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Technological ecosystems and ontologies for an educational model based on Web 3.0

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ABSTRACT

Active learning promotes knowledge creation as a learning strategy for students working both individually and cooperatively. Learning 2.0 supported by the Web 2.0 model is based on the idea that students are creators of resources that can be used by students and teachers. This work begins in a context in which active learning is used and a model 2.0 through which students create, share and use resources through different channels of a technological ecosystem. From this context, a framework 3.0 was developed and tested, based on the Web 3.0 model, in which all the resources generated by students and teachers are organised and classified through an ontology which can be transferred to other subjects. Moreover, a semantic search system was developed that operates by drawing inferences between the elements of the ontologies. The framework was validated in two groups respectively. One group was able to use the content they generated in real time, while the other group was only able to use content generated by students in previous courses. The result obtained was that both groups preserved the characteristics of learning in the 2.0 model, and the transition to the 3.0 model allowed better access to the knowledge created in the subject as well as an improvement in the searchability of resources. A relationship was also identified between model 3.0 and an improvement in students' grades.

Keywords: Active learning, Collective intelligence, Cooperative learning, Ontology, Technological ecosystems, Web 3.0

1. Introduction

The Web 1.0 model is accessed through a web portal and was designed using an approach similar to that of media design, with a unidirectional flow of information which is selected and organised by the content manager of each web server. A basic similitude exists between the Web 1.0 model and the classic learning model, as knowledge flows in only one direction (from teacher to students) and the knowledge selection and organisation is generated exclusively by the teacher. The ultimate expression of this model appears in e-learning systems, which are used in a similar way to online portals. From a simplistic point of view, teachers create, select and organise each learning object (LO) to give students access to it. In other words, the teacher acts as an author of the web page [1].

However, that information management methodology changes dramatically with the Web 2.0 model. In this model, information flows in a multidirectional way though the most important contributors are users, as they create, select and manage that information. The majority of the most-used tools on the Internet [2], such as social networks, blogs and wikis, follow the Web 2.0 model. As a result, platforms such as YouTube, Instagram, Facebook, Wikipedia and Twitter are employed daily by millions of users worldwide to exchange information in a social context.

Over the last few years, Web 2.0 tools have been used increasingly in educational contexts [2] and are used frequently in both innovation projects and traditional learning activities. E-learning systems such as Moodle [3] have become an important support system for traditional on-site learning and have evolved to include Web 2.0 functionalities such as forums, wikis, etc.

The Web 2.0 model when used in an educational context is termed Learning 2.0. This Learning 2.0 model, in which social networks are the most-used technologies [4], proceeds from the assumption that students are knowledge creators and that, as a result, that knowledge can and must be used during the training process. Therefore, students apply the LO created by the teacher and can also create other materials [5]. Previous research has shown that students can create, share, and employ a diverse range of materials [6]. Moreover, the academic value of those resources has been demonstrated, which means that teachers can use those resources as LOs for their teaching [7].

Learning 2.0 integrated improvements of Learning 1.0 in contents (teachers and students are allowed to create LO), and open technology (social networks) rather than proprietary technology as in the first generation of e-learning systems and new roles for teachers and students (now the teacher enriches the content created by students through proactive methodologies).

Moreover, the name Web 3.0 or ‘Semantic Web’ appeared as a consequence of the great quantity of information present on the Internet and the challenge of finding the right information for a given purpose. The main objective of this model is to give meaning to content, with the aim that an information search works as a kind of virtual personal assistant which selects and organises the information for the user [8].

In addition, the spread of Web 2.0 tools with the emergence of new and diverse technological devices, formats, and communication channels for the content make necessary the ability to integrate and manage information in order to share it. The technological ecosystems were born as a response to this need [9].

The Web 3.0 model includes the Semantic Web and the use of technological ecosystems. This represents a new challenge for education [10] in instituting the Learning 3.0 model. This drives to a direct impact on the roles of teachers such that [11] “Recognising that learning and relearning is increasingly taking place beyond formal education and training settings, at different times and locations, implies that the role of teachers will also have to evolve from dispensers of information and knowledge to facilitators and enablers of learning”.

Learning 3.0 adds a new dimension to the creation of LOs by students since cooperation between students [12] and active participation in their learning is considered [13]. All these things create an important increase in content and technologies around the subjects, as shown in previous research [7]. The integration of all the collected information over the available technologies is needed to give real meaning to that information [14].

As explained in the previous paragraphs, the objective of giving meaning to the information is suitable for content generated in a Learning 3.0 or Web 3.0 environment. While in Web 3.0 that meaning is framed globally in relation to all the information found on the Internet and for all its users, in Learning 3.0 the information is limited to that which can be considered as LOs in the context of a subject. Hence, users are teachers and students of a subject, and the information to which they need meaning given is the information generated by students and teachers of that subject.

In the context of data structure, the process of searching for relevant content would be easier if a single data structure existed in both Web 3.0 and Learning 3.0 [15]. However, this is difficult to achieve even within Learning 3.0 and in the same subject, as the technological ecosystems information is created in different formats and structures [16]. The key to giving meaning to the information and producing relevant search results lies in describing information through metadata [17] and an ontology that allows its conceptualisation [18]. Ontologies permit the description of concepts and their relationship [19] and can help students to find more accurate LOs to pursue their learning activities in a personalised way [20], because ontologies open the way to move from a document-oriented view of Knowledge Management to a content-oriented view [21]. Moreover, norms of logical inference are needed to make the search relevant [22].

The main objective of this research is to include a semantic layer which transforms a Learning 2.0 subject in a Learning 3.0 context. This allows measuring its impact against Learning 2.0 in terms of the learning method and the academic results. The specific objectives of this work are as follows:

- Suggest a conceptual framework for 3.0 that incorporates technological ecosystems, ontologies, and interplay between student-student and student-teacher;
- Establish an ontology that allows users to organise the knowledge of a subject according to the information gained from a technological ecosystem;
- Develop a software prototype suitable for any subject that allows management of the ontology;
- Develop a software prototype suitable for any subject that permits inferences to be drawn between the ontological elements. This allows getting relevant results for the implementation of academic activities;
- Make a quantitative analysis of the impact of framework 3.0 against the 2.0 model.

In the next sections the proposed framework 3.0 is introduced, then the context of the research, the instrument used, and the research method. Finally, the results of the research and the conclusions based on these results are presented.

2. Conceptual Framework: ACCI 3.0

The Learning 1.0 model has a unidirectional flow of data that emanates from teachers to students. It is the teacher who identifies, organises, and provides the LO and any other content.

This model is associated with the e-learning systems of software 1.0, as, for example, a web page where students can only navigate through the page or an e-learning platform on which students access the contents and resources index designated by their teachers. The learning 1.0 model is shown in Figure 1-a.

Tools in 2.0 are based on the idea that users are at the same time producers and receivers of knowledge. However, the option to use 2.0 tools in a 1.0 model is possible, as shown in Figure 1-b; for example, using a social network to send didactic resources to students. Although 2.0 tools are used, the information flow is unidirectional.

A characteristic of the Learning 2.0 model is that teachers and students create and share content suitable for use as LOs. Figure 1-c shows this model, in which the primary characteristic is a bidirectional flow provided by 2.0 tools. Moreover, the traditional 1.0 tools as e-learning platforms (for instance, Moodle), incorporate elements of the 2.0 model (chat, wikis, even social networks).

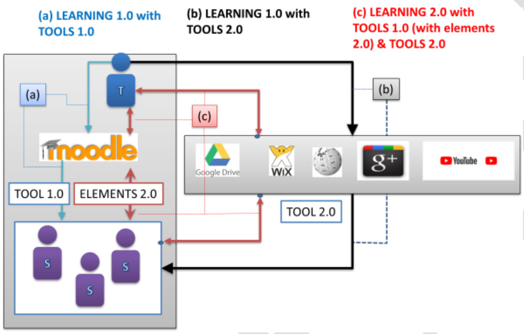

Fig. 1 Learning 1.0 Model Based on a Unidirectional Knowledge Flow and Learning 2.0 Model Based on the Bidirectional Flow of Knowledge

Previous research has introduced the ACCI (Active Cooperative Collective Intelligence) model, the objective of which is to generate a 2.0 framework for use in learning 2.0 [7]. This model includes active methods to promote the creation of knowledge on the part of students and technological ecosystems formed by 2.0 tools. Using this model the capacity of students to create, share, and use the knowledge generated by their peers was tested [23] as was the utility of this knowledge for LOs [24]. This model was applied with knowledge created by students in previous courses to the course in which the study was conducted [25], or with knowledge created by students during the development of the subject in which the study was conducted [7].

Those studies found that students identify the following as potentially problematic: the way resources are organised, how to relate the resources created by students through different technologies, and the difficulty in finding those resources with the available technologies. As a result, students also identified the necessary improvements based on creating a system which facilitates the organisation and searches for the knowledge created, as much for the students as for the teachers [7].

Based on those previous studies, this research incorporated into the ACCI framework a semantic layer to identify, classify, organise, and facilitate searches of the created content, as much for the students as for teachers. From a semantic point of view, the layer was composed of an ontology which included a motor to make inferences between its elements. From a technological point of view, the layer was composed of a knowledge management system and a browser which used as a search method the elements of the ontology and the inferences between them. This new framework is called ACCI 3.0.

2.1 Elements of ACCI 3.0

This proposed framework is suitable for any Learning 2.0 model with any technological ecosystem. To achieve this, it is necessary to build a semantic layer over the Learning 2.0 model, as shown in Figure 2. The following components of the semantic layer are included:

1. *Ontology*. This is defined as an ontology that allows classification and gives meaning to the content that flows through the learning ecosystem (see Figure 2-a);
2. *Repository*. A repository was created which allows management of the ontologies regardless of the thematic area, profile, and objectives of the educational context of the experience (see Figure 2-b);
3. *Inferences between the elements of the ontology*. An inference system was built between the elements of the ontology. Using this system, searches can be done which produce relevant results. This can be corroborated by the impact of the learning activities measured with respect to the Learning 2.0 model (see Figure 2-c);
4. *Meta-information*. Meta-information was added to the created content through the available technologies and then stored in the repository according to the created ontology (see Figure 2-d);
5. *Semantic search through the inferences between elements of the ontology*. A semantic browser was used to find content based on different approaches (syllabus, assigned activity, doubt, etc.) (see Figure 2-e).

With the objective of validating the proposed model in a particular experience, a university subject, an online development was made: a plugin for WordPress called 'Ontological Search'.

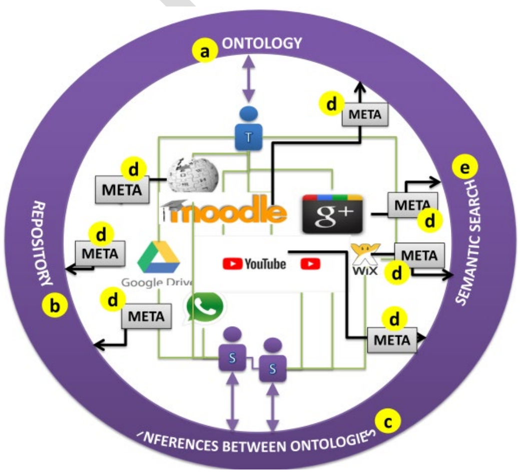

Fig. 2 Framework 'Active Cooperative Collective Intelligence 3.0'

2.2 Ontological Search

This plugin provides the content manager, the WordPress repository, with a semantic layer that allows the implementation of ACCI 3.0. In this way, the proposed framework is transferable to any other context and learning field.

The WordPress tool was chosen because 30 % of current web pages worldwide were created with this tool and, in terms of web pages worldwide which specifically involve a content manager, 60 % are built with [26].

WordPress allows the creation of pages and posts with a structure similar to that shown in Figure 3. A template web page (with similar characteristics to any web page) allows the user to add categories and labels managed by WordPress. In ACCI 3.0, video is a learning resource developed by a student along with text and meta-information associated with the resource. The categories and labels available in WordPress belong to a previously defined ontology.

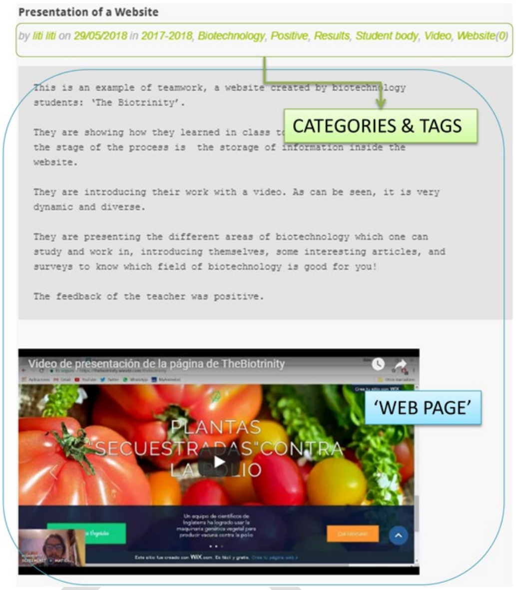

Fig. 3 Example of WordPress Page with Categories and Tags

The plugin 'Ontological Search' allows the creation of an ontology which defines the knowledge of a particular subject. Figure 4 shows the process. The plugin (Figure 4-b) describes a knowledge ontology (Figure 4-c) through the categories and labels available in WordPress (Figure 4-a). The ontology is formed by groups (In Figure 4, only one group 'TEAMWORK', is included). Each group could have different ontologies, because each organization has different ontological levels corresponding to the individual, the group and the full organization. In this example each group is composed of branches (In Figure 4, the branches are called 'Academic Year', 'Degree', 'Feedback', 'Resource', 'Source', and 'Stage'). Each branch is composed of a set of labels or categories available in WordPress. For the branch 'Feedback', the categories are 'Negative' and 'Positive'. An ontology can have 'n' groups, each group can have 'm' branches, and each branch can have 'p' categories and/or labels. In addition, hierarchy can exist between branches, labels, or categories.

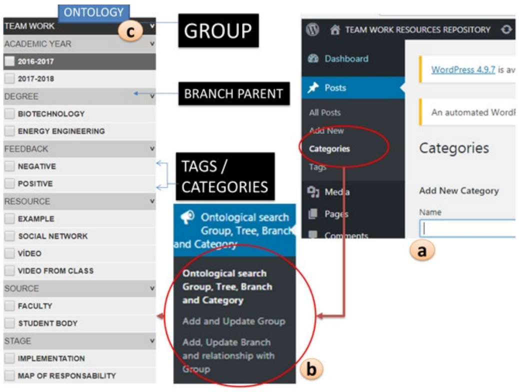

Fig. 4 Plugin 'Ontological Search'

The defined ontology could be used as a semantic system of searching through the inferences between the different elements that compose it. WordPress allows searches by category and label, using the selection of a single label. The plugin 'Ontological Search' facilitates searches by selecting several labels and computing logical expressions between them. By default, the inferences are made by logic 'or' between elements of the same branch and with logic 'and' between elements of different branches. Figure 5-a shows the results of a particular search. It can be observed that the inference between elements of the selected ontology provides a list of pages that fulfil the inference. The search is iterative, which means that elements can be added or subtracted in a list of results. Figure 5-b illustrates a search with more elements marked than in the previous case.

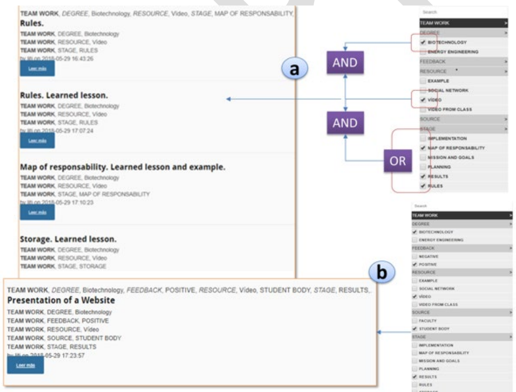

Fig. 5 Example of an Ontological Search

3. Context and Research Methodology

3.1. Context of implementation

ACCI 3.0 was used in the course 'Informatics and Programming' (IP), in the degree programme Engineering of Energy in the Technical University of Madrid. This course included a teamwork component, and over the last three years an active methodology was used to enhance the creation of content by students during teamwork activities. The content is created using a technological ecosystem composed of 2.0 tools. Therefore, a pre-existing context was in place in which, over the last two academic courses, students used a Learning 2.0 model; specifically, a Learning 2.0 model based on the bilateral flow of knowledge (see Figure1-c) in which the LOs have been created by teachers and students.

Students created the LOs in previous semesters or courses. In other words, during the course, students use resources created by other students and resources they generated themselves (teachers validated the publication of the resources), and those resources will in turn be used in the next course or in another subject. This is the basis of the ACCI model previously mentioned, in which the active methodology used is based on the idea that students must complete group activities online before class. In the class, every student works with their results, regardless of whether the results are correct. Teachers use positive or negative feedback as a learning method, by depending on the good or bad results used as model. ACCI promotes the use, creation, and sharing of content by students in a cooperative way.

3.2 Research methodology

The research was conducted during the 2017-18 academic year applying a quasi-experimental methodology. A control group (CG) and an experimental group (EG) were established. The control group generated resources for the next courses and subjects and used the materials of different students and courses. The experimental group not only generated resources, but also used them in real time during the exploration of their subject.

In this research, a semantic layer was added to the ACCI model. In other words, the proposed model ACCI 3.0 was applied. It managed all the resources generated by students, both in previous courses and in the present course. Figure 6 presents a schema of the research.

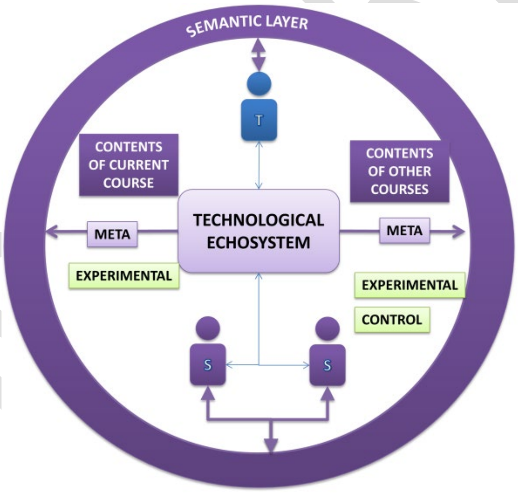

Fig. 6 Schema of the Research

The experimental group was composed of 66 students from one academic group and the control group was composed of 60 students from another academic group. Both groups used Moodle, Wiki, YouTube, Google Drive, web pages, and the semantic layer of WordPress. The experimental group also used the social network Google+.

The teamwork corresponding to the subject IP, that is, the object of this research, was conducted over the entire three-month duration of the course. The assessment of the teamwork was based on individual evidence (liability and involvement of each member of the team), group evidence (regulation, mission and objectives, planning, storage, and implementation), and the result of the work. Until the completion of the group phases (two months), the learning process was executed using Learning 2.0; in the final month, Learning 3.0 was applied, through the framework proposed in this work.

3.3. Measuring instruments

To measure the impact of using model 2.0 compared with the impact of using model 3.0, a set of quantitative tools was used.

Students completed a pre-test during the provision of the Learning 2.0 model concerning their perception of using the active methodology, and the impact of the academic results of model 2.0 was analysed. Students also completed a post-test after the implementation of the ACCI 3.0 model, and the impact of that model on the academic results was then analysed.

The pre-test and post-test contained a set of questions as described in the following.

3.3.1. Profile of the student

Nine questions were asked regarding the profile of the user:

Q1 - Anonymous identification. Use your birth date;
Q2 - Sex: (male, female);
Q3 - The highest course in which you are enrolled;
Q4 - Year of birth;
Q5 - I have chosen this degree in the position (option number);
Q6 - Entrance grade in the university;
Q7 - Is this the first time you have enrolled in this subject? (Yes/No);
Q8 - In the case of a 'no' answer, how many times have you been enrolled in this subject? (1, 2, 3, 4, more than 4);
Q9 - Indicate what average or superior studies you have previously studied to enter this degree (bachelor's degree, professional degree, etc.).

3.3.2. Question Q10: Students' perceptions of the active methodology

Q10 - Perception of the active methodology. Assess the extent to which you agree or disagree with the following questions (Likert scale: 1=totally disagree to 5=totally agree).

Question Q10 uses a validated tool to assess students' perceptions of the active methodology [27]. This question was used in both the pre-test and post-test for each group. It was nuanced with regard to the integration of the semantic layer into the methodology in the post-test so that students could identify the distinguishing element between Learning 2.0 and Learning 3.0. The model was used throughout the course. Moreover, it was contrasted to question 12, which concerned whether the creation of knowledge by students (the main characteristic of the Learning 2.0 model) was affected by the use of ACCI 3.0.

Some questions were included in the pre-test that were excluded from the post-test; for this reason, they have been deleted in the following list.

Pre-test:

Q10.1 - This learning methodology (online videos and discussion of the results in class) was useful to me in order to develop a better understanding of the content;
Q10.3 - The teacher helps me to understand the content;
Q10.4 - I think that this methodology lets me achieve the learning objectives;
Q10.6 - I like this system as an aid to learning;
Q10.7 - I am pleased with the teamwork;
Q10.8 - I have the perception of learning to work on a team after this experience.

Post-test:

Q10.1 - This learning methodology (online videos and discussion of the results in class organised in the repository) was useful to me in order to develop a better understanding of the contents;
Q10.2 - The teacher helped me to understand the content through use of the repository;
Q10.3 - I think that this methodology lets me achieve the learning objectives;
Q10.4 - I like this system as an aid to learning;
Q10.5 - I am pleased with the teamwork;
Q10.6 - I have the perception of learning to work on a team after this experience.

Six of the questions in the pre-test were repeated in the post-test but with different question numbers. Table 1 presents the number equivalence between pre-test and post-test.

Table 1 Equivalence between Q10 questions in Pre-Test and Post-Test

Question pre-test	Question post-test
Q10.1	Q10.1
Q10.3	Q10.2
Q10.4	Q10.3
Q10.6	Q10.4
Q10.7	Q10.5
Q10.8	Q10.6

3.3.3. Question Q11: Students' perceptions of the creation of content during teamwork

Question Q11 was about the Students' perceptions of the creation of content during teamwork:

Q11- Assess the extent to which you agree about the development of content during teamwork (Likert scale: 1=totally disagree to 5=totally agree).

Pre-test about the contents:

Q11.1 - They are elaborated in a cooperative way;
Q11.2 - A previous reflection was done before the elaboration;
Q11.3 - Decisions are taken in order to determine which content is going to be generated.

Post-test about the repository of contents (the use of repository has allowed…):

Q11.1 - New elaboration of the contents by my team;
Q11.2 - Reflection on the content elaborated by my team;
Q11.3 - Decision making about the contents by my team.

3.3.4. Question Q12: repository used to share resources

Question Q12 enquired about the repository used to share resources:

Q12- Assess the extent to which you agree about the repository used to share resources (Likert scale: 1=totally disagree to 5=totally agree).

Q12.1- I have a vision of the different resources in the repository;
Q12.2- I can recover the information quickly;
Q12.3- I think that the experience of surfing the repository was good;
Q12.4- I recommend using the repository for other subjects.

The pre-test does not include question Q12.4.

4. Results

One of the main objectives of this research was to measure the impact on learning of a method based on Learning 3.0 (ACCI 3.0) compared with Learning 2.0. The results measure the influence on learning results when an evolution was made from the Learning 2.0 model to the Learning 3.0 model.

In section 4.1, a study is elaborated regarding the homogeneity and equivalence between the control group and the experimental group. Section 4.2 explains the results regarding the transformation impact in terms of the active participation of students. Finally, section 4.3 reflects the results regarding the perceptions of students about the use of the semantic layer employed in the Learning 3.0 model.

Microsoft Excel was used to collate data and the statistical processing was conducted with R (version 3.3.2, 64 bits).

4.1. Equivalence and homogeneity of control and experimental groups

The students who participated in the control group and the experimental group were assigned by university management before the start of the subject. For this reason, it was necessary to establish two comparisons. The first comparison verified that people in each group were statistically equivalent. The second was produced during the learning process as it was necessary to test if both groups had the same scope of content.

To establish the equivalence between the control and experimental groups and the equivalence of the scope of content, the first nine questions of the questionnaire were used (Section 3.3.1). In both cases it was possible to prove that both the control group and the experimental group were equivalent [28]. Regarding the impact of the learning results, the results showed that the more difficulty was perceived in the knowledge the greater the difference was in the learning results in favour of the experimental group [28].

4.2. Change in the perception of the experimental methodology in the transition from the Learning 2.0 model to the ACCI 3.0 model

This section details the results regarding perceptions about the active methodology which provides the creation of LOs by students under the Learning 2.0 and 3.0 models.

Both the experimental group and the control group completed the same pre-test and post-test. They completed the tests before and after the procedure conducted with the experimental group. In the pre-test, 64 answers were collected from the experimental group, two of which were rejected as they were duplicates. In the post-test, 39 answers were collected from the experimental group, five of which were rejected as duplicates.

In order to match students in pre-test and post-test their birth date was requested. In the experimental group, it was possible in 29 answers to confirm that the participants were the same person in pre-test and post-test. In the case of the control group, it was possible to check that the participants were the same person in 36 answers.

The results obtained from the instrument in questions Q10 and Q11, detailed in section 3.3, will be analysed in the next section of this paper. The Q10 questions refer to aspects of the teamwork. The Q11 questions refer to the development of the essay in the course.

4.2.1 Q10 - Students' perceptions of the active methodology

Several tests were conducted using the data obtained from the Q10 questions on the two tests (Section 3.3.2). As a preliminary step, the normality of the distribution of probability of data was tested for the Q10 questions using a Shapiro-Wilk test [29], where W is the test statistic, and when the p-value is greater than 0.05 the distribution of probability is normal. The results obtained, displayed in Table 2, show that none of the questions has a distribution of probability of normal. The non-parametric statistic was used for the remainder of the data testing [30].

Table 2. Normality Test for Q10 questions

Question	Normality Shapiro-Wilk test
EG Pre-test	
Q10.1	W = 0.91159, p-value = 0.0003184
Q10.3	W = 0.90729, p-value = 0.0002175
Q10.4	W = 0.8927, p-value = 6.32e-05
Q10.6	W = 0.89111, p-value = 5.555e-05
Q10.7	W = 0.91575, p-value = 0.0004641
Q10.8	W = 0.89444, p-value = 7.29e-05
EG Post-test	
Q10.1	W = 0.90979, p-value = 0.008404
Q10.2	W = 0.86238, p-value = 0.001382
Q10.3	W = 0.89241, p-value = 0.002908
Q10.4	W = 0.8816, p-value = 0.001551
Q10.5	W = 0.81862, p-value = 5.998e-05
Q10.6	W = 0.90463, p-value = 0.006091
CG Pre-test	
Q10.1	W = 0.85968, p-value = 2.859e-05
Q10.3	W = 0.87663, p-value = 8.854e-05
Q10.4	W = 0.909, p-value = 0.0009655
Q10.6	W = 0.91732, p-value = 0.001889
Q10.7	W = 0.9105, p-value = 0.001088
Q10.8	W = 0.91128, p-value = 0.001158
CG Post-test	
Q10.1	W = 0.89098, p-value = 0.003133
Q10.2	W = 0.90797, p-value = 0.008632
Q10.3	W = 0.88933, p-value = 0.002849
Q10.4	W = 0.89195, p-value = 0.003315
Q10.5	W = 0.90156, p-value = 0.00585
Q10.6	W = 0.90076, p-value = 0.005575

Once the lack of normality of data was proved, the results of the pre-test and post-test were analysed. The non-parametric Wilcoxon signed-rank test was used [31][32] to determine if any significant difference existed between the mean of both samples. The obtained value V represents the sum of the absolute values of couples of elements in the samples. If a p-value was lower than 0.01 for a significance level of 99% or lower than 0.05 for a significance level of 95% [33], the mean values in the samples were different. In this case, the results of the pre-test and post-test in both the experimental and control groups were compared, though no statistically significant difference was found (see Table 3), with a significance level of 99% between the means of both groups between pre-test and post-test.

Table 3. Wilcoxon Test for Q10 questions

Question Pre-test	Question Post-test	Wilcoxon test
EG		
Q10.1	Q10.1	V = 182.5, p-value = 0.348
Q10.3	Q10.2	V = 243.5, p-value = 0.3507
Q10.4	Q10.3	V = 235.5, p-value = 0.2588
Q10.6	Q10.4	V = 190, p-value = 0.7153
Q10.7	Q10.5	V = 240.5, p-value = 0.09447
Q10.8	Q10.6	V = 263.5, p-value = 0.3135
CG		
Q10.1	Q10.1	V = 96.5, p-value = 0.7614
Q10.3	Q10.2	V = 65, p-value = 0.3689
Q10.4	Q10.3	V = 29.5, p-value = 0.1448
Q10.6	Q10.4	V = 61, p-value = 0.467
Q10.7	Q10.5	V = 77, p-value = 0.2934
Q10.8	Q10.6	V = 46, p-value = 0.1453

Next, to verify the degree of acceptance by students of the teamwork method, the mean and standard deviation (SD) of the answers to the Q10 questions in the post-test of the experimental group was computed with a sample of 34 students (see Table 4). A high grade of acceptance can be deduced between students because averages are over the 3 value.

Table 4. Mean and Standard Deviation of Q10 for Post-Test

Question	Mean	SD
Q10.1	3.235294	0.9865404
Q10.2	3.029412	1.0867046
Q10.3	3.088235	1.1110368
Q10.4	3.058824	1.1531558
Q10.5	3.911765	1.1643088
Q10.6	3.470588	1.1344547

4.2.2 Q11 – Students' perceptions of the creation of content during the teamwork

Following a similar procedure to that described above (see Section 3.3.3) for the Q11 questions, a normality test was computed using the Shapiro-Wilk procedure. The results of this test are shown in Table 5. In no case was the p-value greater than 0.05; thus, none of the three variables has a normal behaviour for the experimental or control group.

Table 5. Normality Test for Q11 questions

Question	Normality Shapiro-Wilk test
EG Pre-test	
Q11.1	W = 0.9081, p-value = 0.0002335
Q11.2	W = 0.89951, p-value = 0.0001113
Q11.3	W = 0.87119, p-value = 1.182e-05
EG Post-test	
Q11.1	W = 0.8372, p-value = 0.0001467
Q11.2	W = 0.86238, p-value = 0.0005362
Q11.3	W = 0.8993, p-value = 0.004396
CG Pre-test	
Q11.1	W = 0.89763, p-value = 0.0004015

Q11.2	W = 0.90792, p-value = 0.0008868
Q11.3	W = 0.85516, p-value = 2.141e-05
CG Post-test	
Q11.1	W = 0.82811, p-value = 0.0001164
Q11.2	W = 0.85139, p-value = 0.0003654
Q11.3	W = 0.84705, p-value = 0.0002934

As the previous results showed a lack of normality of the probability distribution for data, to verify if the opinions of students changed between the pre-test and post-test a non-parametric Wilcoxon signed-rank test was used. This test allowed the comparison of means in the results of the pre-test and post-test of the experimental and control groups for question Q11. No significant difference was found between the answers, with a significance level of 99%. The results are shown in Table 6.

Table 6. Wilcoxon Test for Q11 questions

Question Pre-test	Question Post-test	Wilcoxon test
EG		
Q11.1	Q11.1	V = 120, p-value = 0.8843
Q11.2	Q11.2	V = 170.5, p-value = 0.8343
Q11.3	Q11.3	V = 90.5, p-value = 0.08307
CG		
Q11.1	Q11.1	V = 66, p-value = 0.1295
Q11.2	Q11.2	V = 67.5, p-value = 0.6706
Q11.3	Q11.3	V = 76, p-value = 0.08528

To confirm the level of acceptance of the elaboration method of the task, the average of the 34 answers to the Q11 questions in the experimental group were calculated. The results are shown in Table 7. In each question, a high level of acceptance of the elaboration method by students could be observed, as the averages were higher than 3.4 for the three questions.

Table 7. Mean and Standard Deviation for Q11 questions

Question	Mean	SD
Q11.1	3.441176	0.8595692
Q11.2	3.705882	1.0597144
Q11.3	3.529412	1.1608590

4.3. Impact of the ACCI 3.0 model on academic results

Teamwork activities were conducted for three months. During the first two months, the group phases were generated, and during the last month the final task was completed. During the first two months, both the experimental and control groups learned with model 2.0. Previous studies [28] showed a contrast in the impact on learning between experimental group and control groups. Experimental groups achieved better academic results because the teachers of the experimental groups managed the knowledge generated by students during the learning of the subject, while in control groups the teachers did not perform that management [28].

In the final month of lessons in the IP subject, the Learning 3.0 model was used in both groups. The main difference was that the experimental group had access to the knowledge generated by the teaching of the subject, while the control group did not.

To analyse the influence of the 3.0 model on learning, the researchers analysed the relationship between the Q10 and Q11 questions of the post-test and the academic result. Two analyses were conducted, the impact on the assessment obtained during the learning using ACCI 3.0 and the relationship between the post-test and the grades.

4.3.1. The relationship between the academic results and the use of the browser by ontologies

To explore the influence of the students' answers to the Q10 and Q11 questions in the post-test on the qualifications obtained in teamwork, a linear correlation technique was used. As established in sections 4.2.1 and 4.2.2, the probability distribution was not normal. As a result, a unilateral Spearman correlation was used [34]. This test was used to find the relationship between the answers given for students in the experimental and control groups to the Q10 and Q11 questions and their marks. The marks used for comparison were those corresponding to the teamwork phase, during which the students were following the ACCI 3.0 model and the ontologies browser was used. In this test, a high positive correlation was found when a majority of students with a high qualification had a good opinion of the tool and a high negative correlation was found when a majority of students with a high qualification had a bad opinion of the tool.

The results for the experimental group are shown in Table 8, where the Rho value is the level of correlation between the variables. A correlation greater than 0.35 was considered significant [35]. S is the coefficient of Spearman and when the p-value was lower than 0.05 the correlation found was considered statistically significant. As can be observed in Table 8, four questions (Q10.2, Q10.5, Q10.6 and Q11.1) showed a high correlation between the score of the student and their answers. Question Q11.2 showed a low correlation which was not statistically significant, but was close to being statistically significant.

Table 8. Correlation Test between Questions Q10 and Q11 for the Experimental Group

Question	Rho	Spearman unilateral correlation test
Q10.1	-0.068470	S = 1421.1, p-value = 0.3871
Q10.2	-0.397944	S = 1859.3, p-value =0.04113**
Q10.3	0.196770	S = 1068.3, p-value = 0.2028
Q10.4	0.203125	S = 1059.8, p-value = 0.1952
Q10.5	0.550731	S = 597.53, p-value = 0.005927*
Q10.6	0.433042	S = 754.05, p-value = 0.02825**
Q11.1	-0.450187	S = 1928.7, p-value = 0.0232**
Q11.2	-0.327830	S = 1766, p-value = 0.07911
Q11.3	-0.081044	S = 1437.8, p-value = 0.3671
*Significant with confidence interval of 99% **Significant with confidence interval of 95%		

The results for the control group are presented in Table 9. As in the previous case, in order to find relationships between students in the post-test and the qualifications obtained during the month in which the experimental group was using the ACCI 3.0 model, a unilateral Spearman test was conducted using the answers of control group students to the Q10 and Q11 questions and their qualifications. As is shown in Table 9, there was no statistically significant correlation between qualifications and students' answers, as the p-values were greater than 0.05 for all the answers.

Table 9. Correlation Test between Questions Q10 and Q11 for the Control Group

Question	Rho	Spearman unilateral correlation test
Q10.1	0.059990	S = 5625, p-value = 0.3701
Q10.2	0.208142	S = 4738.5, p-value = 0.1225
Q10.3	0.067662	S = 5579.1, p-value = 0.3542
Q10.4	0.061982	S = 5613.1, p-value = 0.3659
Q10.5	0.119535	S = 5268.7, p-value = 0.2538
Q10.6	-0.166445	S = 6980, p-value = 0.1773
Q11.1	0.028516	S = 5813.4, p-value = 0.4374
Q11.2	-0.110196	S = 6643.4, p-value = 0.2708
Q11.3	0.035808	S = 5769.7, p-value = 0.4216

4.3.2. Comparison between CG and EG groups

Finally, the researchers analysed the differences between the academic result in the teamwork activity achieved by both groups during the teaching period when the ACCI 3.0 model was used. A T-student was used [36] to compare the mean qualification for both groups. Table 10 presents the relationship between both groups. The T value represents the difference between the statistic observed and one hypothetical parameter of the population in units of standard deviation. DF is the number of degrees of freedom of the same minus one, and the p-value indicates whether the result had statistical significance. A value below 0.01 indicated that the mean in the groups was different.

Table 10. T-student between Experimental Group and Control Group

	T	DF	p-value
Qualification	2.7502	57.281	0.003979**
**With confidence interval of 99%			

4.4. Perception about the use of the semantic layer – the searcher by ontologies

The next step was to analyse the questions referring to the use of a shared repository in the experimental and control groups (question Q12, section 3.3.4). The method was similar to that used in previous analyses. The first step was to test the normality of the data; the second step was to compare the answers in pre-test and post-test to find correlations between the qualifications and the answers; finally, the post-test results were compared between the experimental and control groups.

To check the probability distribution of answers to question Q12, a Shapiro-Wilk test was conducted. The results of this test can be found in Table 11. There was no case in which the p-value was greater than 0.05; thus, none of the variables had a distribution of probability of normal.

Table 11: Normality Test for Q12 questions in Pre-Test and Post-Test for EG and CG

Question	Normality Shapiro-Wilk test
EG Pre-test	
Q12.1	W = 0.90049, p-value = 0.000121
Q12.2	W = 0.87976, p-value = 0.00002263
Q12.3	W = 0.89038, p-value = 0.00005234
EG Post-test	
Q12.1	W = 0.89139, p-value = 0.002738

Q12.2	W = 0.81516, p-value = 0.00005104
Q12.3	W = 0.8562, p-value = 0.0003864
Q12.4	W = 0.88996, p-value = 0.002517
CG Pre-test	
Q12.1	W = 0.85243, p-value = 0.00001802
Q12.2	W = 0.80424, p-value = 0.000001099
Q12.3	W = 0.80037, p-value = 0.0000008943
CG Post-test	
Q12.1	W = 0.83493, p-value = 0.0001614
Q12.2	W = 0.87626, p-value = 0.001364
Q12.3	W = 0.91008, p-value = 0.009827
Q12.4	W = 0.91716, p-value = 0.0153

Because the previous result indicated a lack of normality of the data, to verify if there was a change in the perspectives of students between pre-test and post-test, a non-parametric Wilcoxon test was conducted.

Table 12: Wilcoxon Test in questions Q12 between Pre-Test and Post-Test

Quest. Pre-test	Quest. Post-test	Wilcoxon test
EG		
Q12.1	12.1	V = 163, p-value = 0.2163
Q12.2	12.2	V = 389.5, p-value = 0.0004499*
Q12.3	12.3	V = 231.5, p-value = 0.00874*
CG		
Q12.1	12.1	V = 256.5, p-value = 0.000122*
Q12.2	12.2	V = 272, p-value = 0.000185*
Q12.3	12.3	V = 372.5, p-value = 0.000003852*
*Significant with confidence interval of 99%		

In this case, as shown in Table 13, a difference was identified in the averages of most of the questions between pre-test and post-test of the experimental and control groups with a confidence level of 99% except in the question Q12.1 in the experimental group. That means that students in the experimental group had a more positive perception of the repository after the implementation of ACCI 3.0 for questions Q12.2 and Q12.3 and that students in the control group had the same positive perception for Q12.1, Q12.2, and Q12.3.

To analyse if there was a change in perception in the Q12 answers among the experimental and control groups a unilateral Wilcoxon test of average comparison was done. This test allowed researchers to determine if students in one group had a different opinion than students in the other group because the averages of the answers were tested to identify which was greater. The results of this test are shown in Table 13. In this test, a p-value lower than 0.05 indicated a statistically significant difference between averages. For this question, a significant difference was found, with a confidence interval of 95%, in question Q12.1. That indicates that students in the experimental group had a better understanding of what resources were contained in the repository than their classmates in the control group. For the rest of questions Q12.2, Q12.3, and Q12.4 their opinions were statistically equivalent.

Table 14. Comparison for Q12 questions between Experimental Group and Control Group

Question	Wilcoxon test
Q12.1	V = 232.5, p-value = 0.0258*
Q12.2	V = 124.5, p-value = 0.6763
Q12.3	V = 211, p-value = 0.08793
Q12.4	V = 179.5, p-value = 0.1997
*Significant with confidence interval of 95%	

5. Discussion

The main feature of Learning 2.0 is that the user is at the same time a producer and consumer of content [5]. Previous research proved that active methodologies draw the active participation of students. That means that students, in a subject with active methodology, create content that can be used as learning objects for that subject or for another [6]. If 2.0 tools are added to the active methodology the ACCI model is obtained [7].

In this study, a transition from the 2.0 to the 3.0 model was made. One of the first research questions was whether this transition would change students' perceptions of the main characteristic of the 2.0 model, which is the active participation of students in producing content.

The results obtained showed no significant differences between the 2.0 and 3.0 model for the experimental and control groups. These results confirm that the active model, in which students take an active part in the learning process, is considered more heavily in students' perceptions of learning change than the number of technological tools.

The results obtained in question Q11 in the pre-test and post-test showed no significant differences. That means that one of the indicators of the active methodology (student as resource generator) is not affected by the model change from 2.0 to 3.0.

Therefore, the conclusion can be drawn that the perception of the student's role in the creation, sharing, and use of the LO remains the same in model 3.0. There were no significant differences between the perception of the Learning 2.0 model and the 3.0 model in terms of the student's role in the creation and use of the content because both models follow the same active methodology. Some authors [12][13] consider active participation in the 3.0 model. This study corroborated this affirmation, with the caveat that the 2.0 model also presents this behaviour. Consequently, it is conserved in both models.

The results of the correlation between the use of the search engine by ontologies with respect to the qualification obtained confirm that the use of the repository as a tool provided by teachers is correlated with such qualification. The better the perception of use of the repository, the better the qualification gained. The experimental group, then, represents a defined relationship between the use of the repository and the results in their grades. Moreover, there was a correlation in the experimental group between the elaboration of content in a cooperative way and grades in the Learning 3.0 model.

In the control group, there was not a defined correlation between questions Q10 and Q11. The control group did not use content generated by classmates.

Thus, it can be concluded that in the Learning 2.0 model [28] as in the ACCI 3.0 model, the creation, management, and use of the resources created in a cooperative way during the development of the course must be considered as these elements have an impact on the academic result compared with the use of content generated in other courses or in different academic years Likewise, this conclusion is supported by the results of the comparison between the qualifications of the experimental and control groups; the experimental group achieved better grades than the control group with both models 2.0 and 3.0

Question Q12 indicates positive opinions among students in the experimental group and the control group about the use of the semantic layer as it obtained very high averages. The students indicated that the semantic layer allowed them to visualise the different kinds of resources available, that it allowed them to recover information very quickly, and that the surfing experience was good. This confirmed that the ontologies allow a visualisation of all the available resources even before conducting a search. The inferences between different ontologies facilitate rapid access to the resources and the system is easy to use.

In addition to the averages test, a comparison was made between the visualisation of different resources, ease of access, and ease of browsing between the Learning 2.0 and 3.0 models. For the control group, there were significant differences in three aspects, while for the experimental group there were differences in the ease of search and browsing. This is because the experimental group used a social network according to the 2.0 model in which labels were used to determine the locations of different kinds of resources.

If an ontology is used to classify the resources, a vision of the different kinds of resources is obtained regardless of whether one is using a Learning 2.0 or 3.0 model, however, to facilitate finding the resources and browsing through them, a Learning 3.0 model is necessary.

6. Conclusions

The proposed ACCI 3.0 framework allows the construction of a learning model 3.0 from a 2.0 model regardless of the 2.0 technological ecosystem used. The construction of the 3.0 model was accomplished by adding a semantic layer to the 2.0 model. The semantic layer organises the resources through an ontology and allows inferences between their elements to facilitate the search of contents.

The established ontology is valid for a wide range of subjects. It is only necessary to change the 'contents' group of the subject. In the researchers' ontology it is called 'Stage', as it refers to the different phases of teamwork.

The developed software 'Ontological Search' uses WordPress; consequently, it would be easy to use in another subject.

The study of the perceptions of students regarding the change from the Learning 2.0 to the Learning 3.0 model, with respect to the active participation of students, demonstrates that the perceptions of students about their role in the creation, comparison, and use of the LO is preserved in the Learning 3.0 model.

The analysis of the impact of the ACCI 3.0 model on the learning of the subject indicates that the positive perceptions of students about the use of the repository is directly proportional to the qualification obtained in the phase of teamwork where this model was applied.

Moreover, both the Learning 2.0 and the ACCI 3.0 models must be included in the creation, management, and use of resources by students in a cooperative way during the development of their own subject as this has a positive impact on the academic results of the learning.

The analysis of the semantic layer shows positive results in students' perceptions of their vision of the different resources available, ease of access, and ease of browsing. Therefore, it is proved that the semantic layer included in the ACCI 3.0 model brings advantages to the 2.0 model in terms of vision and the ability to search within the different resources.

Therefore, this work shows how the design of technology enhanced learning allows the definition of new roles for students and teachers from classic to the new learning framework 3.0. This proposal is oriented to technological ecosystems, with the teacher as a facilitator and the students as the creators of data/contents.

Future research should focus on how the repository can work with content distributed among the different technologies of the ecosystem and on the development of a neural network of repositories that allow content and ontologies to be shared between different subjects.

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