Developing Technical Writing for Engineering Students Under a Paper Conference Format

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Abstract. This paper's objective was to share our experience in developing technical writing for Engineering students based on the cognitive process theory of writing and based on the sociocultural perspective that affirm that writing is social practices that vary depending on the contexts in which it is carried out. Since 2014 we included a new course called "Writing Technical Articles" were students have to write a six-page paper in a conference format. We believe that the conference format shows students in an active learning approach how to communicate specific ideas according to the requirements of their field of study. We have structured the technical contents based on technical writing recommendations suggested by the Institute of Electrical and Electronic Engineers (IEEE), a professional association that produces over 30% of the world's literature in the engineering and computer science fields, publishing approximately 200 peer-reviewed journals and magazines. Students develop skills for organizing sections and subsections, relationships among parts of an argument, and combining paragraphs with diagrams, formulas and codes very common in Engineering. Until now 630 Ingeniería de Sistemas students from Universidad de San Agustin de Arequipa has been part of the course. Our experience showed that this format gives students the scope to start the process of technical writing. As initial results, we have surveyed students about their perception of usefulness of technical writing under the conference format. The initial results showed us that more than 90% of the students are Agree and Strongly Agree about the usefulness of developing technical writing.

Keywords: Technical writing, cognitive process theory, conference paper

1 Introduction

In recent decades the Engineering field has recognized the need for graduates to develop strong communication skills. Institutions such as the National Academy of Engineering (NAE) in its report "The Engineer of 2020: Adapting Engineering Education for the New Century" [1] describes a set of attributes that are necessary in a world directed by rapid technological and environmental changes, one of these

attributes refers to communication. International accreditation institution for Engineering programs like ABET (Accreditation Board for Engineering and Technology) requires that programs must include for student outcomes the ability to communicate effectively: orally and written [2]. Engineering discipline has generated theoretical and empirical studies presenting suggestions for curriculum design, interdisciplinary courses, integrated programs, and a variety of support systems, including writing and communication centers and online resources to emphasize communication instruction in engineering [3-6]. Donnell, Aller & Kedrowicz [7] focused an important study on identifying why the industry considers these skills to be weak. They found that part of the disparity arises because the communication tasks that engineering students perform at university differ significantly from the writing situations (audiences, purposes, and occasions) that engineering graduates encounter in the industry.

From the literature review Solé et al. [8] affirms that students are used to responding to simple writing demands that primarily require writing for a single recipient - the professor - and with the objective of demonstrating what they learned. Also Catelló [9] presented as the main difficulties faced by university students regardless of the type of text and the disciplinary area: (a) lack of knowledge of the nature of the written composition process (b) lack of knowledge of structural characteristics of academic texts and the useful strategies to produce them. Students do not know the differences between a report, a personal comment or between a bibliographic review and a synthesis or a technical paper for a conference. Also Rienecker and Jörgensen [10] stressed that writing to meet the expectations of university education contexts requires having a set of competencies that go beyond the basic learning acquired in primary or secondary education. They have shown that the skills necessary to master the writing of higher studies are not acquired spontaneously. Authors affirm that writing requires an instructional process. Under these context our work seeks to answer the research question: Is it possible to develop technical writing skills in Engineering under the conference paper format?.

The course "Writing Technical Articles" was implemented since 2014 at the Escuela Profesional de Ingeniería de Sistemas at Universidad Nacional de San Agustin de Arequipa [11]. The activities of the course were designed based under the cognitive process theory of writing [12] and taking as foundation technical writing standards for Engineering. Technical writing recommendations are long stablished by the Institute of Electrical and Electronic Engineers (IEEE) [13] that produces over 30% of the world's literature in the electrical and electronics engineering and computer science fields, publishing approximately 200 peer-reviewed journals and magazines..

2 Background

Hayes and Flower [10] developed the cognitive theory process of writing where they identified three main activities in the writing processes: planning, translating and reviewing. Planning takes the writing assignment and produces a conceptual plan for

the document as output. Planning includes sub-activities of generating ideas, organizing those ideas logically, and determining what effects one wants to achieve. Translating takes the conceptual plan for the document and produces text expressing the planned content. In reviewing, the text produced so far is read, with modifications to improve it (revise) or correct errors. Hayes and Flower [12] presented evidence that these processes are frequently interleaved in actual writing, authors may be planning for the next section even as they produce already-planned text; they may read what they have written and detect errors and change their goals and plans for the next section. Hayes and Flowers affirm that writing involves complex problem solving. From the social cultural perspective knowledge is conceived as a cultural and discursive fact, a social construction that the human community has made, with the rational instrument of language [14]. Education must be understood by the activity of production and communication of knowledge in different disciplinary fields. This assumption implies for our work the need to teach the particularities of the production of the texts that circulate in the disciplinary field of Engineering.

The Institute of Electrical and Electronic Engineers (IEEE) [13] is a professional association for Electronic Engineering and Electrical Engineering . It is the world's largest association of technical professionals with more than 423,000 members in over 160 countries. Its objectives are the educational and technical advancement. IEEE produces 200 peer-reviewed journals and magazines. IEEE publishes more than 1,200 leading-edge conference proceedings every year. IEEE has standards and recommendations for technical writing [15]. It identifies three main blocks: macro level, micro-level, and paragraph [15] *Macro-level:* determine a document's purpose. IEEE highlights: (a) Organization of sections and subsections, (b)Relationships among parts of an argument, (c) Formatting and (d)Navigational aids. Sectioning a document involves identifying argumentative units of similar scope or size that have some logical relationship. In research reports, for example, sections are often named using scientific argument terms that research communities tend to recognize such as: "Abstract", "Introduction", "Related Work", "Background", "Method," "Analysis," and "Result." **Micro-level**: is related to carrying out the document's purpose. IEEE highlights (a) Choosing words and phrases in sentences, (b) Recognizing the function of words and expressions (c) Writing in regular sentence patterns, and (d) Including linguistic cues to indicate the structure of an argument. Writing at the micro-level is about identifying the immediate purpose of a sentence related to the sentences around it. The reader should feel an argumentative "flow" as they read a document that moves along unambiguously from point to point. There are five parameters to consider in the micro-level: unity, coherence, emphasis, clarity, and concision [15]. *The paragraph* between the macro and micro-level in a document, there is an intermediate level: the paragraph. paragraph is a block of text that functions to group statements that have some logical relationship so that they can be understood together. Less textually dense alternatives to paragraphs at this level are lists, tables, pictures, illustrations, charts, graphs, diagrams, formulas and codes. Each of these can be used effectively to make argumentative points, and each requires specialized literacy to access.

3 Methodology

3.1 Description

The course of Writing Technical Articles was added to the curriculum of the Escuela Profesional de Ingeniería de Sistemas [11] at the Universidad Nacional de San Agustin de Arequipa in 2014. The course has 17 weeks duration. It is taught in the 3rd semester. It has two lecture hours per week. The design of the course has been developed based on the cognitive process of writing [12] and following IEEE technical writing recommendation [15] since the authors agree that writing is social practices that vary depending on the contexts in which it is carried out. The topics taught in the course are listed in Table 1. From the 17 weeks of classes only six are dedicated to developing the topics shown in Table 1. the rest of the time is devoted mostly to a dynamic and iterative process of translating and reviewing. Students are asked to deliver incremental drafts and they receive continue feedback.

Table 1. Topics of the Course

IEEE Main Blocks	Course Topic – IEEE
Macro Level	Unit 1: Overview
	1.1 Why is Technical writing important
	1.2 What is a Call for papers
	1.3 IEEE conference paper format – navigational aids
	1.4 Parts of the article
Micro Level	Unit 2: Planning
	2.1 Keywords, synonyms and related terms
	2.2 Implementing the search strategy and search parameters
	2.3 Searching information: Scopus, Web of Science, IEEE Xplore
	2.4 Credibility and reliability of sources of data
	2.4 Critical Reading
	2.5 The writing plan
Paragraph	Unit 3: Technical Writing
	3.1. Writing sentences and paragraphs
	3.2. Tables, images, diagrams, formulas and codes
	3.3. References and citation in IEEE format with Mendeley
	3.4. Developing unity, coherence, emphasis and clarity
	3.5. Writing Related Works
	3.6. Writing the Proposal
	3.7. Writing Abstract, Introduction and Conclusion

3.2 The conference paper format

Throughout the semester, each student writes a technical paper. Each student is assigned the topic and also the title in the first week. Each topic has been formulated in order to give students knowledge about the scope of the software engineering field and its impact on a global and social context and to motivate them. The final paper only will have six pages, with a minimum of 20 references. There are five reviews throughout the semester. Students deliver incremental drafts of the paper. The description of the deliverables are shown in Table 2.

As we have set in the background section writing academic texts is a complex cognitive process that requires intense cognitive activity. In a specific field like Engineering, writing a conference paper to show a new design, a prototype or a new software is an important professional skill. The process of writing requires described in our experience requires students to search for information, select the one that they consider most relevant after a critical reading, organize this information for propose a writing plan, to write according to the writing plan and rehearse various formulations on the paper. The process that we have just described involves planning, writing (translating) and review activities that, in general, do not occur in a linear way (Fig. 1).
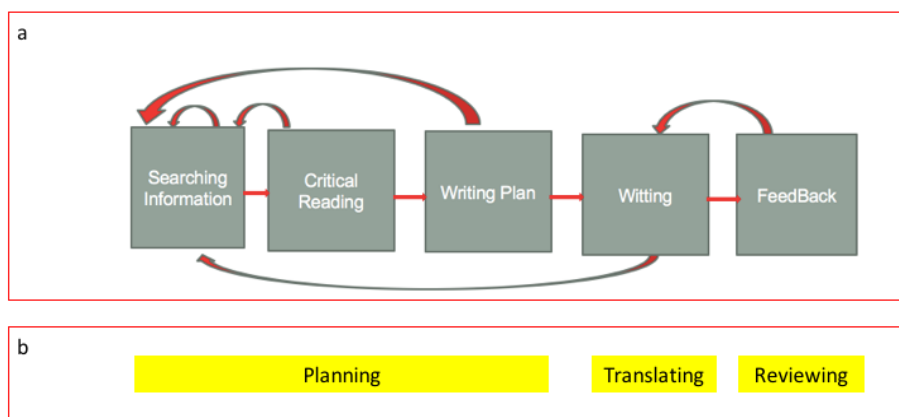

Fig. 1. (a) The main activities of developed in the course for writing the paper are iterative and dynamic. (b) There is relation with the cognitive process theory of writing

Table 2. Deliverables of the Paper

Deliverables description	Week
Basic Information	2
a. Present the keywords and synonymous related to the topic assigned	
b. Present the Search Strategy used and the refined search strategy	
c. Share in the course drive at least five related articles of the topics (justify why they were selected)	
d. Complete the Paul-Elder template for critical reading for the five articles you selected	
Writing Plan	3
a. Based on the previous activity develop your writing plan; consider IEEE section format	
b. Use Title, subtitles and sub-subtitles.	
c. Describe from general concepts to detailed concepts	
d. Consider at least 5 references from IEEEXplore, ACM Digital Library, SCOPUS, WOS, SJR.	
Draft 1	5
a. IEEE paper format	
b. 1 page and 10 references.	
c. No abstract, no introduction and no related works	
Draft 2	7
a. Make up observations in Draft 1	
b. Write 2 pages and 10 references	
c. No abstract , introduction and related work	
Draft 3	10
a. Make up observations in Draft 2	
b. Write 4 pages including Related Works and your Technical Proposal.	
c. No abstract and introduction	
d. At least 15 references	
Draft 4	15
a. Make up observations in Draft 3	
b. Write 6 pages with Abstract, Introduction and Conclusions	
c. At least 20 references	
Final paper	17
Make up observations in Draft 4	

Fig. 2 shows a papers that correspond to the Draft 1 version, we can observe grammatical errors and also the use of citation that do not coincide with the IEEE standard. There is also a reference to Graphic 1 that was not found on the text. Students receive personal feedback after each presentation. Also we summarize common mistakes and prepare a special class to explain again the topics we have found still confuse or difficult for students.
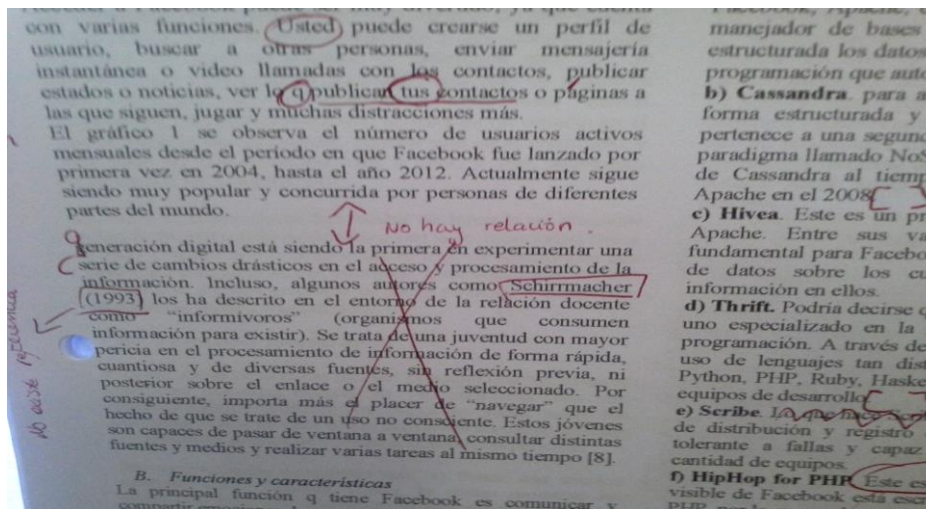
Fig. 2 Paper in Draft 1 version

4 Material and Methods

This experience was implemented in the Escuela Profesional de Ingeniería de Sistemas at Universidad Nacional de San Agustin de Arequipa. To answer our research question "Is it possible to develop technical writing skills in Engineering under the conference paper format?, we conducted an exploratory study. The study population were 90 students from the second year of studies. The sample was stablished though a non-probabilistic convenience sampling with 50 students that were part of the course in semester 2020-A. Students have an age range between 18 and 20 years with no previous experience in writing technical article and no experience in reading technical conference article eater[16-17]. The objective was to verify the perception of the students about the developing technical writing skills under the conference paper format. The instrument was prepared based on the MUSIC Model [9] that consists of five components (1) empowerment, (2) usefulness, (3) success, (4) interest, and (5) caring. For measuring students' perceptions we focus only on Usefulness component. The instrument consists of eleven statements that students responded to on a 6-point Likert scale (ranging from "Strongly Disagree" to "Strongly Agree"). Questions are Q1: In general, writing a paper was useful to me, Q2: The writing paper process was beneficial to me Q3: I found the coursework to be relevant to my future. Q4: I will be able to use the knowledge I gained in this course, Q5: The knowledge I gained in this course is essential for my future.

4.   Results and Discussion

Table 3. Results

Question	Answer					
	Strongly Disagree	In Disagreement	Somehow disagree	Somehow agree	In Agreement	Strongly Agree
Q1	0	0	0	4%	34%	62%
Q2	0	0	0	10%	14%	76%
Q3	0	0	0	8%	38%	54%
Q4	0	0	0	4%	44%	52%
Q5	0	0	0	6%	28%	66%

Results in Table 3 shows values over de 50% in all the question in the Strongly Agree answer. Q2: "The writing paper process was beneficial to me" have scored higher with 76%. Considering only "In Agreement" and "Strongly Agree" results shows us that students consider Useful developing technical writing skills in more than 90%. We consider that the results allow us to affirm that we have a positive approach to answer our research question: it possible to develop technical writing skills in Engineering under the conference paper format.

From 2014 to 2020, the course has been taught for seven years. Each year we have had a range from 90 to 100 students. From the beginning, the course has been improved each year. We have emphasized the permanent feedback and incremented the lecture hours devoted to teach how to write the abstract, introduction, and related work. Supported in the experience of the first two years, we suggest reducing the number of students per group, by increasing the number of class sections. This reduced the student/faculty ratio to have more time for feedback sessions and include spaces for discussion. We have found it very useful to compile common mistakes and review the papers in special lectures asking students to suggest improvements to the papers we have shown as samples. In the writing process, the most common mistakes are made in the correct use of citations. Fig. 2 is a sample of it, many times students make a copy/paste from the original paper bringing a different kind of citation like APA (American Psychological Association). A second challenge is given by making a good argumentation when it comes to explaining related works and the similarities and differences with the work that students write. The incremental deliverables allow students to overcame common mistakes. We believe that teaching technical writing at the beginning is essential for students since we give them standards for writing, and they have other courses to apply what they have learned. It is also crucial to motivate them to keep on writing papers and to send them to conferences.

The closed work to ours is the presented by Popescu and Jovanovic [3] who introducing a writing assignments in an Electrical Circuits course, for electrical engineering technology students. Students were required to write a three-pages IEEE format paper. The topics for the assignment were selected from among the concepts studied in the course. The final paper was expected to contain the main results related to the selected topic, which, depending on the topic, could have been theorems,

formulas, examples with commentaries, relationships with other concepts, discussions on related applications, or other relevant information for the chosen topic. The main coincidence we found with our work are: both are IEEE conference paper-oriented, we consider the same important activities like: paper is well written, IEEE format is followed, no grammar or spelling errors, information is well organized in sections, relevant references are included and the proper format is used. One main different is that our work is a specific course in the curriculum that is devoted to teach technical writing while [3] presented and specific assignment as part of the course. Another difference is that we have show the detailed contents of the course that could be reproduced, we have also share the structure of the deliverables of the paper. The proposal has been structured under the cognitive theory process of writing.

5. Conclusions

Our work presents the experience of the development of technical writing skills in Engineering students based on a conference paper format. This experience teaches students the process of writing (planning, translating and reviewing) based on the theory of Flower and Hayes [12] and under the particularities of the production of technical paper in the disciplinary field of Engineering. The writing process is a complex process even more so if it is oriented to a Engineering conference. From a practical point of view students experience during seventeen weeks the dynamic and iterative writing process that includes activities such as information search (in reliable sources), critical reading, organization of the writing work, the writing itself and the reviewing . The results obtained describe in the previous section show us that there is a high acceptance of the importance of incorporating the practice of writing an article in conference format and that student consider it useful for their future professional live. Although the experience has been proven in students of Ingeniería de Sistemas we consider that the experience presented can be adapted to other specific Engineering field, making use of topics appropriate to each discipline. Likewise, starting in the early stages of study allows students to train in information literacy, critical reading and writing practices that are valuable not only for writing articles but for their lifelong learning.

References

1. National Academy of Engineering. The Engineer of 2020: Adapting Engineering Education to the New Century. Washington, D.C., (2004).
2. ABET. Criteria for Accrediting Engineering Programs, 2015 – 2016. http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2015-2016/#outcomes, , last accessed 2020/11/28.
3. Popescu, O., Jovanovic, V.M.: Introducing Writing Assignments in Engineering Technology Courses to Enhance Technical Writing Skills and Critical Thinking" (2016). Engineering Technology Faculty Publications. 71. https://digitalcommons.odu.edu/engtech_fac_pubs/71

4. Armarego, J.: Enhancing Writing Skills in IT Students. International Journal of Learning, vol. 18, 1-15 (2012).

5. Vidal, E.: Improving Writing and Oral Communication for Engineering Students–the Conference paper and poster format experience. In *2019 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON), pp* 1-7. IEEE, Chile (2019). http://www.doi.org/10.1109/CHILECON47746.2019.8988094

6. Vidal, E., Castro, E., Baluarte, C.: Experience of the integration of YouTube for the development of communication competence in an Engineering Career". 17 th LACCEI International Multi-Conference for Engineering, Education, and Technology. Jamaica, (2019). http://dx.doi.org/10.18687/LACCEI2019.1.1.69

7. Donnell, J. A., Aller, B. M., Alley, 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)

8. Solé, I., Gómez, N. C., García, M. G., Datsira, S. E.: Aprender psicología a través de los textos. *Anuario de psicología/The UB Journal of psychology*, 157-176 (2006).

9. 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 (2008).

10. Rienecker, L., Jörgensen, P. S.: The genre in focus, not the writer: Using model examples in large-class workshops. In *Teaching Academic Writing in European Higher Education.* Springer, Dordrecht, 59-74 (2003).

11. Escuela Profesional de Ingeniería de Sistemas http://fips.unsa.edu.pe/ingenieriadesistemas/, last accessed 2020/11/28.

12. Flower, L., Hayes, J. R.: A cognitive process theory of writing. *College composition and communication*, *32*(4), 365-387 (1981).

13. Electrical and Electronic Engineers (IEEE). www.ieee.org, , last accessed 2020/11/28.

14. Cassany, D., Morales, O.: Leer y escribir en la universidad: Hacia la lectura y la escritura crítica de géneros científicos. *Revista Memoralia*, *5*(2), 69-82 (2008).

15. Kmiec, D., Longo, B.: *The IEEE guide to writing in the engineering and technical fields*. John Wiley & Sons, (2017)

16. Jones, B.: User Guide for Assessing the Components of the MUSIC® Model of Motivation. https://www.themusicmodel.com/wp-content/uploads/2020/01/User-Guide-January-2020-2.pdf, last accessed 2020/11/28.

17. Jones, B., Skaggs, G.: Measuring Students' Motivation: Validity Evidence for the MUSIC Model of Academic Motivation Inventory. International Journal for the Scholarship of Teaching and Learning, 10(1), n1, (2016).