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Integrating Individual and Collective Skills: A Rubric-Based Model for Teamwork Competence Assessment

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Abstract. The competence of teamwork comprises a set of skills that enable the assessment of teamwork evolution (collective skills) and the involvement of each team member (individual skills). In most research works, these skills are grouped without making this distinction between collective and individual skills. In this study, collective skills are associated with the different phases that constitute the evolution of teamwork, allowing for the identification of the precise moment when such a skill should be applied. Individual skills are applied in all phases of teamwork, as they measure individual involvement and responsibility, along with the competencies necessary at an individual level to develop teamwork. This work presents a rubric that associates phases, evidence, technology, and indicators and allows educators to measure the degree of acquisition of each and collective skill. The method used for the development of teamwork has been the Comprehensive Training Model of the Teamwork Competence, which supports both the continuous and transparent creation of evidence of teamwork development by the teams and each of their members, as well as the continuous monitoring of this development by educators.

Keywords: Teamwork Competence · Rubric-Based Assessment · Individual Skills · Collective Skills · Comprehensive Training Model · CTMTC

1 Introduction

Teamwork is a cross-cutting competence highly demanded in the labor [1] and academic sectors [2]. In both contexts, teamwork is considered a tool that enhances cooperation [3] to solve complex problems [4] and leads to greater efficacy in outcomes [5–7]. However, in the educational sector, additional objectives include training, assessing, and improving the motivation of students on teamwork competence [8, 9].

This competence presents a set of intrinsic problems to the method itself, among which the difficulty in coordinating team members [10], measuring individual workload [11], individual responsibility [12], and even the team's own identity [10] stand out. In the academic context, all these factors complicate the training and evaluation of this competence.

In this latter aspect, in traditional evaluation, the entire team usually receives the same grade after completing the teamwork, leading to unfair situations among its members. Having evidence that can show the teaching staff the individual workload, responsibilities, and cooperation among team members, along with a rubric that analyzes such evidence, would be a way to assess teamwork and improve the learning outcomes of the competence itself [13].

Other research works have highlighted the need to apply rubrics that allow measuring team formation, planning, communication, coordination, mediation, contribution, meeting management, and assumption of responsibilities [14–17]. Some of these skills are associated with a specific stage in the evolution of teamwork [18]. For example, team formation and planning are applied in the early phases of teamwork.

Other skills are vertical, as they are applied throughout all phases of teamwork [19], such as coordination, mediation, and assumption of responsibilities. Moreover, although these skills are used throughout the development of the work team, they are used in different ways in each phase. For example, in the initial stages, coordination is greater and more complex than in the final stages of teamwork.

Based on this approach, this research identifies the following terms:

- *Phases*: Stages of the evolution of teamwork.
- *Skills:* Capacities that make up the teamwork competence.
- *Indicators:* Allow measuring the degree of skill acquisition.
- *Evidence*: Resource generated by the work team members during their participation in the work. The evidence can be of two types: associated with the team (such as a timeline) and those associated with the individual (such as individual responsibility).

Evidence is an essential part of this research work as it is the resource that allows measuring competence acquisition. Associated with it are two factors: the temporality with which they are generated and the type of evaluation of the skill analyzed. If evidence is only obtained at the end of the teamwork, for example, with a peer evaluation, a knowledge questionnaire, a satisfaction survey, or by analyzing the final results, then only a final summative evaluation would be taking place (which is the traditional method).

Suppose evidence is generated and analyzed during the development of the teamwork, without waiting for its completion; a diagnostic and formative evaluation can be carried out throughout the development. In addition, a summative evaluation at the end of the process might be developed.

In this context, it is vital to apply a teamwork model that allows monitoring the progress of each team member to report on the degree of task compliance [20] and thus regulate learning [21]. That is, the method must generate individual evidence from the beginning of the teamwork until it ends. This type of method is called "open box," as opposed to "closed box" methods that do not show continuous evidence during the development of the teamwork. On the contrary, once the teamwork is finished, the evaluation is based on the final result and sometimes on a peer evaluation among team members or on questionnaires of perception of the use of such teamwork skills by each team member. This research aims to design a rubric that can measure the acquisition of teamwork competence through skills via measurable indicators associated with the phases of teamwork, the continuous generation of evidence, and the type of evidence (collective or individual).

The following sections will describe the evidence model used, the developed rubric, and the connection between the components. The last section includes the conclusions of this work.

2 Comprehensive Training Model Description

This section describes the various components used to contrast the rubric indicators: the phases, evidence generation, technologies, and the proposed final evidence model.

2.1 Phases

The development of teamwork progresses through phases: Forming, Storming, Norming, Performing [22], and Delivering [23, 24]. The primary objective of each phase is:

1. *Forming*: Formation of the work team and leader selection. Definition of the work team's common vision, mission, and objectives.
2. *Storming*: Distribution and assignment of tasks, responsibilities, selection, and handling of technologies. Reinforcement of the team's common vision.
3. *Norming*: Establishing norms to regulate conflicts, decision-making, communication, and overall planning.
4. *Performing*: Development of teamwork based on individual responsibilities and tasks. Coordination, monitoring, and meeting management. Monitoring of individual and group progress.
5. *Delivering/Conclusion*: Final work results, reports on the resources used to carry out the work, conclusions, and lessons learned.

This model, initiated by Tuckman, consisted of five phases, with the last one called "Adjourning" (team disbanding). However, the application of the IPMA [23], along with the application of Tuckman's model in universities conducted by Stein [25], adapted Tuckman's last phase, "Adjourning," to emphasize the idea that teamwork does not end when the final product is delivered. Instead, other resources can be managed for the organization to retain the experience of the completed teamwork and leverage resources in future teamwork. This phase was named "Conclusion and deliverables." Therefore,

the modified Tuckman model consists of the following phases: Forming, Storming, Norming, Performing, and Conclusion and deliverables.

This model is applied in both universities and professional environments. Notably, the International Project Management Association (IPMA) based in Switzerland stands out in professional settings. This association comprises 59 national associations from over 30 countries and certifies the acquisition of teamwork competence.

2.2 A Method for Evidence Generation

In this research work, the "Comprehensive Training Model of the Teamwork Competence" (CTMTC) [26] is utilized to generate both individual and collective evidence [19] and to monitor them continuously and progressively. This method has been validated through various scientific publications and allows for the continuous and transparent validation of both types of evidence. The transparency in evidence generation allows the team to verify the work's evolution [27], besides enabling the assessment of skill acquisition. Transparency in individual evidence enables the verification of the involvement and responsibility of the work team members.

2.3 Technologies

The use of technological platforms by students generates a set of evidence resulting from their interaction. This evidence originates from two sources: the technology itself through student interaction (such as logins on the platform) and the evidence provided by the students using technological tools (for example, messages in a forum). In this work, the open-source e-learning platform Moodle and other tools provided by educational institutions, such as those from Google and Microsoft, have been used.

2.4 Evidence Model

Throughout the development of this teamwork method, the team progresses through the various phases. To demonstrate that a phase has been completed the CTMTC method presents a set of evidence [28] displayed in Table 1. The first column indicates the phase, and the second column shows the evidence that the phase has been completed. In the CTMTC method, these are referred to as collective evidence.

In the evidence column of Table 1, some of the competencies identified in the literature review are reflected, such as team formation, meeting management, planning, and assumption of responsibilities. In this work, these competencies are called collective competencies, as each corresponds to a specific phase in the evolution of teamwork. Their measurement is carried out through the collective evidence in Table 1, which is generated by the team.

However, other competencies, such as communication, coordination, shared leadership, and contribution, apply in all phases of the method and must be present throughout the development. These competencies have been termed individual competencies, as each team member must maintain them throughout their development. Their measurement is carried out through the individual evidence generated by everyone. Therefore,

Table 1. Phases and associated evidence

Phase	Collective evidence
Forming	Team formation Leader selection Common vision of mission and objectives Identification of achievements to be accomplished as a team
Storming	Tasks of shared leadership to be exercised by different team members Identification of technologies and their functionality within the management of teamwork Development tasks leading to the final product that each team member must undertake
Norming	Norms governing the behavior of the work team Planning of tasks assigning products to be achieved and completion dates Work schedule
Performing	Monitoring of individual work Monitoring of group work
Conclusion and deliverables	Final results. The outcome of the work Resources and technologies used in some part of the work, indicating their utility within the team Documentation of partial results, consulted reports, meeting minutes… Lessons learned: experience where the team reflects on certain tasks, what needed to be done, what was done, and how it was done

teamwork competence is defined by both individual and collective competencies, and each member must acquire them during teamwork [19]. In the case of collective competencies, interaction among team members is necessary to achieve them, and individual competencies are associated with the person's involvement.

Competencies are measured through indicators from evidence produced by individuals and the team. Collective evidence indicates that the team is evolving correctly. However, these pieces of evidence are insufficient to guarantee that individuals have acquired teamwork competence. For example, a piece of collective evidence is the regulations, which can be well formulated; however, how can it be ensured that all team members have participated in their creation? To guarantee this, individual evidence must be used, thus ensuring the acquisition of collective competence. All this must be done transparently for the entire work team [29]. Thus, the rubric must measure both collective and individual competencies and be able to contrast them. Table 2 shows the individual evidence to be applied during all phases of teamwork.

As mentioned, the CTMTC method [30] is an academic adaptation of the professional method used in IPMA. However, in the academic context, applying all phases is only sometimes necessary. For example, in the following cases:

Table 2. Individual evidence applicable throughout the evolution of teamwork

Individual evidence
Coordination
Shared leadership tasks
Fulfillment of assigned tasks
Technology management
Contribution

- The teaching staff or an automatic system forms the teams.
- The work's outcome mission, and objectives are defined by the teaching staff and, therefore, not chosen by the team.
- The work is simple, applying very specific contents of the subject, or it is a task whose development involves a short period (e.g. a few weeks within a semester).

For these situations, the phases of the method present some restrictions. In the Storming phase, the evidence of mission and objectives is not used, and in the Norming phase, planning and the schedule are not utilized. For these cases, a version of CTMTC called Agile CTMTC [26] is applied, where the evidence for each phase is restricted, (the table of collective competencies vs. individual competencies is defined as shown in Table 3.

Table 3. Relationship between phases, collective competence, and individual competence

Phase	Collective competence	Individual competence
Forming	- Team formation - Leader selection	- Coordination - Shared leadership tasks - Fulfillment of assigned tasks - Technology management - Contributions
Storming	- Tasks of shared leadership to be exercised by different team members - Identification of technologies and their functionality within the management of teamwork - Development tasks leading to the final product that each team member must undertake	
Norming	- Norms governing the behavior of the team	
Performing	- Monitoring of individual work - Monitoring of group work	

(*continued*)

Table 3. (*continued*)

Phase	Collective competence	Individual competence
Conclusion and deliverables	- Final results. The outcome of the work - Resources and technologies used in some part of the work, indicating their utility within the team - Documentation of partial results, consulted reports, meeting minutes - Lessons learned. Experience where the team reflects on certain tasks what needed to be done, what was done, and how it was done	

This work presents a rubric based on the above method to assess individual skills, workload, commitment, and individual responsibility. Likewise, it enables the contrasting of such evidence in each teamwork phase. This assessment can be carried out progressively and finally. Doing it progressively allows the teaching staff to make decisions, introduce corrective actions, and conduct training in teamwork competence. Having a final assessment will enable the teaching staff to make an individual assessment of the teamwork based on each individual's commitment, responsibility, and workload.

The following section defines the indicators associated with collective evidence (associated with the phases of the evolution of teamwork) and individual evidence (associated with each team member). This includes the technology used to conclude with the proposed rubric model for assessing collective and individual skills.

3 A Rubric Model for Assessing Collective and Individual Skills

The rubric described below was applied in the Mathematics II subject of the Chemical Engineering degree at the University of Zaragoza (Spain) during the first semester of the 2023–24 academic year. The sample comprises 93 students grouped into 16 teams (5–6 members/team).

This section will present the results related to the indicators associated with the evidence that allows measuring the skills, the technology that helps to follow these indicators, and finally, the designed rubric.

3.1 Indicators

The design of the rubric focuses on four critical aspects of skills, which are the following collective evidence:

- *Norms (Norming).* The norms are evidence that the team designs a set of rules and standards that affect the behavior of members during the development of teamwork.
- *Responsibilities (Storming).* This is expressed through a consensual table where the responsibilities and tasks associated with shared leadership, the commitment to handling ICT, and the tasks associated with the academic development of the final work are indicated. All for each team member.
- *Execution of Work (Performing).* It is a table that reflects the evolution of the tasks and responsibilities included in the responsibilities table for each team member and the generation of their collective evidence.
- *Results (Delivering/Conclusion).* The different resources that make up the outcome of the work are in the various required formats (text, audiovisuals, etc.).

A list of indicators has been designed to confirm the expected results for each piece of evidence. Table 4 shows these pieces of evidence and the indicators that have been identified to validate the acquisition of the evidence.

Table 4. Collective evidence and indicators

Collective evidence	Collective indicator
Norms	Consensual and accepted elaboration of norms including rules affecting: - Meeting management - Conflict resolution - Consequences of compliance with norms - Internal communication (among team members) and external (with teachers, other teams, and other entities) - Decision making - Ethics and values - Organization - Coordination
Responsibilities	Creation of a table indicating responsibilities of three types: - *Technological* (handling of technologies associated both with the development of the teamwork and the outcomes to be obtained) - *Academic* (tasks of knowledge creation to perform the final product of the teamwork) - *Shared leadership* (tasks of coordination, monitoring, and micro-planning for the proper functioning of the teamwork)
Execution	- Calendar with the responsibilities of the three types carried out by each team member Communication among team members Use of technologies to share what is being done, in a transparent and continuous way - Sharing of partial results
Results	- Achievement of the work objectives - Organization and communication of the work results

Each piece of evidence is measured in two aspects: the collective, that is, the evidence demonstrating that the team has achieved competence, and the individual, which is the involvement of each team member in acquiring the competence.

3.2 Technology

Below are some technological tools used during the application of the teamwork method:

- *Moodle forums.* Students communicate, coordinate, and indicate the tasks each member performs continuously (like a work diary). Communication is organized into well-defined threads: one for each discussion around the evidence (Norms, Responsibility Map, Execution, and Results), a thread to include meeting minutes, an individual thread for each team member's diary, and other threads considered by the team.
- *Moodle Wiki.* Students cooperatively build knowledge, share, and disseminate to all team members (and the teaching staff) the operating norms, the responsibility tables (the three types), and the monitoring table (where individual contributions, dates, incidents, and their resolution, as well as collective achievements are specified). In the Wiki, useful Forum threads (discussions, minutes, individual threads, etc.) are linked, and all information is organized so that the teaching staff can consult and access the information easily.
- *Moodle polls.* To conduct self-assessment polls of the process and co-assessment among team members halfway through and at the end of the development.
- Google Drive. For storing and sharing intermediate documents among members and with the teaching staff.
- *Word Processor, Video Creation and Editing Applications, and YouTube.* To create and publish the final work in different formats.

3.3 Final Rubric

Table 5 presents the final rubric for collective evidence and reflects the evidence (first column), the location where the evidence is stored (second column), and the learning outcomes of the competence (third column). It contains the key aspects that allow assigning values to the indicators.

Each learning outcome is evaluated between 0- None, 1- Somewhat, 2- Quite, and 3- A lot. Except for points 1.1.4, 1.2.4, 1.3.1, and 1.3.4, the values are 0- Never, 1- Somewhat, 2- Quite, and 3- Always.

Table 6 shows the same evidence as Table 5, but the indicators are individual and allow for the verification of student participation in achieving them. Each learning outcome is evaluated between 0- None, 1- Somewhat, 2- Quite, and 3- A lot. Except for points 2.1.2, 2.1.3, 2.1.4, 2.2.2, and 2.2.4, the values given are 0- Never, 1- Somewhat, 2- Quite, and 3- Always.

To carry out the final grading of the teamwork, both collective and individual indicators are considered, and a grade is assigned to each indicator as indicated. The weight of each indicator in the grading is the same. However, a grade of 4 out of 10 is not achieved in the total of the individual indicators; in that case, it is impossible to average it with the grade obtained in the collective indicators. This way, it prevents a team member from passing the competence without working because the rest of the members did, and the

Table 5. Rubric for collective evidence

Evidence	Source of evidence	Learning outcome
Norms of operation and behavior	Wiki and Forum	1.1.1 The team has adapted the normative from the example (where the types of norms expressed in Table 4 are indicated) with the contributions of its members 1.1.2 The team has correctly included its norms in the Wiki 1.1.3 The norms developed include the necessary aspects for the good functioning of the team 1.1.4. The team has applied its norms to resolve conflicts
Responsibility map (roles and functions of each member, shared leadership)	Wiki and Forum	1.2.1 The team has created its responsibility map adapting the given example with their contributions 1.2.2 The team has correctly included its responsibility map in the Wiki 1.2.3 The team's responsibility map includes balanced tasks (in time and effort) among its members 1.2.4 The team has considered its responsibility map in each phase to execute the work
Execution of work	Wiki and Forum: Meeting minutes s	1.3.1 The team has met the schedule of partial deliveries to carry out the final work jointly 1.3.2 The team has communicated following the instructions of the teacher through the Moodle course forum 1.3.3 The team has used in each phase the Moodle course wiki and the shared drive folder to follow the teachers' instructions 1.3.4 The team has created a final version of the work that has been agreed upon by all members
Results	Wiki and Forum	1.4.1 The team has correctly solved the proposed work 1.4.2 The team has presented the work in an appropriate digital/audiovisual format 1.4.3 The team has correctly used mathematical language 1.4.4 The team has respected the ethical norms of knowledge creation not to copy, plagiarize, etc.

collective grade is high. The final grade is distinguished in qualitative (quantitative):

Table 6. Rubric for individual evidence

Evidence	Source of evidence	Learning outcome
Norms of operation and behavior	Forum: Meeting minutes and individual threads Co-evaluation	2.1.1 The team member has contributed ideas to create the norms 2.1.2 The team member has behaved consistently with the team's norms and has not caused conflicts 2.1.3 The team member has behaved respectfully towards the opinions of other members 2.1.4. The team member has participated in resolving conflicts within the team
Responsibility map (roles and functions of each member, shared leadership)	Wiki and Forum (thread, meeting minutes, individual threads) Co-evaluation	2.2.1 The team member has made contributions to create the team's responsibility map 2.2.2 The team member has fulfilled his/her responsibilities established in the team (tasks and times), including surveys 2.2.3 The team member has assisted other team members upon request 2.2.4 The team member knows how to share leadership responsibilities with another member
Execution of work	Wiki and Forum (thread, meeting minutes, individual threads) Co-evaluation	2.3.1 The team member has sent useful messages to the forum 2.3.2 The team member has used the technologies needed to perform their tasks 2.3.3 The team member has had a good attitude towards meeting with other members 2.3.4 The team member has asked for help from other members if needed to complete their tasks
Results	Forum In-person sessions with the teachers	2.4.1 The team member knows how to solve the work 2.4.2 The team member has sought correct solutions to solve the work 2.4.3 The team member has expressed himself/herself correctly in the presentation of the work in-person/audiovisual

Excellent ($x \geq 9$), Adequate ($7 \leq x < 9$), Developing ($5 \leq x < 7$), Not achieved ($x < 5$). The qualitative grade is reflected in an individual certificate issued by the educational center and signed by the teaching staff. The quantitative grade accounts for a maximum of 15% of the overall grade of the subject for each team member.

4 Conclusions

Teamwork methods that generate evidence continuously allow the team to understand the evolution of their work [27]. From this evidence, the teaching staff can collectively and individually evaluate the development of teamwork. Such evidence can be analyzed to assess the acquisition of teamwork. However, it is necessary to establish indicators that measure not only the evolution of the work but also the degree of competence acquisition.

Teamwork competence can be measured through a set of indicators. Individual indicators [31] measure the individual acquisition of the competence; however, this is not sufficient to guarantee its acquisition, as it must be endorsed by overcoming achievements that allow measuring the team's evolution, that is, the results generated both during the work's development and in the final product.

In this work, an open-box model is applied where, continuously and progressively, students generate evidence through interaction with technologies. This evidence shows both individual involvement (responsibility, commitment, contributions, participation in communication, coordination, involvement in conflict resolution, and respect) and the result of individuals' involvement in group work (collective evidence) through the development of norms, the responsibility map, monitoring tables, and the final result of teamwork.

One of the main contributions of this work is that it distinguishes between collective evidence, which measures the team's evolution as a group, and individual evidence, which measures the involvement of individuals in achieving collective competencies. The joint analysis of such evidence defines teamwork competence.

The rubric relates collective evidence to individual evidence through measurable indicators. Likewise, its application is supported by technologies commonly used in universities, such as Moodle e-learning platform [32, 33].

In this research work, the rubric was applied once the teamwork was completed. Future studies will examine the grades obtained when applying the rubric. As future work, it could be used in the Storming, Norming, and Performing phases of teamwork, thus allowing for formative evaluation at each phase and measuring the competence's evolution progressively, taking formative actions based on the degree of competence acquisition.

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