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CALL FOR PAPERS: THE GAME, A GAMIFIED TOOL FOR TEACHING SCIENTIFIC WRITING IN ENGINEERING STUDENTS

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KEYWORDS

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ABSTRACT

This paper presents the evaluation of the alpha version of a gamified tool called Call for Papers: The Game (CfP:TG), specially designed for teaching scientific writing in the training of future engineers. A non-probabilistic convenience sampling was carried out with the participation of engineering students from a Peruvian public university. The short version of the user experience questionnaire (UEQ) was applied, and usability was qualitatively evaluated. The main results indicate that the Pragmatic Quality of CfP:TG is in the neutral range with a value of 0.729, and the Hedonic Quality receives a positive evaluation with a value of 1.089.

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1. Introduction

In recent years, a number of digital tools have emerged for use in education. Some of them use gamification, which consists of the incorporation of game design elements in non-game contexts, such as educational contexts, in order to facilitate the achievement of learning objectives, improving the participation of those involved (Willig et al., 2021; Rutledge et al., 2018; Deterting et al., 2011). The goal of gamification is to enhance the user experience, stimulate motivation and foster learning engagement in learners; it can also be considered as an enabler of long-term learning (Romano et al., 2018; Bouchrika et al., 2019). Achievement levels are recognized by markers or insignia that evidence them, generating commitments and motivations for more interaction in learning activities.

This innovative didactic strategy invites to rethink on the forms of teaching-learning in higher education institutions, which should include challenges and playful ways to increase the motivation of students to learn (Ardila-Muñoz, 2019). It also incorporates dynamics and processes of serious games in virtual environments, with the intention of understanding and perfecting competencies that favor their employability. The implementation of gamification seeks to dynamize the contents to be developed in classes for the acquisition of learning and, therefore, increase the motivation and interest of students through relevant tools (Pegalajar, 2021).

Gamification contributes towards the development of knowledge, promoting student participation; likewise, it manages to maintain the student's motivation, thus favoring their learning. From the beginning of the activity, the student must be informed of the process and its evaluation; this way, it favors competence development, as well as commitments and interests (Prieto, 2020). Gamification of learning provides the possibility of inducing motivation, regulating effort, loyalty and cooperation (Alabbasi, 2017).

Its incorporation in the educational environment has led to greater interaction and motivation of users (students and teachers). Likewise, its acceptance as a learning tool is increasing, as it is useful to generate more attractive educational environments, based on the proposal of rewards, challenges, comments, etc. (Saleem, 2022). The main considerations for the use of gamification in higher education institutions is to develop enjoyable activities in the training process, allowing that the error can become a learning opportunity for the student-player (Ardila-Muñoz, 2019).

The purpose of gamification is to increase students' commitment to their learning process. For Pérez-Manzano and Almela-Baez (2018), the involvement of all participating subjects is important in a common and coordinated effort, which configures opportunities for motivation, as well as for solving difficulties. In these scenarios, gamification is attractive to students during learning (Gay & Burbridge, 2016), due to its meaningful character and the promotion of student protagonism (Marín-Díaz, 2015). Thus, learning is not only fun, but active, by promoting active self-learning or collaborative work, both of which are enhanced through gamification (Alonso-García et al., 2021, p. 14) and its intensive use.

Similarly, gamification promotes collaborative work among students. Riar et al. (2022) argues that gamification presents three distinct approaches to motivate cooperation, and they are based on usage: i) individualistic, motivates individuals to cooperate based on individualism (i.e., personal or egocentric benefits and goals); ii) cooperative, motivates individuals to cooperate based on collectivism (i.e., collective benefits and goals); and iii) hybrid, motivates individuals to cooperate based on a combination of personal and collective benefits and goals. The framework of approaches provides a strategic platform to investigate the interplay between gamification possibilities and individuals' motives for cooperation, as well as how gamification results in cooperation (individualistic or collectivistic) and the corresponding individualistic and socio-psychological outcomes.

The uses of gamification for learning various subjects reveal encouraging results. For Wang (2023), its use significantly improves English performance by providing a fun and interactive hands-on experience for content comprehension and vocabulary acquisition. In academic writing learning, the gamified experience elicits modest satisfaction, with improvements in writing skills (El Tantawi et al., 2018). In addition, gamified approaches provide web or mobile platforms and applications that enable the delivery, fostering, and assessment of computational thinking skills (Vinu & Renumol, 2023). In areas such as Science and Mathematics, gamification has been shown to significantly increase students' positive emotions and grades (Yllana-Prieto et al., 2023).

It can be said that gamification has achieved a significant penetration in higher education institutions, although its implementation varies in different countries, being lower in Spain compared to Mexico and Ecuador (Torres-Toukoumidis et al., 2020). However, its use in recent years has been carried out without the appropriate level of theoretical knowledge, since it is still unclear how gamification motivates cooperation and collaboration, and what is its effectiveness for learning (Riar et al., 2022; Nuñez et al., 2023). Therefore, it is important to take these aspects into account when designing relevant and appropriate gamifications to overcome obstacles in the learning process.

The implementation of gamification in the classroom is a task that requires a clear commitment and enjoyment on the part of students and teachers. The latter are responsible for reviewing the products available on the market, getting to know them and defining their use in the development of competencies and their integration into the curriculum of the subjects (García-Holgado et al., 2020). The penetration of gamification in training processes is closely linked to the search for and maintenance of educational quality, in order to ensure the achievement of satisfactory learning outcomes (Herrera et al., 2018).

On the other hand, virtual platforms such as websites enable the storage of various types of information, allowing for subsequent execution through access and interaction of various applications under the same environment. Web platforms have evolved from static pages (Web 1.0) to more collaborative and social pages (Web 2.0) to Web 3.0, 4.0, 5.0 and 6.0. These versions promote the integration of objects into the network and the development of sensory and emotional networks that allow collaborations, expressions and participations, that are integrated to the Semantic Web. In these evolutions, gamification is incorporated, integrating features that improve participation and engagement and, therefore, learning (Valda & Arteaga, 2015).

Gamified technological tools must be designed in terms of usability and user experience. Usability has to do with the degree of ease with which a product can be used by users to achieve objectives with effectiveness, efficiency and satisfaction in specific contexts of use (ISO 9241-110, 2006). User experience is constituted by the user's perceptions and responses to the product (ISO 9241-210, 2019), i.e. the degree to which the user is satisfied with the product.

In the use of a gamification platform, two aspects of the interface are important: i) the comprehensibility of the interface, which refers to whether the design effectively guides users in performing their tasks, without generating confusion or discomfort, and ii) the navigability of the application, which ensures a structure that prevents loss during interaction (Romano et al., 2018). Effectiveness and usefulness are essential in determining the gamification platform, so that users can enjoy and perceive the utility of the application. Mobile applications within a gamified platform prove to be useful and versatile as they engage students in activities that promote participation and preparedness, and their effects gravitate to the behavioral changes that derive from their use (Khaldi et al., 2023).

When designing gamified strategies, it is important to consider simplicity, feedback, real time, progress, autonomy, and individual responsibility. This helps gamification platforms related to sustainable development, by integrating them into e-learning environments for the promotion of multidisciplinary work (Dicheva et al., 2015; Caro-Alvaro et al., 2017). This integration can be achieved through selected models based on suitability and relevance criteria. The gamification framework creates challenges for adaptation, both in terms of students' knowledge and the process of achieving goals through intermediate milestone. It also takes into account, immediate feedback for progress towards a new task, the use of appropriate games for activities, failure as part of learning process, assuming different identities and roles, acknowledging achievements by other users, and using competition to encourage valuable behaviors (van Roy & Zaman, 2017).

In the scientific-technological field, there are gamified platforms dedicated to other areas of higher education such as κPAX, a gamified platform for designing serious games aimed at engineering students (Riera & Arnedo-Moreno, 2016); Gamelab©, a game-based 3D platform designed to support research courses for nursing students (Gallegos et al., 2017); EDUMAT, a gamified web tool for teaching mathematical operations (Muñoz Sanabria & Vargas Ordoñez, 2019). There is also other software dedicated to scientific writing such as WriteWise (Fuentes et al., 2019), but it is not gamified.

1.1 Scientific writing in engineering

In higher education institutions, there is an increasing demand for the inclusion of written communicative competence as the foundation of students' education. This competence requires various skills, including scientific writing, which involves the ability to construct a university-level text, presenting opinions and reflecting the model of "transforming knowledge" (Scardamalia & Bereiter, 1992), that is, going "beyond what it means to reproduce (or transcribe) what others have said" (Flores, 2018, p. 27). The emphasis on academic and scientific writing as an essential competence to express what one thinks. In that sense, it constitutes a knowledge that allows reviewing, transforming and increasing one's own knowledge. Scientific writing comprises a set of knowledge and skills that involve understanding the structure of scientific texts, knowing how to disseminate scientific findings, knowing the citation and referencing system, etc.

Scientific writing is an important skill for the training of university students, and in particular, for those studying engineering because it will allow them to participate in the scientific community. Traditionally, the approach to teaching writing has been conventional, but the introduction of gamification offers a more engaging and playful alternative for learning (Martins et al., 2020). Gamification can increase interactivity and student engagement in the learning process, making it a valuable tool for educational systems (Bouchrika et al., 2019).

In engineering education, student motivation and pedagogical strategies are fundamental to achieve effective learning (Anaya et al., 2020). However, engineering students often show insecurity in the academic writing process, which affects their ability to construct knowledge (Flores, 2018, p. 43). This underscores the importance of differentiated instruction that addresses the specific difficulties of engineering students in relation to academic writing (Vine-Jara, 2021). Academic writing not only contributes to the development of other skills, but also helps to relate information and communicate ideas effectively (Sanmartí et al., 1999).

To improve scientific writing in engineering education, it is necessary that an institutional commitment be made that includes the teaching of superficial aspects of the text, such as spelling, structure and formats of an academic document, as well as the ethical dimension. Teaching workshops on these aspects, together with constant practice, collaborative work and self-regulation of writing, are fundamental to achieve this goal (Castelló, 2015; Flores, 2018). In addition, the teaching of scientific writing requires new proposals that incorporate ICT, as well as multimodal and multimedia resources (Vásquez-Rocca & Varas, 2019).

The use of digital resources in higher education is an imperative for the achievement of the competencies demanded by today's world. It also requires that university teachers have a good level in the management of information and communication technologies (ICT), that is, that they have a good level of digital skills, which enable a critical and creative use of ICT (Wild & Schulze, 2020). Therefore, it is necessary for teachers to have a positive attitude towards digital technologies so that they can incorporate them into their academic work with students (Paz-Saavedra et al., 2022).

The teaching of written communicative competence is one of the pillars of university education; in particular, scientific writing is necessary to promote research at the university level. In this sense, this article presents the evaluation of the user experience of the alpha version of a gamified application, Call for Papers: The Game, specially designed for teaching scientific writing to engineering students. The central question of this research is the following: What user experience do engineer students have when using Call for Papers: The Game? The main objective of this study is to evaluate the user experience of engineering students after using this gamified tool.

2. Methodology

2.1. Design

A mixed approach methodology was used. For the quantitative analysis, the short version of the UEQ user experience evaluation questionnaire (Schrepp et al., 2017) was applied. For the qualitative analysis, students were asked two open-ended questions related to the usefulness of the gamified application and what improvements they suggest to the application. The students' responses were analyzed using

MAXQDA software, which is used to analyze qualitative data and belongs to the CAQDAS family, an acronym for Computer Assisted Qualitative Data Analysis Software (Rädiker&Kuckartz, 2020).

2.2. Participants

The UEQ questionnaire was administered to 48 respondents, selected by non-probabilistic convenience sampling. The questionnaire was applied virtually through a Google Forms questionnaire. The study participants were engineering students from a Peruvian university. of these, 64.6% belonged to the Professional School of Industrial Engineering, and 35.4% to Systems Engineering. Likewise, 38 (79.2%) were male; and 10 (20.8%) were female. In terms of age, 47.9% were between 16 and 18 years of age; 37.5% were between 19 and 21 years of age; and 14.6% were older than 22 years of age. A total of 64.6% were in their first year of studies, 12.5% in their second year, and 22.9% in their fifth year. All respondents were taking the courses *Comprehensive Communication and Scientific Report Writing*. Data collection was carried out at the end of the 2022 academic year.

2.3 Data analysis

The short version of the UEQ user experience evaluation questionnaire (Schrepp et al., 2017) consists of eight questions analyzing two scales: i) pragmatic quality and ii) hedonic quality, based on the semantic differential of 1-7 items in Spanish language. The questions are organized into eight opposing pairs: obstructive - supportive driver; complicated - easy; inefficient - efficient; confusing - clear; boring - exciting; uninteresting - interesting; conventional - original; common - novel.

Pragmatic quality comprises: i) clarity, which implies simplicity for familiarization with the application, as well as simplicity and ease of learning and understanding; ii) efficiency, which refers to the resolution of problems without major effort by the user, and whether the interaction is efficient and fast, as well as the speed of user input; and iii) confidence, which refers to whether the user feels in control of the interaction, whether it is possible to predict the behavior of the system, and whether the user feels confident in using the application.

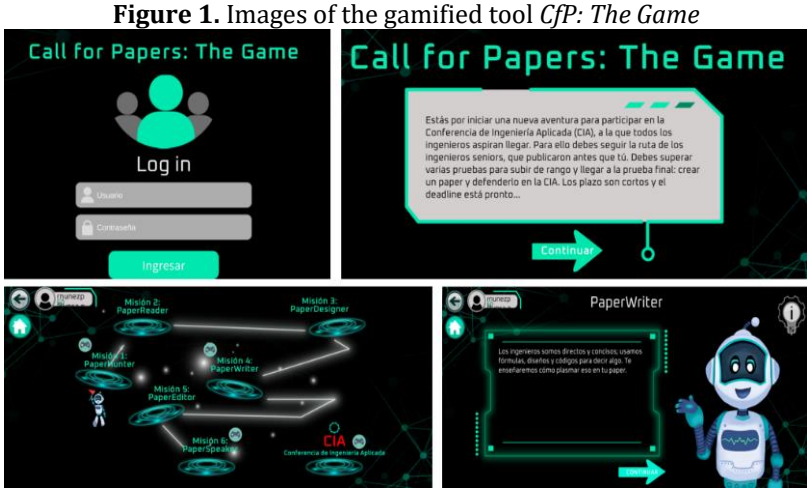
The hedonic quality is configured on the basis of: i) stimulation, which is linked to the motivating and pleasant nature of the product's use; and ii) novelty, on the innovative and creative sense of the product and whether it captures the user's attention.

The application of the instrument allows measuring the impression of the application or software, on its attractiveness, pleasantness or pleasure. Values between -0.8 and 0.8 represent a neutral evaluation of the corresponding scale. Values above 0.8 represent a positive evaluation, and below -0.8, a negative evaluation. The scale ranges from -3 (very bad) to + 3 (extremely good).

2.4 Description of the gamified tool

The gamified tool is composed of six missions represented in an interactive map that guides the student through the game (Figure 1). In the first one, called *PaperHunter*, a mockup was created where the student must collect open access articles and add the following data of a scientific article: doi, title, authors, keywords, abstract, journal name, URL, year and subject. Missions 2 and 3, PaperReader and PaperDesigner, present a narrative related to reading scientific articles and using formats. Mission 4, PaperWriter, comprises four games designed to allow students to practice the topic of textual connectors, scientific phrases for each section of a scientific article, APA style references, as well as relating the title, abstract components and keywords. Missions 5 and 6, PaperEditor and PaperSpeaker, contain a narrative aimed at enabling students to revise and share their papers. The game's six missions relate to the three main phases of the writing process: planning, drafting, and revising.

Figure 1. Images of the gamified tool *CfP: The Game*



Source: Own work

3. Results

3.1. User experience evaluation - UEQ

Table 1 shows that in relation to the Hedonic Quality, the highest values have been obtained in the values of original and novel; on the other hand, the value of exciting is in a neutral range (=-0.8 <0.4 < 0.8). We consider this result due to the fact that the focus of the application is referred to the complement of the learning process. The value of interesting presents a value of 0.9, only 0.1 above the neutral value. This result is complemented by the comments received by the students in the open questions.

With respect to the Pragmatic Quality only one positive value has been obtained: efficient: 1.0, 0.2 points above the neutral value. The values related to clarity, ease and support are in the neutral range. Therefore, the values per item are higher in the hedonic quality than in the pragmatic quality, highlighting the original and novel values.

Table 1. User experience evaluation (UEQ)

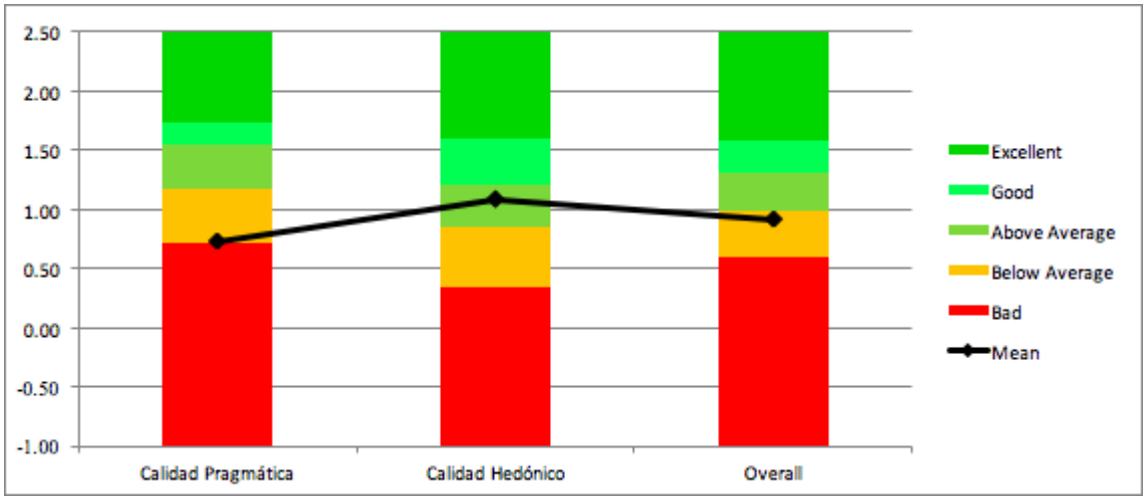
Item	Average	Variance	Est. Dev.	N.	Negative	Positive	Scale
1	0.9	1.3	1.1	48	Obstructive	Support driver	Pragmatic Quality
2	0.5	2.0	1.4	48	Complicated	Easy	Pragmatic Quality
3	1.0	1.2	1.1	48	Inefficient	Efficient	Pragmatic Quality
4	0.5	2.1	1.4	48	Confusing	Clear	Pragmatic Quality
5	0.4	2.1	1.5	48	Boring	Exciting	Hedonic Quality
6	0.9	1.5	1.2	48	Not interesting	Interesting	Hedonic Quality
7	1.5	2.1	1.5	48	Conventional	Original	Hedonic Quality
8	1.5	1.7	1.3	48	Common	Novel	Hedonic Quality

Source: Own work

In relation to the results for each scale, it was found that the pragmatic quality is in the neutral range with a value of 0.729, and the hedonic quality receives a positive evaluation with a value of 1.089. Although it is a positive value, the result is below the ideal value (close to +3). Likewise, the overall

impression of the application was found to have a value of 0.909, which means that the students find it partially attractive or pleasant. Figure 2 shows that the hedonic quality has a value that is above average; unlike the pragmatic quality and the overall, which are below average.

Figure 2. UEQ reference diagram in the gamified application *Call for Papers: The Game.*



Source: Own work

The results constitute important feedback to be able to make the necessary improvements to the prototype. The results obtained in the Pragmatic Quality correspond to the answers that the students have given in relation to the fact that this gamified application is useful in their scientific writing process. Likewise, the results of the pragmatic quality correspond to the suggestions they have given to improve the web application in question.

3.2. Qualitative analysis of the gamified tool

In addition to the UEQ questionnaire, two open-ended questions were posed to the students:

a) Do you consider that this gamified application can support you in improving your scientific writing? Why?

Of the 48 students, almost all of them, 95.91%, responded that the gamified application can help them improve their scientific writing. They emphasized that the platform is interactive, playful, intuitive, didactic, practical, motivating and predictable. It should be noted that in the playful feature it includes fun and the presence of challenges; and as for the didactic, they pointed out that it allows them to understand concepts and that there is feedback. They also pointed out that they find the tool useful because it allows them to reinforce the structure of the scientific article, the formats and the citation system.

Some of the responses (R) from the students were:

R2: "Yes, because it offers a good motivation to continue learning and researching."

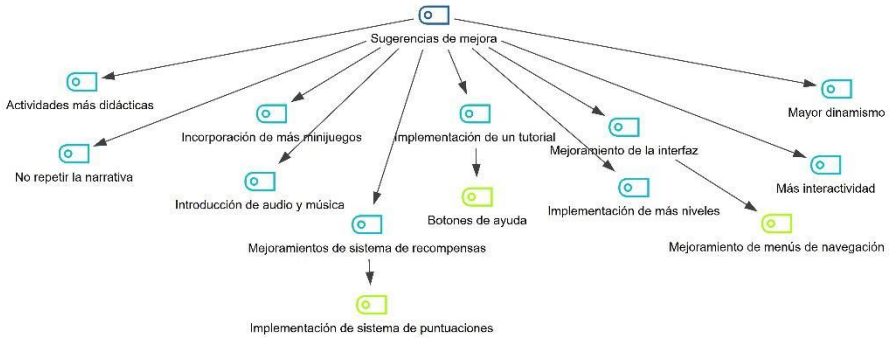
R14: "Yes, because it allows us to learn or reinforce different aspects for writing articles in a playful way."

R 37: "Yes, since it presents various games in which our knowledge is tested and helps us to improve."

b) In what ways do you think the gamified application needs improvement?

The main suggestions (Figure 3) made by the students were the following categories: more interactivity; more dynamism; implementation of more levels; improvement of the interface; improvement of navigation menus; improvement of the reward system; implementation of a tutorial; introduction of help buttons; introduction of audio and music; incorporation of more mini-games; more didactic activities.

Figure 3. Suggestions made by the students.



Source: Own work

Some of the responses (R) from the students were:
R2: "I think it could be improved if more levels were implemented, this way the user would have more learning time."
R26: "Add more mini-games so it doesn't feel repetitive."
R28: "I would say only in some activities where the directions are not totally clear and there is not something specific to perform per se; otherwise, it was entertaining and enriching in knowledge."

4. Discussion

Universities are experiencing an innovative transformation from gamification. Learning is influenced by the use of platforms and social networks, which have given rise to the Game-Based Learning methodology. In this perspective, the inclusion of digital-dominated platforms contributes to the improvement of the perception of learning, increasing participation in activities and motivation to learn in a more interactive and stimulating environment (Campillo-Ferrer et al., 2020; Torres-Toukoumidis et al. 2019; Kurniawan et al., 2019); it also favors the work of competencies and skills in students (Riera & Arnedo-Moreno, 2016). The gamified platform becomes an articulating mechanism of knowledge, dialogical exchange, experiences and good practices; at the same time, strengthening and improving teaching practice, improving knowledge, through the promotion and generation of new ideas and innovations (Alonso-Garcia et al., 2021; Ng et al., 2020; Bouchrika et al., 2021).

This research was based on the use of *Call for Papers: The Game*, a gamified web application that was designed to improve the scientific writing level of engineering students. The objective was to evaluate the user experience of engineering students after its use. The main results indicate that the Pragmatic Quality is in the neutral range with a value of 0.729, and the Hedonic Quality receives a positive evaluation with a value of 1.089. Although the results present a positive value, the result is well below an ideal value (close to +3); however, it has had a positive reception from the students indicating that the tool does help them to improve their writing level. Other studies indicate that learning academic writing with gamified techniques is not entirely satisfactory (El Tantawi et al., 2018).

In addition, it should be considered that engineering students present more difficulties in writing (Vine-Jara, 2020) so it is necessary to propose new innovative strategies for the achievement of their written communicative competences. The developed gamified tool proposes content in a structured way and the exercises help to improve the writing level, as shown in the qualitative analysis section. From that perspective, the use of gamified tools directed for that purpose is timely in engineering education.

5. Conclusions

The alpha version of the software proposed in this study, although designed to meet the needs of engineering students, requires adjustments based on the results of this pilot study. The software prototype developed is in the Alpha version, so the results obtained through the user experience questionnaire will allow us to ostensibly improve the proposal.

In future work, the design and development of the final version of the gamified web application *Call for Papers: The Game* will be released with technical validation by experts in the field and

experimentation with a larger number of engineering students, and the pedagogical experience will be extended throughout the academic semester to obtain more representative data. In this way, a more extensive game-based platform will be developed and implemented to improve the scientific writing skills of undergraduate students. Another relevant contribution is that our approach is adaptable for students in STEM (Science, Technology, Engineering and Mathematics) areas allowing them to improve their level of scientific writing.

Finally, the teaching of scientific writing in the area of engineering requires new motivational strategies to achieve this goal, in this sense, gamification is presented as an alternative to motivate students to enter the world of scientific writing.

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