Technique of Classification, Organization, Creation, and Use of Collective Knowledge

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ABSTRACT

During the teaching of a subject, engineering in this particular case, students acquire knowledge through different learning activities that are guided by the teaching staff. In this process, students work with the resources and activities provided by the faculty, acquiring knowledge and demonstrating it through an exam. In this work, students have been asked to share their learning experience and to create knowledge resources that can facilitate learning. Thus, collective knowledge has been created in the subject, which can be used by anyone. The work has shown that students can create useful knowledge for the subject, as well as establish an ontological classification of all the knowledge necessary for learning the subject. The results of this analysis show the ontology defined by the students that is applicable to any subject. This study also describes the process carried out for the creation and management of knowledge by the students themselves, as well as the perception of the use of the collective knowledge created.

KEYWORDS

Cooperative Knowledge, Knowledge Management, Ontology, Teamwork

INTRODUCTION

In the current educational model, present at all academic levels, classroom training is mainly based on lectures in which the teacher transmits knowledge while students merely listen and receive the contents. Direct consequence is a total inactivity or passivity of the students, who tend to memorize a series of concepts that, most probably, they will forget once the exam has been taken because nobody will ask them about them again.

Different authors have shown that if students participate actively in the training process, the obtained learning is more effective and efficient, both from a cognitive and emotional point of view, which translates into a lower failure rate and, consequently, a decrease in the dropout rate. Kolb (Kolb, 1984) states that the learning cycle should begin with an initial period based on the continuous and active participation of the students. Dewey (Dewey, 1916), (Dewey, 1929) associates learning by doing with the improvement of learning, since in this way more cognitive actions than mere listening are involved.

The active process is the most important pillar of the constructivism theory (Mathews, 1998) which is based on the fact that learning takes place when new knowledge is created from existing knowledge, by combining both (Bringuier, 2000), integrating social interaction (Vygotsky, 1978) and

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interacting with the environment, which facilitates the learner's understanding of his or her immediate reality (Ausubel, 1969).

Other works focus more on procedures and activities. Thus Bloom, in his well-known taxonomy, highlights the creation and evaluation of knowledge (Bloom et al., 1956) and uses different levels of cognitive activities that are directly related to the impact on learning.

Currently, methodologies such as Flip Teaching (FT) promote active learning (Strayer, 2012). This methodology consists of moving the lesson home while the tasks are performed in the classroom (Baker, 2000), (Lage et al., 2000). Traditional classes are replaced by videos, readings and other activities that students can execute individually outside class hours; meanwhile, the classroom becomes a meeting place where knowledge is implemented through the development of practical activities and in a cooperative way between students and teachers (Angelini et al., 2015), (De Oliveira et al., 2015), thus encouraging interaction amongst them (Brahimi et al., 2015). In addition, in the TF the learning process is enhanced with didactic resources generated by the students (Danker, 2015).

However, the implementation of this methodology requires an important organizational change in learning, which is not always easy to put into practice and, in addition, it demands a great effort on the part of the teaching staff. Some authors such as Bergmann and Sams (Bergmann et al., 2012) state that the implementation of FT implies an increase in interaction among students, the assumption by students of responsibility for their own learning, the role of teachers as advisors in the classroom, virtual spaces for storing content and classrooms where students can carry out learning activities. The Flipped Learning Network (FLN) detailed the FLIP model, establishing four essential pillars (Hamdan et al., 2013): a flexible context, a learning culture (modifying the role of the teacher), intentional content (in order to encourage student participation) and a professional educator.

In order to solve the problems of disconnection between the activities at home and those performed in the classroom (Fidalgo-Blanco et al., 2018a) presented by the FT methodology, the Micro Flip Teaching model is developed which is implemented for a traditional classroom course (García-Peñalvo et al., 2016) where a linking factor is introduced between the activities inside and outside the classroom, solving this lack of connection.

The unifying activity is very important in the Micro Flip Teaching model because it allows the linking of the learner between the lesson at home and the in-class activities (Strayer, 2012). TF requires the learners to be active in their learning so that they can be more engaged in their learning and thus enjoy the opportunity to be able to practice what they have learned (Bachnak et al., 2014). The production of content by the students themselves is an indicator of this activity.

Thus, this binding activity in which students create learning resources, presents three main objectives: first, to check the degree of assimilation of the contents in the activities outside the classroom; second, to generate educational resources to be used in the activities inside the classroom; and finally, to turn students into active and more collaborative subjects in the learning process. In addition, this activity promotes the use of the knowledge generated by the students as a learning resource (Sein-Echaluce et al., 2016) and creates evidence that the teacher will later include in the class (Fidalgo-Blanco et al., 2017a). Previous research has shown that this method makes students active and encourages them to create useful knowledge for the learning process (García-Peñalvo et al., 2016), (Fidalgo-Blanco et al., 2017b).

Therefore, it is shown that learners are capable of creating useful knowledge for themselves (Fidalgo-Blanco et al., 2017a) and, that this knowledge is diverse because it depends on the academic level of each learner. Consequently, knowledge creation and diversity can lead to learning (Mazur, 2012). The production of knowledge by students is the result of the application of active methodologies in which students are participants in their own learning process, during which they acquire experience in contents, competencies and skills about a specific academic discipline, reaching its zenith when the student has completed the learning of a specific knowledge. Thus, students can generate useful knowledge [14] that can be used by students in another course or academic year (Sein-Echaluce et al., 2016).

In addition to creating knowledge, students and teachers need to manage it (Fidalgo-Blanco et al., 2014), (Fidalgo-Blanco et al., 2015a) for learning to take place; it is obvious that collective capabilities always exceed those of a single member (Mann et al., 2017). Knowledge management is based on the creation, identification, classification, organization and use of knowledge created by the organization, but not only by one person but by each of the members that compose it (Nonaka et al., 1995). Knowledge management implies a better performance of the organization through the continuous learning of their members and requires the cooperation of each of them.

Information and Communication Technologies (ICT) are designed to work and manage information and knowledge (García-Peñalvo, 2016), so they are a suitable support for sharing and organizing knowledge among different people in an organization (García-Peñalvo, 2011).

The tools that facilitate the optimal management of distributed knowledge belong to Web 2.0, and the most common are social networks, which represent a means of communication amongst people and their organizations, as well as a means of knowledge. The integration of social networks in knowledge management is feasible, since these networks allow information sharing and encourage the creation of appropriate means for knowledge dissemination (Altinay et al., 2016).

A characteristic of social networks is that it is the user himself who organizes the information shared with tags, being the most common tool for this purpose (Ma et al., 2015). The set of tags used in a community is called folksonomy (Sinclair et al., 2007) and can be considered as the knowledge organization system of that community (Mai, 2011).

In a previous research (Fidalgo-Blanco et al., 2018), social networks were used to organize the knowledge created by students. One of the aspects that students liked the least was the difficulty in finding contents on the network, being considered more important the organization and search of contents (Argelagós et al., 2012).

This work presents a knowledge system in which students have designed the classification and organization of knowledge through tags and defining folksonomy. In addition, the knowledge was created in a cooperative way through work teams. As a result, a platform where cooperative knowledge can be easily searched and located is obtained.

The objective of this research is:

1. Identify the folksonomy that defines the students' view of the different knowledge they generate.
2. To indicate the type and amount of knowledge that students create throughout the course.
3. Determine the students' perception of the knowledge created collectively.

The following section defines the functional and conceptual model used. Subsequently, the context in which the research work has been applied is described, followed by a summary of the results. Finally, the conclusions and discussion conclude the work.

MODEL

The model is based on the concept of education 3.0, whose main points are:

1. Students are consumers of knowledge, but also producers of it.
2. Students are able to organize the knowledge they create through folksonomies.
3. Collective knowledge created is always greater than knowledge created by a single member of the collective.
4. Connections between the different members of the collective produce both individual and collective learning.

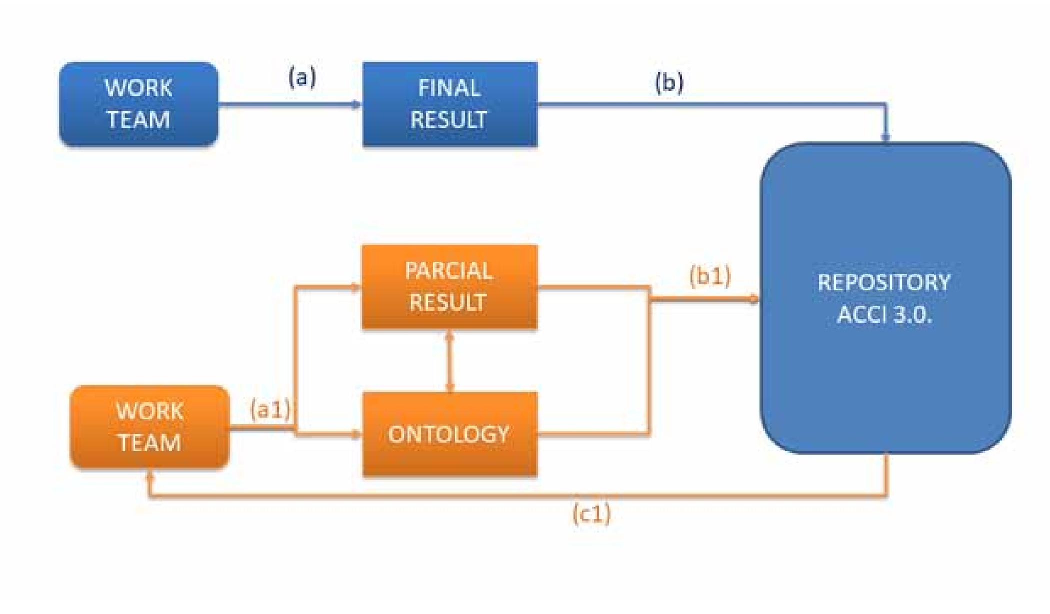
A knowledge management model based on these principles is the "active cooperative collective intelligence" model, ACCI 3.0 (Sein-Echaluce et al., 2019). The model has the following main components:

1. Ontology: knowledge classification.
2. Repository: management system, both knowledge and ontology.
3. Search engine: semantics based on inferences of the elements that compose the ontology.

In addition, the effectiveness of the search results through the ACCI 3.0 model engine (Fidalgo-Blanco, 2020) has been scientifically validated by contrasting the searches performed by human experts with those performed by the search engine. The peculiarity of the works in which the ACCI 3.0 model has been used is that it is the faculty of the subject itself who establishes the knowledge ontology and the knowledge produced by the students is not used by the students who created it but by the students of subsequent courses.

The contribution of this research work does not modify the model, but it does affect the way it is used. In this work, the students are the ones who create the ontology, they upload the created knowledge and this is used by the same students who created it. Figure 1 shows traditional methods on the management of contents generated in teamwork and the proposed model in this research work.

Figure 1 ACCI 3.0 model applied



Flow of contents identified by letter "a" (in figure a and a1) represents a traditional model of teamwork and results management. In the traditional model, teamwork goes through a series of stages: forming, storming, norming, performing and delivering-documentation (Tuckman, 1977), (Stein, 2016), (IPMA, 2006). At a specific stage: "delivering-documentation" corresponds to the moment when the documentation, including project results, is delivered. This means that any attempt to manage knowledge is done when the work is finished and the results have been delivered. If the work deadline is placed at the end of the course, then knowledge management will be done at the end of the course.

In previous works (García-Peñalvo et al., 2019), (Fidalgo-Blanco et al., 2019), (Sein-Echaluce et al., 2017), (Sein-Echaluce et al., 2015a) this is the model that was applied; that is, when the course is over, the faculty will manage the results of the work. Figure 1-a represents the results which are delivered after the work is finished and Figure 1-a1 the faculty manages the work results after the course is finished. The results are stored in a knowledge management system that has the ACCI 3.0 model. This working method involves two situations:

1. Students do not benefit from the resources provided by the community. Final results are made public once the course is finished, therefore the use of them is available for the students of the following courses.
2. Teachers are responsible for identifying, selecting, sorting, classifying, organizing and entering the works in the repository.

Data flow "b" in figure 1-b, 1-b1 and 1-b2 represents the strategy followed in this work. First of all, the contents to be worked with are parts of the work instead of its final result. As soon as a part of the work is finished, the students themselves manage it in the repository. In the management process, students must identify, classify, organize and upload the contents publicly to the repository. This implies not only uploading the resources but also defining an ontology to classify them. The process to define the ontology is the following:

1. Each resource is associated with a set of tags that identify the content of the resource, the type, the learning action in which the resource arises and the usefulness of the resource (Figure 1-b).
2. The students check if these labels already exist or are similar. If so, the name of the label is modified with the one that already exists, thus avoiding duplication in the ontology (figure 1-b1).
3. If they do not exist, the tags are associated to the ontology.

In this way, the students are who, in first instance, define the ontology. Subsequently, in face-to-face sessions, the teacher and the students review and, if necessary, redefine the ontology (for example, by grouping labels). This data flow is significantly different from the previous one:

1. The students who generate the contents benefit from them since they are made public during the course, as opposed to the previous model, which was done at the end.
2. The work of resource management, from identification to uploading to the repository, is done by the students. The faculty assumes the role of coordinator and reviewer, as opposed to the previous model in which the faculty had to do all the management.

In this research work, there are aspects which are common to the scientific works where the ACCI 3.0 model has been used, these are:

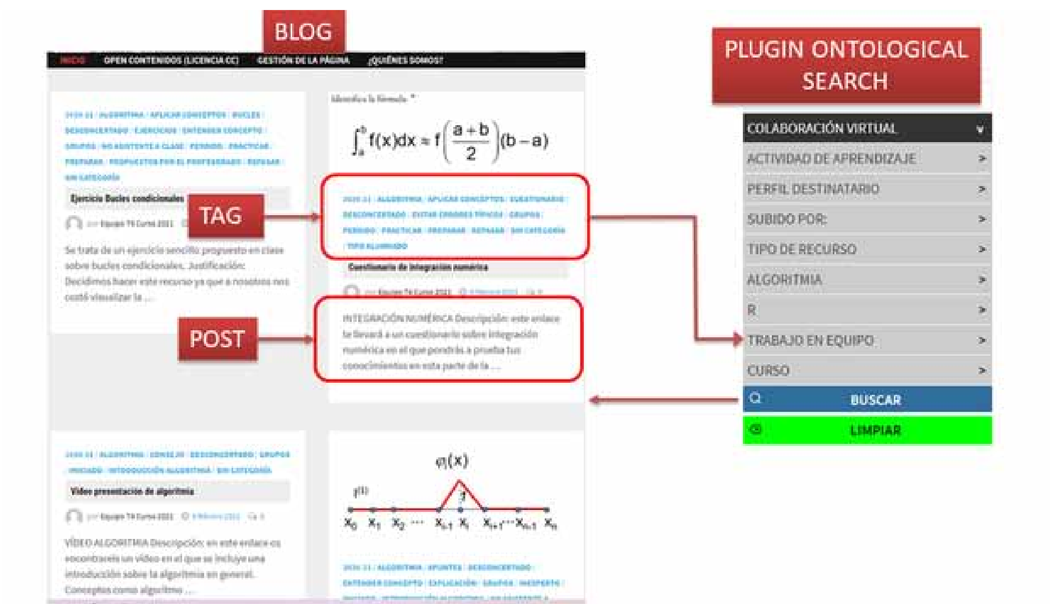
1. Methodology used during the course is an active methodology called MicroFlipTeaching (MFT), which promotes knowledge creation by the students (Sein-Echaluce et al., 2015b).
2. Students create knowledge in working groups. The teamwork method used is the CTMTC, which allows transparency in the individual participation of each member of the work team (Fidalgo-Blanco, 2015b).

Results of the repository, ontology and search engine of the technological platform used to support the ACCI 3.0 model are described below. The content management platform is Wordpress (WP), which supports more than 30% of the existing websites in the world, as well as 60% of the content managers: https://w3techs.com/technologies/overview/content_management/all.

This platform includes a self-developed plugin (Fidalgo-Blanco et al., 2018a) called “Ontological Search” (OS). OS is a search engine of the content manager with a semantic layer and, being a plugin, is transferable to any other context and training environment, allowing authenticated users to organize the shared information, generating the most appropriate folksonomy for the knowledge hosted in the repository.

Figure 2 shows the different parts of the knowledge repository uploaded by the students. The left part of the figure presents the entries according to the upload date. The last uploaded contents are the first to appear. The structure is very similar to the organization of posts in a blog or messages in a social network. The left side is the Wordpress document management system. The resources uploaded by the students are composed of two parts: the categories and the post. Categories correspond to the ontology classification which is defined in the course by the students themselves. The post is the content itself and it includes:

Figure 2 Knowledge repository



1. Description of the resource
2. Reason why the resource has been developed and the need for it
3. Recommendation for use
4. Quality control
5. Knowledge resource

Right part of figure 2 corresponds to the plugin developed to perform resource searches based on inferences from the different tags that make up the ontology.

Figure 3 shows the relationship between the search plugin and the Wordpress category and tag management system.

Figure 3 Search plugin and the Wordpress category and tag management system

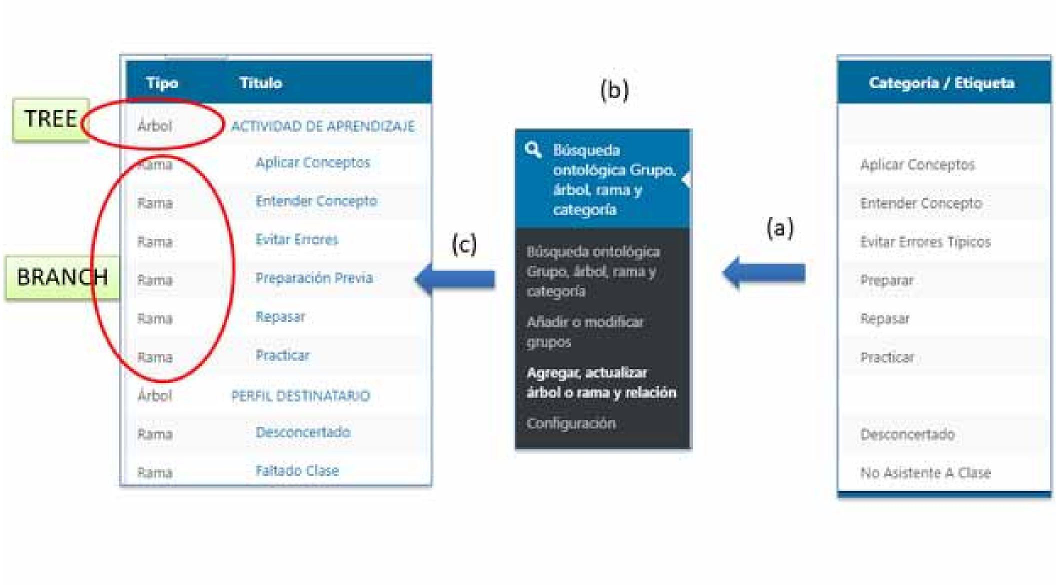


Figure 3-a represents the categories and tags that are incorporated into Wordpress. Categories are usually used to define a well-defined organizational structure and tags usually clarify and expand the classification based on a category. It could be said that categories represent the thematic blocks, for example, of a subject and tags provide specific information to learning resources that are within a category. For example, a knowledge resource may have the categories: Block1, Subject1 and the tags: video, teacher narrating the video and difficulty. Moreover (Figure 3-c), the developed plugin can also organize categories and tags hierarchically. The system does not distinguish between tags and categories, but allows to establish a hierarchy between them.

Hierarchies are:

Tree: It corresponds to the different groupings in which the resources of the subject will be classified. The groupings are the students' visions of the resources. For example, in this experience the students have defined, among others, the following groupings:

1. Learning activity
2. Students' profile for whom the resource is designed
3. Type of resource
4. List of topics for a subject

Branch: These are the labels that define each Tree (each category). Branches are the elements that make up the category, for example, in the case of the "SYLLABUS" tree, the labels would correspond to the different topics.

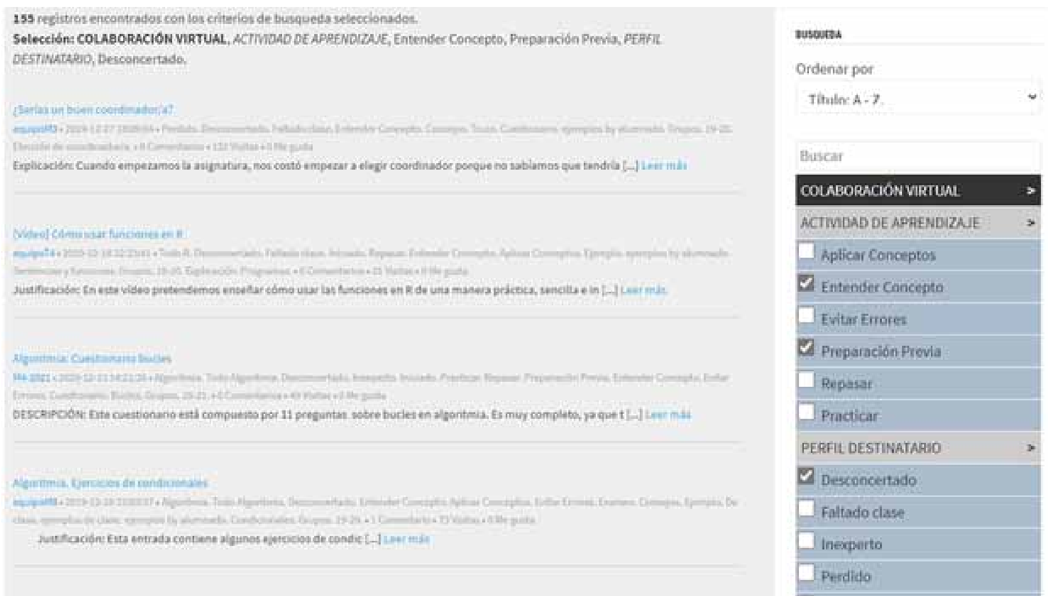
The developed plugin allows to relate Wordpress categories and tags with the trees and branches that compose the ontology. A branch can be assigned a single category or tag. This way of sharing allows Wordpress to work as a document manager and to use the corresponding categories and tags, and also allows the plugin to manage searches. Searches in Wordpress and other Web 2.0 systems allow you to search by text and by a tag or category. What the plugin does is to expand the possibilities of the search, allowing you to search by text + by a logical expression formed from branches (which correspond to the different tags). The operation defined for logical expressions is the following:

1. If they are labels of the same tree, then a logical expression with the "or" operator will be made between them.
2. If they are labels of different trees, then among the selected labels a logical expression will be made with the operator "and".

This search system is designed to serve situations where the learner does not know what content there is, or even the very content they want to search for. But they do know, for example, what they want to use it for. Figure 4 shows an example of a search:

To search for all resources that can be used to perform the learning activity "Understanding a concept" or "Prior preparation" and that the target profile is "Puzzled". As it can be seen in the Figure 4, the plugin has found 155 resources that meet these conditions. The search is recursive; that is, further refinement can be performed on that search, e.g., in figure 4-b a new tag corresponding

Figure 4 Example of a search



to the "Resource type" tree is added to the previous search. In this case the search would be: to search for all resources that serve to perform the learning activity using a specific type of resource, "Understanding a concept" or "Prior preparation" and that the target profile was "Puzzled" and that the type of resource was "Example provided by the learner". In this case the search was refined and the system found 29 resources.

The developed plugin is currently in a testing period and it is being used in subjects of 5 degrees belonging to three different degrees. By the end of 2021 the tests will be finished and the aim is to leave it as free software.

CONTEXT

This work has been carried out with students of the subject "Fundamentals of Programming", corresponding to the first year of the degree of "Biotechnology" of the Name of Institution. The academic year in which it has been carried out is 2019-2020. The two main specific competences of the subject are related to Numerical Calculus and the R programming language. The main generic competence is teamwork. The results of the teamwork are presented in the final exam of the subject, but its development is done during the course. The course is taught in 4 months. The system of teamwork is as follows: during the first two months, students form the team, decide the topic of the work (related to the specific competences) and receive training on the CTMTC teamwork method. During the other two months, the team members have to develop an ontology and upload the knowledge to the repository at the same time they create it. Therefore, the results of this research work are produced during the last two months of the course.

RESULTS

Sixteen work teams and a total of 97 students have participated in this research work. The repository where the results are organized, accessible and open, can be found at the following web address: http://trabajo-cooperativo.net/

Organization of this section is structured according to the data necessary to verify the achievement of the objectives of the work. Thus, we will start with the data for the identification of the folksonomy, continuing with the analysis of the type and amount of knowledge contributed by the students (based on the folksonomy) and, finally, we will show the survey on the perception of the usefulness of the collective knowledge.

Folksonomy

Folksonomy defines the process of defining the classification (ontology) of all the resources of a subject, but defined under the students' own vision. The students have defined two main groups: contents and learning. The content group has been subdivided into the most important specific and general objectives. This group is defined by Algorithm (corresponding to Numerical Calculus), R (to R programming language) and teamwork. As a result, this group has three subgroups.

Table 1 shows the ontology related to the content. The first row shows how students have grouped the class content. This corresponds to the different scoring blocks of the subject: Algorithm (lecture test), R (lab test) and Teamwork (score deliverable assignment). The second row identifies the grading for each block.

Table 1. Ontology Related To The Course Content

Algorithm	R	Teamwork
Conditionals First steps Loops Algorithms	Data structure Functions and Sentences Programs	Coordination Normative Mission Responsibilities Planning Execution Results

The learning process has been divided into three subgroups: the learning activity to which the created resource is associated, the profile of the resource recipient and the type of resource. Table 2 shows the classification defined by the learners for each subgroup.

1. Bewildered: This is the student who, although attending class and studying what has been taught in the classroom, is not able to understand the contents of the course.

Table 2. Ontology Related To The Learning

Activities	Addressee	Type of Resource
Apply Understand Avoid errors Prepare Review Practice	Bewildered Unexperienced Initiated Missed class Lost	Notes Advices Doubts Examples Exercises Surveys Interviews Errors Texts Explication Map Tricks Learnt lesson

The first column shows the students' view of the different learning activities they perform. It can be seen that, according to their vision, the subject has six learning activities.

The second column shows the learner's profile. This classification should be clarified because it is an interpretation of the students.

2. Inexperienced: is the student who has not studied yet the content and it has not been taught in class.
3. Initiated: the student has seen the content in class or in other courses, but has not studied yet it in depth.
4. Missed class: for students who have not attended class for any reason, or for students who have not taken yet the class.
5. Lost: Students who have not followed the lesson or course for some time, usually because they have found it too complex.

The third column shows the variety of types of resources that students work with. This is the broadest classification. All this classification was done in class, following large group and brainstorming techniques. When a student, or a group, created new knowledge to upload to the repository, a new discussion was opened to classify it. The teachers were in charge of taking notes and sharing them.

The classification was uploaded to the knowledge repository and the different columns of row 1 of tables 1 and 2 were called tree. The second row of each column of tables 1 and 2 was called a branch. Thus, for example, the "Addressee" tree has the branches Bewildered, Unexperienced, Initiated, Lost and Missed Class.

Content Uploaded by Students

This section will describe the number of contents uploaded by the students, as well as the most used branches. The students uploaded a total of 272 contents, which means an average of 2.8 contents uploaded per participating student in the research. The same knowledge can have several branches, but this classification allows us to know the preferences in the creation of knowledge by the students. The following is a breakdown of the amount of content uploaded according to the branches of the trees: learning, profile and type of resource. This option has been chosen because it presents a more general interest than the different contents of the course.

Tables 3, 4 and 5 show in the first column the type of knowledge uploaded to the repository in each branch; the second columns show the amount of knowledge uploaded for each branch.

Table 3. Type of knowledge and occurrences for the tree “student profile”

Profile	Number
Initiated	142
Unexperienced	76
Bewildered	74
Lost	65
Missing class	58

Table 4. Type of knowledge and occurrences for the tree “profile of learning activities”

Learning Activities	Number
Understand	96
Review	81
Avoid errors	70
Practice	61
Prepare	59
Apply	59

Table 5. Type of knowledge and occurrences for the tree “type of resource”

Type of Resource	Number
Explanation	81
Notes	66
Advice	57
Examples of students creation	54
Exercises of students creation	40
Class example	30
Errors	27
Test	24
Learnt lesson	18
Trick	14
Class exercise	13
Interviews	12
Questions	11
Surveys	3
Map	2

Perception of the Use of The Collective Knowledge Created

1. Q1: The resource I have created and uploaded has helped me to improve my knowledge of my own content.
2. Q2: Resources uploaded by my team have helped me to improve my learning.
3. Q3: Resources uploaded by other groups have helped me to improve my learning.

The questions belong to the Likert scale of 1-5, where 1 is "never" and 5 is "always".

Questions were asked to all students who participated in this research, but they were asked in two groups. One group consisted of the people who led the teams and the other group consisted of all the people who had not been leaders. On the one hand, out of a total of 16 possible "leaders" the survey was completed by 16 people, which means 100% of the leaders. On the other hand, out of a total of 81 participants in the experience who were not leaders, a total of 76 people answered questions Q1 and Q2 (93% of the participants in this group) and a total of 44 people answered question Q3 (54% of the total). The results are reflected in Table 6 for the people who acted as leaders and in Table 7 for the rest.

Table 6. Perception of the impact of the knowledge creation in the learning process. Leaders.

Leaders	Average	Deviation	N
Q1	3,938	0,771	16
Q2	4,312	0,478	16
Q3	4,125	1,024	16

Table 7. Perception of the impact of the knowledge creation in the learning process. No leaders.

No leaders	Average	Deviation	N
Q1	4,46	0,701	16
Q2	4,039	1,051	16
Q3	4,295	0,78	16

CONCLUSIONS

Objective 1. Regarding the Folksonomy

Students have created the classification of resources around two axes: the different evaluable blocks of the subject and the learning tasks performed in it. In the first axis, the evaluable blocks are specific to each subject and these will vary significantly for each of them.

In the axis related to learning, the students have used a classification that could be applied to very different subjects. The classification has been divided into three main groups: learning activities, type of created resource and recipient of the resource. Therefore, objective 1 has been met because the students have made a distribution that can be exported to any subject. In the case of content, to the evaluable blocks, and in the case of learning, it has been possible to export practically the entire classification (trees and branches).

Objective 2. Regarding the Type of Knowledge Created By The Learner

In terms of the target audience of the resources, the profile of the initiated student stands out first, i.e., the student body that attends class for the most part. As for the learning activities, most of the resources are related to the "Understanding a concept" and "Reviewing already acquired concepts" activities. This can provide information about the students' demands on the types of resources. Finally, in terms of the type of resource, the most important are those of an explanatory nature. These resources are very interesting because their objective is to acquire learning and the resource is associated with a strategy to explain it. Thus, the most common knowledge resource was the guideline *knowledge so that the students attending the class understand the different contents presented*.

Objective 3. Students' Perception of the Learning Acquired in the Creation and Use of Knowledge

All questions scored close to 5 (the highest), demonstrating that the creation and use of knowledge created by students influences their learning. It should be noted that the same trend of results has not been obtained for people who have been teamwork leaders as for those who have not. While for the leaders the most useful knowledge has been that created by the team, for the rest of the people it has been that created by themselves. As for question Q3 asked to the group of non-leaders, the significant difference in the answers to questions Q1 and Q2 should be studied.

FUTURE WORKS

There are three future working lines to be developed. The first is to verify scientifically the degree of exportability of ontology in other subjects, as well as the detail of the trees and branches that can be studied the most. Another line consists of looking for relationships between the created resources and the needs of the students in the subject. We will also analyze the resources that have strategies associated with them, such as the explanation of contents, since part of the learning could be modeled in a peer to peer format. Finally, we will study the reasons why the people who have acted as leaders have a different view of the impact of the created resources in the learning process. Leaders have placed a higher value on group knowledge, while non-leader participants have placed a higher value on individual knowledge.

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REFERENCES

Altinay, Z., Saner, T., Bahçelerli, N. M., & Altinay, F. (2016). The Role of Social Media Tools: Accessible Tourism for Disabled Citizens. *Journal of Educational Technology & Society*, *19*(1), 89–99.

Angelini, M. L., & García-Carbonell, A. (2015). Percepciones sobre la Integración de Modelos Pedagógicos en la Formación del Profesorado: La Simulación y Juego y El Flipped Classroom. *Education in the Knowledge Society*, *16*(2), 16–30. doi:10.14201/eks20151621630

Argelagós, E., & Pifarré, M. (2012). Improving Information Problem Solving skills in Secondary Education through embedded instruction. *Computers in Human Behavior*, *28*(2), 515–526. doi:10.1016/j.chb.2011.10.024

Ausubel, D. P. (1969). A cognitive theory of school learning. *Psychology in the Schools*, *6*(4), 331–335. doi:10.1002/1520-6807(196910)6:4<331::AID-PITS2310060402>3.0.CO;2-W

Bachnak, R., Maldonado, S.C. (2014). *A flipped classroom experience: Approach and lessons learned*. Academic Press.

Baker, J. W. (2000). Presentations - Classroom Flip. The Classroom Flip: Becoming the "Guide by the Side." *Eleventh International Conference on College Teaching and Learning*, 9–17.

Bergmann, J., & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. International Society for Technology in Education.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. David McKay Company.

Brahimi, T., & Sarirete, A. (2015). Learning outside the classroom through MOOCs. *Computers in Human Behavior*, *51*, 604–609. doi:10.1016/j.chb.2015.03.013

Bringuier, J.C. (2000). *Conversations libres avec Jean Piaget*. Academic Press.

Danker, B. (2015). Using Flipped Classroom Approach to Explore Deep Learning in Large Classrooms. *The IAFOR Journal of Education*, *3*(1), 171–186.

De Oliveira Fassbinder, A. G., Fassbinder, M., & Barbosa, E. F. (2015). From flipped classroom theory to the personalized design of learning experiences in MOOCs. *Proceedings - Frontiers in Education Conference, FIE*, 1–8. doi:10.1109/FIE.2015.7344146

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. The Macmillan Company.

Dewey, J. (1929). *Experience and Nature*. George Allen & Unwin, Ltd. doi:10.1037/13377-000

Fidalgo-Blanco, Á., Leris, D., Sein-Echaluce, M. L., & García Peñalvo, F. J. (2015b). Monitoring Indicators for CTMTC: Comprehensive Training Model of the Teamwork Competence in Engineering Domain. *International Journal of Engineering Education*, *31*(3), 829–838.

Fidalgo-Blanco, A., Martinez-Nuñez, M., Borrás-Gene, O., & Sanchez-Medina, J. J. (2017a). Micro flip teaching – An innovative model to promote the active involvement of students. *Computers in Human Behavior*, *72*, 713–723. doi:10.1016/j.chb.2016.07.060

Fidalgo-Blanco, Á., Sánchez-Canales, M., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2018b). Ontological search for academic resources. *ACM International Conference Proceeding Series*, 788–793.

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2014). Knowledge spirals in higher education teaching innovation. *International Journal of Knowledge Management*, *10*(4), 16–37. doi:10.4018/ijkm.2014100102

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2015a). Epistemological and ontological spirals: From individual experience in educational innovation to the organisational knowledge in the university sector. *Program*, *49*(3), 266–288. doi:10.1108/PROG-06-2014-0033

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2017b). APFT: Active peer-based Flip Teaching. *ACM International Conference Proceeding Series*.

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2018a). Learning and Collaboration Technologies. *Design, Development and Technological Innovation. Lecture Notes in Computer Science*, *10924*, 400–415. doi:10.1007/978-3-319-91743-6_30

Fidalgo-Blanco, A., Sein-Echaluce, M. L., & García-Peñalvo, F. J. (2019). The Neuro-Subject: A Living Entity with Learnability. *LNCS, 11590*.

Fidalgo-Blanco, Á., Sein-Echaluce, M. L., García-Peñalvo, F. J., & Sánchez-Canales, M. (2020). Validation of a Semantic Search Engine for Academic Resources on Engineering Teamwork. *International Journal of Engineering Education*, *36*(1), 397–408.

García-Peñalvo, F.J. (2011). *Capítulo 8: La Universidad de la próxima década*. La Universidad Digital.

García-Peñalvo, F. J. (2016). La socialización como proceso clave en la gestión del conocimiento. *Education in the Knowledge Society*, *17*(2), 7–14. doi:10.14201/eks2016172714

García-Peñalvo, F. J., Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & Conde, M. Á. (2016). Cooperative micro flip teaching. Lecture Notes in Computer Science, 14–24.

García-Peñalvo, F. J., Fidalgo-Blanco, A., Sein-Echaluce, M. L., & Sánchez-Canales, M. (2019). *Active peer-based Flip Teaching: An active methodology based on RT-CICLO*. IGI GLOBAL.

Hamdan, N., McKnight, P., & McKnight, K. (2013). *A White Paper Based on the Literature Review Titled a Review of Flipped Learning*. Academic Press.

IPMA. (2006). *ICB-IPMA Competence Baseline Version 3.0*. IPMA.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall, Inc.

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, *31*(1), 30–43. doi:10.1080/00220480009596759

Ma, T., Zhou, J., Tang, M., Tian, Y., Al-Dhelaan, A., Al-Rodhaan, M., & Lee, S. (2015). Social Network and Tag Sources Based Augmenting Collaborative Recommender System. *IEICE Transactions on Information and Systems. E98.D, 4*, 902–910. .10.1587/transinf.2014EDP7283

Mai, J.-E. (2011). Folksonomies and the New Order: Authority in the Digital Disorder. *Knowledge Organization*, *38*(2), 114–122. doi:10.5771/0943-7444-2011-2-114

Mann, R. P., & Helbing, D. (2017). Optimal incentives for collective intelligence. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(20), 5077–5082. doi:10.1073/pnas.1618722114 PMID:28461491

Mathews, M.R. (1998). *Constructivism in Science Education. A Philosophical Examination.* Academic Press.

Mazur, E. (2012). New interactive teaching techniques. *Harvard Magazine.* https://harvardmagazine.com/2012/03/twilight-of-the-lecture

Nonaka, I., & Hirotaka, T. (1995). *The Knowledge-Creating Company*. Oxford University Press.

Sein-Echaluce, M. L., Fidalgo-Blanco, Á., & Esteban-Escaño, J. (2019). Technological ecosystems and ontologies for an educational model based on Web 3.0. *Universal Access in the Information Society*, *18*(3), 645–658. doi:10.1007/s10209-019-00684-9

Sein-Echaluce, M. L., Fidalgo Blanco, Á., García Peñalvo, F. J. (2015a). *A repository of students' resources to improve the teamwork competence acquisition*. Academic Press.

Sein-Echaluce, M. L., Fidalgo Blanco, Á., García Peñalvo, F. J. (2015b). *Flip Teaching Methodololgy supported on b-learning and knowledge management*. Academic Press.

Sein-Echaluce, M. L., Fidalgo-Blanco, Á., & García-Peñalvo, F. J. (2016). Students' Knowledge Sharing to improve Learning in Engineering Academic Courses. *International Journal of Engineering Education*, *32*(2B), 1024–1035.

Sein-Echaluce, M. L., Fidalgo Blanco, Á., García Peñalvo, F. J. (2017). Trabajo en equipo y Flip Teaching para mejorar el aprendizaje activo del alumnado. *La innovación docente como misión del profesorado: Congreso Internacional Sobre Aprendizaje, Innovación y Competitividad*, 610–615.

Sinclair, J., Cardew-Hall, M. (2007). The folksonomy tag cloud: when is it useful? *Journal of Information Science*, *34*(1), 15–29. .10.1177/0165551506078083

Stein, J. (2016). Using the Stages of Team Development. *HR at MIT | Learning and Development*. Available: http://hrweb.mit.edu/learning-development/learning-topics/teams/articles/stages-development

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research*, *15*(2), 171–193. doi:10.1007/s10984-012-9108-4

Tuckman, B. W., Ann, M., & Jensen, C. (1977). Stages of Small-Group Development Revisited. *Group & Organization Studies*, *2*(4), 419–427. doi:10.1177/105960117700200404

Vygotsky, L. S. (1978). Interaction between Learning and Development. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind and Society: The Development of Higher Psychological Processes* (pp. 79–91). Harvard University Press.

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