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Enhancing the main characteristics of active methodologies: a case with Micro Flip Teaching and Teamwork

Ángel Fidalgo-Blanco
Laboratory of Innovation in Information Technologies. LITI. Technical University of Madrid. Calle de Ríos Rosas 21, 28003 Madrid, Spain. E-mail: angel.fidalgo@upm.es

María Luisa Sein-Echaluce
Department of Applied Mathematics, University of Zaragoza, Campus Rio Ebro, University of Zaragoza. Calle de María de Luna 3, 50018 Zaragoza, Spain. E-mail: mlsein@unizar.es

Francisco J. García-Peñalvo
Computer Science Department, Research Institute for Educational Sciences, GRIAL research group, University of Salamanca, Faculty of Science - Plaza de los Caídos S/N. 37008 Salamanca, Spain. E-mail: fgarcia@usal.es

Abstract

All active methodologies have common objectives and processes. Their mission is to ensure that students participate actively in the learning process, cooperating with other students, reflecting, making decisions and creating knowledge. For this purpose, groups that work in a timely manner to carry out an activity or in a more stable way through work teams are usually formed. In both cases, active learning takes place within the groups. This work proposes fostering an active inter-team learning; that is, forming a meta-team where active learning takes place. The aim is checking if students who follow an active methodology, have the active habit; that is, if the work teams share knowledge among themselves and use it to improve their own knowledge. The proposed model contains a virtual layer that all teams can access, making possible the cooperation, the creation of new knowledge, reflection and decision making. This model is applicable to any active methodology and the proposed model has been applied to the Micro Flip Teaching methodology. This quasi experimental research methodology, based on quantitative and qualitative assessment, shows how the work teams, in an Engineering context, in this case, use this virtual layer and how that use impacts the academic performance of their members. Another conclusion of this work is that feedback must be included in active methodologies.

Keywords: Active methodology; Flip Teaching; Cooperative work; Feedback.

1. INTRODUCTION

The traditional academic learning is based on a set of activities previously programmed by the faculty and that students must perform. These activities are carried out in different physical and virtual scenarios. In some scenarios, the activities are related to knowledge. For example, in a classroom the master classes are usually taught, where teachers orally transmit knowledge and students must acquire that knowledge through the action of listening. In a different scenario, like a laboratory, the students handle instruments to apply the knowledge they have acquired in the classroom. Thus, each scenario contains specific knowledge actions with a different degree of student involvement. In a master class the students limit themselves to listening (students are considered “passive”) and in the laboratory, the students make decisions and learn through their acts (the students are considered “active”).

Many authors have shown that learning is more effective and efficient when the students’ involvement is higher, both from the emotional and cognitive points of view. Dewey [1], [2] links the "learning by doing" with the improvement of learning, precisely because more cognitive actions intervene than with the simple "listening". Other authors, such as Kolb [3]say that the learning cycle should start with a phase based on the active and continuous participation of the students.

The active process is the main support of the theory of constructivism, which fundament is that learning is produced by creating new knowledge from the background knowledge, through recombining both[4], incorporating social interaction [5]and interacting with the environment to facilitate students' perception of their close reality[6]. Therefore, cross-cutting elements can be considered in active learning, such as the creation of new knowledge, social interaction and interaction with the environment.

In addition to the theories that justify the advantages of active learning, there are other works more based on procedures and activities. Bloom highlights the creation and evaluation of knowledge[7] in his well-known Bloom's taxonomy, through different levels of cognitive activities directly related to the impact on learning. The more active students are, the more capacity for learning they acquire. The activities on knowledge creation and evaluation have the greatest impact on learning.

The active methodologies seek that most of the learning activities, which students must complete in a subject, imply an active participation for them. In this context, several authors present methods, processes and activities that are associated

with active methodologies. Cognitive processes such as action-reflection[8] or cooperative work[9] or activities based on working with real problems, the discovery of new knowledge, problem-solving, brainstorming, group discussion, puzzles, competitions, games, etc. [10]–[12]
Regarding the creation of knowledge, it can be created either individually or cooperatively. The active methodologies try to create knowledge in a cooperative way since if the act of creating is added with the one cooperating, the learning produced is much greater than just from one of these actions. Paavola & Hakkarainen[13] studied the relations between three metaphors of learning: knowledge acquisition, participation, and knowledge creation and they said that "one should distinguish a "trialogical" approach, i.e., learning as a process of knowledge creation which concentrates on mediated processes where common objects of activity are developed collaboratively. The third metaphor helps us to elicit and understand processes of knowledge advancement that are important in a knowledge society."

Currently, some active methodologies are already consolidated, such as problem-based learning, case studies, cooperative work, experiential learning or challenge-based learning. Other methodologies, such as Flip Teaching, have been adapted to become active. In the adaptation, called Micro Flip Teaching and proposed by Fidalgo et al.[14] and Peñalvo et al. [15], the "activity at home" includes activities based on the application of knowledge, to later work with their results (correct and incorrect) in the classroom. On the other hand, to ensure that students participate actively in the learning process, active methodologies usually use groups that work in a timely manner to carry out an activity or in a more stable way through work teams, with a planning to work.

All active methodologies have three common aspects:

1.- Cooperation and collaboration between students and teachers improve learning.

2.- Students must create knowledge.

3.- Students must make decisions that involve actions.

That is, there is cooperation (interaction), knowledge creation (knowledge construction) and decision making (or reflection), three aspects also identified in the constructivist theory, with processes and activities that involve an active participation. Thus, it is considered that these three aspects are common to any active methodology, to the characteristic processes and pedagogical theories in which it is framed.

But in any methodology, active or not, the feedback provided by teachers is a technique that improves learning and allows students and teachers to check it, as immediate as possible[16]. Therefore, any study on active methodology should include the role of feedback.

On the other hand, previous research [17] used a technological layer (a social network) with activities on a non-active methodology. They showed that the success of students actively participating in this social network, does not depend on technology nor on the contents to be shared nor on the model of active cooperation. However, a previous strategy of usage influences on students to get used to an active methodology.

This paper presents a conceptual model with two levels of abstraction. One that can be applied to any active methodology and another is applied to Micro Flip Teaching. This model proposes fostering an active inter-team learning; that is, forming a meta-team where active learning takes place. All teams can access a virtual layer that, making possible the cooperation, the creation of new knowledge, reflection and decision making. This model is applicable to any active methodology.

The current research also uses a technological layer but upper imposed on the active methodology Micro Flip Teaching. Therefore, the objectives of this work are the following:

- Demonstrate that the work teams share, with the rest of the teams, knowledge obtained from cooperation and reflection.
- Check if students, who follow an active methodology, have the active habit; that is, if the teams share knowledge and use it to improve the own.
- Assess the impact of cooperation between teams, regarding the learning outcome.
- Identify the relationship of feedback with active methodologies.

The following sections include the proposed conceptual model and the application context with the quasi-experimental methodology used to check the objectives of this research. Next, both qualitative results (perception survey) and quantitative results (through evidence such as participation and performance) will be included as well as the discussion and the conclusions.

2. CONCEPTUAL MODEL

As it is mentioned before, active methodologies are based on the creation of knowledge by students in a cooperative way. These two cognitive activities (cooperative work and knowledge creation) are carried out through the activities of work teams, such as brainstorming, debates, the creation of resources and decision making. In addition, it is said that teamwork is being carried out if the team remains stable during the implementation of the subject, if there are a planning of activities, an assignment of responsibilities, commitment and coordination, and the team's objective is to develop a product or service.

Thus, this model of the behavior of participants in an active methodology can be used for cooperation and creation of timely knowledge, in groups without planning the work overtime or implementing teamwork with a needed planning. In any case, the creation of knowledge and decision making are not shared out of the group or work team itself. Therefore, it can be said that the active methodology has a scope within each team since it is the context where cooperation, the creation of knowledge and decision-making take place.

This research is based on the "CI Sub-Model" model[17] which provides a channel so that, independently of the used active methodology, the students can share their own created resources (these resources are created by applying an active methodology or an active habit). This channel is supported by three pillars: content, technology and strategy. The contents are generated by the students, either individually or cooperatively (like in this study). The technology must allow to classify, organize, share and facilitate the use of the contents generated by the students. The strategy derivatives of the used active methodology, although the model can also work without any active methodology, it is enough for the students to have the habit of actively participating in their own learning process.

The CI Sub-Model is here adapted to an active methodology associated with a subject. The technological component is the same (social network Google +), the shared contents are created by the work teams, following the active methodology. The methodological point of view for the virtual layer is based on an active methodology (now the work teams share the information, instead of the people) and there is no strategy for the students to acquire the active habit because an active methodology is already used in the subject.

The proposed model presents two levels of abstraction: the first level (figure 1) is a model that can be adapted to any active methodology. It surrounds the methodology and connects with the flow of data generated by a work team (knowledge shared by each team) and with the resources generated by other teams that a specific team uses during its work (knowledge used by a team and generated by other teams). The second abstraction level (figure 3) shows the connections, type of knowledge and context of an active methodology with the knowledge shared by each team and the knowledge used by other teams.

2.1 First abstraction level

The first abstraction level of the model is based on adding an additional layer where each team shares with the rest of the teams the created knowledge. They also share the reflections about the shared knowledge, produced in each stage of teamwork. The rest of teams benefits by incorporating that experience into their cooperative activities. The inclusion of new resources, to the knowledge already created by the team, can produce a more active participation of its members. It provides a new spiral of active participation in students and increases the number of activities that can be considered active.

Figure 1 shows an overview of the first level. Each team creates knowledge cooperatively, makes decisions and generates new knowledge about the existing one (figure 1a). Each team shares the knowledge created in a cooperative way and the existing one (figure 1b). The knowledge, created by all teams, travels through a general highway (figure 1c) called, in this case, Internet (but it could be any other channel). Knowledge is organized in a learning community through common categories and labels (figure 1d) and finally, each team can use the created knowledge (after cooperation, reflection and decision making) to incorporate it, reflect or make decisions in their own team (figure 1e).

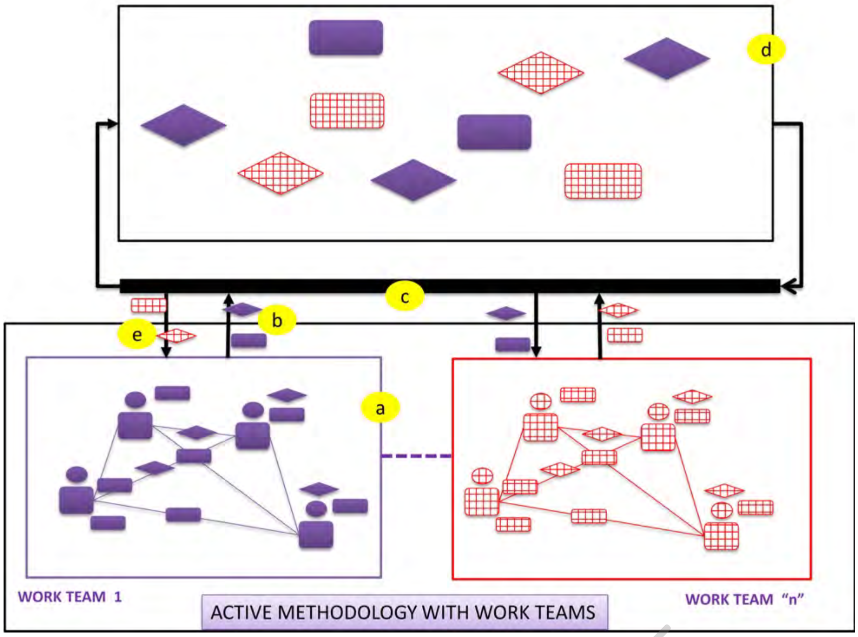

Figure 1. First abstraction level of the model

From a conceptual point of view, teams are the individuals and this first abstraction level is the common space used by this new team (the set of teams). The work teams can do among them the same active actions than the ones the members do in their team: create new knowledge from the existing one, do it in a cooperative way, reflect and make decisions. This model can be applied to any active methodology with working groups cooperating in a timely manner or in a more stable and planned way (work teams). Therefore, this level represents a generalist part of the model.

2.2 Second abstraction level

The second level of the model shows a deeper detail about the connection of the active methodology with the first level of abstraction. This second level (figure 2) connects with the first abstraction level (figure 1) and allows specifying the type of knowledge that can be shared, the context where it is shared (online or face-to-face) and the use of knowledge created by other teams.

Shared knowledge (knowledge created in a cooperative way and after reflection and decision-making) is included in the common knowledge space (figure 2a). In the case of cooperative actions or punctual actions (without planning) only the knowledge created in the current phase can be shared (figure 2b). In case of actions which are continuous over time, planned and coordinated through stages (like teamwork), knowledge could be shared in current phase (figure 2b), previous phase (figure 2c) and future phase (figure 2d).

During the face-to-face activity also, the social network can be used to share knowledge, but in this case, it is limited to knowledge in the current time, since that knowledge is used in the face-to-face session (figure 2e). This knowledge to be shared makes the model to be applied to a cooperative or a timely situation as well as to teamwork.

The shared space (figure 2f) is organized by categories and labels and the knowledge may correspond to the three times (previous, current and future). The team can use the knowledge shared by any other team and apply it to their own team (figure 2g) to change the result of each phase in the development of teamwork.

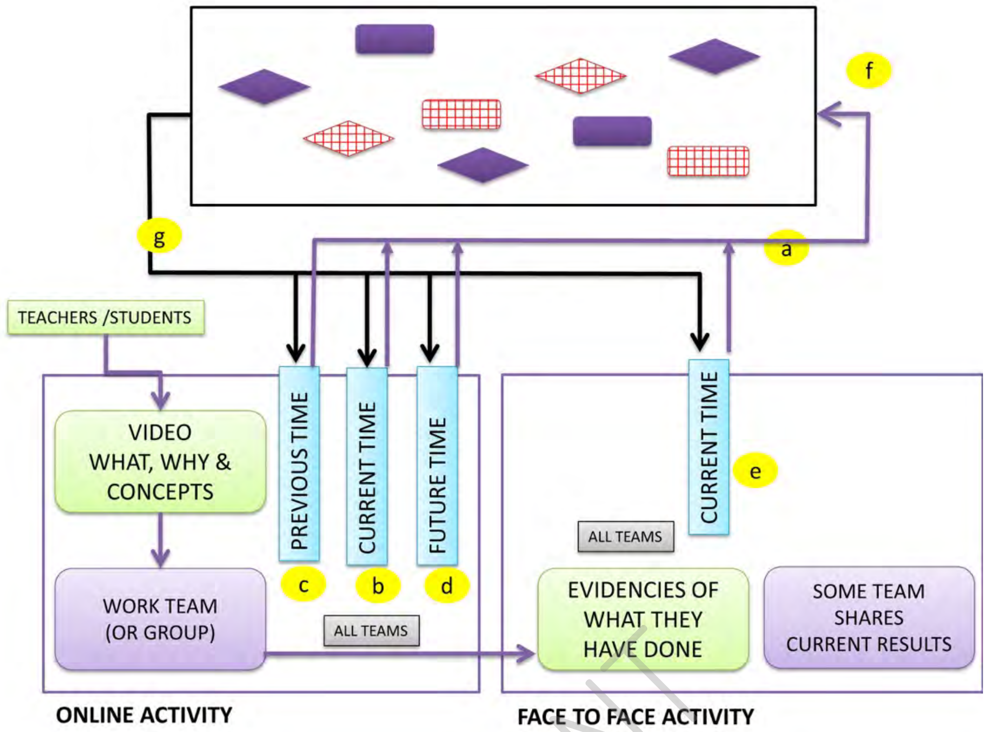

Figure 2. Second abstraction level of the model

3. RESEARCH CONTEXT

The research context was the subject of “Computer Science and Programming”, of the first course of the degree of Engineering of the Energy of the Technical University of Madrid. There are three teaching groups, two in the morning and one in the afternoon. The students of the afternoon group are formed mostly by grade repeated and they do not usually attend to face to face sessions. For this reason, that group has not been included in the research. The other two groups in the morning are very similar, EG has 12 work teams and CG has 11 teams, with an average of 6 people per team.

The result of the teamwork consists of a final product (very related to the subject) and partial resources (related to the different stages of the teamwork development). The final product (challenge, project, report or any other product) is usually used to assess the learning of the subject. To evaluate if the members of the work team have acquired teamwork competence, we use the knowledge generated in each teamwork stage.

The stages, also called phases, are a set of intermediate steps that a work team must perform in a cooperative, participatory and reflective way to organize their own work. For small work teams Tuckman[18] identified four stages (forming, storming, norming and performing). This method is widely used both in the engineering context at the university[19] and in companies through the International Project Management Association (IMPA) model [20]. Consequently, the Comprehensive Training of the Teamwork Competence (CTMTC) method [21], [22] is used for the training and evaluation of these stages through the analysis of individual and group evidence.

As mentioned before, the final result is knowledge specific of the subject where the research is being done, therefore the generated resources can be used as teaching resources in the same subject, but with very limited scope for transferability to other subjects. However, the knowledge generated in the teamwork phases is common to any planned cooperative action and, therefore, it is very likely to be used as a teaching resource in other subjects. For this reason, this research focuses on the learning of the phases, since in this way the results can be used in any active methodology where knowledge is generated in a cooperative way through work teams.

The active methodology included in this model is based on the Flip Teaching method. In most cases, this method simply transfers the passive activity of the students out of the classroom to be participatory and active in the classroom. The Micro Flip Teaching method (MFT)[14] incorporates processes that involve the active participation of students also outside the classroom. Therefore, it is an active methodology that occurs throughout the process (online and face-to-face) to incorporate the cooperative dimension in the “lesson at home”, the MFT method is applied to teamwork. Previous research shows that this method achieves an active participation of students through a set of evidence on cooperation and the creation of knowledge [15].

The scientific method considered in this paper is quasi-experimental because the academic groups are previously defined by the institution. For this reason, it is necessary to perform a statistical analysis (done in subsection 4.1) to determine the equivalence between the members of the control group (CG) and the experimental one (EG) with respect to the initial conditions of students. Different statistical tools are used, depending on the type of data to be compared, and they are included in each comparison table, as well as why they are used.

Subsection 4.2 studies the scope of contents; that is, if the members of EG and CG have received the same learning contents and if they have the same difficulty perception of them. The point is to find out if both groups are homogeneous in those aspects in order to validate the rest of results in the application of the new model. The method has already been used by several authors[23] and in other studies regarding teamwork competence [14][9].

In subsection 4.3 the use of the social network by students is quantitatively analyzed and subsection 4.4 includes the analysis of the academic performance through the final grades.

In both groups CG and EG the active methodology MFT is used and it is carried out during five sessions. Each session consists of an online activity and a face-to-face activity for 2 hours. The online activity is based on a video made by the teaching staff (it explains what to do, how to do it and the conceptual bases of a certain phase of the teamwork). Teams have an average of 15 days to do what is specified in the video and, after that period, all the teams participate in the face-to-face part of the session. In this face-to-face activity, the faculty selects two work teams (with correct and incorrect results), each team shows its results and a debate (cooperative learning) takes place under the guidance of the faculty.

4. RESULTS

This section includes the quantitative and qualitative results obtained from the evidence of the groups EG and CG. EG has 12 work teams and 70 students. CG has 11 teams and 67 students.

The results are grouped into four subsections and include the study of:
4.1. Homogeneity between the members of EG and CG before beginning the subject (necessary for the research)
4.2. Perception of the learning process for EG and CG
4.3. Use of the virtual layer (social network)
4.4. Impact on the learning of CG and EG

A survey, anonymous and optional, has been used to obtain the qualitative results. The questions of the survey correspond to a tool validated in previous works[9] and to a validated pre-test to evaluate the implementation grade of active methodologies [24].

4.1 Homogeneity of EG and CG

Nine questions of the survey have been used to check the homogeneity of groups EG and CG, in relation to the entry conditions of students (i.e. students' profiles before starting the subject). The questions are the following: Q1_Anonymous identification. Use your birthdate.
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_It is the first time you enroll this subject (Yes / No)
Q8_In the negative case, how many times have you been enrolled in this subject? (1, 2, 3, 4, more than 4)
Q9_Indicates what average or superior studies you have previously studied to enter this degree (bachelor degree, professional degree, etc.)

In EG 54 students answered the survey from 70 students (but there is one not valid) which makes a participation of 75,71% and in CG 41students of 67 which makes a 61.19% participation.
Q1 is not considered since it is an identification that protects the anonymity for later use of the survey.
Q8 is not processed since there has only been one response indicating that it is the first year that repeats

Table 1 shows the data for gender (female and male). A proportionality test was made in order to show that both groups had the same proportion of men and women: p-value = 0.0826 (> 0.01). This result shows that both groups are equivalent.

Table 1. Q2- Gender

Q2	Female	Male
EG	64.2%	35.8%
CG	80.5%	19.5%

In table 2 the answers to Q3- "the highest course where you are enrolled" are included. The answers correspond to the options: first course and second course. The option "first year" corresponds to the highest percentage. A proportionality test was made in order to show that both groups had the same proportion: p-value = 0.3766 (> 0.01). This result shows that both groups are equivalent.

Table 2. Q3- The highest course where you are enrolled

Q3	First course	Second course
EG	98.1%	1.9%
CG	100%	0%

Question Q4 represents the year of birth, it has been grouped into two options since all the students were born either in 1998 or in 1999. Table 3 shows that the highest percentage corresponds to the year 1999. A proportionality test was made in order to show that both groups had the same proportion of the year of birth: p-value = 0.423 (> 0.01). This result shows that both groups are equivalent.

Table 3. Q4- Year of birth

Q4	1998	1999
EG	11.3%	88.7%
CG	17.1%	82.9%

In table 4 more than 50% of students express that they have chosen the degree in the first option and around 75% in the second one. There is full agreement between the first two options (column 2 and column 3).

Table 4. Q5- In what position you have chosen this degree?

Q5	First	Second	Third	Fourth or more
EG	52.83%	26.42%	9.43%	11.32%
CG	53.66%	24.39%	12.20%	9.75%

The Shapiro-Wilk normality test has been applied and for the EG as well as the CG, the entrance grades have a normal distribution. The t- comparison test between EG and CG yields a p-value of 0.2664 (> 0.01), therefore it can be affirmed that the university entrance grades between EG and CG are equivalent (table 5).

Table 5. Q4- Entrance grade

Q6	Mean	Deviation
EG	10.01	1.17
CG	9.69	1.56

Question Q7 asks if it is the first time you enroll this subject. Table 6 shows that the highest percentage corresponds to the answer Yes. A proportionality test was made in order to show that both groups had the same proportion of First enrolment (yes): p-value = 0.253 (> 0.01). This result shows that both groups are equivalent.

Table 6. Q7- Is your first enrolment on this subject?

Q7	YES	NO
EG	100%	0
CG	97.6%	2.4%

Table 7 indicates the students' background in EG and CG. Most students come from Bachelor's degree, except two students with a different option. A proportionality test shows that both groups are equivalent with respect to their background: p-value = 0.854 (> 0.01).

Table 7. Q9- Academical Background

Q9	Bachelor's degree	Other
EG	98.1%	1.9%
CG	97.6%	2.4%

4.2 Perception of the learning process

The second group of variables (question Q11 and Q12 of the survey) is intended to measure the process of teaching the subject. In this case, it concerns the students' perception about the difficulty and the methodology performed. It is important to measure the perception of the difficulty for each phase of teamwork in order to contrast the impact of learning in both groups CG and EG. The questions Q11 and Q12 are the following:

Q11- Indicate the level of difficulty of the teamwork phases. Likert scale (1 very easy to 5 very difficult). Q12- Creation of contents in the work teams. Likert scale (1 totally disagree to 5 totally agree)

54 students of EG filled out the survey (77.14%) and 41 students of CG (61.19%). Firstly, the Shapiro-Wilk normality test was applied and in all the results, for both groups, a p-value <0.01 was obtained. Therefore, the samples do not have a normal distribution.

Table 8 shows the students perception of the effort to do the teamwork (results of Q11). Each row represents a phase of teamwork. The columns include the phase, the mean and deviation for EG and CG and the p-value (comparison of two samples unpaired by the Wilcoxon test). The p-value is higher than 0.01, then the results are equivalent for both groups.

Table 8. Perception on the difficulty of teamwork phases

Phase	Mean EG	SD EG	Mean CG	SD CG	p-value
Forming	1.49	0.89	1.32	0.72	0.2095
Normative	2.64	0.90	2.61	0.80	0.8831
Mission	2.79	1.01	2.78	0.89	0.9646
Map	3.19	0.90	3.65	0.89	0.4537
Schedule	3.5	0.97	3.29	1.03	0.2921
Execution	3.47	0.91	3.83	0.89	0.05313

With the results of question Q12, the perceptions about the activities of the active methodologies are checked. Table 9 shows the main activities of the active methodologies through question Q12, cooperation to create knowledge (row 2), reflection before the creation of knowledge (row 3) and decision making to create knowledge (row 4). The columns include the activity, the average and deviation of EG and CG and the p-value obtained by comparing two unpaired samples using the Wilcoxon test. The p-value is higher than 0.01, then the results are equivalent for both groups.

Table 9. Characteristics of the active methodology

Characteristics	Mean EG	SD EG	Mean CG	SD CG	p-value
Cooperative creation of knowledge	3.35	1.00	3.51	1.07	0.5328
Reflection previous to the creation of knowledge	3.47	0.99	3.56	1.02	0.6614
Making decisión to créate knowledge	3.77	0.97	4	0.80	0.3404

4.3 Use of the social network

The work teams of the EG can freely use the social network, through individual users (team members) or with a generic user for the team (39 individual users and 8 team users). Table 10 shows the total number and percentage of people who sign up with their own profile and those who have put the generic name of the team. As well as the number of contributions made for each type of profile.

Table 10. Users and contributions in the social network

Profile	Users	Contributions
Individual user	39	30
Team user	8	37

The type of resource used is to obtain feedback from the team; that is, either a specific doubt or the knowledge generated in each phase. There are no contributions or reflection between teams. Only the interaction has been with the teachers.

This section analyzes the contributions made by each team regarding the different phases of teamwork that will be evaluated. Not all teams have made contributions in all phases. The contributions are shown in table 11, whose first column includes the total number of phases where the teams have provided some resource and the second column includes the percentage of teams that have contributed.

Table 11. Contributions in the phases of the teamwork

Number of phases with contributions from teams	Teams with contributions

5	16.67%
4	33.33%
3	25%
2	16.67%
1	0%
0	8.33%

Regarding the second level of abstraction, using the model with the MFT methodology, all the knowledge uploaded to the virtual layer has been done outside of the face-to-face activity; that is, it was used while the activity was being carried out at home. Realizing a follow-up of the map of responsibilities (space where the teams place the responsibility of each member) it can be seen that all the participating teams (except one) have assigned the task of following up on the social network.

The types of contents that has been shared between students in the social network have been the following:

- Doubt included by student and solved by everyone.
- Doubt with its solution, both included by the same student.
- Examples solved by students to explain some topic
- Exercises proposed by faculty and solved by students
- Examples of mistakes with their corrections, that students have been obtained from the faculty's feedback
- Students' requests of complementary material

4.4 Learning impact

The evaluation consisted of analyzing the results of the following phases of teamwork: normative, mission and objectives, map of responsibilities, schedule and execution phase. The evaluated phases are the following: Norming, Mission, Map, Schedule and Execution. The final grade of each phase (scored on 10 points) is common to each member of the team, since it is based in the final products of the team. The phase of Forming has not been considered because the groups are freely formed, and the members of each team choose a coordinator, this phase is therefore not evaluated CG has 67 students and 11 teams and EG has 70 students and 12 teams, with an average of 6 members per team. Table 12 shows the mean and deviation of the grade obtained in each phase of EG and CG. In some cases, the grades are similar, such as in normative and mission phases. However, this first analysis is not valid since it does not show the real impact of using the virtual layer (CG do not use it).

Table 12. Grades per each phase of teamwork

	Norming		**Mission**		**Map**		**Schedule**		**Execution**	
	Mean	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**
EG	7.20	1.14	4.80	1.14	5.34	1.88	5.29	2.59	3.76	2.94
CG	6.85	1.03	4.39	1.27	3.96	1.56	3.64	1.53	1.37	1.64

The use of the virtual layer (social network) is optional, therefore each team has used it in one or several specific phases, (a team has never used it). Thus, to calculate the true impact, EG is divided into two subgroups: the teams that have used the virtual layer and those that have not. Each team can use the virtual layer during one phase and not in another phase. For this reason, the sample size is variable for each phase.

It has been verified that the obtained grades do not follow a normal distribution and a nonparametric technique bilateral Wilcoxon test was used to verify the equivalences. Tables 13, 15, 17, 19 and 21 correspond to the following values of each phase: the first column is for the group (Group), followed by the name of the phase. The teams correspond to these groups: the experimental group using the virtual layer (EGVL), the experimental group not using the virtual layer (EGnoVL) and the control group (CG). The second column is the average value of the grades, the third column includes the deviation of grades and the fourth column (n) the size of the sample. Tables 14, 16, 18, 20 and 22 include the p-value for each phase between CG (second column) and EGVL (first row) or EGnoVL (second row). If p-value> 0.01 there is equivalence and there is no equivalence in other cases.

In the case of Normative phase, there is the equivalence of CG with both subgroups of EG. This is explained because Normative was the first phase carried out and therefore it was worked with during two class sessions and most of the groups obtained feedback from faculty. This is the only phase without feedback in the virtual layer, since every included resource was previously reviewed.

Table 13. Grades of the phase Normative

Group/ Normative	Mean	Deviation	n
EGVL	7.29	0.90	41
EGnoVL	7.07	1.41	29
CG	6.85	1.03	67

Table 14. Equivalence between EGVL and EGnoVL with respect to CG for the phase Normative

EG / Normative	Equivalence CG (p-value)
EGVL	0.01861
EGnoVL	0.4585

There is equivalence between EGnoVL in the Mission phase with CG and there is no equivalence between EGVL and CG. The difference of grades (shown in table 15) is greater for EGVL.

Table 15. Grades of the phase Mission

Group/ Mission	Mean	Deviation	n
EGVL	4.91	0.84	59
EGnoVL	4.19	2.09	11
CG	4.4	1.26	67

Table 16. Equivalence between EGVL and EGnoVL with respect to CG for the phase Mission

EG / Mission	Equivalence CG (p-value)
EGVL	0.003035
EGnoVL	0.6669

It can be observed that there is equivalence between EGnoVL in the Map phase with the control group and there is no equivalence between EGVL. The difference of grades (shown in table 17) is greater for EGVL.

Table 17. Grades of the phase Map

Group/Map	Mean	Deviation	n
EGVL	6.17	1.23	36
EGnoVL	4.47	2.06	34
Control	3.96	1.56	67

Table 18. Equivalence between EGVL and EGnoVL with respect to CG for the phase Map

EG /Map	Equivalence CG (p-value)
EGVL	2.03e-09
EGnoVL	0.3262

In this case (Schedule phase) there is no equivalence with any experimental group, since as shown in Table 19 the sample for EGnoVL is very small and all the students belonged to the same group.

Table 19. Grades of the phase Schedule

Group/ Schedule	Mean	Deviation	n
EGVL	5.69	2.21	65
EGnoVL	0.0	0.0	5
CG	3.64	1.53	67

Table 20. Equivalence between EGVL and EGnoVL with respect to CG for the phase Schedule

EG / Schedule	Equivalence CG (p-value)
EGVL	2.746e-08

EGnoVL	0,0001586

Finally, there is equivalence between EGnoVL in the Execution phase with CG and there is no equivalence between EGVL (that used the virtual layer) with CG. The difference in grades (as can be seen in Table 21) is greater for the EGVL. It is the most significant difference of all obtained in the rest of phases.

Table 21. Grades of the phase Execution

Group/ Execution	Mean	Deviation	n
EGVL	6.4	1.03	30
EGnoVL	1.77	2.34	40
CG	1.37	1.64	67

Table 22. Equivalence between EGVL and EGnoVL with respect to CG for the phase Execution

EG / Execution	Equivalence CG (p-value)
EGVL	2.22e-15
EGnoVL	0.5038

5. Discussion

The results of this research, obtained from two groups with proved equivalence in the initial conditions (section 4.1), give information on the proposed objectives in the introduction. The work teams create and share knowledge with the rest of the teams (section 4.3), after a process of cooperation, reflection and making decisions (section 4.2). The teams share knowledge and use it to improve the own, but they prefer to receive feedback, not giving it. Finally, there is a direct impact of cooperation between teams on the grades obtained during the learning process (section 4.4).

The main purpose of the virtual layer in the proposed model was that the teams had an active participation among them, in this way the active participation prolongs out of the work teams. From the analysis of the use in the social network, it is possible to confirm that the teams have shared knowledge (91.67%) and more than 50% of the teams have included resources in the virtual layer in four or five phases (the maximum). The creation of knowledge in a cooperative way is preceded by reflection and making decisions, such as all students' perceptions confirm in section 4.2. All are characteristics of active methodologies[3]and other authors have taken into account in their works, creation [4][13],cooperation [9] , reflection and making decisions [8] . On the other hand, the direct impact of cooperation between teams on the grades obtained during the learning process confirms previous studies on the advantages of "learning by doing" [1], [2]

But the objective of the inclusion of resources for students has not been to cooperate with each other but to obtain feedback on what they have done (from the analysis of the resources uploaded to the virtual layer). Teams have not given feedback to test of teams, the teacher has done it. This fact shows that the teams looked for receiving feedback rather than giving feedback to other teams.

Feedback is necessary for learning to occur[16] and it is usually obtained from the evaluation process in passive methodologies. There are authors who link the evaluation process to the feedback, as an only strategy[25]. In the active methodologies, according to what students are demanding in the virtual layer, the feedback must be continuous because the teams produce constantly content and they need to receive feedback.

On the other hand, in previous studies with passive methodologies, for students to use the virtual layer to perform cooperative learning, it was necessary for teachers to follow a strategy to create the habit among the students. This strategy was carried out in the classroom [26], but it is possible that also in this study a strategy is needed to create the habit of actively using the virtual layer.

6. Conclusions

This research allows to prove that the proposed model enhance the main characteristics of active methodologies by the inclusion of a virtual layer to the methodology of an academic subject (active or not). It allows the work teams to enhance the characteristics of active methodologies (cooperative creation of knowledge after reflection and making decisions). In this case, the model is formed by a version of the model FlipTeaching (i.e., MFT), a cooperative methodology to follow the acquisition of the teamwork competency (i.e., CTMTC) and a social network for the virtual layer.

The teams are willing to share knowledge, but not to follow active learning among the teams. The virtual layer of the proposed model allows meeting the demand of students for continuous feedback to the progressive creation of knowledge in the work teams. But it also allows teachers to observe the real and continuous learning situation of teams in order to improve the feedback provided. The study shows that it is necessary to include feedback on the characteristics of active learning: content creation, cooperation and decision making.

The use of the virtual layer (with feedback) directly impacts on teams' grades. On the other hand, the method CTMTC, used in this research, has been shown as a very good tool to follow and evaluate the learning progress of the teams and of each of their members. Thus, suppose that this cooperative method will allow checking the impact of the virtual layer on the individual grades.

The most perceived difficulty of the knowledge to create with the difference in the impact of learning. The least complex phase (normative) does not present differences in the learning impact between EG and CG and the highest differences between both groups occur in the most complex phase (execution, for example).

Several lines of study are opened after this work: the relationship between active methodology and the perception of difficulty for the knowledge which is acquired, the impact of this proposed model in the academic performance of the individuals (once the impact on the teams' performance has been proved), the frequency of use of feedback in active methodologies and whether working with an active methodology is enough for acquiring active learning habits.

This research work is transferable to any subject that promotes active participation among students, and that allows, on the one hand, to manage, transfer and use the knowledge resources that each student creates as a result of the active methodology. The greatest effort to achieve the objectives of the project is based on creating an active and cooperative habit among the students, so the effort should be focused on the strategy to create that habit.

On the other hand, for those subjects where teamwork is used as a part of the active methodology, the proposed method allows to create a channel of communication between the teams to share the new resources generated by their members. In both situations, the system guarantees that teachers and students obtain feedback from the creation of knowledge by students.

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REFERENCES

[1] J. Dewey, *Experience And Nature*. London: George Allen & UNWIN, LTD, 1929.
[2] J. Dewey, *Democracy and education; an introduction to the philosophy of education :* New York: The Macmillan Company, 1916.
[3] D. A. Kolb, *Experiential learning: Experience as the source of learning and development*, vol. 1. Englewood Cliffs. New Jersey: Prentice-Hall, Inc, 1984.
[4] J.-C. Bringuier, *Conversations libres avec Jean Piaget*. Paris.
[5] L. Vygotsky, "Interaction between learning and development.," *Mind Soc. Harvard Univ. Press.*, pp. 79–91, 1978.
[6] D. P. Ausubel, "A cognitive theory of school learning," *Psychol. Sch.*, vol. 6, no. 4, pp. 331–335, Oct. 1969.
[7] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. k. Hill, and D. Krathwohl, "Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain," in *Taxonomy of educational objectives: The classification of educational goals. Handbook I:* , New York, New York, USA: David McKay Company., 1956, pp. 201–207.
[8] C. C. Bonwell and J. A. Eison, *Active learning : creating excitement in the classroom*. School of Education and Human Development, George Washington University, 1991.
[9] M. L. Sein-Echaluce, A. Fidalgo-Blanco, and F. J. García-Peñalvo, "Students ' Knowledge Sharing to Improve Learning in Academic Engineering Courses," *Int. J. Eng. Educ. (IJEE)*, vol. 32, no. 2B, pp. 1024–1035, 2016.
[10] "Honey and Mumford — University of Leicester." [Online]. Available: https://www2.le.ac.uk/departments/doctoralcollege/training/eresources/teaching/theories/honey-mumford. [Accessed: 01-May-2018].
[11] D.W. Johnson, R.T. Johnson, and K.A. Smith, *Active Learning: Cooperation in the College Classroom*. Edina: Interaction Book Company, 1998.
[12] "Phil Race — University of Leicester." [Online]. Available: https://www2.le.ac.uk/departments/doctoralcollege/training/eresources/teaching/theories/race. [Accessed: 01-May-2018].
[13] S. Paavola and K. Hakkarainen, "The Knowledge Creation Metaphor – An Emergent Epistemological Approach to Learning," *Sci. Educ.*, vol. 14, no. 6, pp. 535–557, Aug. 2005.
[14] A. Fidalgo-Blanco, M. Martinez-Nuñez, O. Borrás-Gene, and J. J. Sanchez-Medina, "Micro flip teaching – An innovative model to promote the active involvement of students," *Comput. Human Behav.*, vol. 72, pp. 713–723, 2017.

[15] F. J. García-Peñavo, A. Fidalgo-Blanco, M. L. Sein-Echaluce, and M. A. Conde, "Cooperative Micro Flip Teaching," in *Learning and Collaboration Technologies. LCT 2016. Lecture Notes in Computer Science*, vol. 9753, I. A. Zaphiris P., Ed. Springer, Cham, 2016, pp. 14–24.

[16] A. W. Chickering and Z. F. Gamson, "News Seven Principles For Good Practice in Undergraduate Education A Focus for Improvement," *Washingt. Cent. News*, 1987.

[17] A. Fidalgo-Blanco, M. L. Sein-Echaluce, and F. J. García-Peñalvo, "Micro Flip Teaching with Collective Intelligence," in *Learning and Collaboration Technologies. LCT 2018. Lecture Notes in Computer Science*, I. A. Zaphiris P., Ed. Las Vegas: Springer, Cham, 2018.

[18] B. W. Tuckman, "Classics for Group Facilitators Developmental Sequence in Small Groups'," *Psychol. Bull.*, vol. 63, no. 6, pp. 384–399, 1965.

[19] J.- Stein, "Using the Stages of Team Development," *HR at MIT | Learning and Development*. [Online]. Available: http://hrweb.mit.edu/learning-development/learning-topics/teams/articles/stages-development. [Accessed: 20-Sep-2016].

[20] IPMA, "ICB-IPMA Competence Baseline Version 3.0," p. 212, 2006.

[21] L. Dolores, A. Fidalgo, and M. L. Sein-Echaluce, "A comprehensive training model of the teamwork competence," *Int. J. Learn. Intellect. Cap.*, vol. 11, no. 1, pp. 1–19, 2014.

[22] L. D. Fidalgo-Blanco A, G.-P. F. Sein-Echaluce ML, and F. J. García-Peñalvo, "Monitoring Indicators for CTMTC : Comprehensive Training Model of the Teamwork Competence in Engineering Domain," *Int. J. Eng. Educ.*, vol. 31, no. 3, pp. 829–823, 2015.

[23] G. S. Mason, T. R. Shuman, and K. E. Cook, "Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course," *IEEE Trans. Educ.*, vol. 56, no. 4, pp. 430–435, Nov. 2013.

[24] M. J. Rodríguez-Conde, F. J. García-Peñalvo, and A. García-Holgado, "Pretest y postest para evaluar la implementación de una metodología activa en la docencia de Ingeniería del Software. (Technical Report GRIAL-TR-2017-007).," Salamanca, 2017.

[25] F. Grimaldo-Moreno and M. Arevalillo-Herráez, "Metodología Docente Orientada a la Mejora de la Motivación y Rendimiento Académico Basada en el Desarrollo de Competencias Transversales," *IEEE-RITA*, vol. 6, no. 2, pp. 70–77, 2011.

[26] A. Fidalgo-Blanco, M. L. Sein-Echaluce, and F. J. García-Peñalvo, "APFT: Active peer-based Flip Teaching," in *ACM International Conference Proceeding Series*, 2017, vol. Part F1322.

BIOGRAPHIES

María Luisa Sein-Echaluce is Director of Virtual Campus and Professor of Applied Mathematics in the School of Engineering and Architecture at the University of Zaragoza. She is principal researcher in the "Research and Innovation Group in Training supported by Information and Communication Technology" (GIDTIC, Spanish abbreviation). She is President of the Scientific Committee of the International Conference of Learning, Innovation and Competitiveness (CINAIC, Spanish abbreviation) and sits on evaluation committees for calls for local innovation projects and for international conferences. Her research currently focuses on the application of technologies to cooperative methodologies and usage of Open Source LMS and other tools for online adaptive learning.

Ángel Fidalgo-Blanco is Director of the Laboratory for Innovation in Information Technology at the Polytechnic University of Madrid and has participated actively as principal investigator in R&D projects. He has organised seminars and conferences over many years and is currently President of the organising committee for the International Conference of Learning, Innovation and Competitiveness (CINAIC, Spanish abbreviation). His work as an active researcher in educational innovation, knowledge management, educational technologies and educational communities based on social networks has generated numerous publications and information products.

Francisco J. García-Peñalvo completed his undergraduate studies in Informatics at the University of Salamanca and the University of Valladolid and his PhD at the University of Salamanca. He is a full professor and the head of the GRIAL research group (Research Group on Interaction and eLearning) at the University of Salamanca. His main research interests include eLearning, Computers and Education, Adaptive Systems, Web Engineering, Semantic Web and Software Reuse. He has led and participated in more than 50 research and innovation projects and was Vice-Chancellor Innovation at the University of Salamanca between March 2007 and December 2009. He has published more than 300 articles in international journals and conferences and has been guest editor of several special issues of international journals, including Online Information Review, Computers in Human Behaviour and Interactive Learning Environments. He is also a member of the program committee of several international conferences and is a reviewer for several international journals. He is currently coordinator of the Education in Knowledge Society PhD Programme at the University of Salamanca.