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TOOLS TO CORRECTLY EVALUATE THE INDIVIDUAL CONTRIBUTIONS IN A TEAM WORK

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Generally speaking, coordinated team work presents better results than when the work is done individually or individually distributed. However, this does not mean that the contributions of each team member are equal, which has special relevance in educational environments where teachers should evaluate the quality of both the collective and the individual contribution to the team work. This study, which is part of the innovative educational project EQUIPA'T supported by the ICE-UPC, presents the processes taken to select tools allowing teachers to individualize the work in group's grade in those subjects including the team work transversal competence. Three different tools are selected for some specifications or functionalities typically observed in team work in classrooms (i.e. group's selection or creativity among others) ranging from dynamization activities to gamification and through current virtual project management applications among others. These tools, in addition to the associated performance indicators, allow teachers to have a clearer picture of the individual implication and contributions of students in a team work scenario.

Keywords: Team work; Teaching innovation; Projects

SELECCIÓN DE HERRAMIENTAS PARA FACILITAR LA EVALUACIÓN INDIVIDUAL DEL TRABAJO EN EQUIPO

El trabajo en equipo tiene resultados más relevantes cuando es coordinado que cuando hay distribución del trabajo o que cuando se realiza de forma individual. Aun así, las aportaciones de cada miembro no siempre son equitativas, cosa que tiene especial relevancia en entornos educativos dónde se pretende evaluar el trabajo y las contribuciones tanto grupales como individuales. Este estudio, que se enmarca dentro del proyecto de innovación docente EQUIPA'T de la ICE-UPC, presenta el proceso de selección de herramientas que permitan, al profesorado de asignaturas que incluyan la competencia transversal de trabajo en equipo, poder individualizar, en cierta medida, la nota grupal. Se seleccionan tres tipos de herramientas para distintas especificaciones o funcionalidades típicas del trabajo en equipo en las aulas (i.e. selección de grupos o creatividad entre otras) que van desde actividades de dinamización hasta la gamificación pasando por recientes aplicaciones virtuales de gestión de proyectos. Dichas herramientas, junto con los indicadores asociados, permitirán al personal docente tener una imagen más clara de la implicación y contribuciones individuales del estudiantado dentro del trabajo en equipo.

Palabras clave: Trabajo en equipo; Innovación docente; Proyectos

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1. Introduction

Since ages, working together has shown greater achievements than the individual work (Adesina et al., 2022). Newton already said in the XVII century that "if he had seen further it is by standing on the shoulders of Giants"(Chen, 2003), highlighting the value of other's work so he could reach a new stage of knowledge.

Even though this fact is acknowledged by most of people, when the moment comes to take it into practice, all kind of problems arise, such as conflicts between members derived from unequal implication and/or communication (Lantz, Ulber, & Friedrich, 2020) or the resistance to work in groups (Wong, Kan, & Chow, 2022). In fact, it is not strange that the failure of projects comes more because of problems related to teamwork rather than from technical issues (DeMarco & Lister, 2013).

For this reason, Engineering studies at the *Universitat Politècnica de Catalunya* (UPC) count with the development of the transversal competence of "teamwork" in different subjects through the 4-year courses. This competence has 3 levels of mastery divided in:

1. First contact with the competence, where the student should reach the expected goals of the group having clearly marked directives from the teacher.
2. The second level differentiates from the first one mainly because the teacher is just guiding, not directing the team's work, who has to take most of the decisions on their own (Keim et al., 2015).
3. This last level aims that groups work autonomously, being able to work "alone". In this level is when the acquisition of soft skills like leading and coordination should be most relevant.

Nonetheless, the implementation of this competence in the classes is uneven and left freely to the teacher's own responsibility to decide how to apply it. As a consequence, is not strange that teachers find difficulties in how to implement it, in how to evaluate it and even in how to solve teamwork problems that might arise within the groups of students they deal with (Strom & Strom, 2011).

Trying to solve these issues and to homogenize and spread some good practices, the ICE-UPC funded and launched the innovative educational project EQUIPA'T. The project works in 22 subjects from several Master and Bachelor's degrees in two technical schools (ETSEIB and ESEIAAT) involving 19 teachers and around 1800 students.

The first step of the project was to identify the main necessities that teachers identified as urgent to solve concerning teamwork in educational framework, presented in a previous work (Tejedor et al, 2022)).

Trough applying tools to cover these necessities, the EQUIPA'T project aims to reach a change in the attitude of students in front of the teamwork (Freeman, 1996), to generate motivation to develop the group's project allowing to increase the knowledge and abilities of transversal skills and, in particular, of teamwork. Moreover, the use of Project Based Learning (PBL) during most or the totality of a subject has proven to increase the teamwork skills in addition to acquire the necessary knowledge (Melguizo-Garín et al., 2022). The EQUIPA'T project uses rubrics to measure and correlate the development of transversal skills, teamwork in particular, with the project execution. Nonetheless, there are other factors that might interfere, such as groups' dimensions (Casquero-Modrego, Núñez-Andrés, & Iniesto-Alba, 2022) or their heterogeneity/homogeneity (Thomas, 1999). In any case, work-in-group activities have an inherent difficulty, which is the individualization of the final grade within the group, as it is known that not everybody will work with the same intensity and will learn the same things but all group

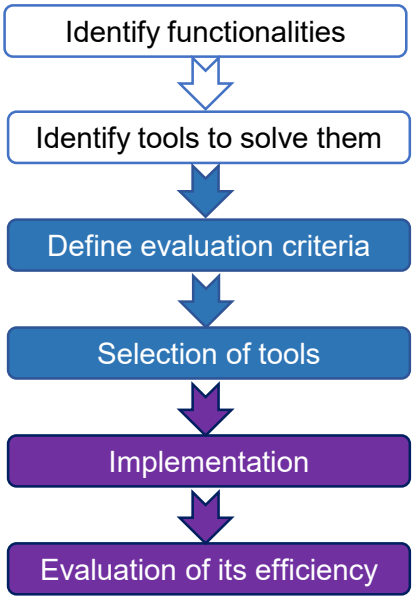
members should reach, at least, a minimum threshold.

The second step of EQUIPA'T, which is what this study presents here, concerns the selection of these tools that allow teachers to implement and evaluate the work-in-group's grade in those subjects including the teamwork transversal competence. These tools, in addition to the associated performance indicators, allow teachers to have a clearer picture of the individual implication and contributions of students when PBL methodologies are applied for most or all the subject.

2. Methodology

As mentioned already in the introduction, there are 19 teachers involved in the EQUIPA't project that teach in 18 subjects. The work with students began in September 2021 and will end together with the final evaluations of the current course in June 2022. Some of the subjects repeat among semesters and others don't but, in any case, the first semester was dedicated to the identification of needs and tools (Figure 1 white boxes) and to the selection of those that are useful (blue boxes in Figure 1, which is the process and results this study presents) while the second semester is the one in which teachers put in practice the agreements fixed after the first half of the course and to evaluate the results (purple boxes in Figure 1).

Figure 1: Project's steps



Note that, for the implementation phase, not all the teachers should implement the same tools and activities, as subjects differ in the number of students, the number and size of groups and the follow-up and feedback that the teacher is capable to do, as it is clearly not the same to manage a 7 student's subject like in the optional "Agile methodologies & processes for the creation of innovation solutions" from the Master degree in Industrial Engineering or a 60 student's mandatory subject "Aerospace Project Management" from the Master degree in Aerospace Engineering (both subjects taught at ESIAAT).

For this reason and also because different tools could serve to present different performance indicators, three different tools were selected per each necessity or functionality identified during the previous phase (except for the repository, as there is no need to use 3 at a time). These functionalities, classified as designed to evaluate (E) or to enhance collaboration (C),

are described in Table 1.

Table 1: Functionalities desired

Functionality*	(Description)
Evaluation of the individual contribution in the teamwork (E)	This functionality is related to how the teacher is capable of doing a close follow-up of the work done
Dynamic group activities (C)	It was identified that, in many occasions, students had difficulties to find a group (there are multiple reasons, such as late registration in the course or some students build their groups from their previous knowledge in other courses leaving some unattended). In the past, those "lost" students were put together to form a group and the teachers informed that, when this occurs, their performance is clearly below the average
Internal team management (E, C)	This functionality is thought to give some teamwork management tools. They could also be used for the teacher although it is not the main scope
Communication within the group and with the teacher (C)	This functionality had several goals and, as a consequence, multiple tools. These goals are: To enhance the communication among students in the team, to facilitate online communication between students and the teacher and inversely, to have an effective communication from teachers to students and, as the last point, to invigorate the oral and written presentation of the work to wider audience
Creativity & generation of ideas (E, C)	This functionality focusses on tools to enhance the generation of ideas so useful in projects and teamwork to find solutions to an external or internal problem. Tools to do brainstorming or mind maps and other creativity methodologies are considered here
Design thinking	Meant to enhance the visibility and attractiveness of the results
Repository (E)	As a consequence of the teamwork, there should be some place where to store documents. In this case, as it is an evaluative measure, the study focuses only on finalized documents and how to make them accessible for the teacher
Development of educational material (E)	This functionality is related to the interaction of students with the teacher and its educational material, serving as an evaluation of the different activities (i.e. using questionnaires) or the gamification that can also be used to enhance the feeling of pertinence in a team

* E: Evaluate; C: enhance collaboration

Thus, as defined in Figure 1, the present study begins by identifying the criteria (shown in Table 1) that serve to choose the best tools among the identified ones to enhance and evaluate teamwork both from a teacher but also from a student perspective.

These criteria were selected after a brainstorming session in which the different participants indicated the aspects or factors that they appreciated more when implementing tools at class. It was agreed that the final number of criteria to use should be limited to 5 so the weighting process of each criteria during the selection of tools had sense and to avoid unnecessary work (Yu & Lai, 2011).

This limitation was set because, when there are too many criteria, some of them have low weighting (<5%) and thus scarce impact. Therefore, it was considered a wiser option to put the focus on those that are most relevant. The selection of those 5 was done by putting a green dot on those 3 criteria that each teacher (each participant had only 3 dots t put) and keeping

those having more dots, like in (Canals Casals, Amante, & González Benítez, 2021).

Table 2: Criteria and description

Criteria	(Description)
Institutional service (C1)	Meaning that, from the UPC, there are some already stablished tools that could be used and that are used by both teachers and students. Examples of that could be: The moodle space named Atenea, the Google tools like institutional e-mail, meets, calendar, youtube… or Microsoft office 365 and other software related to projects and presentations (MS project, adobe acrobat…)
Effort (C2)	This criterion evaluates the workload the teacher has to identify the contribution and effort of individuals in the team. Additionally, it refers to the fact that maybe teachers already use them (in this or other subjects), which might ease its implementation
Useful for the specific purpose (C3)	Some tools are more or less aligned with the specific functionality identified. When teachers easily identify its utility, they might positively decide to implement it
Novelty/intuitive (C4)	This criterion indicates if the tool is rather new or if it is significantly different to other institutional tools or tools already used by teachers. The more different the more difficult might be for teachers to adopt it. In fact, The adoption of tools depend on the knowledge of this technology or how spread it is among the community (Šumak, Pušnik, Heričko, & Šorgo, 2017)
Change in dynamics (C5)	A monotone or continuous way to teach or work is tiring and boring, thus, changes in dynamics are generally seen as something good from the student's point of view (Oosterheert & Vermunt, 2010)

The decision of the best tools is done using a multi-criteria decision making (MCDM) through the weighted product model (WPM) scoring method (Zhou & Chen, 2020). To do so, each alternative has a valuation according to the different criteria. This valuation, which is done for each of the criteria, is done according to the parametrization in Table 3.

Table 3: Parametrization of criteria

	1	2	3	4	5
C1	The institution recommends not to use it	Nothig specific, no support.	Implemented but not publicly	Recently implemented or sub-service from others	Fully implemented at an institutional level since years
C2	- Days of preparation - 1h > use	- Prep. > 3h - 1h > use	- Prep > 3h - 1h > use	- 3h >Prep > 1h - 1h > use	-Prep. < 1h - 1h < use
C3	Slighly useul	Superficil	OK	Very satisfactory	Perfect
C4	15 years Very low	10 years Low	6 years Average	3 years Quite	1 year Very much
C5	Monotone	Change, but similar to other activities	Change but short in time (<10 minutes)	Quite a change for more than 10 minutes	Very much and for more than 20 min

Knowing that this methodology has been criticized for being somehow fuzzy because of the inherent human perception (Chang & Ku, 2021), the selection is later validated using the methodology PRESS to evaluate the gains between the different strategies for each criterion (Aragonés, 1997) and also using the Analytic Hierarchy Pocess (AHP) to determine the weights of the criteria and to evaluate the consistency of the method (Ishizaka & Labib, 2011) (Ho & Ma, 2018).

3. Results

From the 8 functionalities identified, a list of 68 tools that might be useful to satisfy those purposes was retrieved. In fact, there were some tools that appeared more than once, as they seemed to fit more than one functionality. Figure 2 shows, in a visual way through a wordcloud, all the tools and, in a bigger size, those appearing more often.

Figure 2: Wordcloud of the tools that were considered during the identification phase.

Note that Atenea appears, by far, as the biggest one because Atenea is the teachers-student platform stablished by the UPC as a workplace, where teachers prepare the subject and upload all possible documents having a message system linked to the institutional e-mail.

Table 4: Parametrization of criteria

	C1	C2	C3	C4	C5	Weight vector
C1	1	3	1	3	5	0.34
C2	1/3	1	1/3	1	3	0.13
C3	1	3	1	3	5	0.34
C4	1/3	1	1/3	1	3	0.13
C5	1/5	1/3	1/5	1/3	1	0.06
Sum	*2.86667*	*8.33333*	*2.86667*	*8.33333*	*17*	*1*

Then, although Microsoft Teams appears as a relatively big in the wordcloud, most of its functionalities are also implemented by some Google services (such as Meets, Sites, Forms and also online working documents and storing…) which are, indeed, highly supported by the UPC.

The weight vector is obtained after comparing each criterion against the rest of criteria indicating which is considered to be more valuable. Table 4 shows the values used to calculate them according to AHP rating scale, which indicates that the first criterion (C-1 Institutional service), with a value of 3, is moderately more relevant than the second and fourth criteria (C2 – effort & C4 – Novelty/intuitive) but equal to the third criterion (C3 – usefulness) and much more important (value of 5) than the fifth criterion (C5 – Change in dynamics). Then, these values are normalized (dividing by the Sum row in Table 4) and for each row (criteria) the average is taken forming the weight vector that is afterwards used in the VPM model. Note that the consistency ratio of this weight vector is of 0.0126, significantly less than the limit of

0.1 that expresses its validity.

The MCDM is created adding the weight vector to apply the WPM, following the procedure presented in section two, to evaluate the tools for each functionality and criterion. Although having only 8 functionalities, the study ended up building up to 13 of these MCDM tables having each one between 4 and 11 alternatives or tools. This increase in the number of decision matrix is, basically, caused by the fact that some functionalities, such as the "Communication within the group and with the teacher" or "Development of educational material" had more than just one specific purpose and, thus, it was necessary to extend the study adding more tools for those specific cases, which are indicated in Table 1.

Table 5: Multi-criteria decision matrix followed by the results of the weighted product model for the analysis of the function: Evaluation of the individual contribution in the teamwork.

	MS teams	Gforms	Atenea	Gmeets	Whatsapp telegram	*Weight*	*MS teams*	*Gforms*	*Aenea*	*Gmeets*	*Whatsapp telegram*
C1	4	5	5	5	1	*0.34*	*1.37*	*1.72*	*1.72*	*1.72*	*0.34*
C2	3	4	5	5	3	*0.13*	*0.39*	*0.52*	*0.65*	*0.65*	*0.39*
C3	4	5	3	4	5	*0.34*	*1.37*	*1.72*	*1.03*	*1.37*	*1.72*
C4	2	4	3	3	4	*0.13*	*0.26*	*0.52*	*0.39*	*0.39*	*0.52*
C5	3	4	1	3	5	*0.06*	*0.17*	*0.23*	*0.06*	*0.17*	*0.28*
							3.55	*4.68*	*3.83*	*4.29*	*3.24*

For the sake of clarity, the study presents the MCDM and results of the WPM (Table 5) for just one of the functionalities (i.e. Evaluation of the individual contribution in the teamwork). The MCDM for the rest of functionalities follow the same approach.

Table 6: Domination vs dominated table according to the PRESS method.

	MS Teams	Gforms	Atenea	Gmeets	Whatsapp Telegram	*Dominated*
MS Teams	0	0.24	0.15	0.15	0.16	*0.70*
Gforms	0	0	0.03	0.03	0.01	*0.06*
Atenea	0.09	0.20	0	0.09	0.21	*0.60*
Gmeets	0	0.11	0	0	0.12	*0.23*
Whatsapp Telegram	0.21	0.30	0.33	0.33	0	*1.16*
Domination	*0.30*	*0.85*	*0.51*	*0.60*	*0.50*	

In the example presented in Table 5, it is clear that having the support of the institution (C1) is of great value to finally choose a tool, as for Atenea. This support is linked to, for instance, the facility to register and to have access to premium services (such a high number of students in a virtual meeting in the case of Google Meets). Moreover, as Atenea is somehow of mandatory use, people are used to it and, thus, the effort to implement some of its features in class is lesser than for other tools not within the umbrella of the UPC.

On the other hand, the criterion of change in dynamics (C5), although being positively appreciated by students, was considered to be of lesser relevance and it ends up having small impact in the final results. For instance, the use of chat applications such as Whatsapp or Telegram have the lower final result (3.24) in comparison to the rest of tools.

For this case, the three tools selected would be Google Forms, Google Meets and Atenea, while MS teams, although being under the umbrella of the UPC for its recent incorporation of

the office 365, has a lower acceptance in the teacher's community and it is, therefore, discarded.

As reported in the methodology section, these values have been validated through the PRESS and the AHP methods. First, the weighted numbers from the MCDM are divided by the maximum valuation of that criterion (i.e. in the same example in Table 5, the maximum value put for C1, C2 C3 and C5 in all the alternatives is 5, while it is 4 for C4). Second, it is necessary to identify the dominancy among alternatives or tools. This is done by subtracting for each tool in comparison to the rest of tools individually, the lower numbers in each critera. This step of the PRESS method is presented in Table 6.

Afterwards, the relation between domination vs dominated is done, showing how Google Forms is the tool that clearly dominates the rest of tools (with a value of 13.54) followed by Google meets (with a value of 2.53). The rest of tools have similar values of domination, which coincide with the lower scores received in the WPM (Table 5).

Following the same proceeding for the rest of functionalities (and sub-functionalities), Figure 3 presents the tools selected for each functionality and, in brackets, the results from the WPM and the value of dominance of each tool over the rest.

Note that, in some cases, there were less than 3 tools selected, like in the case of the repository, as the other alternatives and tools had a substantially lower value. In other cases, like in the development of materials (for questionnaires to settle concepts presented in class) they were too similar to other existing tools or the alternative had a trend during the last years of decreasing the free services (like Kahoot), which directly enters in contradiction to the project restriction that no cost should be transferred to teachers or students.

These results show the relevance of the institution support for choosing software related tools to work with, as 37.5% (12 over 32) of the tools selected to be used on each functionality, or 22% (6 over 27) if we do not consider those tools that are repeated in several functionalities, are within the umbrella of the UPC. Moreover, if this institution support is expanded to reach the suggested tools by the ICE (Institut de Ciències de l'Educació) from the same institution that is in charge of the continuous formation of teachers, this percentage increases up to a 62.5% (as the ICE actively suggest the use of EsPuzzle, Genially, Socrative, Quizzis, Miro and Padlet in their courses).

Future work will present the impact of the application of these tools in the teacher's evaluation of the student's work and also of its acceptance and usefulness by the students, as these tools are currently being implemented in the spring quadrimester ending in June 2022.

Figure 3: Selected tools for each functionality

4. CONCLUSIONS

After analyzing the 8 key teamwork functionalities identified by teachers from several masters and degrees at the UPC, the study performed a multi-criteria decision making through a weighted product model scoring method to identify which are the most appropriate tools to work with in order to maximize the learning and profit of the teamwork transversal competence.

The results indicate that, from the 68 tools identified as useful for the purpose, it was enough to work just with 27 of them, being Atenea the reference tool to work with in most cases, as this is the platform used by default by the institution (UPC), that is, that all the subjects, students and teachers are introduced automatically in this platform at the beginning of the course and, thus, the effort to prepare them is much lower than to prepare non-institutionally-supported tools.

5 Google based services (Gdrive, Gforms, Gmeets, Gsites and Gmail) are also suggested in this work for similar reasons (the UPC contracted Google as mail server and, due to the pandemic, it contracted all the other services, including other applications bought by Google, such as Youtube). However, if other institutions have agreements with google competitors (i.e. MS with Teams, Outlook and the Office 365), these tools should rapidly swift to the one offered by these competitors.

The study shows the impact of the institutional support at the moment of choosing tools, as about 37.5% of the selected tools fall within tools receiving direct support from the UPC and over 62.5% of them are somehow encouraged to be used by the continuous formation of teacher's services by the UPC.

Once the tools for teamwork development and evaluation are selected, the project will focus on the evaluation of their effectiveness during the next quatrimester, taking as much information as possible from their use.

Finally, EQUIPA'T will take advantage of rubrics and surveys to analyse the degree of satisfaction from the student's side but also to have evidences of the learning process and to ease the individualization of the grade.

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Communication aligned with the Sustainable Development Objectives