

A repository of students' resources to improve the teamwork competence acquisition

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ABSTRACT

The general aim of the proposed research methodology is to prove the advantages of using a knowledge management system called BRACO (with resources created by peers in cooperative way), as support for learning during the development of the teamwork competence. The search engine of BRACO allows student to search a useful resource only knowing the objective for user; namely, by specifying the circumstantial requirements (making a class work, preparing a specific exam, etc.). In this research the teamwork competence has been considered as knowledge central topic because its transversal characteristics. The resources created by students are used only by the experimental group, not by the control group during the teamwork process. This paper shows the measurement tools to start the quasi-experimental research, that will allow proving that there are no significant differences between both groups on the acquired knowledge about resources sharing and teamwork competence in previous experiences. The results also show that both groups have similar perception on difficulty of activities during the experiment.

Categories and Subject Descriptors

• Applied computing → Learning management systems
Information systems~Database management system engines

Keywords

Knowledge management system; knowledge spirals; teamwork competence

1. INTRODUCTION

An academic course is an activity that can be improved every time it is performed. When a new instance of the course starts, teachers often include new knowledge, mainly of two types: their own experience, gained from the previous editions, and external knowledge (courses, books, conferences, etc.). But also students usually generate new resources during the time they are involved in the subject, gaining also experience with this kind of proactive activities. Although the academic courses are designed for students to acquire skills, they also acquire other knowledge internal to the course (contents, notes, examples, exams, etc.) and external to it (dependencies training center, procedures, rules,

associations, etc.). Students can improve skills by creating resources cooperatively in order to be added to the academic contents of the course for future students.

Based on these ideas, several methods to improve activities have emerged, such as ARC (Action Review Cycle) [1], wide-mind method (After Action Review) or AAR of military origin, based on cooperative work, crowdsourcing, etc. On the other hand, teamwork (hereinafter TW) methodologies are being applied in all university degrees because they are demanded from companies. Benefits of TW are shown in previous works [2], such as: increasing efficiency, greater effectiveness and faster speed, more thoughtful ideas and mutual support and outcomes, which make better use of resources. Some authors show the importance of TW to convert tacit knowledge into organizational knowledge [3]. In educational organizations the knowledge created by work teams during a course can improve the academic contents if they are accessible to the next course edition. The method of the knowledge spirals is used to create organizational knowledge and transform the individual knowledge into organizational. Two types of spirals are considered: epistemological spiral (interaction between types of knowledge) and ontological spiral (interaction between the individual's knowledge and organizational knowledge) [4].

But knowledge created and used in an academic course is usually managed by teachers in websites or Learning Management Systems (thereafter LMS) and Learning Content Management Systems (thereafter LCMS) [5, 6]. The structure of the contents may be presented by a list format or an index format. Commonly, the content of the subjects consists of learning resources and activities chosen and sequenced by the faculty according to the course design, and students must adapt his/her learning to that organization. Therefore, eLearning systems are still used under the paradigm centered on the teacher, who sets the approach of the course and the activities to carry out. That organization of resources and activities by teachers, must be adapted to the way that LCMS store the resources and the kind of activities allowed under a predefined sequence. Knowledge Engineering can break this scheme, making it possible managing the learning process individually and adapting the resources and their organization to each student's profile and needs.

This work is based on the integration of resources created cooperatively by students in subjects of different Engineering Degrees. As it has been mentioned, when someone develops an activity, he or she gains experience and often uses the experience to improve the activities. Any activity can be improved by incorporating internal and external knowledge (from other people who have done a similar activity previously). The improvement is

greater when more knowledge is incorporated. Thus, if many people share the internal knowledge during an activity, it provides more benefits than using the isolate knowledge of each participant. But these systems, which continuously leave traces on the learning process, are not giving service to the increasing need of informal learning which is developed in parallel to any subject and which makes use of resources developed by teachers, students and external resources (social web).

It is increasingly frequent that the students use resources “in the cloud” to share learning resources with classmates. These resources can be class notes, solutions to problems, questions and, in general, any useful resource for their activities (studying, carrying out practices and works, etc.). But students normally develop these activities in an informal way [7,8], in circles of trust (friends) and in punctual circumstances (commonly when the deadline of a work or an exam is approaching).

The definition of a learning content management and sharing culture requires, firstly, that individuals to generate pieces of knowledge; secondly, the definition of a reward system for the users that create knowledge [9]; and finally, promoting knowledge exchange [10]. This culture has been launched in previous works of this research team by promoting the knowledge sharing in different contexts: informal learning in the MARIA project [11], distance learning [12], educational innovation experiences [13, 14], teamwork competence [15], and academic resources [16].

This work proposes a methodology that promotes the creation, classification and organization of students’ learning resources during a teamwork process. Teamwork process is monitored by a proactive method that makes possible the generation of resources collaboratively. A knowledge management system (thereafter KMS) allows to Classify, Search, Organize, Relate and Adapt the generated resources and includes a semantic search engine, based on ontologies, which provides a final product for users’ needs. The general research has already answered questions such as the types of resources created during the TW (with academic, social and service orientation), how to establish a common organization of the created knowledge for all potential users, to improve educational resources of an academic course with these collaborative resources.

The final objective of this research is to prove the positive learning impact on students of this cooperative methodology and the supported technology (a repository) that allow integrating resources generated by peers of the same engineering sector, as well as managing them for their adaptation to the different learning requirements and needs (from both teachers and students). This paper presents the measurement tools to establish the initial conditions which will allow choosing the experimental and the control groups for the experiment. The proposed cooperative methodology can be used in any course but we consider the teamwork subject because of its transversal character.

The following section describes the research methodology. Afterwards, the specific context is presented and finally, the results, after applying the measurement tool, are presented, ending the paper with the conclusions.

2. RESEARCH METHODOLOGY

This research is based on a knowledge spiral (Figure 1) which contains the following stages already described in [16]:

- **Stage I.** Identification and creation of learning content by students (with TW). It corresponds to the knowledge created

by students and, in this case, the new knowledge is created during each semester of an academic year.

- **Stage II.** Knowledge management system (BRACO repository). Management system to classify, categorize, organize and search the knowledge.
- **Stage III.** Qualitative and quantitative results assessment. It corresponds to the application of the knowledge generated in the previous semester and the evaluation of the learning impact.

The amount of knowledge increases in the spiral (knowledge circle, transversal section of cone), the services and products are improved (ontology and search engine) and the knowledge generated by students during the first stage is also improved by the users of that knowledge who determine the usefulness of those resources, and stored in BRACO repository (stage II). Each circle corresponds to an academic year and two courses of different degrees are involved on it. The different circles of the spiral are connected from a second semester of one academic year to the first semester of the following one. The generated knowledge is used in the different courses and its learning impact is evaluated at the end of each circle (stage III).

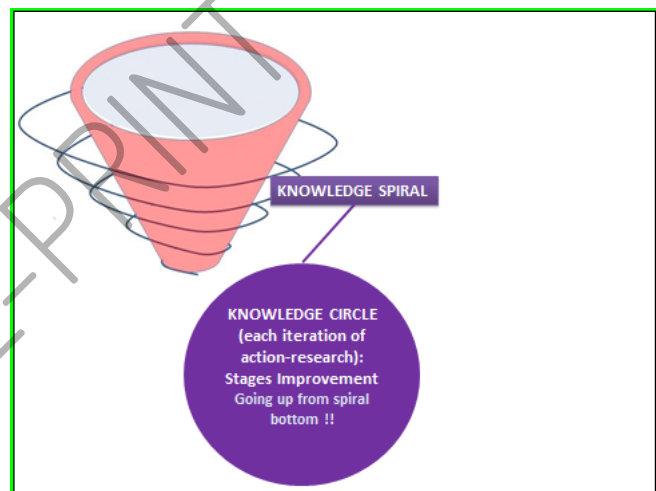


Fig 1. Knowledge spirals

Stage I. Identification and creation of learning contents by students (with TW). Work teams corresponding to an academic course are established to create contents during the TW process. Components of each team chose the type of resource they were going to create. As a reward, the resources created during TW process were taken into account in the final evaluation of the course.

This stage I includes the creation and identification of those resources. The types of the generated resources were: teacher’s notes, exam solutions, solved exercises, levelling questionnaires, videos with difficult concepts, useful academic information, web pages, papers, interviews to fellow students, teachers, engineers, professionals of the sector, etc. See more in [15, 16].

Stage II. The goal of this stage is the management of the knowledge created by students of a course, in a dynamic, flexible and adaptable way and it leads to a KMS development. To achieve the flexibility, dynamism and adaptability of the management system organization, a multilayer is used: physical layer, semantic layer and user-oriented conceptual layer. The multilayer structure is based on what Nonaka [4] called *hypertext organization* that organize the resources in a way based on users’

groups and their specific needs. This means that new functionalities can be modified and included without changing the structures. In Figure 3 the layers described are shown.

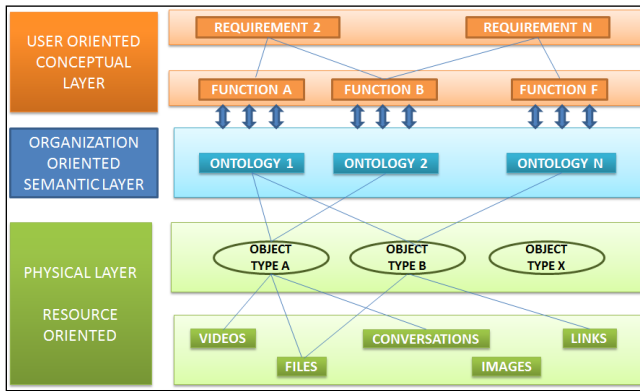


Fig 3. Multilayer structure

In the previous work [15] an ontology (set of tags) is proposed for this educational environment and a resume, of more than 60 tags grouped in 10 categories, is shown in Table 1. These categories identify the context while the tags identify the specific need. The ontology has been assigned to resources created by students and defines the source of the resource, its type, utility and the activity where it was generated. It is based on the traditional models used in innovation [19] which have been already tested in educational innovation contexts [20]. The proposed tags are grouped in categories following the classification: input, process and output. Input includes categories referred to the knowledge source. Process refers to academic activities related with the knowledge. Output refers to the type of created knowledge: academic support, welcome pack, professional opportunities, etc.

Table 1. Proposed ontology

Category (tags)	
INPUT (knowledge source)	Author (Students, Faculty)
	Academic Course (2013-2014, 2014-2015)
	Degree (Biotechnology, Energy, Mining)
	Subject (Computing and Programming, Programming fundamentals)
	Topic (Numeric, Computing, Algorithms, Matlab)
PROCESS (usefulness and activity related to resource)	Learning (Theory, Laboratory, Examples, General description, Notes, etc.)
	Activity (Exam, Practical session, Theoretical session, TW)
	TWC (Mission and goals, Chronogram, Results, etc.)
	Technology (Wiki, Dropbox, Website, Forum)
OUTPUT (type of knowledge)	Type of knowledge (Professional opportunities, Welcome pack, Degree information, Academic support, Leisure, Students' Associations, etc.)

In the KMS development, some management functions were defined, such as: searching, classifying and organizing resources based on certain requirements. At the physical layer all the knowledge generated by students and faculty are accumulated. The semantic layer is based on an ontology related to the physical system objects. The ontology allows the evolution of the system

with respect to the type of present and future generated knowledge. The conceptual layer is based on the CSORA (Classify, Search, Organize, Relate, Adapt) method [21], which allows the use of tags that make up the ontology as a search system.

The search engine, included in this KMS, combines text searches with logical expressions of tags. It also offers a knowledge search system for students (adapted to specific needs), for faculty (use of resources to various topics of the course) and for academic activities, such as the search of a resource designed for people who have partially failed the course, or supporting a particular laboratory.

CSORA is being successfully used in the "Information Points Network on Research Development and innovation activities". It has shown its effectiveness to search R&D&i projects because the user's searching is based on generic search targets, without knowing the specific nature of what is searched [14]. The search engine included in CSORA system allows defining a search based on logical expressions, with connectors (and, or), between different tags and by means of text. CSORA allows several ways of selecting and organizing the contents. Any user of this search engine (current students that create the contents and contribute to the repository, future students that will use the search engine and teachers) can generate a portfolio (file with editable text) with a selection of resources obtained during the search. Faculty also can organize the search outcomes as a personalized webpage with their own selection. The search structure is shown in [15].

On the other hand, different users can generate the requirements by combining activities, context and information of the user profile. The final product generated is the BRACO "Collaborative Academic Resource Finder" repository. BRACO consists of the KMS (through which staff and students introduce knowledge), an adaptive search engine (used by students and teachers to locate and identify resources) and a set of specific subsystems designed to support various academic activities. As the result of the system, each user can have his/her own organization and selection of learning results, depending on the requirements that every user defines (or teachers) and in base to a specific need of learning (e.g. preparing for an exam).

Each layer is analyzed from a functional perspective in [16]. The proposed KMS has been defined and employed, specifically adapted to strategic environments of Engineering, both by the Ministry of Economy and Competitiveness [22] and the Ministry of Education, Culture and Sports [23].

Figure 4 presents an example of the search engine, included in BRACO. As an example, a selection of the following categories and tags are presented: learning (aprendizaje in Spanish) – "examples" (ejemplos) and "activities" (actividades)- "work" (trabajo) and "technologies" (tecnologías)- "video record" (grabación vídeo) and "academic life" (vida académica)- "academic assistance" (ayuda académica). That selection generates 5 learning resources: videos recorded by students where they present their works. On the learning outcomes of a search, two actions can be performed: direct access to the content or the pre-selection a set of results to generate a portfolio with their characteristics (title, description, link to the content, tags) as an editable file.

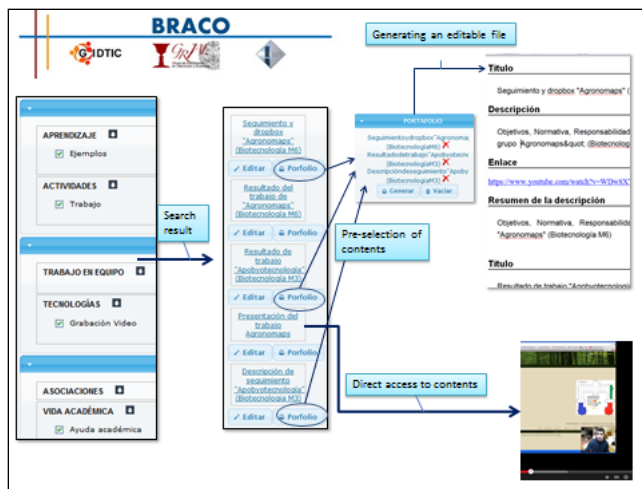


Fig 4. BRACO search engine

Stage III. Qualitative and quantitative results assessment. The first two stages of the study have been completed in previous works [15,16] and the number of gathered resources in BRACO (more than 200 in two semesters) shows the high rate of involvement of students. BRACO repository offers adaptive search options to the teacher and student needs.

In order to get the final research objective (to prove the improvement of learning on TWC in an academic environment through the transfer of knowledge created by students with their peers) we focus the attention in the third stage of the knowledge spirals, for which a quasi-experimental research is used. The commitment of this paper is showing the tools to know the initial conditions of students, to determine the experimental and control groups where research will be applied. Also evaluation of process indicators are included here in order to prove the aim of the general research in future works.

In the general research the measurement tools used are focused on indicators of three types: input, process and output.

- Input indicators are used to check if the two target groups, considered in this research, have significant differences in order to choose the experimental and control groups. In this sense, the indicators are: previous students' experiences on learning content sharing culture and TW knowledge acquired in previous experiences.
- Process indicators are also considered to prove that activities and tests are similar. The measurement tool allows asking on the difficulty of activities for both groups. The other variable is the perception of students on the complementary resources (selected from BRACO) on their utility for experimental students (because they use the resources) and on their necessity for control students (because they do not use them).
- Output indicators are used to find out the influence of the control variable (grades, student-student interaction, for example, measure the impact learning of this methodology, objective for the next work).

The measurement tools included in this paper are surveys filled up by all students of the target groups. Data obtained from those surveys (input and process indicators) will be used to choose the experimental and the control groups in the research.

3. RESEARCH CONTEXT

The research has been applied to the students of the course "Computer & Programming" (hereinafter C&P) of Energy Engineering Degree's first year at the UPM (two academic groups in the second semester of academic year 2014-15). Students of two groups GIE1 and GIE2 work on TWC with CTMTC method [17,18], which allows to form and evaluate individual and group skills during TW development, as well as the evaluation of the final result. It is a proactive method based on three aspects: TW phases (mission and goals, map of responsibility, planning, implementation and organization of documentation), collaborative creation of knowledge and cloud computing technologies (wikis, forums, social networks and cloud storage systems).

In a previous study 107 students (grouped into 18 teams) of the subject "Programming Fundamentals" (hereinafter PF) of the Biotechnology Degree, at the Technical University of Madrid (thereafter UPM) (the Degree's first year) were trained in TWC during the first semester of the academic year 2014-15. The knowledge generated by students of that subject, during the TW process, is used in this research. In a previous section the types of generated resources have been described (Stage I) and they have been classified and organized in the BRACO repository (Stage II), depending on the stakeholders (subject' students, external students and graduates) [15]. We also use some resources created during the previous year (2013-2014), by 70 teams, with an average of 6 students per team [16].

One of the two groups GIE1 and GIE2 will be the experimental group and the other will be the control group during the TW development explained below. The experimental group will use the resources about TW created by students of the previous semester meanwhile they use the CTMTC method. Control group will use the same CTMTC method without complementary resources created by peers.

Although BRACO repository is available for students, in this experience only the faculty selects a wide range of contents and work teams of the experimental group select some of them. Faculty along the TW phases and through this cloud technology continuously monitors team members' collaboration and individual evidences. This monitoring carries out training assessment by teachers to guide students' individual learning. At the same time, this method allows teacher to do partial summative assessments in order to compose the final summative evaluation of TW [15].

During the implementation of CTMTC method to all students, teachers provide recommendations for activities. When the deadline to perform an activity comes, a participative classroom session is hold and teams present their results. Those results are used by teachers as educational resources and used as good or bad practices. During sessions the teams correct mistakes to continue with the following phases of TW process. The first two activities proposed by teachers include all phases that take part of the TW process till the implementation phase. *Activity 1* (for one week) each team must elect the leader, define the work rules and describe the mission and goals. *Activity 2* is 5 weeks long and teams must correct previous wrong actions and make the map of responsibilities, the chronogram and the implementation phase. Each team members perform different actions (e.g. election of leaders) by cooperating between them through forums and social networks. The results of each TW phase are shown in a private wiki. The monitoring of the CTMTC method is explained in details in previous works [17,18].

The data for input indicators are obtained before starting the implementation of CTMTC method and the data for process indicators are obtained after each activity (1 and 2). The next section includes the results of the surveys to measure the input indicators and the process indicators.

4. RESULTS

First of all, the results of a diagnostic survey are presented to justify the need of a sharing knowledge culture between students in academic environments. Secondly the initial conditions for both academic target groups are shown to justify that they can be used as experimental and control groups. Thirdly the perception of students on activities difficulty and knowledge usefulness is obtained from an opinion poll.

A survey about habits of sharing academic resources and its usefulness was done to students endorsed in the subject “C&P” in the Degree of Engineering of Energy at the beginning of the course. The survey was answered by 150 of 167 students. The results, included later in this paper, show that there is a culture of sharing con-tents but majority with friends or close classmates.

A survey is filled by students of the two academic groups (GIE1, GIE2) at the beginning of the subject C&P, to prove that both groups have similar initial conditions and choose the experimental and control groups. The degree of similarity between experimental and control groups is determined in the following aspects: entry grade at university, previous training on TW, previous TW experience, TW processes previously done and number of students. The group selected as experimental group would be the one with an average lightly less favorable or whatever if there is not significant differences (if a non parametric test is added).

4.1 Previous sharing conditions

The questions of the survey, related to the previous sharing of resources are the following:

Q35_ Do you often share contents of this subject with other students in your classroom? 97,33% of students said Yes.

Q36. Do you usually share contents with your classmates? Contents are problems, notes, works or any other relevant information for the subject. 97% of students said Yes.

Q37. Do you think that the resources shared with classmates are useful? 100% of students said Yes.

Q38. Rate the frequency (1-never, 2-sparsely, 3-sometimes, 4-often, 5-always) in which you share the contents of the subject with the following groups:

Friend students (average rate 4,44). Any acquaintance in my classroom (average rate 3.54). Any fellow student who asks me for contents. (average rate 3,92). All my classroom (average rate 2,85). Students in other classrooms (average rate 2,38).

These results conclude that it is necessary to spread the culture of knowledge sharing between students of academic subjects beyond their friends or close classmates.

4.2 Initial conditions on TW

The survey about previous TW experiences was analyzed: student profile (table 2), TW planning (table 3), TW training received previously (table 4) and the procedure to do the TW process (table 5) in previous experiences. The rate is 1 (never), 2 (few times, less than 20%), 3 (sometimes, from 20% to 40%), 4 (half the time,

from 40% to 60%), 5 (quite a lot, from 60% to 80%), 6 (many times, more than 80%) and 7 (always).

The 89.41% of the GIE1 members completed the survey (76 of 85) and the 89.15% of GIE2 members completed the survey (74 of 83).

However, the GIE2 research group has slight better academic conditions. Regarding the TW experience (table 3), GIE2 has a previous experience closer to CTMTC context than GIE1. Differences are light but, in the vast majority of survey items, GIE2 gets the best results. Regarding the training previously received (table 4), GIE2 has exceeded all survey items to GIE1 and the results are slightly better in GIE2 for the rest of measurements. In the TW process (table 5) the results of GI2 are also slightly more similar to CTMTC method. The deviation values are very similar for each item in both groups. Therefore, the conclusion of the survey results is that both groups are very similar in average but, in principle, GIE2 has better conditions: better access grade, TW training, TW process and experience in CTMTC method used in this research and fewer students. Overall GIE1 group is chosen as the experimental group and GIE2 as the control group.

In any case, a non-parametric test of Wilcoxon is being applied for a future work to fix the significance in the differences between both groups, in order to choose the experimental group with a higher degree of accuracy.

Table 2. Student profile

PROFILE			
Questions	Answers	GIE 1	GIE 2
Q01_Genre	Female	23.7%	27.0%
	Male	76.3%	73.0%
	No	75.00 %	70.27 %
Q02_Have you taken this subject previously and failed the computing part (TW)?	Yes	2.63%	5.41%
	No response	22.37 %	24.32 %
Q03_Age	Average	18.8	18.5
	Deviation	2.04	1.0
Q04_Grade obtained in the university entrance exam	Average	10.8	10.9
	Deviation	1.43	1.1

Table 3. Teamwork planning

TEAMWORK			
Questions	Answers	GIE 1	GIE 2
Q05_Number of team works you have done previously	Less than 5	13.1 %	14.8 %
	Between 5 and 10	34.2 %	27.0 %
	Over 10	52.6 %	58.1 %
Q09_In your previous experiences, since you knew the team work to carry out and the members of your work team till the handing out of the final result of the work, rate the degree of fulfilment of the following tasks: (1 never, ..., 7 always)			

A part of the work was assigned to each member of the team and a deadline was set	Average	4.74	5.04
	Deviation	1.55	1.57
A procedure was established to monitor the team work	Average	3.17	3.77
	Deviation	1.45	1.52
The team planned the steps to be set before the tasks were distributed among members	Average	4.89	5.24
	Deviation	1.54	1.25
A schedule with activities and their expected results was planned	Average	3.16	3.19
	Deviation	1.46	1.57
Q10 _Did faculty mark the planning (work execution, main tasks, coordination...) as a part of TW final grade?	Average	2.99	3.57
	Deviation	2.02	2.18
Q12 _When did faculty mark the planning?	Before ending the final work	17.9 5%	23.2 6%
	After the end of the final work	82.0 5%	76.7 4%
Q13 _Did you develop a map of responsibilities in any work team (a document which shows the tasks and responsibilities of each member and is visible for all team members)?	Average	2.68	2.80
	Deviation	1.67	1.90
Q14 _Did faculty mark the development of this map of responsibilities?	Average	2.03	1.69
	Deviation	1.66	1.47
Q16 _When did faculty mark the map of responsibilities?	Before ending the final work	29.1 7%	50.0 0%
	After the end of the final work	70.8 3%	50.0 0%
Q17 _Did you help your teammates in any work team (answering doubts, giving important information, helping in complex tasks, giving improvement ideas...)?	Average	5.54	4.84
	Deviation	1.48	1.01
Q19 _Did the faculty mark this help?	Average	2.00	2.14
	Deviation	1.80	1.77
Q22 _Did your teams use any mechanism for their members to know in every moment how the work progressed?	Average	2.79	3.34
	Deviation	2.08	2.10
Q24 _Did faculty mark the use of this mechanism?	Average	1.86	1.55
	Deviation	1.70	1.39

Table 4. Previous TW training received by participants

TEAMWORK			
Questions	Answers	GIE 1	GIE 2
Q33 Have you been trained in the following aspects skills and knowledge to develop the TW? (1 never, ..., 7 always)			
Explanation of TW characteristics	Average	3.96	4.09
	Deviation	1.70	1.69
Approach of the work depending on the target group or its application	Average	3.67	4.15
	Deviation	1.65	1.83
Planning, task assignment, milestones, schedule, map of responsibilities	Average	3.50	3.61
	Deviation	1.70	1.84

How to develop a work planning	Average	3.55	3.73
	Deviation	1.62	1.79
How to carry out the monitoring of the work process	Average	2.96	3.11
	Deviation	1.60	1.72
Which are the parts of the final report	Average	4.00	4.18
	Deviation	1.91	1.70
How to make the work presentation and final defence	Average	4.39	4.70
	Deviation	1.75	1.63

Table 5. Teamwork process

TEAMWORK			
Questions	Answers	GIE 1	GIE 2
Q34 _Rate the following situations in your previous team works (1 never, ..., 7 always)			
Teams freely chose the work thematic	Average	4.37	4.80
	Deviation	1.40	1.47
Teachers offered a list of work thematic and the teams chose	Average	5.63	5.47
	Deviation	1.55	1.45
Teacher evaluated the work approach and/or its usefulness	Average	5.21	5.35
	Deviation	1.40	1.44
Some members of my work teams avoided any responsibility and did not work	Average	4.78	4.26
	Deviation	1.65	1.74
Team controlled or took actions against its members who avoided any responsibility and did not work	Average	3.79	3.80
	Deviation	1.67	1.81
Teacher controlled the presence of members who avoided any responsibility and did not work.	Average	3.46	3.18
	Deviation	1.90	1.82
Teacher punished members who avoided any responsibility and did not work	Average	3.54	3.45
	Deviation	1.95	1.96
There were students in my team who put off their part of the work till the last moment	Average	4.99	5.12
	Deviation	1.44	1.37
Teacher checked if members put off their part of the work till the last moment	Average	2.61	2.61
	Deviation	1.64	1.69
Teacher punished members who put off their work till the last moment	Average	2.50	2.35
	Deviation	1.67	1.58
Teams had unbalanced work distribution	Average	4.24	4.09
	Deviation	1.48	1.64
Teacher tested if the work distribution was balanced in each team	Average	2.68	2.50
	Deviation	1.66	1.61
Teacher punished members with the least work weight assigned	Average	2.26	2.31
	Deviation	1.60	1.62
In my teams the final reports were done by copying and pasting each member's part straight away	Average	3.78	3.91
	Deviation	1.66	1.77
In my teams the final presentations were done copying exact sentences from the final report	Average	3.25	3.23
	Deviation	1.58	1.71

4.3 Results of the perception on activities difficulty and knowledge usefulness.

The third part consists of a study on learning process for each group, and the comparison between both target groups. The basic TW training methodology (teachers' resources, activities and deadlines) is identical for both groups but teachers provide extra knowledge, created previously by peers, to the experimental group. A survey, filled by the two groups, measures the perception on the difficulty of different tasks and the usefulness of shared knowledge (real sharing for experimental group and hypothetical sharing for control group).

Two surveys have been filled by all students (one after finishing each activity) to measure the perception of the difficulty for each activity. In the experimental group the survey measures the utility of knowledge provided by faculty and also the perception of the control group on a hypothetical use of knowledge created by peers. 61 GIE1 members and 58 GIE2 members took part in the first survey. 42 GIE1 members and 36 GIE2 members participated in the second survey. See table 6.

Students were specifically asked about the exact processes to be performed in each activity. In the first activity the perception of the difficulty for both groups is very similar (and exact in two items). About the usefulness/necessity of knowledge of other students, the rates for both groups are very similar. The GIE2 perception of hypothetical contents usefulness has the same trend as the proven usefulness noticed by GIE1. Same results are obtained for activity 2.

Table 6. Perception on activities difficulty and knowledge usefulness

	GIE 1	GIE 2
ACTIVITY 1		
Q1. Rate the amount of effort required by the following tasks regarding to the TW (1 no effort, 5 great effort)		
Team leader election	1.7	2.1
Mission and goals	3.5	3.5
Work rules	3.2	3.2
Q2. (For GIE1) Several videos have been provided showing how to organize the forums, as well as some examples of the PF subject. Rate the grade of usefulness of these videos (1 useless, 5 very useful)		
Q2 (For GIE2) Rate how helpful would it be to have available contents from previous work teams which already did the work (1 not helpful, 5 very helpful)		
Forums organisation	3.7	3.7
Team leader election	2.1	2.4
Mission and goals	3.9	4.1
Work rules	4.2	4.1
ACTIVITY 2		
Q1. Rate the amount of effort required to do the following tasks carried out in the TW (1 no effort, 5 great effort)		
Map of responsibilities	3.0	3.3
Chronogram	3.5	3.5
Final work execution	3.5	3.5

Q2 (For GIE 1) A collection of good practices on work rules, chronogram and final work execution, created by the work teams of the previous semester, have been provided. Rate the usefulness of this resources (1 useless, 5 very useful)

Q2 (For GIE 2) Rate how helpful would it be to dispose of examples on map of responsibilities, chronogram and final work execution which have been created by other groups (1 not helpful, 5 very helpful)

Map of responsibilities	3.8	4.3
Chronogram	3.9	4.4
Final work execution	3.5	4.2

5. CONCLUSIONS

Students have created and identified resources not only for the specific subject of the presented case study, but also for all the subjects of the first year of the degree. This proves the great success and impact of the cooperative culture.

Popular LCMS force both faculty and students to adapt themselves to organization and to the platform requirements. Nevertheless, the proposed BRACO repository gives the possibility to evolve following the software engineering criteria in order to adapt the system to any subject. The high number of created resources proves the high satisfaction of the participant students with methodology/technology. Thus, it contributes to improve their cooperative and communicational competences and to raise their motivation up.

One of the presented surveys gives the input indicators to select experimental and control groups to implement the research which will prove the main research objective (this work is in progress): if students share knowledge on TWC, with both roles creator and user, then their learning competences improve and their final results of TWC (new contents) have better quality.

The proposed BRACO repository grants permanent access to the resources, what is not the common way to set up courses at the beginning of academic years (the normal behavior is to restart the subject every year and previous students cannot access again to the course's contents). It opens a big amount of future applications, such as the long live learning for the students who have made contributions to some knowledge spiral of the research or for mentoring activities (for mentors to support future students). Also in the following implementation, students will directly search and choose the useful contents created by other students from the BRACO repository, without the faculty intervention.

On the other hand, the current and easy access to knowledge promoted by technologies as Internet and mobile applications has opened some sensitive aspects such as the intellectual property, author's rights, plagiarism etc. Promoting the knowledge sharing among students is the best way to improve their ethics, moral aspects such as the respect to the property of the own and external knowledge. In the present part of the research, faculty promoted the good practices on intellectual property, citations, etc. by means of some specific session in the classroom. In future experiences this training will be increased by means of direct talks with experts in this topic and the written compromise of the students of protecting the own and external knowledge. Also a revision of quality in learning contents will be included in the next spirals.

The work intensity of each team and the final grades, through CTMTC phases, in order to prove the learning impact of this research, will be measured in future works. The selected type of

knowledge focuses on TWC, which is widely used in university courses at engineering degrees. Therefore the results of this research are easily exportable to any subject that trains on TWC.

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7. REFERENCES

- [1] Signet Research & Consulting. Adapting AAR cycles to business environments. [online]. 2015. Available in: http://www.signetconsulting.com/methods_stories/proven_methods/after_action_reviews.php. [Accessed 30-mar-2015].
- [2] Boundless, Advantages of Teamwork. 2014. Accessed 30 March 2015. <<https://www.boundless.com/management/textbooks/boundless-management-textbook/groups-teams-and-teamwork-6/defining-teams-and-teamwork-51/advantages-of-teamwork-259-4562/>>
- [3] Sapsed, J., Bessant, J., Partington, D., Tranfield, D. and Young, M. 2002. Teamworking and Knowledge Management: A Review of Converging Themes. *International Journal of Management Reviews*, 4, 71–84.
- [4] Nonaka, I. and Takeuchi, H. 1995. *The knowledge creating company: How Japanese Companies Create the Dynamics of Innovation*. New York, NY: Oxford University Press.
- [5] García-Peñalvo, F. J. 2008. *Advances in E-Learning: Experiences and Methodologies*. Hershey, PA, USA: Information Science Reference (formerly Idea Group Reference).
- [6] García-Peñalvo, F. J., Johnson, M., Ribeiro Alves, G., Minovic, M. and Conde-González, M. Á. 2014. Informal learning recognition through a cloud ecosystem. *Future Generation Computer Systems*, 32, 282-294.
- [7] Viegas, C., Marques, M., Alves, G., Mykowska, A., Galanis, N., Alier, M. et al. 2014. TRAILER – a Tool for Managing Informal Learning. *International Journal of Human Capital and Information Technology Professionals (IJHCITP)*, 5, 1-17.
- [8] Wang S. and Noe, R. 2010. Knowledge sharing: A review and directions for future research. *Human Resource Management Review*, 20, 115-131.
- [9] Hooff, V. and Weenen, F. 2004. Committed to share: commitment and CMC use as antecedents of knowledge sharing. *Knowledge and Process Management*, vol. 11, no. 1, 13-24.
- [10] Fidalgo Blanco, A. and Fernández Cabanillas, F. A. 2009. Cooperación Invisible. El proyecto MARIA (Métodos de Apoyo y Recursos Interactivos de Aprendizaje). *Arbor: Ciencia, pensamiento y cultura*, 185(Extra), 139-153.
- [11] Fidalgo, A., Sein-Echaluce, M. L., Leris, D. and Castañeda, O. 2013. Teaching Innova Project: the Incorporation of Adaptable Outcomes in Order to Grade Training Adaptability. *J. UCS*, 19(11), 1500-1521.
- [12] Fidalgo-Blanco, A., Sein-Echaluce M. L. and García-Peñalvo, F. J. 2014. Epistemological and ontological spirals: from individual experience in educational innovation to the organisational knowledge in the university sector. *Program: Electronic library and information systems*, 49(3), 266-288. doi: <http://dx.doi.org/10.1108/PROG-06-2014-0033>
- [13] Fidalgo-Blanco, A., Sein-Echaluce, M.L. and García-Peñalvo, F.J. 2014. Knowledge Spirals in Higher Education Teaching Innovation. *International Journal of Knowledge Management*, 10(4), 16-37
- [14] A. Fidalgo-Blanco, M. L. Sein-Echaluce, F. J. García-Peñalvo, and M. Á. Conde. 2015. Using Learning Analytics to improve teamwork assessment, *Computers in Human Behavior*, 47, 149-156.
- [15] Sein-Echaluce, M.L., Fidalgo, A., García, F. and Conde, M.A. 2015. A knowledge management system to classify social educational resources within a subject using teamwork techniques. *Proceedings 17th International Conference on Human-Computer Interaction HCII, 2015*. due to appear in Volume 9192 of the Lecture Notes in Computer Science series. LCT 2015, LNCS 9192, schedule for paper approval (978-3-319-20608-0, 339820_1_En,Chapter 48)
- [16] Fidalgo-Blanco, A., García-Peñalvo, F.J., Sein-Echaluce, M.L. and Conde-Gonzalez, M.A. 2014. Learning content management systems for the definition of adaptive learning environments, *International Symposium on Computers in Education (SIE)*, IEEEExplore digital library, 105-110.
- [17] Leris, D., Fidalgo, A., and Sein-Echaluce, M.L. 2014. A comprehensive training model of the teamwork competence, *International Journal of Learning and Intellectual Capital*, 11(1), 2014, 1-19.
- [18] Fidalgo, A., Leris, D., Sein-Echaluce, M.L. and García Peñalvo, F.J. 2015. Monitoring Indicators for CTMTC: Comprehensive Training Model of the Teamwork Competence, *International Journal of Engineering Education*, 31(3), 829-838.
- [19] Oslo Manual. *Guidelines for collecting and interpreting innovation data*. OECD Publishing European Comision, 3RD Edition. 2005.
- [20] Sein-Echaluce, M., Leris, D., Fidalgo Blanco, A. and García-Peñalvo, F.J. 2013. Knowledge Management System for Applying Educational Innovative Experiences. *Proceedings of the First International Conference on Technological Ecosystem for Enhancing Multiculturality*, ACM Digital Library. New York, NY, USA, 405–410.
- [21] Fidalgo, A. and Ponce, J. 2011. Método CSORA: La búsqueda de conocimiento, *Arbor: Ciencia, pensamiento y cultura*, 187, 51-66.
- [22] Centro para el Desarrollo Tecnológico Industrial (CDTI), Maps of financial assistance [online]. Accessed 30 March 2015, <http://138.4.83.162/mapas/ayudas/>.
- [23] Programa de estudios y análisis (EA), EA-WEB search tool [online]. Accessed 30 March 2015, <http://138.4.83.162/mec/ayudas/>