Perception of Scientific Writing and Gamification in Engineering Students: A Mixed Study

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Abstract. The main objective of this study was to analyze engineering students' perceptions of scientific writing and gamification. A semi-structured questionnaire with five open-ended questions on scientific writing and gamification was applied to 400 engineering students at a Peruvian university. The methodological design was mixed. For the quantitative analysis, a frequency analysis of the students' responses was performed. For the qualitative analysis, Atlas ti software was used. The main results from the quantitative approach indicate that the predominant conception of scientific writing in students is related to research and publication of results, 135 (33.75%); likewise, the essay was indicated as the most recurrent textual genre with 147 (36.75%); and the most frequent difficulty in writing was the search and verification of information with 96 (24%). From the qualitative approach, it was found that students emphasize not only the academic aspect in relation to the importance of scientific writing, but also the process of knowledge, research, science and technology. Likewise, regarding the evaluation given by the students to the use of gamification in the teaching of scientific writing, mostly positive evaluative judgments were found. It is concluded that gamification is perceived as a motivating and innovative strategy for teaching scientific writing to engineering students.

Keywords: Scientific writing · Gamification · Engineering · Motivation · Innovation

1 Introduction

Knowing how to communicate effectively and according to the professional context is a necessary skill in the training of engineers [1]. However, several studies show that there is a gap between academic training and industry requirements in terms of writing needs, the most important of which are precise and unambiguous content, fast and predictable reading, and attention to detail [1, 8, 9, 15]. One of the main challenges in the training of engineers is to teach them the process of written composition and the structural characteristics of academic texts and the useful strategies to produce them [7].

In particular, the writing of academic and research articles presents several challenges such as learning the structure of the abstract, adequately documenting the introduction, discussing the results, and knowing the citation rules [24]. In addition, students must consider how sections are divided, how paragraphs are combined with illustrations, diagrams, schemes, codes, and how equations/formulas are integrated into the text [14].

Although the above is evident, writing is a process that should be taught in a methodological way. The literature shows us several experiences related to the importance of teaching writing in engineering as well as the ways in which it has been incorporated into the curricular programs. Nunes Reis & Reis [23] give advice on how to write a scientific article for the first time. Pierson & Pierson [21] present the keys to better technical writing in engineering. Erdil [10] designs a proposal for teaching technical memoranda, poster presentations, oral presentations, lab reports, proposals, and high-level design reports. Wright et al. [28] evaluated students' technical writing skills, as well as the impact of instruction related to technical writing and associated curricular and pedagogical approaches. Researchers Weissbach and Pflueger [29] have suggested that effective writing center assistance for engineering students is possible, and the authors have designed an interdisciplinary training method that has produced positive results.

Vine-Jara [25] reports that engineering students in a Chilean university have greater difficulties in writing, because they do not have sufficient knowledge about how to write a paragraph and they do not revise their writing after rewriting it. On the other hand, Berdanier & Zerbe [4] conducted a study on academic writing in engineering graduate students in the United States, and found that although most students understand that writing is a process where knowledge is transformed, they have problems with perfectionism, procrastination and writing block. Along the same lines, Conrad [8] reports that even in prestigious engineering programs, graduates state that they are dissatisfied with the training they have received in writing.

On the other hand, educators are in search of new methodologies that facilitate and motivate their students' learning. It is difficult to compete against technological and multimedia stimuli that are so attractive to young people, so gamification becomes one of the main trends in education [20]. In that way, gamification can be an ally for educational and learning objectives. Gamification serves as a tool to increase interest and participation in the process of engaging people, motivating to action, promoting learning and solving problems [13]. Alabbasi [2] defines gamification as a process that transforms or mechanizes a system to approach it from a playful perspective.

Education is one of those scenarios where gamification is being applied through the introduction of serious games to students, expanding the possibilities of experiential and lifelong learning, engaging students and rewarding them with knowledge and skills [3]. In this educational environment, gamification is intended to stimulate students to solve problems and encourage learning through cooperation and other positive values [16]. Several studies show that gamification as an educational tool can influence student engagement in learning [5, 6, 22, 27].

Learning using gamification has been addressed in different disciplines, but specifically in engineering the use of gamification has increased in recent years with the most commonly used techniques being the use of points, medals and levels [16–18]. The most

common use of gamification in the teaching of engineering careers is given in gamification based on simulation games to stimulate student interest, increase participation and be able to track student learning [26].

Given the importance of scientific writing in the formative processes of university students, this study poses the following general question: What perceptions do engineering students have about scientific writing and the use of gamification? The general objective is to analyze the perceptions that engineering students have about scientific writing and the use of gamification.

2 Methodology

2.1 Specific Objectives

Identify the notion of scientific writing and the most frequent types of text written by students.

Identify the students' difficulties in writing scientific texts.

Analyze the assessment of the teaching process experience in scientific text writing through the application of gamification in engineering students.

2.2 Method

The mixed method was used, which involves the collection, analysis and integration of quantitative and qualitative data [12]. For the qualitative approach, a theory was applied based on the categories derived from the data [11].

2.3 Participants

This study involved 400 students from the engineering area of a Peruvian public university: Industrial Engineering, 109 (27.25%); Civil Engineering, 43 (10.75%); Mechanical Engineering, 42 (10. 5%); Electrical Engineering, 52 (13%); Systems Engineering, 41 (10.25%); Sanitary Engineering, 5 (1.25%); Electronic Engineering, 70 (17.5%); Geological Engineering, 9 (2.25%); Mining Engineering, 20 (5%); Telecommunications Engineering, 9 (2.25%). Also, 73 (18.25%) were female and 327 (81.75%) were male. Their ages ranged as follows: 17 to 19 years old, 279 (69.75%); 20 to 22 years old, 75 (18.75%); 23 to 25 years old, 22 (5.5%); 26 and older, 24 (6%). Respondents had previously taken the courses of Comprehensive Communication and Scientific Report Writing. Data were collected between April and May 2022 through a Google Forms questionnaire. The sampling was non-probability convenience sampling.

2.4 Data Analysis

For the quantitative analysis, frequency analysis was performed based on the students' responses. For the qualitative analysis, the Atlas ti software was used.

Table 1. Table of categories and open-ended questions of the questionnaire

Category (C)	Definition	Open-ended questions	Type of analysis
C1. Meaning of academic writing	Process by which ideas about a topic are expressed in writing.	What does it mean to you to write scientific texts in college?	Quantitative
C2. Writing experience	Writing practice on the different types of text	What types of texts have you written before?	Quantitative
C3. Difficulties in writing	Set of obstacles and limitations that prevent students from writing.	What difficulties have you had in doing so?	Quantitative
C4. Importance of writing in engineering	Attitudes and evaluations towards engineering writing	Do you consider that writing scientific texts is important for an engineer? why?	Qualitative
C5. Gamification	The use of game elements in non-game contexts.	Have you ever applied gamification to teach you how to write scientific texts? How do you value that experience?	Qualitative

2.5   Research Instrument

A semi-structured questionnaire with six open-ended questions was applied, and a categorical system was developed for data analysis (Table 1). A definition was made of the categories of analysis, which were related to their corresponding open-ended questions.

3   Results

3.1   Quantitative Analysis

The question "What does it mean to you to write scientific texts at the university?" elicited a variety of responses, the most representative of which were: to research and publish the results, 135 (33.75%); to acquire and contribute new knowledge, 67 (16.75%); and 32 (8%), as shown in Table 2. These results show that most engineering students emphasize the final product of the research process, which in this case is to publish and disseminate the results.

In relation to the question "What types of texts have you written before?", the essay was indicated as the most recurrent textual genre with 147 (36.75%), followed by narrative texts with 59 (14.75%) and monographs 53 (13.25%), as shown in Table 3. These results highlight the importance given to the essay genre in the previous formative courses.

Regarding the question, "What difficulties have you had when writing?", the search and verification of information was the most recurrent, with 96 (24%), followed by

Table 2. Meaning of the writing

Sub-categories	f	%
Search for information sources	32	8%
Write scientific articles	19	4.75%
Writing theses, reports, essays or monographs	21	5.25%
Use specialized and technical language	16	4%
Research and publish the results	135	33.75%
Follow a research process	12	3%
Read continuously	4	1%
Have critical capacity	4	1%
Improve as a future professional	20	5%
Acquire and contribute new knowledge	67	16.75%
Contribute to science and technology	14	3.5%
Contribute to society	20	5%
To be part of the scientific community	3	0.75%
Innovate	9	2.25%
To assume a great responsibility	4	1%
Take on new challenges	12	3%
Other	8	2%
Total	400	100%

Table 3. Types of text produced by students

Types of texts	f	%
Essays	147	36.75%
Monographs	53	13.25%
Articles	32	8%
Reports	28	7%
Theses	2	0.5%
Argumentative texts	31	7.75%
Narrative texts	59	14.75%
Descriptive texts	10	2.5%
Poetic texts	2	0.5%
Summaries	4	1%
Others	18	4.5%
None	14	3.5%
Total	400	100

text structure 58 (14.5%), and the generation and ordering of ideas 48 (12%), as shown in Table 4. The greatest difficulty reported by students could be related to accessing scientific databases such as Scopus and Web of Science.

Table 4. Difficulties in writing

Difficulties in writing	f	%
Lack of reading habits	21	5.25%
Generate and order ideas	48	12%
Search and verify information	96	24%
Poor teaching	11	2.75%
Lack of experience	10	2.5%
Spelling, grammatical and	43	10.75%
textual problems	9	2.25%
Use of technical language	58	14.5%
Text structure	32	8%
Use of quotations	16	4%
Formatting	4	1%
Use of foreign language	4	1%
Use of programs (latex)	7	1.75%
Creative block	4	1%
Lack of motivation	17	4.25%
Time availability	3	0.75%
Other	17	4.25%
None		

3.2 Qualitative Analysis

For the qualitative analysis, only 87 responses from students who said that the use of gamification in the teaching-learning process is important were considered. For this purpose, a grounded theory was applied based on the categories derived from the data [11].

From the analysis and interpretation of the data, it can be observed that the students first mentioned the importance of writing in different areas, which are not only limited to academics. Thus, with regard to the importance of scientific writing, the participants referred to aspects related to the stages of the knowledge process; to research, science and technology associated with their repercussions; to the professional and work career; to the teaching-learning process associated with the development of different types of skills as well as different characteristics associated with this process; and to society, its development and benefit (Fig. 1).

The following are narratives of some participants (p) of this study: (p. 63) "… it is important because throughout his career the engineer will have greater challenges and therefore if he does not know any topic, he will have to conduct research and show the results in an article or scientific text" (p. 71). "It is really important, since engineering careers are based on applied sciences in order to develop, so writing scientific texts will be part of our work".
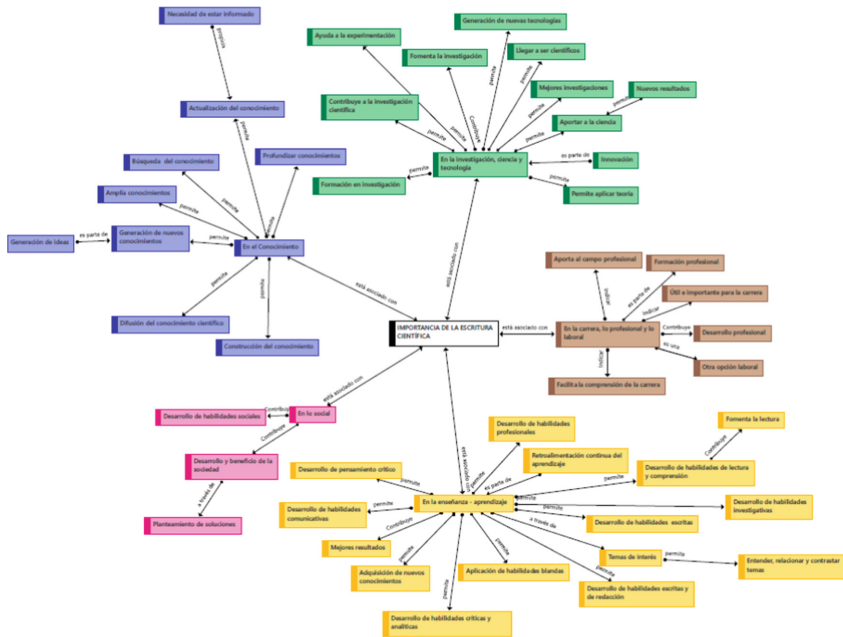
Fig. 1. Importance of Scientific Writing. Source: ATLAS ti semantic network.

On the other hand, regarding the valuation given by the students regarding the use of gamification in teaching the writing of scientific texts, in Fig. 2 we can observe mainly positive evaluative judgments such as: important, interesting, entertaining, easy, satisfactory, useful, novel, etc. although in one case it was described as exhausting as expressed by (p. 1): "… it was very exhausting to be honest, but at the end it was very gratifying since it feels like one develops that research and being able to concretize all the knowledge acquired in a well-done essay". In addition, while for some students it was perceived and defined as a method, a strategy or a teaching technique, for others it was a way of learning that was characterized by the dynamic and playful experience associated with emotional memory, which was carried out through the use of technology and digital tools. Likewise, different advantages of the use of gamification in the teaching of scientific writing are mentioned, such as facilitating learning, encouraging research, better understanding of the procedure, improvement and development of different skills, as well as a better predisposition to learn, among others, as expressed by; (p. 24) "… I consider it a different and very pleasant experience. It makes our learning easier and perhaps more fun, the subject does not become so tedious".

Fig. 2. Assessment of Gamification in the Teaching of Scientific Writing. Source: ATLAS ti semantic network.

4   Discussion and Conclusions

The purpose of this study was to analyze the perceptions that engineering students have about scientific writing and gamification. From the main results it can be concluded that the notion that engineering students have about scientific writing is linked to the processes of research and publication of results; likewise, the essay turns out to be the most used textual genre and the most frequent difficulty when writing has to do with the search and verification of information. Likewise, in this study it was found that the use of gamification is not the most common among engineering students, which is consistent with other similar studies [19].

Regarding academic writing in the area of engineering, Vine-Jara [25] reports that engineering students in a Chilean university have greater difficulties in writing, because they do not have sufficient knowledge about how to write a paragraph and they do not revise their writing after writing. In this sense, these results are similar to those obtained by Berdanier & Zerbe [4] in which engineering students report problems in scientific writing in aspects such as mental block, perfectionist eagerness and procrastination; in other cases, with the training received in writing [8].

From the qualitative approach, it can be concluded that in the expectation of new methods of teaching writing, gamification is presented as an innovative strategy that can serve to motivate students to get involved in the world of scientific production.

Finally, one of the limitations of the present study is that the great majority of engineering students belong to the first years of study. The research methodology courses only correspond to higher years. A future line of research will be to investigate the perceptions of students who have already taken research methodology courses.

References

1. ABET: Accreditation Board for Engineering and Technology (2020). https://www.abet.org/
2. Alabbasi, D.: Exploring Graduate Students' Perspectives towards Using Gamification Techniques in Online Learning. *Turkish Online Journal of Distance Education*, 18(3), 180–196 (2017). https://doi.org/10.17718/tojde.328951
3. Arnold, B.J.: Gamification in Education. *Proceedings of the American Society of Business and Behavioral Sciences*, 21, 32–39 (2014). http://asbbs.org/files/ASBBS2014/PDF/A/ArnoldB(P32-39).pdf
4. Berdanier, C. & Zerbe, E.: Quantitative Investigation of Engineering Graduate Student Conceptions and Processes of Academic Writing. 2018 IEEE International Professional Communication Conference (ProComm), Toronto, ON, Canada, 2018, 138–145 (2018), https://doi.org/10.1109/ProComm.2018.00037.
5. Bouchrika, I., Harrati, N., Wanick, V., & Wills, G.: Exploring the impact of gamification on student engagement and involvement with e-learning systems. Interactive Learning Environments, 1–14 (2019). https://doi.org/10.1080/10494820.2019.1623267
6. Caro-Alvaro, S., Garcia-Lopez, E., Garcia-Cabot, A., de-Marcos, L., Martinez-Herraiz, J.J.: Development of a Social Gamified Platform for e-Learning. 26th International Conference on Information Systems Development: Advances in Methods, Tools and Management, ISD 2017, 160001 (2017).
7. Castelló, M., Pozo, J. I., Pérez-Echeverría, M. P.: Aprender a escribir textos académicos: copistas, escribas, compiladores o escritores. *Psicología del aprendizaje universitario: La formación en competencias*, 120–133 (2009).
8. Conrad, S.: A Comparison of Practitioner and Student Writing in Civil Engineering. Journal of Engineering Education, 106(2), 191-217 (2017). https://doi.org/10.1002/jee.20161
9. Donnell, J. A., Aller, B. M., Alley, M., & Kedrowicz, A. A.: Why industry says that engineering graduates have poor communication skills: What the literature says. In ASEE Annual Conference and Exposition, Conference Proceedings. (2011). https://doi.org/10.18260/1-2-18809
10. Erdil, N. O., Harichandran, R. S., Collura, M. A., Nocito-Gobel, J., Adams, D. J., & Simson, A.: Preliminary assessment of and lessons learned in PITCH: An integrated approach to developing technical communication skills in engineers. (2016). https://doi.org/10.18260/p.25944

11. Glaser, B. G. & Strauss, A. L.: *The discovery of grounded theory: strategies for qualitative research*. Aldine de Gruyter (1967).
12. Hernández Sampieri, R., Fernández, C, Baptista, M.: Metodología de la investigación. Sexta edición. McGraw Hill. (2014).
13. Kapp K. M.: The gamification of learning and instruction: game-based methods and strategies for training and education. Pfeiffer (2012).
14. Kmiec, D. & Longo, B.: The IEEE guide to writing in the engineering and technical fields. Wiley, (2017). https://doi.org/10.1002/9781119070269
15. Male, S., Bush, M., & Chapman, E.: Perceptions of competency deficiencies in engineering graduates. Australasian Journal of Engineering Education, 16, 55–67 (2010). https://doi.org/10.1080/22054952.2010.11464039
16. Manzano-León, A.; Camacho-Lazarraga, P.; Guerrero, M.A.; Guerrero-Puerta, L.; Aguilar-Parra, J.M.; Trigueros, R.; Alias, A.: Between Level Up and Game Over: A Systematic Literature Review of Gamification in Education. *Sustainability*, 13(4), 2247 (2021). https://doi.org/10.3390/su13042247
17. Markopoulos, A. P., Fragkou, A., Kasidiaris, P. D., & Davim, J. P.: Gamification in engineering education and professional training. *International Journal of Mechanical Engineering Education*, *43*(2), 118-131 (2015). https://doi.org/10.1177/0306419015591324
18. Milosz, M., & Milosz, E.: Gamification in engineering education–a preliminary literature review. In *2020 IEEE Global Engineering Education Conference (EDUCON)*. pp. 1975–1979 (2020). https://doi.org/10.1109/EDUCON45650.2020.9125108
19. Núñez-Pacheco, R., Vidal, E., Turpo-Gebera, O., & Castro-Gutiérrez, E. (2023). Call for Papers: The Game, a Gamified Tool for Teaching Scientific Writing in Engineering Students. HUMAN REVIEW. International Humanities Review, 21(2), 299–310. https://doi.org/10.37467/revhuman.v21.5067
20. Paľová, D., & Vejačka, M.: Implementation of gamification principles into higher education. *European Journal of Educational Research*, 11(2), 763–779 (2022). https://doi.org/10.12973/eu-jer.11.2.763
21. Pierson, M. M., & Pierson, B. L.: Beginnings and Endings: Keys to Better Engineering Technical Writing. In Beer, D. *Writing and Speaking in the Technology Professions: A Practical Guide*. IEEE, 2003, 24–29 (2015). https://doi.org/10.1002/9781119134633.ch5.
22. Prieto, J. M.: Una revision sistemática sobre gamificación, motivación y aprendizaje en universitarios. *Teoría De La Educación. Revista Interuniversitaria*, 32(1), 73–99 (2020). https://doi.org/10.14201/teri.20625
23. Nunes Reis, S. R., & Reis, A. I.: How to write your first scientific paper. In *2013 3rd Interdisciplinary Engineering Design Education Conference,* IEEE, 181–186 (2013). https://doi.org/10.1109/IEDEC.2013.6526784
24. Sabaj, O.: Descubriendo algunos problemas en la redacción de Artículos de Investigación Científica (AIC) de alumnos de postgrado. *Signos*, *42*(69), 107-127 (2009). https://doi.org/10.4067/S0718-09342009000100006
25. Vine-Jara, A. E.: Academic Writing: Perceptions of Students of Human Sciences and Engineering Sciences at a Chilean University. Íkala, Revista de Lenguaje y Cultura, *25*(2), 475–491 (2020). https://doi.org/10.17533/udea.ikala.v25n02a02
26. Yasin, A. A., & Abbas, A.; Role of gamification in engineering education: A systematic literature review. In *2021 IEEE Global Engineering Education Conference (EDUCON)*, pp. 210–213 (2021). IEEE. https://doi.org/10.1109/EDUCON46332.2021.9454038
27. Willig, J.H., Croker, J., McCormick, L., Nabavi, M., Walker, J., Wingo, N.P., Roche, C.C., Jones, C., Hartmann, K.E., Redden, D.; Gamification and education: A pragmatic approach with two examples of implementation. J Clin Transl Sci. 2021 Jun 28;5(1):e181 (2021). https://doi.org/10.1017/cts.2021.806.

28. Wright, K., Slaboch, P. E., & Jamshidi, R.: Technical writing improvements through engineering lab courses. International Journal of Mechanical Engineering Education, 0306419020939621 (2020).
29. Weissbach, R. S., & Pflueger, R. C.: Collaborating with Writing Centers on Interdisciplinary Peer Tutor Training to Improve Writing Support for Engineering Students. IEEE Transactions on Professional Communication, 61(2), 206-220 (2018). https://doi.org/10.1109/TPC.2017.2778949