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A Software Engineering-Based Methodology for Selecting and Implementing Web 2.0 Technologies for Teaching*

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Nowadays, university students have grown up surrounded by Web 2.0 technologies, which they are able to use with ease. These technologies provide an opportunity to improve the learning/teaching process through collaboration, the exchange of knowledge and above all, the motivation created by the use of these technologies that are generally utilised by students in their day-to-day social life.

The integration of Web 2.0 technologies into the learning/teaching process must be addressed in a critical way, taking into account the objectives to be achieved and the type of teaching to be undertaken. Teachers can find a wide range of available Web 2.0 technologies and it is often difficult for them to decide which type is the best one for their needs. This paper proposes a methodology based on software engineering methods and designed for software selection that provides recommendations to evaluate the function and options of Web 2.0 technologies according to the specific needs and characteristics of the subject to be taught and the types of students involved in higher education.

The methodology consists of a formal guide to aid teachers when they need to select and put Web 2.0 technologies into practice in a learning/teaching process. In order to offer a practical demonstration of the application of this methodology, the experiences of various teachers in engineering degrees are described.

Keywords: engineering education; Web 2.0; selection methodology; case study; learning and teaching process

1. Introduction

Teachers are aware that the use of Web 2.0 technologies can be very helpful to motivate students and get them involved in the teaching/learning process. The Web 2.0 can be defined as a set of technologies designed to spread knowledge socially that incorporates three essential characteristics: technology, knowledge and users [1, 2]. The term Web 2.0 technologies also include a wide range of tools and products, which are continually being updated and improved.

The use and benefits of the Web 2.0 technologies have been the subject of numerous studies [3, 4] and it can be deduced that there exists a clear consensus about the need to integrate these technologies into the teaching/learning process and that science teachers should adopt Web 2.0 into their practices [5]. It is also evident that the use of these technologies in education is very uneven. They are widely used in some educational contexts such as the University, where Learning Content Management Systems (LCMS), blogs and wikis [6] and e-Portfolios [7, 8] are very popular. In this case these tools are specifically designed to provide teaching and distance evaluation support, and are widely accepted by teachers at every level and in each subject area. The use of these technologies in distance teaching is well considered and the use of online material provides improvements in learning outcomes [9].

However, there are other types of Web 2.0 technologies, which are widely used by students for social issues and leisure time, but their application in education is not so highly valued or widespread.

The use of Web 2.0 technologies is clearly a new challenge that must be faced with a positive and professional outlook. As Bernal [10] indicates, the fact that these technologies are underused is not the result of a lack of training in their use or an insufficient range of available technologies. For many teachers the difficulty lies in choosing firstly, which technology to be used and secondly, which tools from this technology are best suited to their needs. Simply using these technologies is unlikely to produce any benefit for the teaching/learning process. There are studies that indicate that these technologies are most successfully used in circumstances where there is a close connection between the educational objectives and the Web 2.0 practice designed for that context [4]. Therefore in order to be successful in this innovation project teachers need robust principles that, by taking into account the students' characteristics, the material to be taught, and the teaching objectives, enable them to choose which tools can be the best solution.

Knowing and understanding the characteristics, uses, advantages and disadvantages of the wide range of technologies available is a key factor to be able to make successful use of them. At the same

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time it is necessary to clearly identify what is to be learned and to carefully define the characteristics of the students involved and the subject to be taught. Although numerous studies [11] and results have been published about projects of this type, there have been no proposals for a methodology that would specifically address the problem of identifying the most suitable tools taking into account the specific learning objectives, the subject and the group of students.

Therefore, there is a need for a methodology that would guide teachers on how to evaluate and implement Web 2.0 technologies for improving the teaching/learning process. This methodology will provide teachers with a formal basis that will make it easier for them to overcome the challenges involved.

This paper presents a proposal for a methodology for the selection and implementation of Web 2.0 technologies that takes into consideration both the technical and the teaching criteria. This methodology is the result of various projects on the subject of improvement and innovation in teaching and its development is based on software engineering methods. It is evaluated and illustrated by three case studies where the experiences of the application of this methodology to improve the teaching/learning process are described.

In addition of this short introduction, the rest of this paper is organised in the following way. In Section 2, the use of Web 2.0 technologies in education including classification criteria for Web 2.0 technologies and application methodologies is reviewed. Section 3 includes a detailed description of the methodology proposed to aid teachers who wish to select and implement technologies in their subjects. A summary of the experiences of teachers who have put the proposed methodology into practice is provided in Section 4. And lastly, Section 5 outlines the main lessons learned, and in Section 6, the conclusions of the study are presented.

2. Web 2.0 in the teaching/learning process

After the exponential growth of the use of the Internet by a vast range of new users, the Web 1.0 technologies were amply developed and gained a huge amount of attention. However, such was the speed with which these technologies were developed that they were soon considered primitive and obsolete as they only allowed the reading of web contents and the participants could only play the role of passive readers as indicated by Franklin and van Harmelen [12].

Richardson [13] pointed out that we are currently at the beginning of a new and radically different relationship with the Internet, which will have profound effects on the interaction between students and teachers. As stated by Churchill [14], innovative applications of Web 2.0 are appearing and the role of the user has changed from that of a passive reader to writers and creators of new content [15]. There are new users who can be called *Digital Natives* [16], members of the so-called *Net Generation* who use the web not only to access information but to communicate with each other and interact socially [17].

Over the last few years Web 2.0 has been defined by various authors [18–20] from different perspectives [2, 21]. One that is particularly worth mentioning is the definition suggested by O'Reilly [2], according to which "Web 2.0 is the network as platform, spanning all connected devices Web 2.0 applications are those that make the most of the intrinsic advantages of that platform: delivering software as a continually updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users, while providing their own data and services in a form that allows remixing by others, creating network effects through an 'architecture of participation', and going beyond the page metaphor of Web 1.0 to deliver rich user experiences".

All these definitions have one thing in common the reference to the social use of the web that allows users to collaborate and participate actively in the creation of content, which generates knowledge, and to share it openly via shared resources in real time [22]. As Belland [23] defines, the emergence of Web 2.0 technology provides an opportunity to develop online learning tools enabling students not only to participate in online activities more actively, but also to learn from their colleagues. After an analysis of the relevant literature in this field, it may be concluded that thanks to the widespread use of Web 2.0 platforms this technology must play a new and extremely important role in transforming the teaching/learning process in education [24]. Nowadays it is necessary to identify the perceptions which both teachers and students have of these technologies in the educational context. As has been indicated by Hartshorne and Ajjan [25] and Cavus [26] Web 2.0 can bring the improvement to collaborative learning [27].

The importance and convenience of using Web 2.0 technologies in teaching has been identified and discussed by numerous authors [19, 22] not only within the context of university education [4, 28] and distance education [29, 30] but also in infant and primary education [31]. The advantages are identified, not just in designing tasks that fit with the overall learning context and offer appropriate reward, but in helping students to perceive their value and develop relevant academic skills [3]. In S.

Bennett [4], for example, a wide-ranging study is presented about the implementation of Web 2.0 technologies in six different cases within the context of university education. The most relevant conclusion points out the potential for increased learning with an effective use of Web 2.0 technologies, particularly through the creation and sharing of content by the students. Among the possible negative results is the lack of institutional support or the lack of abilities on the part of the students to handle the selected tools properly. According to the authors both problems can be overcome finding the most suitable tool for a given well-designed teaching programme.

2.1 Classification criteria for Web 2.0 technologies

After analysing the literature in this field a number of criteria have been identified for the classification of Web 2.0 technologies, both from the general point of view [32, 33] as well as those specifically aimed at a particular context [22, 34]. These categories refer to the technology that is the basis of the tool and they therefore seek to find common characteristics and leave to one side the specific characteristics of each commercial tool. In the study carried out by Pardo [32] they present a generalised classification of web technologies, organising them into three groups: social networks, content management systems created by the user, and mashups. Alternative classifications have also been offered, for example Bernal [10] proposes three different categories according to their objectives, namely Communication, Creation and Publication of Contents, and Information Management.

Another interesting study [35] provides a different classification of Web 2.0 technologies defining seven principle criteria for the selection of tools to be applied in teaching and cooperative learning.

- Communication platform and collaboration between participants.
- A means by which the degree of participation of individuals and groups can be evaluated.
- Number of Web 2.0 activities and the tools which support them.
- They should be open source with a GPL licence and can be freely used and modified.
- Quality of API Web 2.0 including support.
- Good documentation and instructions for users and developers.
- A rich and well-designed user interface.

On the basis of these criteria the authors then defined a series of twelve tools and applications as possible means to be used in collaborative learning tasks and the sharing of learning objectives. While these criteria are very useful from the point of view of a theoretical analysis of collaborative learning, they are not very helpful for choosing the most suitable tools in a real academic situation.

Other studies present a number of models and theories concerning the adoption of Web 2.0 tools for the purposes of distance education [29] or for example in [30] where the telematic support tools for teleteaching in Web 2.0 are divided into four categories: tools for personal publications, collaborative publication, syndicated contents, and meta-information. Other authors propose a model for one specific tool, for example Facebook [36].

In [37], Web 2.0 technologies are classified in terms of the learning style involved so that they can be integrated into the educational process. De Benito [38] makes a very interesting proposal based on work carried out in previous years, where Web 2.0 tools are classified according to their application to virtual environments in the teaching/learning process. In his work he lays out the following categories:

- Communication tools.
- Tools for collaborative work and learning.
- Tools for academic management and administration.
- Tools for content management.
- Tools for knowledge management.
- Tools for evaluation and monitoring.
- Integrated tools for the creation and distribution of courses.

In Section 3, the authors propose a classification as a starting point for the methodology for the selection and implementation of Web 2.0 technologies developed and presented in this paper. This classification takes into account the technologies analysed here and is adapted to the objectives, which the methodology sets out to achieve.

2.2 Literature review on application methodologies

As has been explained above in the analysis of the state of the art, a number of works have been identified which set out to classify the ever-increasing range of Web 2.0 technologies and tools from the point of view of their application in the educational field. However, it is evident that there are hardly any properly developed systems, which enables teachers to select in an easy and structured way the Web 2.0 technologies best suited to the teaching/learning contexts in which they are working. As shown by Pérez-Sanagustín et al. [39], there are some studies which propose methodologies and support mechanisms for the selection and implementation of Web 2.0 technologies to improve the process of collaboration and to facilitate the generation of content that is suitable for any given educational context. It is also worth highlighting the studies of the integration of tools in mashups

[11, 40], studies on generic tools [41, 42] and so on. Pérez-Sanagustín et al. [39] propose a conceptual framework for the classification and selection of Web 2.0 tools with the aim of establishing their validity for inclusion in a common Web 2.0 platform that is suitable for the functionality required by a KRSM (Knowledge Resource System Management).

In a subsequent study [43] after identifying the lack of methodologies in the educational field for the evaluation of Web Based Learning Resources (WBLRs), the author sets up a conceptual framework for analysing their design and evaluation in the educational field. In this framework a tool evaluation questionnaire based on the concept of usability from two different perspectives, pedagogical and technical, is provided. Their correlation is also analysed in a case study, together with the similarities and differences in their perception not only from the point of view of the students but also from the teachers' but at no time is any method for selecting WBLRs suggested.

On the other hand, concerning the current trends towards using Web 2.0 technologies for sharing knowledge, there are various blogs, which do discuss ways in which the different Web 2.0 technologies can be selected. Among these blogs the one by Tek Trek [44] is worth highlighting. In the selection process he has developed, a series of criteria are defined which allow the user to decide whether the selected Web 2.0 technology is suitable or not. The five selection criteria are: Access; Usability; Privacy & Intellectual Property; Workload & Time Management and Fun Factor. For each one a checklist is presented which allows the user to know whether the selected technology is suitable or not according to the specific aims involved. Tek Trek does not go so far as to suggest a way in which a selected tool could be evaluated as regards a specific teaching/learning context. However an analysis of his checklist for each selection criteria has suggested ways in which some of them can be incorporated into the methodology presented in this paper.

Authors such as Mazman [29] point out the need for further studies to establish new models which would guide teachers in the selection of Web 2.0 tools in distance education taking into account technological characteristics and factors linked to the teaching/learning process, since there is no information about a methodology, which would guide teachers in choosing the Web 2.0 technology which best suits their particular teaching/learning process and their specific aims.

In conclusion, as far as the analysis of existing methodologies for the selection of Web 2.0 technologies are concerned, it should be pointed out that there have been some attempts to define a conceptual framework and criteria for the selection of tools. Yet no complete methodology has been found in the literature, which would enable teachers and others working in an academic environment to select appropriate tools in a straightforward and structured manner that being the objective of the study presented in this paper.

3. Proposed methodology

The research presented in this paper proposes a methodology for selection Web 2.0 technologies in order to improve the learning/teaching process. The concerns, evaluation criteria and points of view of Tektrekker [44] and Hadjerrouit [43] have been taken into account together with other works discussed in Section 2.

A first version of this methodology for the selection and implementation of Web 2.0 technologies has been applied in different projects designed to introduce improvements and innovation in education, which later allowed our methodology to be evaluated and improved. The methodology includes a matrix for the evaluation of Web 2.0 technologies based on methods for selecting software, which are used in the field of software engineering [45].

The classification of technologies discussed in Section 2 is general and was developed in accordance with various criteria or possible uses and also a number of reports and studies such as [46, 47]. However, classification is the starting point in the proposed methodology and a key issue for a correct selection and implementation of the teaching/learning improvement project. Therefore and taking into account teaching criteria and the teaching/learning process, in this project the Web 2.0 technologies are specifically classified as follows:

- *Permanent Content Managers (PCM).* This category includes LCMS (Moodle), ePortfolios (Mahara), and Wikis (MediaWiki, and Google Sites). That is to say sites where content may be created collaboratively with the aim of establishing permanent information sources and where it is not necessary for users to visit the site daily since the rate at which changes are made is no more than average.
- *Dynamic Content Managers (DCM).* These include blogs (Blogger, and WordPress) and micro blogs (Twitter) as well as technologies that allow the collaborative generation of content but where the focus is on opinion and being up to date and which therefore have a high change rate and are altered daily by their users.
- *Multimedia Content Managers (MCM).* Their main objective is to share multimedia material: slides (SlideShare, and Prezi), news (Podcast),

videos (Youtube), photos (Flickr, and Picasa), etc.
- *Social Networks (SN).* Their basic aim is to create a community of users who share particular interests (Facebook, LinkedIn, Google+, and Pinterest).
- *Application and services (Mashups) (A).* Such as folksonomies, labelling, virtual networks (Second Life, and Google Earth, etc.), etc.

A conceptual map offering an overview of the project designed to produce a methodology for the selection and implementation of Web 2.0 technologies is shown in Fig. 1. The initial problem (the lack of means to select and implement of Web 2.0 technologies), the classification of the technologies from the point of view of the teacher, and the processes of the methodology can all be clearly observed.

This methodology has been defined by processes and follows an iterative and incremental paradigm [5]. In the following sections the three processes that go to make up the methodology are described and together with the steps, techniques, and tools which can be used in each one.

3.1 Process 1: Selection of the Web 2.0 technology

The first step to achieve the proposed teaching objective using Web 2.0 technologies is to establish the set of selection criteria to be used to determine which tool best suits the proposed objective. Once the criteria have been identified, the technologies need to be evaluated to choose which one or ones can best respond to the defined criteria.

The results identified in the state of the art analysis need to be taken into consideration to define the criteria, and it is necessary to determine:

- The *features of the subject* to be taught, the idiosyncratic elements of its contents, whether it is compulsory or optional, the theoretical—practical nature of the subject, the size of the teaching groups, the student profile (first year, skilled/degree level or not), etc. These characteristics are the departure point for the teaching/learning process, the conditions of which shape the sought-after secondary teaching objectives.
- The *secondary teaching objectives* that we want to achieve by this implementation. It is necessary to point out that the main objective is always linked to an improved level of learning for the student or, from a more practical point of view, to the results of the learning experience. For this reason, in the methodology it is suggested that we define the secondary teaching objectives, which we are striving to improve. These objectives are the end result we are hoping to achieve with the use of Web 2.0 technologies.
- The *technical requirements* need to satisfy the Web 2.0 technologies in order to achieve the

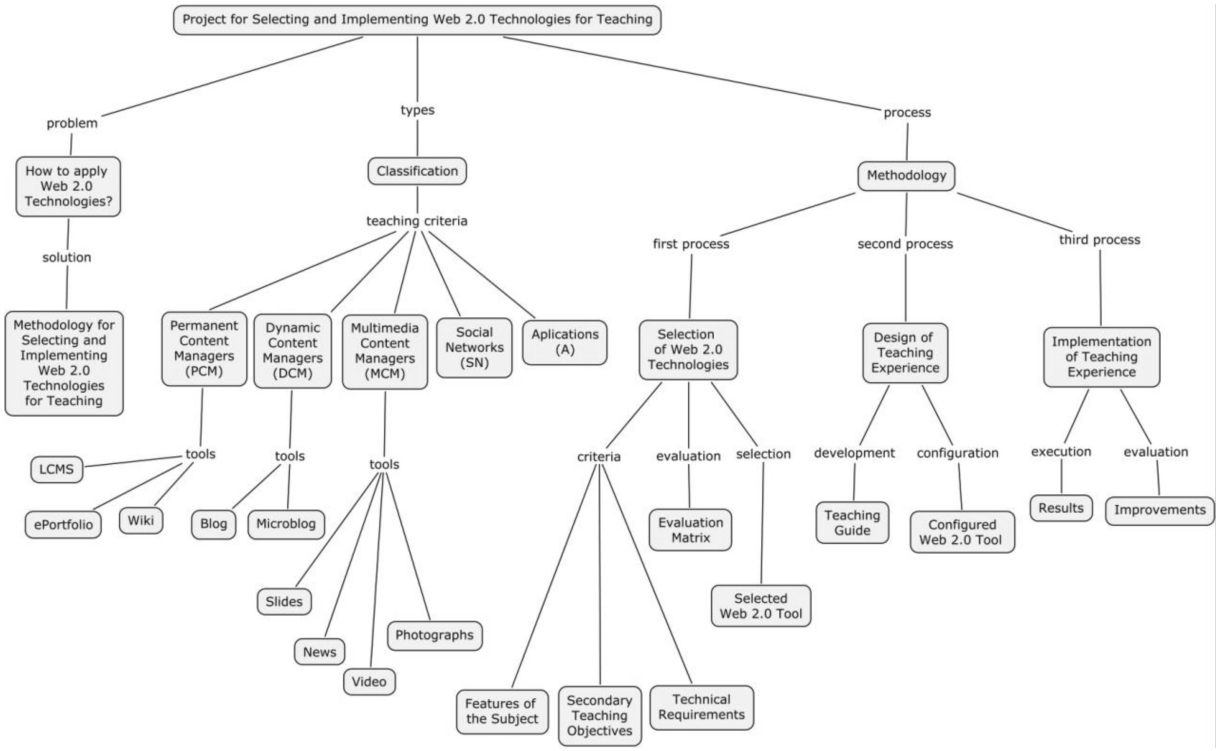

Fig. 1. Overall project scheme for the selection and implementation of Web 2.0 technologies for teaching.

secondary teaching objectives being considered, while taking into account the characteristics of the subject to be taught.

In the following subsections firstly we describe how to establish the selection criteria and how to organise them so that secondly, we can evaluate the type of Web 2.0 technology that offers us the best expectations of successful objectives. This will involve taking into account the proportionate classification of the teaching environment through the methodology.

3.1.1 Definition of the teaching criteria

First we have to identify the *features of the subject* considering all of its related aspects, the teaching environment and the student profile.

- *Teaching context:* profile and origin according to the teaching context: technical, economic, humanistic, health, etc.
- *Characteristics of the teaching:* whether the subject has a practical or theoretical focus, it is compulsory or optional and if it is at beginners' level, etc.
- *Characteristics of the group:* the number of students and the type of groupings that can be arranged when working with the students.

Consistent with the characteristics of the subject defined earlier, we can identify four main types of subjects ordered from greatest to least in terms of technology capacity.

- *Type A:* Subjects at an official level and related to the area of IT, final year degree courses that consequently, are well established in the university context.
- *Type B:* Subjects of a scientific-IT nature, first year degree courses with a less knowledge or which have been present for less time in the university environment.
- *Type C:* Subjects of a financial-legal nature from any of the official teaching levels and in this case there is a marked difference between the environment to which the subject belongs and its likely level of experience.
- *Type D:* Subjects of a social, humanities or health related nature, which as in the previous type, can be from any of the officially recognised courses.

On the other hand, not all of the Web 2.0 technologies can be adapted to improve all of the teaching objectives. Establishing of a list of the *secondary teaching objectives* that you want to achieve through the use of these types of tools is a key factor in successfully implementing the teaching project. To help define the secondary teaching objectives, the methodology suggests four basic objectives defined according to the types of learning as proposed by Pardo [32], namely: learning by doing, learning by interacting, learning by investigation and learning by sharing.

- *Motivation:* (learning by doing) creating interest in the subject for the student and applying technology that they use on a day-to-day basis in their personal life and leisure time.
- *Participation:* (learning by interacting) suggesting new, flexible and attractive methods of interaction with and by the students, thus widening the level of active involvement in the learning process.
- *Innovation:* (learning by investigation) facilitating the discovery of new subject matter through the use of IT.
- *Dissemination:* (learning by sharing) introducing the students to a more professional environment in which the subject matter of the course is shared and are relevant in the real world.

The characteristics mentioned previously determine the learning objectives and these at the same time allow us to identify the necessary *technical requirements* in order to evaluate and select the most suitable technology. In this proposal the following are defined as examples of the technical requirements.

- *Easy to use:* if depending on the profile of the student and the course we need to use more accessible and user-friendlier tools.
- *Portability:* if the student needs to be able to access information by different slides, mobiles and tablets, etc.
- *File management:* if it is necessary to grant access to documents and to control changes, etc.
- *Multimedia support:* if the technology allows the sharing of and access to different types of files such as videos and images.
- *Follow-up through themes:* if we have to establish themes through the contents which allow us to follow the growth of knowledge and the contributions that students make throughout the different subject matters.
- *Access control:* if we need identification to access information, for example about other students registered in another subject.
- *Group management:* if the technology needs to support the management of separate groups.
- *Peer collaboration:* if we want to establish joint and equal working conditions between the teacher and the student.

3.1.2 Evaluation of Web 2.0 technology

Therefore, once we have identified the features of the subject and the secondary teaching objectives we

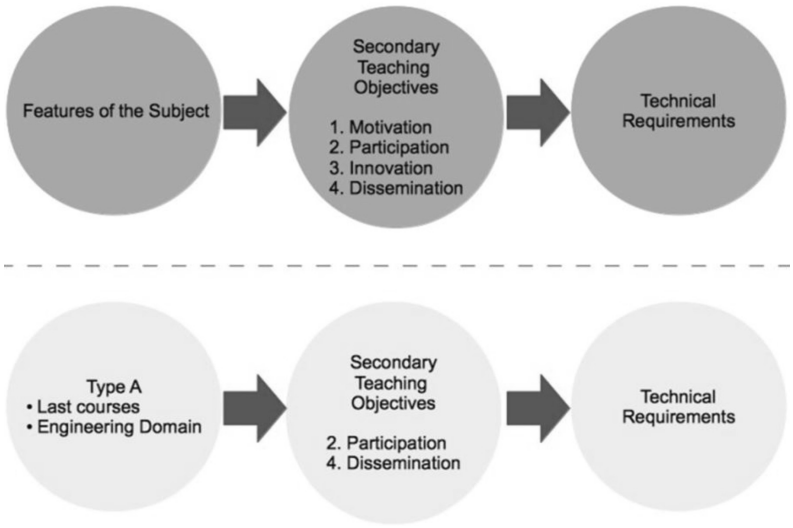

Fig. 2. The process for selection of the criteria for the Web 2.0.

wish to achieve, we need to evaluate what technology there is available, bearing in mind the technical requirements (Fig. 2).

With the aim of performing the evaluation, the methodology suggests the aforementioned classification of Web 2.0 technologies and support templates. In Table 1 we can see an example of a support template for technologies included in the category Permanent Content Managers (PCM). In these templates we have included, for each category, the features of the subject that it suits best, the objectives that best meet the help criteria, and the strengths and weaknesses in relation to the technical requirements. The methodology provides these support templates for each Web 2.0 category defined in Section 3.

Moreover, for the evaluation of Web 2.0 technologies we have to take into account the following tables (Tables 2, 3, and 4), which show each of the Web 2.0 categories outlined in the classification of

Table 1. Example of a Web 2.0 technology support template

Support template for the category *Permanent Content Managers (PCM)*	
Features of the subject	
Teaching context	Adapts better to subjects in the technology area due to the need for knowledge acquisition in IT.
Characteristics of the teaching	Subjects with an important practical part can be used but also those that are theory based. It is better not to use them in first year courses since they require special skills. They can be used in both compulsory as well as optional subjects.
Characteristics of the group	Due to its collaborative features it can be used with bigger groups of students.
Secondary teaching objectives	
Motivation	The technologies included in this category allow the student to learn by practice since they clarify the knowledge as they are used.
Participation	They provide interaction even though they are not the most appropriate technology since their replacement rate is average.
Innovation	These technologies allow the student to learn by searching for information even though it is not their ultimate aim.
Dissemination	They also make it possible to learn by sharing since they allow collaborative sharing of content even though there are other technologies that allow information to be spread further.
Technical requirements	
Easy to use	Weakness
Portability	Weakness
File management	Strength
Multimedia support	Weakness
Follow up through themes	Strength
Access control	Strength
Group management	Strength
Peer collaboration	Strength

Table 2. Evaluation of the Web 2.0 technologies by the features of the subject

	Web 2.0 Categories[1]				
Features of the subject	**PCM**	**DCM**	**MCM**	**SN**	**A**
Type A	5	5	4	5	4
Type B	4	4	3	5	4
Type C	2	3	1	4	2
Type D	1	2	1	4	1

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

Table 3. Evaluation of the Web 2.0 technologies by secondary teaching objectives

	Web 2.0 Categories[1]				
Secondary teaching objectives	**PCM**	**DCM**	**MCM**	**SN**	**A**
Motivation	3	5	4	5	3
Participation	4	5	4	5	3
Innovation	5	3	5	4	3
Distribution	5	5	5	5	4

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

Table 4. Evaluation of the Web 2.0 technologies by technical requirements

	Web 2.0 Categories[1]				
Technical requirements	**PCM**	**DCM**	**MCM**	**SN**	**A**
Easy to use	3	4	3	5	2
Portability	3	3	3	3	3
File Management	5	1	4	2	3
Multimedia support	4	2	5	4	4
Follow up through themes	4	5	4	4	2
Access control	5	3	3	4	2
Group management	5	4	5	5	5
Peer collaboration	3	4	5	5	3

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

the methodology with a scoring system of 1–5 (Likert scale) for each of the aforementioned criteria. Table 2 shows the scale for the features of the subject, Table 3 outlines the scale for the secondary teaching objectives, and finally, Table 4 shows the scale for the technical requirements.

In order to carry out the evaluation we need to complete Table 5 as an evaluation matrix with information from the tables presented earlier (Tables 2, 3 and 4) and from the case study. Therefore, this matrix should be filled in taking into account the criteria defined for the selection process: what kind of subject we have, what the chosen secondary teaching objectives are, and what the selected technical requirements are. Once chosen, we need to copy the corresponding values for each

Table 5. Evaluation matrix for Web 2.0 technologies

		Web 2.0 Categories[1]				
Selection process criteria	**Weight**	**PCM**	**DCM**	**MCM**	**SN**	**A**
Features of the subject						
Secondary teaching objectives						
Technical requirements						
Total						

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

one of the Web 2.0 categories from Tables 2, 3, and 4. Lastly, we need to calculate a final evaluation for each Web 2.0 category according to the weighted value assigned to each of the criteria added in the evaluation matrix.

3.1.3 Selection of the Web 2.0 tool

Finally, for the highest rated category the most efficient tool must be chosen when applying it to the teaching project. At this step and since the technology has been chosen according to the aforementioned selection criteria, the choice of tool can be made based on more practical factors such as popularity amongst students, knowledge base of the teaching staff and so on, and as such taking into consideration the technical requirements.

3.2 Process 2: Design of the teaching project

As was commented on the literature review another key issue for the successful implementation of Web 2.0 technologies in the teaching environment is a well-designed teaching activity where people want to use the technology. For this reason, once the most suitable tool has been chosen, in keeping with the previously agreed criteria, we need to design the teaching project. In order to carry out this design a teaching guide can be created, which should include:

- The definition of the teaching activity to be carried out by the students.
- An explanation of how the activity is going to be carried out.
- The types of materials, bibliographical sources, tools, etc. needed to carry out the task.
- The anticipated objectives of the activity – some specific examples could be outlined.
- An explanation of the evaluation mechanisms and system of self-evaluation.

Moreover, given the nature of the teaching project, which we are going to design, the Web 2.0 tool that is going to be implemented needs to be configured. Although depending on the tool chosen, the steps involved in its configuration may change, the following gives an outline of the more general points:

- The creation of the environment by using the tool and adapting it to the design of the agreed teaching activity.
- The adaptation of the context to the features of the subject and its defined needs: the profile of the subject what kind of group it will be offered to, safety and access issues.
- An introduction to the basic parameters and the minimum contents to be able to start the process to be undertaken.
- A teaching environment test carried out by the teaching staff using the configuration of different roles of users.
- A specially created student environment with roles and profiles assigned, if possible.
- A search for information on help and conditions of use of the chosen tool.

3.3 Process 3: Implementation of the teaching project

Once the teaching project has been designed the last process consists in carrying out the implementation. The actual performance of this process may vary depending on the design of the agreed activity and the chosen tool. During the execution of the teaching project it is important to designate a motivator who may be the teacher of the group or the students themselves on a rota basis. As a final step the need to carry out an evaluation is highlighted here, not only at the end of the process but also throughout its execution.

The evaluation of the results of the application ought to be based on the secondary teaching objectives defined in the first process of the methodology. Therefore, depending on the agreed objectives it will be necessary to determine which indicator we must evaluate. Thus, for example, if the objective was to improve participation (learning by interaction) estimating how many times each student accesses the site makes it possible to measure the level of learning achieved.

4. Teaching projects carried out

This section outlines three case studies involving the selection and implementation of Web 2.0 technologies in teaching using the proposed methodology. These practical applications form part of a larger research project on educational innovation and improvement being carried out by the authors.

4.1 Subject in the degree in computer engineering

This section describes the experience of teaching a core subject worth 9 ECTS (European Credit Transfer System) credits in the Degree in Computer Engineering called *Management and Development of IT Projects*.

4.1.1 Selection of Web 2.0 technology

First, we carried out the process of choosing the Web 2.0 technology in accordance with the defined selection criteria:

- *Features of the subject.* The project was carried out in a core subject in the fifth year of Computer Engineering. It therefore involved a group of students with experience and in the university and its teaching/learning processes. Moreover,

the students had a technical profile and consequently, at that stage of their studies, a high level of knowledge about computer technology so that, although they were relatively unfamiliar with the use of the Web 2.0 tool, students did not take very long at all to understand the new process. Finally, the group was somewhat smaller with about 20 students and after taking all of these features into account, we were able to classify it as being on the first level, that is to say Type A.

- *Secondary teaching objectives*. The secondary teaching objectives were established as participation (learning by interacting) and dissemination (learning by sharing). In the first case, the idea is that the students learn about interaction with professionals from the real world. Second, the objectives were chosen based on the maturity of the students and the features of the subject since one of the inherent themes of the subject is the ability to communicate within a team of individuals who are developing computer applications. Consequently, and since communication and dissemination are key objectives in the subject area, there was an interest in ensuring students could learn while sharing knowledge.
- *Technical requirements*. The most important issues arising from this are access control and the equality of collaboration. Other areas within this field were considered less important.

Once the selection criteria had been defined the Web 2.0 technologies were evaluated according to the proposed methodology and with the help of the support templates and the evaluation matrix presented in Section 3.1.2. The obtained evaluation is shown in Table 6.

In conclusion, it was found that the two most valid categories for the implementation of the teaching project were the Permanent Content Managers (PCM) and the Dynamic Content Management (DCM). Then particular tools that would be used in each of the categories mentioned above were chosen.

First and within the DCM category, Twitter was chosen as a microblog tool that would allow students to participate in a professional and real environment and in discussions related to the point being dealt with in the teaching project. It should be remembered that one of the secondary teaching objectives set out was dissemination; therefore this tool could provide students with a fast and frequent contact with the real world, which would also accomplish the desired technical requirement of equal collaboration.

Second and within PCM category, Google Sites was chosen as a tool that would enable students to generate a wiki about the topic of the teaching project. The main reason for this choice is that it complies with the technical requirements of access control and the peer collaboration suggested in the first step, since other tools such as Moodle make such collaboration among peers more difficult. Other reasons for choosing this tool were based on the ease of use for students in the field of technologies.

4.1.2 Design of the teaching project

In the design of the teaching project, the two selected tools were combined in order to use Twitter as a discussion forum so that the students could learn through interaction, and Google Sites was used as a wiki where students can learn by disseminating and sharing their knowledge. Blending these two tools in the teaching project is also beneficial because Twitter can provide knowledge in a very fast and dynamic way, but after that it is difficult to summarise or represent it in a graphic form. In that sense, Google Sites is the ideal complement because it allows you to organise the knowledge that students have acquired through a collaborative environment. In this way, contents transmitted through Twitter can be permanently collected in a subject knowledge repository.

After selecting the tools to be used, the next step was to develop a teaching guide which explained the objective pursued by the activity, the tasks to be

Table 6. Web 2.0 technologies evaluation matrix adapted to the case study in section 4.1

			Web 2.0 Categories[1]				
Selection process criteria		**Weight**	**PCM**	**DCM**	**MCM**	**SN**	**A**
Features of the subject	Type A	10%	5	5	4	5	4
Secondary teaching objectives	Participation	40%	5	5	4	3	3
	Dissemination	40%	5	5	5	5	4
Technical requirements	Access control	5%	5	3	3	2	2
	Peer collaboration	5%	3	4	5	4	3
	Total	100%	4.90	4.85	4.40	4.00	3.45

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

carried out and their configuration, the assessment criteria and so on.

In relation to the configuration of the tools used in this teaching project the following tasks were performed:

- *Twitter:* An account was created and followers related to the subject matter were established. Students used their own Twitter account or they created a new account and they become followers of this account. Once the account had been set up, their work consisted in following through the news concerning the management of the project and particularly the agile methodology, studied in the course.
- *Google Sites:* A web space was created and its own permissions were set up so that the students could access it. The students were divided into groups so that each group was responsible for carrying out one of the web space pages. The lecturer was the Webmaster. Therefore, the goal was to develop a wiki in a collaborative way, where all the knowledge collected through Twitter should be incorporated. The faculty established the web structure in the different sections, which then were assigned to the groups together with the person responsible for each one.

4.1.3 Teaching project implementation

During the implementation process it should be pointed out that there is a need to establish a motivator, who may be the teacher, if we want the project to work. The reason for this is that since these technologies are used by the students on a daily basis, to be successful in the teaching and learning process they need an engine, which engages the students.

Finally, the teaching project was evaluated the main conclusion being that it had been positive, although an important effort has to be made by the faculty to invigorate the experience. Therefore, it would improve things a lot if the motivator were a role that students could adopt throughout the academic year by groups or on a rota basis.

4.2 Subject in the degree in industrial design engineering

The second teaching project was carried out in the Degree in Industrial Design Engineering, in a subject called *Presentation of a Computer Aided Design*. This is an optional subject with 7.5 ECTS credits. It is a popular subject in the degree because it helps students to disseminate their designs in an attractive way with computer-generated videos and images.

4.2.1 Selection of Web 2.0 technology

First, as in the previous case study, the above-defined selection criteria were analysed:

- *Features of the subject:* The project was applied in an optional subject taught in the third year of the Degree in Industrial Design Engineering. With regard to the teaching environment, the students belong to the last year of this degree, therefore they are used to the latest advances in technology. As a consequence of this even though the Web 2.0 tool is not routinely employ by them, their ample experience in new technologies will accelerate their learning process. Therefore, they can be classified as Type A.
- *Secondary teaching objectives:* The subject is essentially a practical nature as even the theoretical part aims to improve the practical work they need to do in order to pass it. The number of students per class is fairly large, as there are groups with 35 students in them. Owing to this factor the use of Web 2.0 could help to answer questions and complete the training received in the classes. The secondary educational goal was participation (learning by interacting) and innovation (learning by investigation), because there is so much material on the net such as tutorials, which can help the student to do exercises and even expand on them.
- *Technical requirements:* After analysing the features of the subject and the teaching objectives, some associated technical requirements are established. The idea is to develop the work throughout the course, so what is needed is a multimedia-based tool that enables students to have access to information at any moment and on any device. This allows students to collaborate and they can use their own material or the information obtained on the Internet to solve their doubts.

Once all the criteria had been identified, the support templates were reviewed and the evaluation matrix was filled in. The evaluation result is shown in Table 7.

In conclusion, it was found that the Multimedia Content Managers (MCM) was the best option because it has file support and user control. After establishing the category we chose Youtube as a tool that makes it possible to create channels in which we can share useful videos and tutorials. We were also looking for the option to increase the practice material produced in class but it was a difficult task because students needed personalised attention in order to solve their doubts.

4.2.2 Designing of the teaching project

First, we created a Youtube Channel and the

Table 7. Web 2.0 technologies evaluation matrix adapted to the case study in section 4.2

			Web 2.0 Categories[1]				
Selection process criteria		**Weight**	**PCM**	**DCM**	**MCM**	**SN**	**A**
Features of the subject	Type A	10%	5	5	4	5	4
Secondary teaching objectives	Participation	20%	4	5	4	5	3
	Innovation	30%	5	3	5	4	3
Technical requirements	Multimedia support	30%	4	2	5	4	4
	Portability	10%	3	3	3	3	3
	Total	100%	4.3	3.3	4.5	4.2	3.4

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

lecturer added some tutorials and videos found on the Internet. These resources increased the contents taught in the practical part of the subject. All the students became followers of the channel and used it to consult all the information provided by the lecturer.

On the other hand, we thought that the students' role with this Web 2.0 tool could be both passive and active. Students can consult all the information provided by the lecturer, but they also created their own channel on the subject, so that they could upload interesting tutorials or their own work.

4.2.3 Teaching project implementation

This project was very positive. Students had to answer some questions giving their opinion about the use of this methodology and, it was found that the 90% of them said that it has motivated them to follow the subject because they had many videos and a lot of extra material available to them.

Students can consult Youtube from mobile devices and this increased the use of this methodology, because most students have smartphones.

4.3 Subject in the degree in computer engineering

The third teaching project was carried out in the Degree in Computer Engineering in a subject called *Graphics and Multimedia*. This is an optional theoretical and practical subject which is imparted in the third year of the degree and it has 6 ECTS.

4.3.1 Selection of Web 2.0 technology

First, the Web 2.0 technology was selected on the basis of the following criteria:

- *Features of the subject:* The project was carried out in a third year optional subject in the Degree in Computer Engineering. The students have a technological profile and experience at university. Their computer knowledge could be considered as being medium-high, so that using a Web 2.0 tool should be an easy and attractive experience for them. The class had 40 students divided into two smaller practical classes with 20 students in each. Although the subject has theoretical and practical parts, for the sake of convenience we can consider it as being completely practical. Students must do their work alone and this influenced the selection of the Web 2.0 tool. We looked for a useful way for students to communicate with each other in order to solve the general problems that could arise while the project was being carried out. Therefore, they can be classified as Type A.
- *Secondary teaching objectives:* motivation (learning by doing) and participation (learning by interacting) were established as secondary teaching objectives. The first objective was chosen with the aim of fostering students' interest to share the progress made in their projects, so that they could show and explain their achievements to help their classmates. In the second case, since many students will have errors, problems and doubts while the project is being carried out the idea was that they could learn by interacting with their colleagues to share those errors, problems and doubts. Therefore, when a student solved a problem, he or she could easily communicate with his or her colleagues.
- *Technical requirements:* Portability and peer collaboration were considered the most important technical requirements in this subject. Nowadays, there are a large number of devices, and hence portability is important for student to have the information at hand whenever they need it. The importance of peer collaboration is determined by learning by interacting as a secondary educational objective. Although there are other important technical requirements such as its being multimedia-based, the two chosen requirements that were chosen are of prime importance.

After analysing the study of the selection criteria, different Web 2.0 technologies were appraised and

Table 8. Web 2.0 technologies evaluation matrix adapted to the case study in section 4.3

			Web 2.0 Categories[1]				
Selection process criteria		**Weight**	**PCM**	**DCM**	**MCM**	**SN**	**A**
Features of the subject	Type A	10%	5	5	4	5	4
Secondary teaching objectives	Motivation	35%	3	5	4	5	3
	Participation	35%	4	5	4	5	3
Technical requirements	Portability	10%	3	3	3	3	3
	Peer collaboration	10%	3	4	5	5	3
	Total	100%	3.55	4.70	4.00	4.80	3.10

[1] Permanent Content Managers (PCM), Dynamic Content Managers (DCM), Multimedia Content Managers (MCM), Social Networks (SN), Application and services (A).

classified depending on the suggested methodology and with the support templates. Finally, the evaluation matrix was filled in and the result is shown in Table 8.

In conclusion, we found that the two most valid categories were the Dynamic Content Manager (DCM) and Social Networks (SN). Finally, we decided to use Social Networks because they are widely used by young people.

Facebook was chosen from among all the possibilities available in Social Networks. It is a tool, which students frequently use to interact with friends and, from now on to interact with their colleagues in order to share their doubts and progress made in the subject. In addition, Facebook is available on all devices with an Internet connection. The result of the work carried out in this subject is a scene modelled with 2D objects and, since interactivity is included in this work, Facebook affords an easy way to share images. Students could see their colleagues' work when they want to and they could also share their own work with others.

4.3.2 Design of the teaching project

Facebook allows us to achieve the two secondary teaching objectives that were selected, i.e. learning by doing and learning by interacting, and so, it was established as the Web 2.0 tool in this activity. After that, we wrote the teaching guide, which explained all the objectives in this teaching project, the activities to be performed, the tools to be used, the assessment criteria, and so forth.

It should also be pointed out that although this project requires the students to interact with peers, we needed a tool administrator and this was the lecturer of the subject. The administrator created a Facebook account and he added all the students as friends. The lecturer invited the students who did not have a Facebook account to create one. Facebook allows us to create closed or open groups and the decision was made to create a closed one. The group was joined by 40 students from two different practical groups, thereby making communication between the two groups easier. The information could only be accessed by the students because the group was configured as closed.

Students could start an inquiry or include comments to other students' inquiries. The use of this Web 2.0 tool as a way to communicate among peers, allows students to use Facebook as a discussion forum to promote the selected educational objectives of learning by doing and learning by sharing experiences and knowledge.

At the beginning of the course, the lecturer encouraged students to research into the subject so that they could contribute more advanced characteristics to the project than those explained in the class. These contributions were accessible only to the students that included them in the project and the lecturer checked them. In this project, students presented these new contributions to their classmates, so that, they could also include them in their projects. This allows the students to experience learning by doing and learning by interacting at the same time. The tool allowed the students to ask questions and get solutions from other students, thus establishing a fluent conversation that helped them to solve problems and to make progress in their own projects. The tool also allows videos and photos to be uploaded, so that they could present their projects, including both those that are still underway and those already finished. This allows the other students to give them ideas to improve their projects. The tool therefore made the student become more interested and motivated in the subject, because the result of the work was still higher than what they thought they could achieve. Using Facebook allows the students to obtain information in a dynamic practical way because they can access it from any platform and device with an Internet connection, so that the student is able to consult or ask for help at any moment and in any place. Another advantage is that information in Facebook is available during the entire course and students can consult it whenever they want. The Facebook tool configuration is:

- A private closed account was created only for the students of this subject. The students used their own Facebook account or another one. Once the account had been configured, their task was to follow the different posts.
- In order to make using the tool as efficient and simple as possible, some work guidelines were given, such as not creating different posts with the same topic, so that it would be easier to follow the topics. It was also recommended that students should read all the posts before asking a new question about the same topic, because they often have the same problems and doubts.

4.3.3 Teaching project implementation

Although it was a teaching project among colleagues, and the lecturer did not participate in any of the posts proposed by the student, he was the account administrator and he was always paying attention to ensure it was implemented correctly. Therefore, the lecturer controlled the volume of activity on the page by keeping a check on which students collaborated, which students did not collaborate and overall levels of collaboration. During the process of implementing these projects, the students were encouraged to participate with e-mails and advice given by the lecturer during classes.

Finally, the evaluation of the teaching project was drawn from surveys conducted amongst the students. The main conclusion was that the project had been positive. It is necessary, however, to include participation and individual student contributions to the assessment because many of them were reluctant to share their contributions for fear that other students would take advantage of them without having to make any kind of effort. Hence, the most participative and satisfactory part of this project was showing the development of their tasks to the rest of the class. The tops offered to improve their tasks or the appearance of new proposals were a good source of ideas.

In addition, the selection of this tool was rated positively due to its portability. Because it can be used in many places and circumstances outside the university domain, students were able to make frequent use of it.

5. Lessons learned and limitations of the methodology

Concerning the related projects we can conclude that the success of the Web 2.0 application depends on the technology that is selected. Not all technologies are suitable for all teaching objectives, subjects or students. For this reason, it is necessary to have proposals to evaluate, after taking into account different requirements, which technology should be used for learning/teaching process.

The methodology presented in this paper has evolved while different educational projects were being carried out in different subjects. This final proposal includes improvements that were introduced to solve problems that appeared during the trials. As regards evaluation, we have tried to improve the technology assessment method by giving more freedom to the lecturer and at the same time giving him some support templates about the technologies to make it easier for him to decide which is the best. Another interesting modification is the introduction of a person to play the role of stimulator while the teaching project is being implemented. We have observed that while the lecturer or one of the students adopts this role, the results of the project are more efficient and more highly valued.

Within each of the categories of Web 2.0 technologies that have been proposed for the methodology described in this paper, there are so many tools that it is not possible to make a general evaluation of all of them. The problem is that while they have general characteristics that make them fit into a certain category; at the same time they have certain special features, which require them to be evaluated in a different way according to the specific teaching objectives concerned. For this reason, the authors are thinking about applying for another project on innovation and improvement in education which would enable them to conduct a more detailed study of the tools in each category and which would thus complement and complete the study undertaken here.

Finally, to fully demonstrate that better results are gained with the use of this methodology than when it is not used, it would be necessary to have a control group to compare the results. The projects performed have been compared to previous results in the subjects where the teachers use some Web 2.0 tools considering their own knowledge and skills. This methodology provides more factors to be taken into account and, as has been proved, expands the range of selection to other tools that, perhaps, have not previously been considered.

6. Conclusions

Nowadays students have a great interest and many skills in the use of Web 2.0 technologies. In order to exploit their willingness, teachers must change our teaching/learning process by incorporating the use of these technologies in an efficient way.

The aim of the methodology developed in this study is to offer a first version of the mechanisms that can be used to choose the best Web 2.0

technologies for each specific teaching project. At the same time, this methodology gives an idea of how to implement and assess the project once the technology has been selected.

From the experience gained by the authors of this work in different education innovation programmes, using Web 2.0 technologies in teaching could bring significant improvements to the teaching/learning process and the assessment system. Moreover, these technologies motivate students because they become more involved in their own learning process.

Finally, another very important result is that although the methodology aims to help teachers select the Web 2.0 tools so that they have a means that is suited to their particular teaching/learning process, the key points are not those related to the assessment of the different tools or the technology, but to the definition of secondary teaching objectives and the design of the teaching guide.

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