

## Development of Generic and Strategic Skills through a Wiki Plat-form in Industrial Engineering Programs

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### Abstract

This paper describes the collaborative learning task carried out in the framework of a Strength of Materials course in an undergraduate degree program in Industrial Engineering using a wiki platform as a support tool. Stages of the teaching/learning process are described. These are: organization of the wiki to host the work of student groups, creation of working groups and assignation of projects, delivery of guidance material and model, editing the project and publishing pages on the wiki, assessments performed using rubrics, and the results obtained. The wiki platform provides interesting statistics for evaluating cooperation between students and time variation of students' effort. The final quality of the projects is very high because a midterm evaluation in the form of a "peer review rubric" is carried out. Then, students improve their projects. The paper concludes by gathering the opinions made by students; the benefits provided by this teaching experience are then analyzed.

### Keywords

Wikis, cooperative learning, transversal competences, group working, rubrics.

## 1. Introduction

This article outlines the development of generic and strategic skills by students in all three degree programs currently studying Industrial Engineering at the Universidad de La Rioja in the Strength of Materials course. The latest guidelines drawn from the European Higher Education Area stipulate that, when designing, planning and evaluating courses, the primary focus should be on skills. One must consider not only the skills specific to each course or degree, but also the generic and strategic skills that every university hopes to instill in its students.

The most sought-after generic skills in the current labor market are interpersonal skills. Collectively, this skill set is popularly known as “teamwork” and consists of the ability to work on an interdisciplinary team and to communicate in other languages. These skills can be sharpened by having students work in groups to collaboratively complete one shared or several different projects.

The current development of Information and Communications Technologies (ICTs) has enabled the creation of very powerful group-work tools, not just in the field of education but also in the professional sphere. Social networks and messaging apps for smartphones facilitate effective communication between group members. It is vital that our students learn to apply these ICT tools to their learning practices.

The project that each group must complete consists of describing an emblematic or singular feat of engineering or architecture. These are works that have roused the interest of the general public and are internationally recognized for their touristic or historic importance, for their large size, or because they are emblems of a certain population, were converted into internationally renowned monuments, apply the most innovative construction techniques available or, in some cases, because they were poorly designed, famously collapsed or required extensive repairs. These works have received special attention by the mainstream media and audiovisual content producers. We could cite numerous very well-known TV shows that help a general audience understand the inner workings of the

construction process, such as Megastructures, Megaconstructions and Extreme Engineering. These shows are constantly in reruns and they doubtless influenced more than one student's decision to pursue a degree in engineering.

Taking these reports as our point of departure, we proposed that second-year students pursuing bachelor's degrees in Industrial Engineering and enrolled in the course Strength of Materials complete a group project on singular works of engineering and architecture. We asked them to describe these works in greater depth than the televised report, highlighting the chief points of interest for industrial engineers, such as the building type, the new materials used, innovations in the field of construction technology, installations, maintenance and monitoring.

To complete the project, students used the best ICT tool available for group learning: wikis. This technology is described in the following section.

## 2. Wikis

A wiki is a server-based computer application that can be accessed from any computer connected to the internet. From the user's point of view, a wiki is just another webpage, but with the advantage that allows for information sharing. Wikis, along with blogs, social networks and a significant number of applications make up what is known as Web 2.0. The distinctive feature of Web 2.0 is that it is no longer a single user who shares information, but rather the entire community that makes contributions. Working on a wiki is very simple: the user simply registers, logs on and gets to work. All registered users can edit or modify content and create new pages (Leuf and Cunningham, 2001). There are typically one or two administrators who ensure that the wiki is functioning properly and grant permission to other users. It is most convenient if this is the professor of the subject in which the project is assigned. However, granting administrative permissions to a handful of students (representatives from each group, for example) can ease the professor's task load and give students the opportunity to explore the wiki to its full potential. Furthermore, as

leaders on a higher hierarchical level than the other members of the group, these student administrators feel more responsible. They are more motivated to perform their duties, and this motivation carries over to the rest of the group.

Wikis are among the best tools for collaborative learning and teamwork. They make it possible for students to stay in contact, share and contrast their ideas and opinions on a wide range of subjects, complete a group project, and make consensus-driven decisions when solving problems (Moral and Villalustre, 2007, 2008).

Wikis also have numerous advantages for professors. They facilitate visibility in the educational process and direct communication between the professor and the students, giving professors the chance to guide projects towards fixed goals. The teacher can evaluate the participation and individual contributions each student in the group makes to the project, since on the wiki there is a record of contributions and their authors. This helps professors continually assess the progress of the project, giving grades or feedback every week, two weeks, etc. (Adell, 2007).

Wikis are the perfect tool for peer and group assessment when the project is complete. For example, a group can evaluate another group's work according to a specific peer-assessment rubric.

In actual practice, students use other ICT tools to support the material of the other work they do, too, and to communicate between group members and share information. It is normal for members of the group to create a group on messaging apps such as Whatsapp, or on a social network such as Facebook, to help them communicate better and set up group meetings. Another key element is a shared folder on a file storage service on the Cloud, such as Dropbox or Google Drive. These folders hold project files and drafts of text that will make up part of the final draft. This makes students' work more comfortable, since they are not constantly under the watchful eyes of the professor and/or of classmates in other groups. Still, this way of working has a drawback for professors—they cannot track the progress of the assignment without imposing mid-project evaluations of the wiki. E-

mail is essential, but it has largely been dethroned by other, more direct means of communication, such as instant messaging. On some occasions the wiki's internal messaging function is used. Figure 1 shows the homepage of the wiki described in this article.



Figure 1: Singular Works Wiki

### 3. Goals

Students complete their projects within the framework of the course Strength of Materials as part of the degrees in Industrial Engineering (Mechanical Engineering, Electrical Engineering, and Industrial Electronics and Automation Engineering) at the University of La Rioja. Strength of Materials forms part of the mandatory training module in the industrial branch. It is taught in the second quarter of the second years for all three bachelor's degrees in Industrial Engineering. The teaching team is made up of one professor who is also in charge of the course.

Strength of Materials carries 6 ECTS credits, the equivalent of 60 class hours and 90 hours of student study and work. The group wiki project requires two hours of explanation and classroom work, with 10 of the 90 hours assigned to the project outside of the classroom.

Because the project is done in groups of five or six, each group should end up dedicating a total of 50 or 60 hours to their project.

The 60 class hours are distributed as follows: 40 large group hours dedicated to theory and problem solving, and 20 hours in smaller groups, of which 16 are set aside for conventional classroom problem solving and questions; the remaining four are for practice time with the educational software MdSolids (Philpot, 2014) and interactive MecMovies pages (Philpot, 2011).

The criteria fixed in the teaching guide for evaluation in the course are: 60% for the final written test, 20% for the group project described in this article and 20% for individual internship projects.

The goals of the wiki-based group project are:

- ✓ To improve students' general skills, especially:
  - The ability to gather and process information. In order to acquire this skill, it is essential that students be familiar with advanced searching techniques, such as searching within interest domains, use of suitable search terms and how to search in various languages.
  - Interpersonal skills, which consist of two abilities: the ability to work on an interdisciplinary team and the ability to communicate in foreign languages.
  - Digital literacy. Although engineering students are already familiar with ICTs, it is essential that they learn how to use them to their maximum potential.
- ✓ To acquire specific skills, including:
  - Describing practical applications in the field of Structural Engineering and Construction and the theory covered in the course Strength of Materials.

- Describing the chief advances that have been made in the fields of Structural Engineering and Construction Technology.
- Creating a glossary of terms used in Structural Engineering and Construction.
- ✓ To maximize the University's strategic skills: this collaborative working experience has much in common with Project Based Learning methodology (PBL), which students will develop if they go on to do postgraduate studies at the Universidad de La Rioja.
- ✓ To get teaching experience using collaborative learning methodologies through the use of ICTs, especially wikis.
- ✓ To share the completed projects among the students enrolled in the course and, eventually, with a general audience.

#### 4. Stages in collaborative learning process

In this section we outline the stages in our proposed collaborative learning process. After describing the goals and methodologies to be employed, choosing the wiki platform to be used is essential. Our chosen platform is Wikispaces. Although 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. A free version of Wikispaces is available for educational purposes, with a maximum storage capacity of 50 gigabytes and unlimited users. It boasts greater functionality than the wiki tool available in the University's official Virtual Learning Environment (VLE): it allows administrators to leave the wiki open for reading, unaffected by the annual changes made on the course pages without the professor's consent. Wikispaces has been the tool of choice for a wide range of teaching applications

and experiences. It is very easy to use. Students can also access manuals (Palomo et al, 2015), video tutorials on Youtube, and real wikis online.

#### **4.1 Group structure**

Groups of five or six will be made in the first two weeks of the quarter. Through their representatives, every group will keep the professor informed on the group's components and suggest several possible works on which they may base their projects. Finally, since there are often overlaps in group preferences, the professor will ultimately assign the group's work from among their proposals. This improves group motivation, since their work was not imposed on them, but the product of a consensus. A total of 33 groups are formed.

On the wiki, a Wikispaces Project is created for each group under the name of the work on which they are to focus. These projects are set up in such a way that only the members assigned to each group can work on the project; they do not have access to other groups' projects. The shared glossary will require creating a specific project that all members of the wiki can access. By the third week of the quarter all of the groups should already be formed and ready to start working.

#### **4.2 Guidance material and model**

Providing students with guidance materials is essential for producing the high quality of work expected. A bibliographic paper, or a paper based on gathering and processing information, means more than simply "cutting and pasting." Rather, students must check several sources, extract the information of interest to the project and compile it in a coherent way, including graphics, charts, photos, references, conclusions, etc. Students are given a set of rules that they must adhere to while working on their project and the criteria by which they will be evaluated. They are enumerated in these documents:

- ✓ A list of the groups, their members and each group's representative.
- ✓ A guide to the aspects that must be addressed by the project, with insistence that, as future engineers, they must focus on the work's most technical elements and eschew promotional and tourist information. And of course, the professor must point out that the groups can add new aspects or remove those that do not conform to the specific work that they are discussing.
- ✓ Project rules: dates for the midterm revision, final due date, rules for coordinating as a group and with the professor, rules on how to edit pages, as well as on the glossary and formal aspects of the project.
- ✓ Rubric or evaluation matrix for the midterm evaluation by the groups.
- ✓ Rubric or evaluation matrix for the final evaluation of the project by the professor.

Both the guide and the rubrics will give the work direction, given that they enumerate the objective elements to be evaluated. For example, to receive the highest possible score on the glossary aspect, the following requirements must be met:

“At least 10 terms have been added to the glossary. The definitions and/or descriptions provided are in accordance with the use of these same terms in the project. The terms in the glossary itself have been included in the shared glossary. Should some term already be entered into the glossary, the two entries should be merged by the groups.”

Two classroom hours should be dedicated to explaining the content of these documents and answering any questions students may have on the work assigned, or on how to use Wikispaces. Special emphasis should be placed on these two points, which will determine the success of the group project:

*Advanced information searching:* the project aims to teach students to reach a high skill level with the usual online search engines (e.g. Google), how to use article databases (Dialnet, Google Scholar), paper and presentation repositories (Slideshare), videos (YouTube, Vimeo), etc. They should be heartily encouraged to search in English, since this

will return much more substantial and interesting information for the project, given that the works to be analyzed have attained international recognition. Students should also be made familiar with the importance of blogs, social networks, message boards and, of course, how to participate in these media by asking questions and giving answers.

*Using Wikispaces:* Even though Wikispaces is very easy to use, brief tutorials should be given on how to insert images, videos and presentations through editing add-ons called Widgets. Professors should also request the inclusion of a table of contents and links to pages both external to and within the wiki to make navigation easier.

#### **4.3 Editing the project and publishing pages on the wiki**

Over the course of the following eight weeks, students will work in groups, and questions that arise will be addressed in class. This will settle formatting questions and help identify some of Wikispaces' editing abilities and limitations. For example, students cannot change the names of pages or delete them since they only have "Member"-level permissions. To solve this problem, one can temporarily give the representatives of each group "Administrator" permissions so that they can make these changes.

#### **4.4 Rubric-guided group evaluation**

In the twelfth week of the quarter, students conduct a midterm evaluation among their own groups using a rubric prepared specifically for that purpose. The evaluation will be conducted anonymously: each group knows the group that it is going to evaluate, but does not know the group by which it will be evaluated. Afterwards, each group will send the professor a completed rubric in which the ratings given in the different fields will be justified—that is to say, merely assigning numeric evaluations will not be enough. The professor will evaluate the quality of the rubrics, bearing in mind the reasoning given for every aspect and the rubric's objectivity. One important aspect, in terms of improving the

projects, will be the recommendations provided by the evaluators. In general, these recommendations were well-considered and useful.

The rubric is sent to the interested group through its representative. These comments are transferred to the group undergoing evaluation through the professor in order to maintain the evaluating group's anonymity. Of the 33 rubrics requested, the groups completed 32. The evaluations were fairly objective, although some of the reasoning did not achieve the degree of detail desired. They were a good reference for the project improvement phase. The negative aspects highlighted in the rubrics in the midterm revision period consisted of the lack of certain important aspects in the project, such as: a glossary, conclusions and bibliographic references. This last aspect is very important, since it helps separate those who have truly done the work, culling and analyzing information from diverse sources, from those who have simply "copy and pasted". One measure that encourages more objective evaluation is requesting at least three rubrics for each project, completed by three different groups. In this way, the group evaluated has more information to improve the work.

At the start of the thirteenth week of the quarter, the editing feature on the wiki is re-enabled so that groups can make improvements on their projects based on their peers' recommendations. They have a 10-day period to make these changes.

#### **4.5 Final evaluation by the professor**

In the fifteenth and sixteenth weeks of the semester, the professor will conduct a final evaluation of the projects using the professor rubric which, naturally enough, is very similar to the rubric used by the groups. It includes additional fields for which professors must incorporate the progress of student activity by adding new information to Wikispaces. Thus, the evaluation is based on:

- Participation by all members of the group in the publishing of pages

- Continual work, throughout the work period and not just at the end of the quarter
- Revision of the pages
- True teamwork as seen through shared editing of the pages
- Consideration of the recommendations made during the group evaluation

The project grade will be the same for all members of the group, except in exceptional cases, and will be determined as follows:

25% - Grade received on the group-evaluation rubric

25% - Quality of the evaluation that the group made of another group's work

50% - Professor's rubric evaluation

## 5. Results

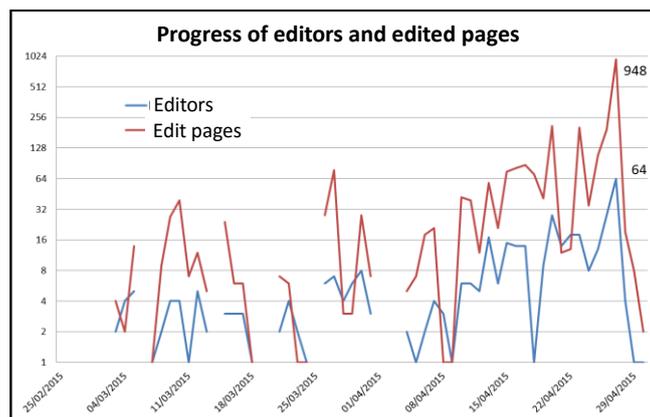
First, we will analyze the general data from the wiki. Later we will analyze the moment-to-moment evolution of editions, editors, visits and visitors produced on the wiki.

The total number of wiki members was 183. The number of projects created for the completion of the group project was 33. At the time of the midterm revision, the number of edited pages included in the shared glossary was 652. The number of terms and definitions in the glossary was 218. Together, the wiki pages were accessed (that is, viewed) 20,300 times.

It is interesting to analyze the moment-to-moment evolution of some of the wiki's parameters. Wikispaces provides a few statistics that can be graphically represented with a spread-sheet. Figure 2 shows the moment-to-moment evolution of the number of editors and the number of wiki pages edited in the period prior to the midterm evaluation. It is clear in the chart that wiki activity increases as the evaluation date approaches. The night prior to the midterm due date sees the highest number of students editing pages, 64, and

the highest number of pages edited, 948. It is important to bear in mind that many groups prepared drafts of the pages and spent these last days solidifying their final versions. Similarly, figure 3 shows the number of visits the wiki received, as well as the number of pages visited. This number saw notable growth in the days prior to the midterm due date. In both graphics we can see a period with no activity in the first days of April, caused by the Holy Week break.

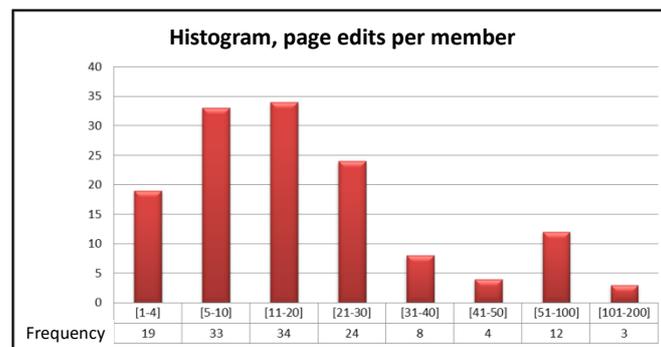
Wikispaces also offers statistics on the number of messages exchanged. However, very few messages were sent, since students communicated directly or coordinated using instant messaging apps.



**Figure 2:** Trajectory of page edits



**Figure 3:** Progress of page visits



**Figure 4:** Histogram, edits per member

Besides the graphics above on general wiki activity's document progress time, it is also possible to determine activity on a project-by-project basis, and even the activity of each member in a given group. It is possible to determine what time pages were edited, and by whom. It is important for the professor to consult this information when it comes time to evaluate the projects.

Wikispaces also allows the administrator to generate statistics for individual members; there are the statistics that were used to determine the number of editions, shown in figure 4. In this histogram, the classes correspond to the number of edits made to pages. We can see that the average student has made between 5 and 20 pages edits, while only 3 have made more than 100. This data corresponds to the state of the wiki during the midterm evaluation period.

In the peer evaluation process, only two projects received failing grades. The rest of the projects received good grades, with an average of 7.1. This could give rise to the low activity in the wiki improvement phase. This is reflected in the following data. The final number of wiki pages included in the glossary was 736, reflecting a 94-page increase in the midterm revision. Nine projects/groups made no changes.

As for the glossary, the final number of terms was 241, from which we can conclude that 23 terms were added in the improvement phase. (These 23 terms, however, were added by only three groups.)

In the final evaluation, according to the professor's rubric, the grades were, in general, better than those given in the peer-evaluation stage. The discrepancies between the professor's evaluation and the peer evaluation were more drastic in the groups that received unjustified evaluations.

## 6. Conclusions

This paper describes a collaborative learning task completed by students in the second year of the degree programs in Industrial Engineering; it makes use of a wiki platform as a fundamental part of the learning process. This task consists, essentially, of gathering and processing information, including peer revision carried out among student groups.

The quality of the projects completed is higher than that of tradition projects that only have a final due date. The causes behind this quality increase are, at their core, the introduction of a tool well suited for the collaborative project, such as the wiki and the implementation of revisions throughout the quarter. The wiki is also a key tool for making these revisions. Managing such a large number of students, nearly 180, is practically impossible without the use of some sort of digital assistance, such as the wiki, which offers the functionalities described above.

With this setup, members of the group relate to one another better: not only must they agree on the content, but also the form—that is, on the layout of the pages on the wiki. Group members take on greater responsibility both individually and in the way they participate in the group. Now their work can be scrutinized by others in real time. Greater responsibility entails greater respect and greater group connection. In this way, students acquire abilities related to group work and cooperation. We can conclude that the projects completed

received better grades as consequence of students' greater academic performance. This fact is motivation enough for students, given that they can improve their grade by nearly two points on the written test when the projects are well done, which in turn improves academic performance.

We gathered students' opinions on the methodology used. The general opinion is that the Wikispaces interface is simple and preferable to other ICT tools. The group evaluation was accepted in practically all cases, even among those groups that received low grades.

It is important to highlight that now, with the implementation of the Bologna Process, students must not only complete "written tests," but also projects, internship reports, portfolios, oral presentations, etc. They are subjected to an excessive workload that may lead them to leave their tasks to the last minute if they do not organize their time well. Coordination between teachers in the same course is critical to avoiding this excessive workload. A cross-disciplinary seminar in which students learn time-management and productivity-boosting techniques is advisable.

The group learning activity carried out is not just of importance for students' professional future; it is also transferable to their postgraduate studies. Those who go on to pursue the University Master's in Industrial Engineering at the Universidad de La Rioja will have to apply the group-work and cooperation skills acquired through the assignments such as the one described in this article. The University Master's is structured around the Project Based Learning methodology, which proposes the solution of an integrated project to first-year Master's students. The integrated project is common to several courses and requires sound coordination between professors and students. A wiki can facilitate this coordination. This experience with wikis acquired during the undergraduate years will yield long-term benefits that will become apparent during students' Master's studies or in their academic and professional future.

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