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Project-Based Learning of Scientific Writing and Communication Skills for Postgraduate Students

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Abstract - This paper addresses education on scientific publication skills for post-graduate engineering students. In particular, a project-based learning strategy is proposed to lead students through the preparation a research paper. Expected learning outcomes are related to finding and evaluating the quality of references, editing and formatting text in \LaTeX, writing scientific papers with appropriate style and structure, peer reviewing, and making technical presentations. This approach has been developed to increase the internationalization and visibility of young researchers by improving the quality standards of their published works. The purpose of this innovative practice is that students confront the major challenges of the publication process in the classroom, which is in contrast with the traditional self-taught approach experienced by the authors and many senior researchers. The proposed strategy is being applied as a required course in the Master in Mechatronics Engineering of the University of Malaga. This paper offers preliminary results from this experience.

Keywords: Communication skills, scientific texts, project-based-learning, engineering education.

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Project-Based Learning of Scientific Writing and Communication Skills for Postgraduate Students

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***Abstract*—This paper addresses education on scientific publication skills for post-graduate engineering students. In particular, a project-based learning strategy is proposed to lead students through the preparation a research paper. Expected learning outcomes are related to finding and evaluating the quality of references, editing and formatting text in LaTeX, writing scientific papers with appropriate style and structure, peer reviewing, and making technical presentations. This approach has been developed to increase the internationalization and visibility of young researchers by improving the quality standards of their published works. The purpose of this innovative practice is that students confront the major challenges of the publication process in the classroom, which is in contrast with the traditional self-taught approach experienced by the authors and many senior researchers. The proposed strategy is being applied as a required course in the Master in Mechatronics Engineering of the University of Malaga. This paper offers preliminary results from this experience.**

I. INTRODUCTION

This paper addresses education on scientific publication skills for post-graduate engineering students. Writing scientific texts and presenting research results are essential competencies for successful researchers, but they remain a key challenge for science and engineering students [1] [2].

Concern about the difficulties found by many engineering students in writing and communicating has inspired innovative educational experiences at the undergraduate level, as these skills benefit learning and are appreciated by employers [1] [2] [3] [4]. These difficulties pose a greater challenge at the post-graduate level, where students with a research-oriented profile require not only effective writing competencies, but also a comprehensive understanding of the scientific publication process, the genre conventions of research articles, publication ethics, and the evolving information technology tools for literature research, and bibliometrics [5]. Besides, introducing novel researchers to the peer-review process is important to develop judgement and self-criticism based on quality standards [6]. Another challenge is to avoid procrastination by favoring a predisposition to write about research results [1]. Furthermore, in non-English speaking countries students have to familiarize themselves with the rhetorical characteristics of a foreign language [7] and to assimilate different ways of defining and understanding problems [8].

Regarding textbooks on technical communication, the work by *Johnson-Sheehan* covers a broad range of genres and contexts [9]. Other texts focus on more specific aspects, like the writing process [10] [11], oral presentations [12] [13], or LaTeX usage [14]. However, these texts do not address some relevant issues for academic research publication, such as the peer-review process or rapidly evolving bibliometric measurements though information technology (IT) tools.

This paper reports on the work in progress towards a novel project-based methodology so that postgraduate engineering students acquire knowledge and abilities to progress effectively through the cycle of peer-reviewed scientific publications. This approach is being applied in the Master in Mechatronics Engineering of Universidad de Málaga (UMA). A one-semester course is articulated though lab-sessions and assignments where students have the goal to develop individual technical paper about a topic of interest and make a presentation in a simulated conference session. The paper offers assessment based on student surveys from two terms.

The paper is organized as follows. Section II describes the academic context. Section III discusses the design of the lab-work project. Section IV gives results from the application of the proposed lab-work. The paper is closed by the conclusions.

II. ACADEMIC CONTEXT

The innovative experience reported in this paper has been applied in the UMA Master in Mechatronics Engineering. This Master has a maximum of 25 students per course and is related to a Doctoral Program. The Master is offered as a three-semester programme (90 credits in the European Credit Transfer System, ECTS): the first semester is for required courses, the second semester is for elective courses, and the third semester is devoted to the Master Thesis.

Concurrently with the Master Thesis, the third semester includes two courses that aim to bridge the gap between technical knowledge and the professional practice of engineering research: technology transfer and scientific communication. In particular, the course on scientific communication, which is the subject of this paper, consists of 16 two-hour weekly sessions as well as one-on-one tutoring activities.

III. COURSE DESIGN

A. Motivation and Learning Objectives

The learning objective of the proposed approach is that through course instruction, individual practice, and interactions, students will acquire knowledge and abilities to progress effectively through the cycle of peer-reviewed scientific publications. Several learning outcomes have been identified to accomplish this objective:

- Students will be able to find relevant and reliable references according to bibliometric indicators in research databases for a subject of interest.
- Students will be able to use LaTeX templates to prepare a properly formatted research paper.
- Students will be able to prepare a technical paper with an appropriate structure, writing style, and ethical considerations required by scientific publishing.
- Students will demonstrate substantial knowledge of peer-review criteria to review works by others and to exercise self-criticism.
- Students will gain competency in presenting and discussing research ideas in technical meetings.

The design of a course to achieve the above learning outcomes in the current IT-dominated cycle of scientific publication requires intensive lab practice in addition to lectures. Moreover, even if independent teacher-led exercises can provide knowledge about certain aspects, a project-based approach offers a deeper and more realistic student-centered experience [15].

In this sense, the backbone of proposed course is a technical publication project, with the support of short lectures, teacher-led exercises, and one-on-one activities. The goal is that students prepare a two-page short paper with appropriate structure and format. This project needs individual research topics that are motivating for the students and have enough entity to apply course techniques. However, the topic should not be too complex to avoid that it takes on major importance over the learning outcomes. To this end, the proposed projects are based on the topic of each student's Master Thesis, which is being developed concurrently.

Furthermore, as projects are individual, additional mechanisms are required to promote multidisciplinarity and collaborative participation of all students. This is accomplished by including peer-reviewing and presentation discussions as part of the simulation of the publication process.

B. Course Description

This section describes the UMA course, which has been organized into four main parts. The first part deals with searching relevant and reliable references for a research topic. The second part introduces students to text editing with LaTeX. The third part is dedicated to writing scientific texts. Finally, the fourth part addresses critical judgement of individual projects through peer-review and oral presentations.

Each session is developed in an IT-classroom (see Fig. 1) and comprises both a short lecture and project-oriented practice. The sessions for each block are detailed below:

1) Introduction, bibliographic databases, and bibliometrics: The first block of the course serves as an introduction, so teacher-led exercises are combined with the first steps in individual project development.

Session 1 is an introduction to the course and the project-based approach. All students participate in a discussion on their particular interests about the course.

Figure 1. A student makes a presentation during a simulated conference session. The complete course is developed in a computer IT classroom.

Session 2 is an introduction to bibliographic databases, including open access and subscribed services. In this session students search references that meet criteria indicated by the teacher and also for the project topic.

Session 3 is devoted to searching papers that cite given references.

Session 4 serves to analyze researcher evaluation through parameters like the h-index [16].

Session 5 is dedicated to the quality and scope of scientific journals. Students are asked to identify appropriate journals for their project topic.

2) Preparation of scientific documents with LaTeX:

Session 6 is an introduction to this tool. Teacher-led lab-work includes paper formatting using conference and journal templates. A template for the project is given to the students.

Session 7 addresses math formulas. Apart from exercises proposed by the teacher, students are asked to edit two chosen formulas from journal papers found in their topic of interest.

Session 8 is for reference management. Students incorporate a bibliography list in their document template.

3) Writing scientific documents:

Session 9 includes a short lecture on the types and the structure of scientific texts. Then, students are asked to analyze the structure and style of a highly cited paper as well as to write their own title for it. Finally, students are asked to choose and analyze a relevant journal paper about their topic.

Session 10 is about the process and the style of scientific writing. Lab-work is for preparing project papers.

Session 11 includes a short lecture with advice about writing in English. Students write a short abstract in English for their project paper.

Session 12 is lab-work for completing the project paper.

4) Judgement and discussion of research papers:

Session 13 is devoted to peer-reviewing. Students learn about review criteria and use a review questionnaire to anonymously review another student's manuscript. The teacher acts as the editor.

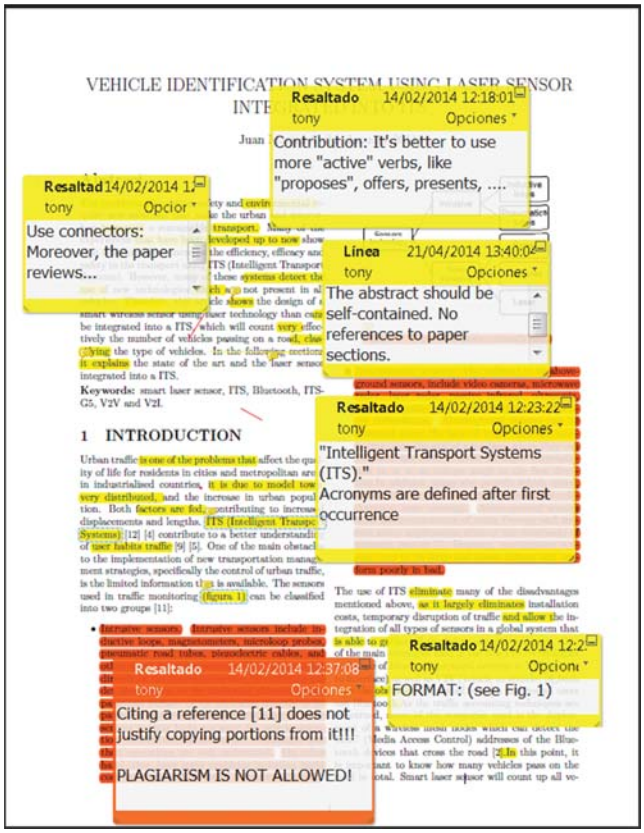

Figure 2. Teacher feedback for a sample student manuscript.

Session 14 is about preparing slides for a scientific presentation.

Session 15 and *Session 16* are for student presentations. These are organized as a simulated conference session (see Fig. 1). Apart from the speaker, students play the role of the chairperson and participate with questions. Besides, students receive advice from the teacher based on their performance.

In addition to the review from other students, the project paper is evaluated by the teacher and sent back to the student (see Fig. 2). After the course sessions are finished, the student has to prepare the final manuscript based on the peer and teacher reviews, as well as ideas appeared in the presentation sessions. Thus, the final manuscript is the result of the project-based learning strategy.

IV. STUDENT ASSESSMENT

For student assessment, anonymous surveys were performed by the end of the 2011-12 and 2012-13 terms, with 19 collected surveys from a total of 22 students. In these questionnaires students evaluated their perceived skills before and after the course with a score between one and five. The results for each skill are given in Fig. 3, where a bar is shown between the mean "before" and "after" values, so perceived improvement is represented by bar length.

Globally, these results indicate that students acknowledge a substantial improvement in the intended learning skills.

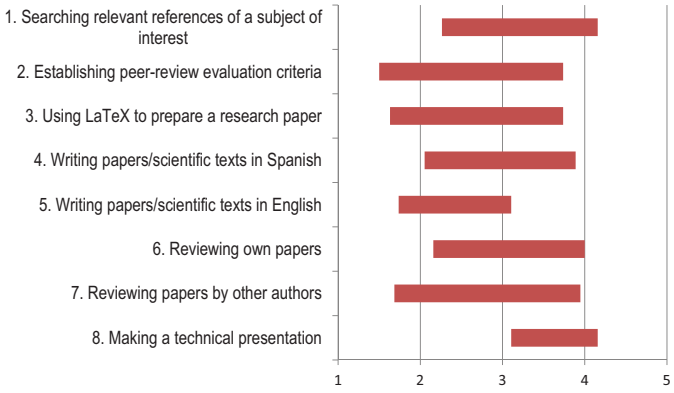

Figure 3. Results from the student survey on acquired skills. Bars represent the improvement between the mean "before" and "after" values.

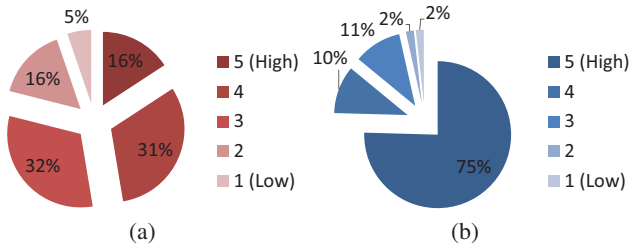

Figure 4. Survey results: a) expectations before the course; b) accumulated satisfaction results.

Interestingly, the skills with a greater gain (2 and 7) are those related with peer-review criteria in academic publishing. These skills share low initial values with LaTeX usage (skill 3) which also has a high improvement value. Moreover, the skills that achieve the highest "after" value are searching relevant references and making presentations (1 and 8), even if students perceive relatively high initial values that are possibly explained by their confidence regarding IT. Besides, the lowest "after" score is for writing in English, as the course was given in Spanish and developing the project in English was an option that was chosen by only six out of 22 students (i.e., 27.3%).

Moreover, the survey included questions about student expectations and satisfaction. Fig. 4(a) summarizes the scores for the expectations before the course (with a mean value of 3.37). Three different questions were related to student satisfaction: "In general, did you find the course interesting?", "If this was an elective course, would you recommend it to other students?", and "Do you think that the course has helped to improve your skills in writing and presenting scientific texts?" The corresponding mean scores for these questions were 4.53, 4.42, and 4.74, respectively. The distribution of scores accumulated for the three questions is shown in Fig. 4(b), which indicates a high degree of student satisfaction.

V. CONCLUSIONS

This paper addresses education on scientific publication skills for post-graduate engineering students. The learning objective of the proposed strategy is that through course instruction, individual practice, and interactions, students will

acquire knowledge and abilities to progress effectively through the cycle of peer-reviewed scientific publications. In particular, a project-based learning strategy is proposed to lead students through the preparation a research paper: from searching references to making a presentation.

The proposed methodology can be useful to increase the internationalization and visibility of young researchers by improving the quality standards of their published works. Confronting the major challenges of the publication process in the classroom is innovative with respect to the traditional self-taught approach experienced by the authors and many senior researchers.

Student assessment results indicate a substantial gain regarding student confidence in technical communication skills as well as high satisfaction levels. Nevertheless, the outcomes regarding English writing should be enhanced, as this is an essential skill for globally competent researchers. In the next term, the course will be developed in English, including the student projects. Future work will also include the definition of measurement mechanisms for learning outcomes beyond student surveys.

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