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Collaborative tools in higher education: The use of Wikis by industrial and mechanical engineering students

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Abstract

Continuous technological advances keep challenging current and future engineers to anticipate and adapt to the new trends and paradigms that are expected to take place in a near future. One of such paradigms is the Industry 4.0 that encompasses the promise of a new industrial revolution based on the interconnectivity of people and systems to communicate, analyse and use information related to industrial processes. New challenges, as well as new opportunities, will rise in this digital landscape, demanding from future engineers the ability to adapt and grow in such ground-breaking environments. With such dynamic changes taking place in the current and future industries, engineering education has to adapt and prepare future graduates to work and function in these demanding environments. The set of skills envisaged to be held by future engineers is the ability to work and collaborate using digital means of participation as well as the ability to effectively use intercultural communicative skills. To this end, an exploratory study was conducted among different European Higher Education Engineering Schools to integrate a project with common aims and goals, resulting in various collaborative engineering activities that were designed to be carried out by undergraduate industrial and mechanical engineering students to further improve their learning outcomes and to acquire, or improve on, dedicated intercultural, communicative and colaborative skills. Following both quantitative and qualitative approaches, this study combined different types of data and methods of analysis in order to provide an exploratory account of the envisaged findings.

Keywords: Engineering education, online learning environments, collaborative learning.

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1. Introduction and Scope

Current adaptive learning technologies allow customising online learning environments to the learner's individual needs by adjusting contents and tools to the envisaged-specific requirements. In higher education (HE) scenarios, abrupt changes have been occurring in the learning process due to the extensive availability of information and communication technologies (ICTs) as well as of the related technological teaching resources. Compared with face-to-face instruction, online learning environments rely on the extensive use of course technology, as it supports multiple aspects of online instruction, including objective specification, material organization, engagement facilitation and outcome assessment (Sun, 2016).

Considering the specific needs of industrial and mechanical engineering students, course contents have to be adapted to current challenges and opportunities that may provide competitive advantages to such students in a massive globalised wold, where physical borders get blurred as barriers to engineering tasks due to the current digital and virtual environments of the mechanical design processes. Intercultural, multilingual and culturally and academically diverse classrooms are a common reality in current HE landscapes, as globalisation is effectively taking place in all major achools, also supported by long time established student and teacher mobility programs in Europe. This new trend highlights the need for engineering students to work in teams with groups that are in diverse locations and have diverse cultural backgrounds.

As a result of various teacher mobility programs, a multi-national experiment was carried out in form of a project with common aims and goals, resulting in various collaborative engineering activities that were designed and carried out in different European Engineering Schools. One of the outcomes of the project was recently presented by Cellorio-Barrague, Ramalho and Gaspar (2016). The main aim of such activities was to promote and enhance multinational students to mutually collaborate and cooperate with each other based on engineering project-based learning activities. Dedicated online learning environment digital tools, combined with dedicated e-strategies, were used to support the collaborative engineering activities and the peer-to-peer learning by the students.

Following both quantitative and qualitative approaches, this study combined different types of data and methods of analysis in order to provide an exploratory account of the envisaged findings, collecting and assessing quantitative data while paying attention to participants' views and practices. After the project was finished, selected students were interviewed on specific domains to complement quantitative data gathered during the completion of the collaborative tasks. The main preliminary findings are presented and discussed, and future developments on the project are proposed.

2. Collaborative Tools in Engineering Education

Engineers focus their activity on solving technical problems with the use of knowledge, ingenuity and skills. As any engineering problem may have more than one solution, engineers usually have to consider different design choices in order to assess their merits and downfalls towards finding the most successful result. On the process of finding the best result, engineers have to identify, understand and interpret technical data in order to characterise the problem to tackle and, as such, they have to be trained on using dedicated tools and technologies. To this end, engineering schools aim at preparing current and future engineers on the best practices of engineering education.

2.1. Challenges and opportunities in engineering education

Currently, engineering problems are ever growing in complexity and aims, whereas teams of multiple engineers with different—and complementary—backgrounds are usually needed to produce a successful result. These collaborative engineering tasks encompass both individual and group efforts towards contributing for the ultimate solution, carrying out complex tasks in very short time frames that no individual element would be able to carry out on their own. Therefore, current Higher

Education Engineering Schools have to prepare engineering students with not only the scientific and technological tools to analyse, characterise and understand engineering problems while producing and weighing different design choices on their merits but also conveying the adequate skills to communicate, interact and negotiate with others in order to pursuit for the best solution(s) for the problem at hand.

According to the National Academy of Engineering (2004), future graduates will need to work and communicate in an emerging global economy that is fueled by rapid innovation and an astonishing pace of technological breakthroughs. As engineering problems gain increasing levels of complexity and intricacy, collaborative teams of engineers are needed to jointly channel their efforts to produce a successful result. These demanding engineering processes require team members to learn from each other and mutually motivate each other using the adequate technologies that define the collaborative environment (Gogan, Popescu & Duran, 2014). Hence, the need to provide current HE engineering students with not only the tools and skills to solve technical problems but also the ability to work and function in such demanding current and future global environments.

2.2. Collaborative engineering design

The design process of complex engineering problems is, in effect, a collaborative process, as it usually involves teams or individuals across different places and with different inputs to the process (Zhang, Ji, Zhao & Li, 2016). Particularly, collaboration is needed when the teams are made up of engineers across widely different fields and with different backgrounds. Evidence from labor-market economics and predictive validity studies (von Davier, Hao, Liu & Kyllonen, 2017) show that collaborative problem-solving is an increasingly important skill for both academic and career success in the current and future work environments.

It is also acknowledged that diverse and multicultural working teams with different cultural backgrounds may bring creativity and new ideas in the projects (Popescu, Borca, Fistis & Draghici, 2014). This allows concluding that teams being formed by people with different backgrounds (like teams of multiple engineers with different and complementary qualifications) will have higher chances of success in the design of innovative and creative solutions through collaboration and may derive new and innovative approaches to problem-solving.

As work teams can be defined as any formal set of at least three interdependent people and collectively responsible with regards to the production of a good or service and whose life is indefinite (Popescu, Suciu & Raoult, 2014), the key aspect to achieve the envisaged results rely on the ability of their member to effectively collaborate and communicate in order to achieve the solution that best match the requirements. To this end, the teams of engineers in any given engineering project must have not only the adequate technical skills but also efficient communicative and interaction abilities to work collaboratively towards the achievement of common goals.

2.3. Wiki pages as digital forms of participation on collaborative engineering tasks

Current engineering activities usually relate collaborative team efforts with the organizational, the team members' and the individuals' aims and objectives (Gogan et al., 2014). As the collaborative aspects of engineering tasks are gaining increased relevance, it becomes necessary to create environments that foster the coordination and the cooperation among engineering teams on solving technical problems (Mejia, Lopez & Molina, 2007). With the development of new and enhanced features of both computer and web-based technologies, significant opportunities to explore and to employ new ways of promoting team members' participation on collaborative work and tasks have arisen. These capabilities play an important role on engineering education and on the preparation of current and future graduates on their use.

When considering the preparation and training of students to carry out engineering activities, even though the potential of computer technologies and web-based learning process to transform classical education remains unquestioned, a revolutionary change in further and HE remains still to take place. In fact, on many engineering schools, current educational practice remains unchanged in many classrooms, as lecturers keep resisting to use online resources in addition—or as an alternative—to conventional face-to-face classroom methodologies. Nonetheless, as new emerging technologies are being developed, significant opportunities to explore and to employ new ways of delivering educational contents have arisen with the aim of supporting interactivity, interaction and collaboration among students. Most of these technologies are embedded on digital (or online) learning environments.

Online learning environments incorporate digital tools and resources to support learning processes. These online resources have been successfully blended with classroom-based learning and with distance or virtual education models, which are all part of digital learning environments. Among the various tools available in these learning environments, Wikis present a few unique features to enhance digital forms of participation on collaborative engineering (and non-engineering) tasks. Wikis are collaborative editing tools supporting the creation of cohesive documents authored by many individuals and present four main features that enhance such collaboration (Ioannou, Brown & Artino, 2015): (i) the existence of a shared online document editable by every member of the group, (ii) a tracking mechanism of every modification on the shared document, (iii) the integration of a notification alert mechanism to communicate to the group any modifications made to the shared document and (iv) complementary supports that allow the group members to communicate, discuss and negotiate the actions related to the construction of the collaborative document.

3. Wikis as Online Collaborative Tools in Engineering Activities

This report refers to an exploratory study conducted among four different Higher Education Engineering Schools in which industrial engineering and mechanical engineering degrees are taught, namely, in the University of La Rioja (Spain), the Lapland University of Applied Sciences (Finland), the 'Universitatea Aurel Vlaicu' din Arad (Romania) and in the Polytechnic Institute of Castelo Branco (Portugal). Two different digital platforms were used to support the Wiki pages managed by industrial engineering and mechanical engineering students undertaking collaborative engineering tasks: Wikispaces Classroom and Moodle Open-source learning platforms.

3.1. Wiki collaborative engineering tasks using Wikispaces

Wikispaces Classroom (Wikispaces, 2017) is known as a social writing platform for education in which students can communicate and work on writing projects alone or in teams. In the situation in which Wikispaces was chosen, the preference went towards the free educational version of the platform. Even though the free educational version based on proprietary code does not offer the same range of possibilities as open-source wikis, it has a simple interface and does not require any programming background or the maintenance of a server for storing the Wiki. The free version of Wikispaces is available for educational purposes, with a maximum storage capacity of 50 gigabytes and unlimited users.

The collaborative engineering activities using Wikispaces were assigned to the students within the engineering course's aim by means of a briefing with a set of formal rules related to the tasks and with the criteria by which they would be evaluated. At least two classroom hours were dedicated to the explanation of the engineering tasks briefing content and answer any student's questions related to the assigned work, or to the use of Wikispaces. The collaborative engineering tasks were to be carried out by the groups of students outside regular face-to-face classes, but whenever necessary, questions that aroused regarding the assignment were addressed in class.

The engineering tasks were carried out by groups of five to six students, with one member of the group assigning the role of group leader. Every group selected the theme of preference within the aim presented on the course briefing. To avoid theme overlapping, the teacher ultimately assigned alternative themes when coinciding themes were proposed by more than one group. Every group created their own Wiki page with the name of their theme among the common Wiki structure of the course where the engineering assignments were due. In the initial stages of the engineering tasks, the groups did not have access to other groups' Wiki pages. After completing their Wikis, groups are assigned to evaluate other group's Wiki and has to send the marks to the teacher. As the teacher validates the groups assessments, he or she also assesses the classes' Wikis, giving dedicated feedback to the groups. In the end, groups are allowed to re-edit and improve their Wikis based on the teacher's feedback.

Complementary to the creation of the groups individual Wiki pages, a common shared glossary of terms had to be created with all groups contributions within the aim presented on the course's briefing. Every group should make, at least, 10 entries on the common shared glossary, that is, 10 terms have been added to the glossary by each group. The definitions and/or descriptions provided in each entry had to be in accordance with the use of the same term in the project. Should some term be entered in the glossary by more than one group, the final entry should result from the negotiated merge by the proposing groups.

3.2. Wiki collaborative engineering tasks using Moodle

The Moodle Open-source learning platform (Moodle, 2017) allows for extending and tailoring learning environments using community-sourced plugins. Even though there are hundreds of plugins for Moodle that allow extending the features of this online learning core functionality, the Wiki activity integrates the standard Moodle. Nonetheless, additional Wiki plugins are available and can be used as alternative Wiki to be installed into the standard Moodle open-source platform.

Like for the collaborative engineering activities using Wikispaces, Moodle's Wiki tasks were assigned to the students by means of a briefing with a set of formal rules related to the tasks and with the criteria by which they would be assessed. Again, at least two classroom hours were dedicated to the explanation of the engineering tasks briefing content and answer any student's questions related to the assigned work or to the use of Moodle's Wikis, as also the collaborative engineering tasks were to be carried out by the groups of students outside regular face-to-face classes, but whenever necessary, questions that aroused regarding the assignment were addressed in class.

However, when concerning the groups assigned, Moodle's Wikis tasks were carried out in a single Wiki page by groups of one or two students. The creation of the Wiki was attributed solely to the students, and the groups had to negotiate the structure and the contents of the Wiki page according to the aim of the briefing. Even though the groups were allowed to select their theme of choice, only two groups could address the same theme within the Wiki. The theme selection took place during classes within a 'first come, first get' basis and was fully negotiated between peers, without any intervention by the teacher.

Like what occurred for the Wikispaces assignments, after completing the shared Wiki page, groups were assigned to evaluate other group's Wiki and has to send the marks to the teacher. As the teacher validates the groups assessments, he or she also assesses the classes' Wikis, giving dedicated feedback to the groups. In the end, groups are allowed to re-edit and improve their Wikis based on the teacher's feedback.

Complementary to the creation of the groups individual Wiki pages, a common shared glossary of terms was created by the students within the aim presented on the course's briefing. Every individual student should make from 5 to 10 relevant entries on the common shared glossary. Every entry (in English) should have both an English description and a student's native language description, resulting in a bilingual glossary of terms on the subject. The definitions and/or descriptions provided in each entry had to be in accordance with the use of the same term in the project. No duplicate terms were allowed.

4. Preliminary Findings

The Wiki collaborative pages were created by industrial engineering and mechanical engineering within their courses, namely, 3-D printing, computer-aided design, computer-aided manufacturing, manufacturing processes and strength of materials. These activities were part of regular assessment tasks carried out according to the courses' curricula and contributed for the final grade of each student within the courses.

Alongside with the courses' specific aims and goals, a set of skills were envisaged to be developed and/or improved by the students within the completion of the collaborative tasks. As for these general collaborative skills, they were common for all industrial and mechanical engineering students alike, whereas the specific skills each engineering course derived the singular expected learning outcomes.

4.1. Students' points of view

On what concerns the general collaborative skills, it was foreseen that students would acquire—or enhance—dedicated interpersonal abilities and knowledge, namely, the ability to research and process information, the ability to effectively use intercultural communicative skills and to improve on their digital literacy. In fact, at the end of the pilot experiments, it was verified that students improved on their research and information processing skills. During the collaborative engineering activities, students showed to be familiar with advanced searching techniques using suitable search terms and, in some situations, carried out the research using terms in English, thus broadening the available range of results to choose from. The effectiveness of the collaborative tasks structure and content resulted from the quality of the research done by the groups and the committed peer revision carried out among the members of each group.

As for the interpersonal skills, special focus was put into the improvement in their intercultural communicative skills and on the ability to work on interdisciplinary teams, as intercultural awareness can be improved with the collaborative tasks done by a group of different students. To complete the proposed activities and tasks, students had to negotiate with each other in order to successfully complete the assignments. Based on Wiki pages as a fundamental part of the learning process, students carried out dedicated engineering activities around specific themes that needed individual research and collaborative learning by means of peer cooperation and peer revision. The combined assessment by the peers and the teacher led to a collaborative effort towards the exploring of the classes' Wikis and allowed students to learn not only from their own Wikis but also from the remaining groups Wikis. In the end, students felt motivated to participate on the assessment, and the group evaluation was accepted in practically all cases, even among those groups that received low grades.

The creation of a dedicated glossary of terms related to the courses' aims also allowed students to improve on the intercultural communicative skills, as most of them were bi-lingual, namely, in English and in the students' native language. It is commonly accepted that in technical environments the main communication language is English, thus the need to acquire specific technical terminology in English to allow students and engineers to effectively communicate and function in such environments. As the glossary of terms was shared among all the students, again it resulted in a common collaborative task that was highly appreciated by most of the students. Part of this motivation was due to the fact that the grade for this task was directly correlated with the number of terms they would submit to the glossary: the more relevant terms, the higher the grade. However, to make the task fair for all the students, a minimum number of terms, as also a maximum number of terms were accepted per student and, in some cases, only a limited number of terms were accepted each week to allow an equal participation from all the students in the class.

Finally, concerning the students' digital literacy, even though most engineering students were already familiar with ICTs, it was essential that they learned how to further improve and use such digital tools to their maximum potential. Cumulatively with the Wikis, students used other Web 2.0 tools like blogs, social media, message boards and other ways to digitally participate and communicate with each other by asking questions and giving answers to their peers related to the Wikis they created and developed. In the end, general opinion was that both Moodle Wikis interface and Wikispaces interface were simple to use and, for some students, preferable to other ICT tools.

4.2. Teachers' points of view

This project involved not only students but also teachers from different European Engineering Schools that prepared and designed both engineering activities and the glossary creation through a significant collaborative effort at many different levels. The preliminary tasks related to the design of the Wiki tasks were negotiated among the teachers, specifying the envisaged aims and goals of the activities, as well as the main rules related to students' participation on the tasks. The development of the dedicated glossary of terms for each course required specific preparation of students and lecturers alike, assuring that the end result would be useful to all of current and future students of the course.

On what relates to the presentation and supervision role of the teachers in each courses' activities every teacher chose to use their own strategy. However, it was observed that generally, every teacher would use approximately two class hours in the initial stage of the activities to present in detail the briefing of the tasks, and to help students to work with the dedicated Wiki platform (Wikispaces or Moodle).

As the activities were carried out by the students using an online learning environment tool, they were allowed to work in the tasks not only during (some few) face-to-face classes but also, preferably, outside conventional classes, using the autonomous work time assigned to every class. During classes, students were allowed to ask for the teacher's help whenever needed to help them moving forward with the task. On the duration of the engineering tasks, teacher used the online learning platforms reports to monitor and supervise the students' activities related to the tasks.

In the end of the tasks, combined student and teacher's assessments were considered motivational for the teachers, as it allowed them to understand the students' points of view related the activities they performed and also, in some situations, a heathy competition took place regarding the assessment grades provided both by the students and by the teacher. In the final evaluation, it was verified in some situations that the teacher's assessment grades were generally higher than those given by the students in the peer-evaluation stage.

4.3. Multinational co-operation perspectives

Considering that new trends based on digital communication and telecollaboration features are key for current engineering students, as they are expected to work in a near future within intercultural, multilingual and culturally and academically diverse teams, special emphasis has to be put into engineering education towards preparing students for such challenging future work environments. This turns out to be one of the main motivations of the various engineering schools associated to this project: to bring together teachers and students of industrial and mechanical engineering from different nationalities and locations to work and collaborate in similar projects.

The Wikis were made available to share among the remaining students enrolled in each course and also with the same course's students of the following school years. Eventually, the created Wikis can also be made available for a wider audience to see and to share, namely, the students from the remaining engineering schools participating in this project.

The next envisaged step is meant to further improve mutual cooperation among multinational groups of students with cross-border collaborative engineering tasks that help students to cooperate and work in multicultural teams at a distance, using ICT tools, in a telecollaborative effort. This also intents to promote dedicated cooperation among Higher Education Engineering Schools on what regards to collaborative cooperation of teachers and students, resulting in an effective way to also support knowledge transfer within the associated institutions.

5. Summary and Conclusions

This study looks into different dimensions of a collaborative scenario for engineering tasks, as it allows interactive and autonomous studying, as well as collaborative performance of engineering tasks with peer-to-peer cooperation and with (or without) the teacher's assistance. Resulting from a preliminary preparation stage by the teachers that resulted from various mobility programs, this paper describes the collaborative effort carried out by industrial and mechanical engineering students of different European Engineering Schools regarding the completion of online learning environment tasks related to specific engineering courses.

Considering both teachers' and students' points of view, it was verified that, generally, they felt more motivated carrying out digital participation and collaboration tasks than with regular classes assignments. On what concerns the results, it was generally verified that quality of the collaborative projects was higher than those of the traditional projects in the same courses. The collaborative and negotiation nature of the assigned tasks also lead to the improvement in student's interpersonal skills, allowing them to be prepared for the envisaged future work scenario that is expected to heavily relay on such type of skills and abilities.

As future tasks it is expected to further broaden the aims and goals of the collaborative tasks, with teams of students integrating engineering students form different nationalities and location of schools to mutually cooperate and work in the same tasks, motivating them to better prepare them to work with intercultural, multilingual and culturally and academically diverse colleagues.

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