j.heliyon.2020.e04340

Santhanasamy, C., & Yunus, M. M. (2022). A Systematic Review of Flipped Learning Approach in Improving Speaking Skills. *European Journal of Educational Research*, *11*(1), 127–139. https://doi.org/10.12973/eu-jer.11.1.127

Sarasa-Cabezuelo, A., & Rodrigo, C. (2021). Development of an educational application for software engineering learning. *Computers*, *10*(9). https://doi.org/10.3390/computers10090106

Shen, P., & Slater, P. (2021). Occupational stress, coping strategies, health, and well-being among university academic staff—an integrative review. *International Education Studies*, *14*(12), 99–124. https://doi.org/10.5539/ies.v14n12p99

Sobrino-Duque, R., Martínez-Rojo, N., Carrillo-de-Gea, J. M., López-Jiménez, J. J., Nicolás, J., & Fernández-Alemán, J. L. (2022). Evaluating a gamification proposal for learning usability heuristics: Heureka. *International Journal of Human Computer Studies*, *161*(January). https://doi.org/10.1016/j.ijhcs.2022.102774

Solís-Castillo, J. C., & Marquina-Lujan, R. J. (2022). Gamification as a methodological alternative in higher education. *With Science EPG*, *7*(1), 66–83. https://doi.org/10.32654/CONCIENCIAEPG.7-1.5

Taguas, E. V., Fernández-Ahumada, E., Borrego-López, N., Ortiz-Medina, L., Benlloch-González, M., Sánchez-Zamora, P., Gallardo-Cobos, R., Lara-Vélez, P., & Guerrero-Ginel, J. E. (2022). Gamification for the Acquisition of Leadership Skills and Formation of Efficient Work Teams: An interactive workshop based on an analysis of the film "the seven samurai". *International Journal of Emerging Technologies in Learning*, *17*(22), 20–38. https://doi.org/10.3991/ijet.v17i22.32351

Torres-Barreto, M. L. (2018). Motivational didactic tool based on gamification and supported by ICT to acquire and apply transversal competencies in engineering students: MOTIVATIC. *Industrial University of Santander*, 1–16. https://hal.science/hal-02166319

Valdés-González, A., & Martín-Antón, J. (2023). La tabla periódica y las lenguas de signos: Una revisión sistematizada. *Revista Eureka Sobre Enseñanza y Divulgación*

de Las Ciencias, *20*(1), 110201–110217. https://www.redalyc.org/journal/920/92072334009/92072334009.pdf

Valencia-Rodríguez, O., Forero-Páez, Y., Pulgarín-Arias, L., Otálvaro, S. M. C., & Pinzón-Salazar, S. (2022). Areas of interest for the incorporation of gamification in industrial engineering. *Human Review*, 2–14. https://doi.org/10.37467/revhuman.v11.4308

Vázquez, E. P., Cerdá, A. G., & Carreres, A. L. (2019). Gamification in university education: The use of the escape room as a learning strategy. In R. Roig-Vila (ed.), *Research and innovation in Higher Education. New contexts, new ideas* (pp. 660–668). Octahedron. https://n9.cl/u1o9w

Vera, R. A. A., Arceo, É. E. B., Mendoza, J. C., & Pech, J. P. U. (2020). Configurable and computable instructional model based on gamification elements: a case study on education in software engineering. *Opening*, *12*(2), 20–35. http://dx.doi.org/10.32870/Ap.v12n2.1905

Villalobos, G. M., & Ríos Herrera, J. F. (2019). Gamification as a learning strategy in the training of engineering students. *Pedagogical Studies*, *45*(3), 115–125. https://doi.org/10.4067/S0718-07052019000300115

Villarroel, R., Santa María, H., Quispe, V., & Ventosilla, D. (2021). Gamification as a challenging response to motivate classes in secondary education in the context of COVID-19. *Innova Education Journal*, *3*(1), 6–19. https://doi.org/10.35622/j.rie.2021.01.001

Wardoyo, C., Satrio, Y. D., Narmaditya, B. S., & Wibowo, A. (2021). Gamification in economics and its impact on students' achievement: Lesson from COVID-19 in Indonesia. *Cypriot Journal of Educational Sciences*, *16*(3), 1194–1203. https://doi.org/10.18844/cjes.v16i3.5839 1

White, B. K., Martin, A., & White, J. (2022). Gamification and older adults: Opportunities for gamification to support health promotion initiatives for older adults in the context of COVID-19. *The Lancet Regional Health-Western Pacific*, 100528. https://doi.org/10.1016/j.lanwpc.2022.100528

Zabala-Vargas, S., García-Mora, L., Arciniegas-Hernández, E., Reina-Medrano, J., de Benito-Crosetti, B., & Darder-Mésquida, A. (2021). Strengthening motivation in the mathematical engineering teaching processes – a proposal from gamification and game-based learning. *International Journal of Emerging Technologies in Learning*, *16*(6), 4–19. https://doi.org/10.3991/ijet.v16i06.16163

Zamora-Polo, F., Sánchez-Martín, J., Hipólito-Ojalvo, F., & Luque-Sendra, A. (2019). Using gamification to develop students' competences in mechanical engineering degree. *23 International Congress on Project Management and Engineering*, *29*(July), Spain. http://dspace.aeipro.com/xmlui/bitstream/handle/123456789/2408/AT10-001_2019.pdf?sequence=1&isAllowed=y

Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2022). The effectiveness of gamification in programming education: Evidence from a meta-analysis. *Computers and Education: Artificial Intelligence*, *3*, 1–11. https://doi.org/10.1016/j.caeai.2022.100096