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A Tool for Preventing Teamwork Failure: the TFP Questionnaire*

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This paper presents the process used to devise the Teamwork Failure Prevention Questionnaire (TFP Questionnaire), a tool that allows teams with problems in functioning to be detected early.

The TFP Questionnaire was formulated in a project management course at the University of Zaragoza (Spain). In this course, teams of five or six students have to manage a project for a real client. The questionnaire was then tested on students on this course and on a similar one at Aalborg University (Denmark).

This article analyses the psychometric characteristics of the TFP Questionnaire and then presents and discusses its results, before moving onto examine the implications of this research for engineering education research and engineering education in general.

Keywords: teamwork assessment; teamwork failure; functioning problems; project management

1. INTRODUCTION

IN RECENT YEARS, active learning methods, such as project-based learning [1] and cooperative learning [2], have been increasingly adopted in engineering schools. This trend is evident in the many references in journals—such as the *International Journal of Engineering Education* and the *Journal of Engineering Education*—which cite the introduction of classroom activities that employ active learning methods. Active learning in the engineering classroom helps students to develop specific skills and competencies that will prepare them for the profession of engineer [3–5]. In this learning process, students assume a more active role than in traditional processes, where they are typically more passive agents. This more active role is usually focused on working on a team project.

Today, one of the skills that employers most frequently require from candidates for engineering positions is the ability to work as part of a team [6, 7]. In order to equip students with the skills they need to work successfully in team situations [8], increasing efforts are being made in the engineering classroom to teach them this ability [9–11].

The research presented in this paper was conducted in a project management course run by the School of Engineering of the University of Zaragoza. During this course, groups of students, supervised by instructors that adopt the role of coach, have to manage a project for a real client. This learning method was first used on the course in 2003. Since that year, the course organisers have analysed the projects that have obtained poor results. Their analyses revealed that one of the most frequent causes of project failure was related to functioning problems in teams. This discovery led to the conception of this research project, which went onto devise a tool that allows conflicts or problems within a group to be detected early. This tool has also been tested in another learning context: the Cooperation, Learning and Project Management course at Aalborg University. In this second context, students work in teams on a project that is based on a real-life situation as opposed to a real-life project.

According to Prince, Felder and Brent [12, p. 291] 'doing research on teaching and integrating successful innovations into classroom practice clearly has the potential to improve teaching and learning'. In the same spirit, the results obtained in this research have been used to make improvements in these project management courses therefore improving student team functioning and learning processes.

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2. CONTEXT AND OBJECTIVE OF THE RESEARCH

The research was conducted in the context of a project management course that is run in the final year of the Industrial Engineering Degree at the University of Zaragoza. Each year 100 students and five instructors participate in this course. From a learning perspective, the course is designed to give students first-hand experience of professional project management in order to prepare them for the profession of engineer. The course's learning approach simulates the operations of a consultancy company: teams of five or six students manage a project for a client, which they must find for themselves. Clients typically consist of small and medium-sized companies, non-governmental organisations (NGOs), cultural associations, sports clubs or town councils from small municipalities. Student projects vary greatly, ranging from company relocations, to event organisation, to preparing proposals for financing NGO activities.

Students are free to form their own teams, although the instructors recommend that group members' timetables be compatible. Compatibility is important for students to be able to meet easily to work as a team on their project and to attend meetings with their coach and client. Each team has two compulsory roles, those of coordinator and secretary. Elected by group consensus, the former is in charge of coordinating the group, and the latter takes control of administrative matters; both combine their role-specific responsibilities with their other project tasks.

During the client search process, the course instructors hold two seminars with all the groups to advise students on the type of projects that best suit the course characteristics and objectives. When deciding whether or not to approve students' project proposals, the instructors assess whether the scope of the project is compatible with the planned course workload and whether the project's emphasis would be on management skills rather than technical skills. The instructors use their accumulated experience to assist them in this approval process.

The students on this course have no prior experience in team working or project management. In order to address with these shortcomings, in the first part of the course, the instructors deliver a series of ten theory lectures explaining the concepts and tools of cooperation and project management that the students will have to use during their projects. These lectures are reinforced with two seminars or workshops on specific teamwork topics and the causes of project failure.

The project deliverable is a written report—the Project Management Plan. This includes all the information needed for the client to implement the project. In addition to the report, groups must also deliver an oral presentation in which they have to defend their project before a panel of three instructors and their client. Both the report and presentation count in the final assessment of each project. The assessment criteria are based upon the scope of the project, its difficulty, the quality of the report and the presentation, and the technical and financial viability of the project. Projects are marked on the following scale of 0 to 10:

- 0–4.9 unsatisfactory (fail): the project is unsuitable. Groups with this mark cannot pass the course
- 5.0–7.9 improvable: the project meets the minimum criteria required, although there are still many areas with room for improvement.
- 8.0–10.0 very good: the project fulfils all the criteria required.

All the members of a project team receive the same mark. This project mark is then added to their mark from an individual multiple-choice exam on basic project management concepts.

With the aim of improving course functioning and student learning, the course organisers analysed the projects marked as 'unsatisfactory' in order to try to understand the causes of failure [13, 14]. It was through this analysis that the instructors detected that group functioning problems related to coordination were the main cause of project failure. This situation does not differ greatly from the situation that occurs in professional project management. In that case, it has been determined that some of the most common causes of failure are related to the individuals that work in project teams [15] and with team coordination [16, 17].

In light of these findings, the course instructors included two seminars in the learning programme entitled 'Causes of Project Failure' and 'Conflict Management'. In the first seminar, instructors and former alumni present their past experiences on the biggest problems identified by earlier teams, and strategies to overcome them. The second seminar is delivered by a psychologist and is based on a series of role-playing exercises.

The students are split into groups and given a fictitious project. They are then given a series of group dynamics in order to experience situations that frequently occur when working in a team. For example, they are asked to elect a project coordinator and leader, and to define the different roles needed in the project and the functions and responsibilities of each one. In another task, students are asked to think about the kinds of attitudes and behaviour that may improve or harm a group's functioning. The groups also simulate different types of group conflicts and discussions (for example, when a team member fails to submit work correctly or promptly) and then propose ways of addressing these situations, which will not jeopardise the group's functioning.

Based on the fact that conflict is an inherent part of team working and is practically unavoidable, the objective of this research project was to:

- Create a teaching tool that allows instructors to detect groups with functioning problems early

on in the course, enabling action to be taken before these problems affect the end quality of students' projects.

The next section presents the process followed when designing the TFP Questionnaire and compares this questionnaire with other such tools devised in the context of engineering education.

3. THE DESIGN OF THE TFP QUESTIONNAIRE

3.1. Group functioning assessment tools. Literature review

As mentioned earlier, most engineering schools set team-working skills as a learning objective for their students. However, simply placing students in a group work situation does not suffice to meet this objective [18]; tools are also needed that measure how these groups are functioning and which help them to work as effectively and efficiently as possible.

On that score, Brewer and Mendelson [19], propose a methodology based on a series of applied psychology metrics in order to evaluate the effectiveness of a group. They chose physical, emotional, mental and energy levels as performance criteria and used 29 metrics grouped together in these levels in order to measure the effectiveness of groups in terms of creativity, cooperation and productivity. Their groups were assessed 14 times per term using these metrics, which allowed a group's effectiveness to be predicted from the characteristics of its members. This technique proved that fully integrated, multidisciplinary, diverse teams are at least twice as effective as non-integrated, single-disciplinary, student-selected teams.

Yang and Yin [20] propose a methodology to measure effectiveness in distributed and co-located engineering teams. They devised a questionnaire consisting of ten team effectiveness characteristics that allow students to self-assess their groups. These characteristics consist of goals and objectives, utilisation of resources, trust and conflict, leadership, interpersonal communication, problem-solving/decision-making, control and procedures, experimentation/creativity, and evaluation and cohesion. Their questionnaire was adapted from one developed by Alexander [21] for teams in the workplace. The results of their study suggest that co-located teams are more socially orientated while distributed teams are more task-focused.

Along the same line, Adams et al. [22] propose a conceptual model to foster and assess team effectiveness in order to improve the quality of team results. Their model is based on the most important characteristics that a group needs to be effective (common purpose, clearly defined goals, psychological safety, role clarity, mature communication, productive conflict resolution and accountable interdependence). These characteristics were compiled from previous studies in the field. In the first stage of this model, group members complete a self-assessment in order to determine their starting point with respect to these characteristics and to detect potential deficiencies, which they then receive training on. In the next step, the team carries out a series of set tasks before once more assessing its effectiveness in terms of the same characteristics.

Likewise, Imbrie, Maller and Immekus [23] propose a scale to measure team effectiveness based on considerations proposed by other authors. Their model contemplates four factors (interdepency, learning, potency and goal-setting) with 24 items.

Loo [24] conducted another student team assessment project using a tool called the Team Climate Inventory® (TCI). This tool was developed by Anderson and West [25] and is now on the market. The TCI consists of a questionnaire comprising 44 items and has been used in educational, professional and cultural situations. Loo focused on applying this tool to assess team climate in a project management classroom context where students worked on research projects. Loo also suggests that there are no previous studies on using TCI for detecting groups with problems in functioning.

Although these tools assess different aspects of teamwork they are not designed to detect team functioning problems in on-going projects. It would therefore be very useful to have a specific tool for this purpose with the following characteristics:

- Useful for instructors. It should facilitate the monitoring of student group functioning and the provision of guidance in order to improve group results.
- Agile and quick. It should be compatible with instructor and student workloads during the course and contain a limited number of items in order to be implemented quickly.
- Predictive character. It should be able to identify student groups whose internal functioning problems will lead to project failure and consequently a negative result in their final project assessment.
- Reliable and valid. It should have psychometric characteristics that ensure is it a good measuring tool.

A tool with these characteristics may be of interest to any instructor who works with teams of students. In the learning context where the TFP Questionnaire was formulated, such a tool is essential given that students carry out projects for real clients who must receive a professional service. In this situation, poor teamwork may be detrimental to client satisfaction and therefore lead to project failure.

The next section details the background to the development of the TFP Questionnaire.

3.2 Background. The teamwork questionnaire

After determining that poor internal group functioning [13] was one of the most common causes of failure in the groups on the project management course at the University of Zaragoza, the course organisers set up a research project to study the relationship between the quality of the work carried out and the quality of group functioning, as well as underlying variables in both constructs.

The course instructors started by examining the course objectives and the bodies of knowledge of the leading project management associations (IPMA and PMI). From this analysis, they defined ten key variables for teaching project management and assessing group projects. These ten variables, listed below, were used to formulate the first version of a tool called the Teamwork Questionnaire (TQ).

TQ1. Perceived quality of the project group's work.
TQ2. Perceived quality of the project group's functioning.
TQ3. Quality of technical/individual contributions to the project group.
TQ4. Quality of individual contributions to the project group's functioning.
TQ5. Teamwork competence in the project group.
TQ6. Work motivation in the project group.
TQ7. Satisfaction with work in the project group.
TQ8. Advice for improving the quality of the project work.
TQ9. Advice for improving teamwork in project groups.
TQ10. Proposals for improving individual work in project groups.

The content, development and results of the TQ will be briefly described below, concentrating on the issues that justified the formulation of the superseding tool, the TFP Questionnaire. Further information on the TQ and its results can be found in the article *An assessment of behavioural variables implied in teamwork: an experience with engineering students of the University of Zaragoza* [26].

The TQ was drawn up in two stages. In the first stage, the 05/06 course, 21 students were randomly chosen from a total of 149 to fill in the questionnaire once they had finished their projects. The students were asked to score each variable using a subjective scale of 0 (very negative, highly deficient) to 10 (very positive, excellent) and to give the reasons for each score in their own words.

This article analyses the first two variables of the TQ (TQ1 and TQ2) since these are the only ones with implications for the TFP Questionnaire. Table 1 shows the mean and standard deviation of these variables obtained in this first stage.

The reasons the 21 students gave to explain their scores were analysed qualitatively by three instructors using the 'inter-judge consensus' method [27]. The instructors had received prior training for this analysis process. The instructors created, by consensus, a series of categories that grouped together reasons with the same meaning. The instructors did not judge the validity of students' contributions. Instead, they restricted their work to compiling all the reasons. Moreover, the instructors tried to use the same vocabulary and language as the students in order to minimise interference.

This analysis allowed content categories (items) to be identified for the different variables (for example, 25 separate items were identified for TQ2). These enabled a new, final version of the TQ to be created comprising ten variables and their respective items. In the second stage (06/07 course), 92 students filled in this second questionnaire—which can be found at (www.didyf.unizar.es/pi/teamworkquestionnaire.pdf). This time the students had to assess the variables and their items using an ordinal scoring system of 0 (very negative, completely disagree) to 10 (very positive, completely agree). Table 2 shows the overall assessment of the TQ1 and TQ2 variables together with the TQ2 items, which were the only items used as a basis for formulating the TFP Questionnaire.

Before the results of the TQ questionnaire were analysed, its psychometric properties were studied, in particular its reliability and validity. Reliability, or the internal consistency of results, can be estimated using Cronbach's alpha coefficient. Variables TQ1 and TQ2 were deemed to have good internal consistency since the coefficients were greater than 0.7 [28]: 0.8761 and 0.8619 respectively. In turn, validity can be defined as 'the level with which a questionnaire measures what it aims to measure' [29, pp. 113–139]. The model that is most commonly used today to determine validity is the model that allows a combined evaluation of content validity, construct validity and criteria validity [30].

Content validity aims to determine whether the sample of questions in a questionnaire represents the relevant content in the domain to be measured. In this questionnaire, the content validity was validated by the process of identifying and analysing the content of the variables through the opin-

Table 1. Mean and standard deviation of the TQ1 and TQ2 variables during first stage of testing (N=21)

	Mean	Standard deviation
TQ1. Perceived quality of the project group's work.	8.175	1.413
TQ2. Perceived quality of the project group's functioning.	7.621	1.918

ions of a representative group of 'experts' (the students).

Construct validity refers to the idea that a questionnaire should measure the construct, or thing, for which it was constructed. In this case, the construct validity was determined through analysing the 'item-total' correlation in order to evaluate the integration of each item in the total of the variable. In accordance with Nunnally and Bernstein [31], the criteria chosen to include an item in a scale was a correlation index with a value of 0.25 or above. As a result of this analysis, items 5, 18, 19 and 25 were eliminated from the TQ2 variable. A low correlation may be caused by a range of factors, such as an item being poorly expressed or not measuring what is was designed to measure.

Finally, criteria validity shows if a test is useful for predicting a certain response in a specific situation. The summary of the findings of the TQ results below shows that the criteria variable '*mark obtained in the project*'—which measures the success of each project group—is an indicator of the predictive validity of the TQ. This variable is the mark given by the panel to the group for its report and the defence of its project.

In addition to these tests, exploratory factor analyses were carried out to check the factor structure of each of the variables and to try to reduce the number of items in each one. However, the factor groups constructed through this analysis were rejected because they did not group together items with the same conceptual meaning.

The most important findings from the analysis of the TQ results were:

- There is a statistically significant positive correlation between the '*mark obtained in the project*' and the '*perceived quality of the project group's work*' (TQ1) ($f = 0.397$ and $p < 0.001$). This result suggests that the criteria used by the instructors to assess the projects matched students' individual perceptions of the quality of their projects and also allows the TQ1 variable to be used as an indicator of project quality.
- The groups of students that received a mark of very good (vg, between 8.0 and 10.0) had a significantly higher score in the TQ2 variable '*perceived quality of the project group's functioning*' in comparison to the group that received a mark of improvable (im, between 5.0 and 7.9) according to Mann-Whitney's nonparametric test ($U = 551$, $p < 0.05$; $Md_{vg} = 8$, $RI_{vg} = 2$; $M_{im} = 7$, $RI_{im} = 2$). This analysis showed that students who received a better mark perceived a better quality in their group functioning than those who received lower marks.
- When studying the relationship between the 21 items in the TQ2 variable and its overall value, statistically significant positive correlations were found in 18 items (see Table 2).

Table 2. Statistical data of the TQ1 variable and the TQ2 variable and its items, during stage 2 testing (N = 92).

	Variable /item	Mean	Standard Deviation	'Item-total' correlation index	Spearman Correlation between TQ2 and its items.
TQ1	**Perceived quality of the project group's work**	8.051	1.004		
TQ2	**Perceived quality of the project group's functioning**	7.419	1.455		
Item 1	All group members had a clear idea of what was to be done.	7.086	1.592	0.456	$r_s = 0.480$; $p = 0.000$
Item 2	The group was united by a common goal.	7.624	1.882	0.541	$r_s = 0.624$; $p = 0.000$
Item 3	There was a pleasant working environment.	7.978	1.877	0.613	$r_s = 0.550$; $p = 0.000$
Item 4	Time allocation for the work was uneven throughout the project.	6.913	2.696	–0.264	$r_s = -0.376$; $p = 0.000$**
Item 5	Work was allocated on a weekly basis to each group member.	6.984	2.244	0.246*	
Item 6	There were differences among group members.	3.591	3.080	0.273	$r_s = 0.438$; $p = 0.135$**
Item 7	Communication within the group was good.	7.685	1.735	0.624	$r_s = 0.598$; $p = 0.000$
Item 8	Work was performed as a team.	7.935	1.680	0.683	$r_s = 0.634$; $p = 0.000$
Item 9	Timetable incompatibilities were solved.	8.183	1.894	0.544	$r_s = 0.399$; $p = 0.000$
Item 10	All group members worked hard.	7.086	2.595	0.645	$r_s = 0.647$; $p = 0.000$
Item 11	All group members worked well.	7.323	2.091	0.682	$r_s = 0.664$; $p = 0.000$
Item 12	Each group member had a clearly defined role.	7.505	1.827	0.407	$r_s = 0.408$; $p = 0.000$
Item 13	The work brought the group together on a personal level.	7.022	2.436	0.430	$r_s = 0.450$; $p = 0.000$
Item 14	A positive attitude prevailed in the group.	7.538	1.704	0.738	$r_s = 0.741$; $p = 0.000$
Item 15	The group members had worked together before.	5.731	3.392	0.364	$r_s = 0.127$; $p = 0.226$**
Item 16	The meetings led to steady work.	6.774	1.906	0.610	$r_s = 0.502$; $p = 0.000$
Item 17	Although the beginning was difficult. day-by-day things improved.	7.826	1.745	0.498	$r_s = 0.424$; $p = 0.000$
Item 18	The group members had incompatible timetables.	6.806	3.015	–0.067*	
Item 19	The group members had different interests.	3.901	3.044	–0.159*	
Item 20	The group held together even in moments of difficulty.	7.828	1.851	0.642	$r_s = 0.490$; $p = 0.000$
Item 21	Tasks were distributed evenly.	6.145	2.781	0.635	$r_s = 0.458$; $p = 0.000$
Item 22	All group members fulfilled their part.	7.344	2.361	0.640	$r_s = 0.597$; $p = 0.000$
Item 23	Group coordination was good.	7.527	1.926	0.555	$r_s = 0.672$; $p = 0.000$
Item 24	Before the group was formed, its members were friends.	6.860	3.091	0.448	$r_s = 0.220$; $p = 0.000$
Item 25	There was not enough time	4.909	3.316	–0.053*	

* Items removed after the item–total correlation analysis.
** Items without a statistically significant positive correlation with the TQ2 variable and so removed from the variable.

The results of the TQ gave the course instructors the idea of going one step further with this research in order to design a tool that would assess how student groups were functioning in order to prevent functioning problems leading to poor quality projects. This next step, as described below, led to the creation of the TFP Questionnaire.

3.3. The teamwork failure prevention questionnaire

At that point, it would have been possible to create a tool to assess group functioning using the 18 TQ2 items with a statistically significant positive correlation with the overall TQ2 value, since this variable represents students' perceptions of the quality of their group functioning. However, this high number of items did not match some of the characteristics planned for this tool—such as agility and speed. The instructors therefore decided to reduce this number through selecting the items that they believed to show the different aspects of group internal coordination, since this had historically been the main cause of failure detected in the groups. They short-listed six items:

- All group members had a clear idea of what was to be done (Item 1).
- Work was performed as a team (Item 8).
- Timetable incompatibilities were solved (Item 9).
- Each group member had a clearly defined role (Item 12).
- Tasks were distributed evenly (Item 21).
- Group coordination was good (Item 23).

The instructors then carried out a confirmatory factor analysis to check whether these items formed a single or multiple-dimension variable or construct. The results showed these items were coherently grouped in a single-dimension construct with high internal consistency (Cronbach's alpha coefficient = 0.804).

Once these items were defined as a single-dimension variable or construct—called '*perceived quality of the project group's internal coordination*'—the correlation was studied between this variable and the TQ1 '*perceived quality of the project group's work*' variable. The results of the overall correlation between these two variables were not statistically significant ($r_s = 0.14$; $p > 0.05$). However, the individual analyses of each of the six items with the '*perceived quality of the project's group work*' variable produced statistically significant positive correlations in five of the six items, as shown in Table 3.

This correlation led to the idea of creating a tool that would be able to check these internal coordination values in order to predict which groups would have a poor quality final project, thus enabling preventative actions to be put into place.

The TFP Questionnaire was therefore constructed using the first five variables listed in Table 3 together with the assessment of the quality of group functioning (TQ2). The item '*group coordination was good*' was excluded from the questionnaire, since this aspect of internal group coordination had no correlation with the TQ1 variable. The students participating in this study had to respond using an ordinal scale with a continuous classification of 10 intervals between 0 (very negative, strongly disagree) and 10 (very positive, completely agree). Fig. 1 shows the TFP Questionnaire that was distributed to students. This template can be downloaded at www.didyf.unizar.es/pi/ptfquestionnaire.pdf.

In order to identify if a group perceived it had internal functioning problems, three variables were created:

- 'P_{member}': sum of the values of an individual's questions (TFP Questions 2 to 6).
- 'P_{group}': average 'P_{member}' value of the members of a team.
- 'P_{course}':25th percentile of the 'P_{member}' values of all students on the course.

A group was identified as potentially having problems if its 'P_{group}' value was below the 'P_{course}' value. A quasi-experimental regression-discontinuity design was therefore used [32]. More specifically, groups were either allocated to a 'treatment group' or 'non-treatment group' according to a cut-off point in the 25th percentile of the assessments of all students. Groups that scored below the cut-off point were assigned to the 'treatment group' and those with scores above this level were allocated to the 'non-treatment group'.

The next section presents the results obtained with the TFP Questionnaire.

4. TFP QUESTIONAIRE RESULTS

4.1 Results in the project management course at the University of Zaragoza

The TFP Questionnaire was tested at the

Table 3. Spearman correlation between the items in the '*perceived quality of the project group's internal coordination*' variable with the TQ1 '*perceived quality of the project group's work*' variable

Items in the '*perceived quality of the project group's internal coordination*' variable	Spearman Correlation
All group members had a clear idea of what was to be done.	$r_s = 0.276$; $p = 0.006$
Work was performed as a team.	$r_s = 0.373$; $p = 0.000$
Timetable incompatibilities were solved.	$r_s = 0.319$; $p = 0.001$
Each group member had a clearly defined role.	$r_s = 0.222$; $p = 0.028$
Tasks were distributed evenly.	$r_s = 0.314$; $p = 0.002$
Group coordination was good.	$r_s = 0.120$; $p = 0.240$

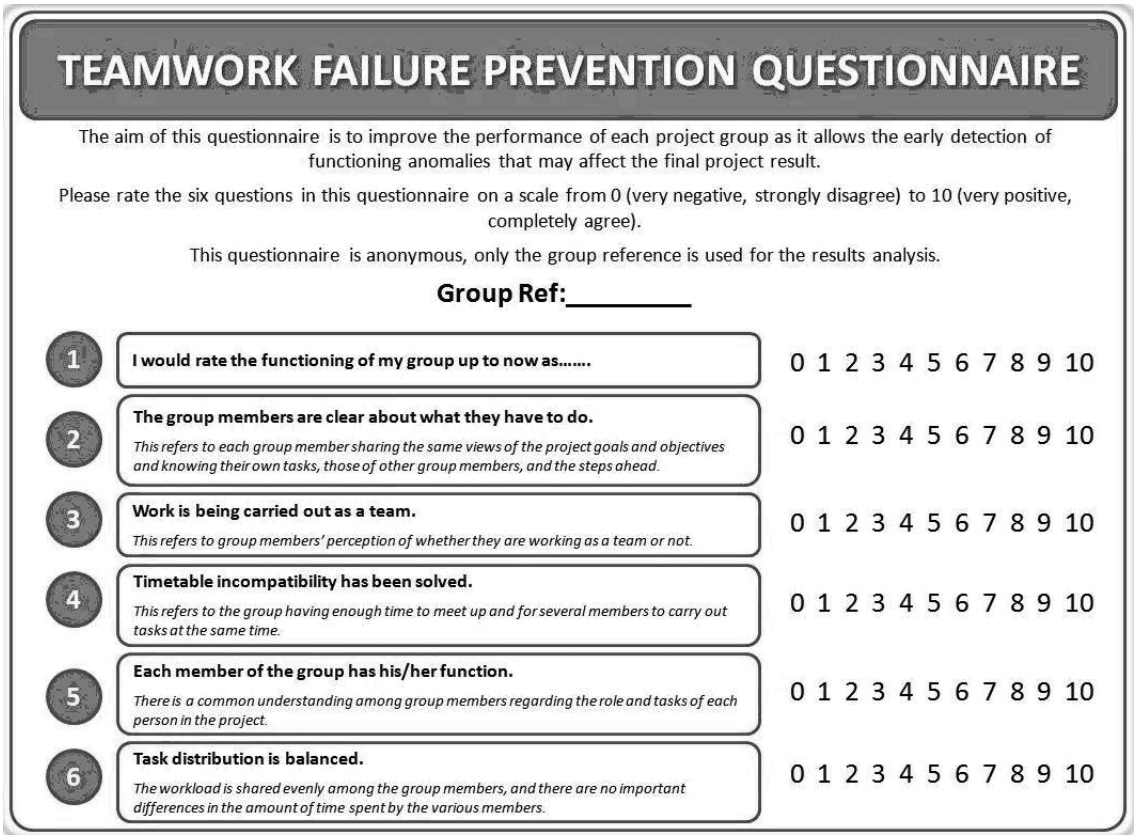

Fig. 1. Teamwork Failure Prevention Questionnaire.

University of Zaragoza during the 07/08 and 08/09 courses. In the 07/08 course, 84 students filled it in (97.7% of the total), representing all the 18 groups on the course. In the following year, 75 questionnaires were filled in (93.7% of the total), representing 17 groups. In both years, the questionnaire was distributed mid-course because at this point the workload increases considerably and this is when the first conflicts and problems in functioning tend to appear.

Students completed the questionnaires individually and away from other members of their groups. The questionnaires were anonymous; students only had to indicate their group reference number. In order to guarantee this anonymity, the completed questionnaires were placed in a sealed box. Students were also informed that the questionnaires would not be marked.

As with the TQ, the psychometric characteristics of the TFP Questionnaire were analysed:

- The reliability was gauged using Cronbach's alpha coefficient, reaching a value of 0.852.
- The content validity was justified because the items were taken from the TQ and had been validated earlier.
- The construct validity was confirmed by the high internal consistency of the TQ, as validated earlier, and by the item discrimination analysis in which all items obtained an item-total correlation index above 0.25 using the criteria of Nunnally and Bernstein [31].
- The validity criteria results in both years, as shown below, confirm the predictive capability of this tool. In this respect, the results show a statistically significant association between the variables measured with the TFP Questionnaire and the marks obtained by students in their projects.

The TFP questionnaire detected internal functioning problems in five out of 18 groups on the 07/08 course and three out of 17 groups on the 08/09 course. Table 3, shows the values obtained in each of these groups ('P_{group}' variable) together with the cut-off values that were used to determine whether a group had problems in functioning ('P_{course}' variable).

The system used to reference the groups in Tables 4 and 5 is GA–B–C, where:

- A is the group reference number.
- B is the year of the questionnaire.
- C is the location of the questionnaire (Z=Zaragoza and A=Aalborg).

Each group and its coach were informed of the questionnaire results as soon as these were calculated so that the results could be discussed at their next meeting. This meeting was particularly important when the tool detected a group with problems. Each coach was given a series of recommendations to help them draw up a tailored action plan for each group affected. Action plans were established because both the students and coaches in the

Table 4. TFP Questionnaire results at the University of Zaragoza

07/08 COURSE		08/09 COURSE	
Cut-off value	'P_{course}' = 33	Cut-off value	'P_{course}' = 33
Groups	'P_{group}'	Groups	'P_{group}'
G2-08-Z	24.0	G6-09-Z	31.5
G5-08-Z	32.0	G10-09-Z	31.0
G9-08-Z	28.0	G13-09-Z	25.0
G12-08-Z	32.0		
G17-08-Z	28.5		

groups affected verified the results obtained with this tool, confirming that the groups had problems in functioning.

The actions recommended by coaches to groups with problems functioning are very diverse and depend on the type of problems identified. One of the most common types of problems in the groups was that students complained that the distribution of the group workload was uneven (TFP Question 6). In these cases, students are recommended to make optimum use of the course timesheet, a tool on which group members record the time they spend on the project each week. Although students' names on the timesheet are hidden from the coach, students can see the names therefore allowing them to identify the team members that are working fewer hours. Another common problem was that students did not find enough time to meet up (TFP Question 4). In these cases, the coach encourages the groups to establish compulsory weekly meetings, which cannot be postponed. In order to get the most out of their meetings, students are also advised to prepare an agenda for each meeting to focus their attention on the most important matters.

After the action plan has been defined, the coaches then monitor the functioning of the groups affected and the effectiveness of any corrective measures. The coaches also compile a report containing all the information gathered in these meetings as well as any corrective measures adopted. This report is then shared and discussed with the other course coaches.

In all groups in which the TFP Questionnaire has detected problems in functioning, both the group members and coaches have verified this diagnosis. After adopting corrective measures, the five groups with problems on the 07/08 course passed the course and their projects were assessed positively. On the 08/09 course, two of the groups overcame their problems; however the third could not sit the exam because their problems prevented them from completing their project on time. Nevertheless, the group passed the course in the second round of exams. In all cases, students informed their coaches that after applying the corrective measures, their group's functioning improved and they were able to solve their problems.

4.2 Results in the cooperation, learning and project management course at Aalborg University

In order to test the TFP Questionnaire in a different context, it was distributed to students on the 08/09 Cooperation, Learning and Project Management course at Aalborg University. The students at the two universities completed the questionnaire at the same time.

This context was chosen firstly because both courses are based on project management and secondly because they use a similar classroom methodology based on group projects. A third factor influencing this choice was the fact that students at Aalborg possess much more honed teamwork skills than those at Zaragoza. This difference is because Aalborg University focuses more on developing these skills. It was therefore interesting to use the TFP Questionnaire on students with more teamwork experience.

The questionnaire was written in Spanish and translated into English using a back translation quality assurance procedure involving two different translators. In this process, one translator translated the questionnaire from Spanish to English and a second translator then translated the English version back to Spanish. The differences between the original and back-translated documents were then analysed in order to verify that the content and wording of the translated questionnaire were true to the original.

A total of 144 anonymous responses were collected from the 252 students on this course (57.1%), representing 36 groups. The reliability of the questionnaire in this context was gauged using Cronbach's alpha coefficient, obtaining a value of 0.892. The questionnaire's validity was justified by using the criteria mentioned above in the case of the University of Zaragoza.

Problems were detected in five of the 36 groups analysed at Aalborg. Table 5, shows the scores obtained in each of these groups ('P_{group}' variable) together with the cut-off value used to determine groups with problems in functioning ('P_{course}' variable).

The groups had to submit a self-assessment report on the functioning of their group. In order to validate the results of the TFP Questionnaire at Aalborg, the self-assessment reports of the groups detected to have problems were consulted. All

Table 5. TFP Questionnaire results at Aalborg University

Cut-off value	'P_{course}' = 26
Groups	'P_{group}'
G6-09-A	19.0
G16-09-A	25.0
G18-09-A	25.5
G24-09-A	25.0
G33-09-A	21.0

these groups reported that they were experiencing problems, although none indicated a crisis that they felt they could not overcome themselves. One of the most frequent problems identified in the Danish groups was that students did not share the same vision of the project and therefore did not have a clear idea of the project tasks (TFP Question 2). Another common problem, as in Zaragoza, was that project workloads were distributed unfairly (TFP Question 6).

5. DISCUSSION

Firstly, with respect to the methodology, since the research involved project management students at Zaragoza from different academic years, it was impossible to establish a control group against which the results could be assessed. A total of 272 students participated in the Zaragoza programme in the 05/06 to the 08/09 courses. The subjects were similar—although not identical—in each year: they had similar weaknesses and strengths and no prior knowledge on project management or teamwork. Nevertheless, the TFP Questionnaire's reliability and validity results in the groups at both Zaragoza and Aalborg suggest that it is a robust and reliable measurement tool in both cultural contexts.

Another important aspect of the methodology is the cut-off value used for determining the existence of functioning problems in a group. This research project set this level as the 25th percentile of the scores of all those who completed the questionnaire ('P_{course}'). This criteria is commonly used to identify the critical region or risk groups in preventive and diagnostic contexts. However, the 25th percentile may be rather conservative and therefore exclude some groups that are experiencing problems in their functioning. If it were necessary, this cut-off value could be raised to a higher percentile. Nevertheless, it was proven that all the groups detected with this cut-off value confirmed the diagnosis made by this tool.

Continuing with the theme of methodology, another key aspect is the procedure used by students when completing the questionnaires. This procedure always ensured the questionnaires were anonymous because group members may be hesitant to complain about group functioning problems or conflicts in front of their peers or instructors. This situation may be exacerbated if the students are also friends, as often occurs in the University of Zaragoza where students are free to form their own groups. The procedure used helps to bring these issues to light and gives instructors an opportunity to intervene to resolve them.

Secondly, it is important to discuss the different cut-off values defined for identifying groups with problems at each university. These differences can be explained by the fact that the Danish students had more experience in team working than the Spanish students, and that the two cohorts encountered different types of problems. The questionnaire scores of the Aalborg students were generally much lower than their counterparts in Zaragoza. The cut-off values were therefore stricter in Zaragoza than in Aalborg, set at 33 and 26 respectively. This difference may be due to the fact that the Danish students, owing to their experience of working in groups, judged their team functioning more critically, whereas the students at Zaragoza seemed to be more optimistic. The different types of problems affecting the two cohorts may also have come into play here. For example, the Danish students did not have problems meeting up, whereas the Spanish students did. Nevertheless, these scores cannot be compared because these students come from different universities with different characteristics, problems and learning experiences. What is important is that, owing to the idiosyncrasies of each context, the TFP Questionnaire has a uniform way of calculating the cut-off point through the 'P_{course}' variable.

Finally, this research has contributed to both engineering education research and engineering education in general.

The main contribution to engineering education research has been a tool, the TFP Questionnaire, which can detect groups with problems in functioning during an on-going project in order to prevent these problems from jeopardising the project's quality. This tool was designed to have good psychometric characteristics, and results show that it does. Moreover, it has been applied successfully in the project management course at the University of Zaragoza, as well as in another context—leading to the ability to improve group functioning in both cases.

The TFP Questionnaire has contributed to engineering education through helping students to reflect on the most important aspects of team working. The questionnaires and subsequent corrective measures, where applicable, have helped students to become aware of behaviours and attitudes they can adopt to improve team working or group functioning. In turn, this awareness has led to better quality work and has ultimately aided their learning. This learning experience also benefits instructors who, through the reports they prepare after interventions in groups with problems in functioning, learn to support their students in resolving group conflicts and problems. Moreover, this learning experience aids instructors in future academic years, which, in turn, benefits future students.

From a project management course design perspective, the TFP Questionnaire has become a regular teaching tool that coaches use to monitor their groups in the course at the University of Zaragoza. However, instructors on this course do not neglect the education of their students in the key areas of cooperation and project management just because they have a tool that can identify groups with problems in functioning. In fact, having realised the importance of these areas, the instructors will place greater emphasis on them in the future.

6. CONCLUSIONS

The aim of this research was to devise a tool that allows the early detection of project groups with problems in functioning.

The result has been the creation of the TFP Questionnaire. This questionnaire has proven to be an agile and flexible tool that instructors can employ to improve their monitoring and supervision of student groups during a course.

In order to test its validity and reliability, the TFP Questionnaire has been tested in project management courses at the universities of Zaragoza and Aalborg. These tests have been a prime example of transferring educational research results to the engineering classroom. In both cases, the reliability and validity values of this questionnaire show it is a suitable measuring tool, which, in practice, has detected eight groups with problems in functioning out of the 35 groups analysed at Zaragoza and five groups out of the 36 studied at Aalborg.

These psychometric characteristics and the TFP Questionnaire's simple and rapid completion and analyses processes make it a good tool to be applied in educational contexts where students work in groups—an increasingly popular learning approach —because the results show that the tool is both effective and efficient.

Future work on this research would consist in testing this tool in different educational contexts, perhaps in other engineering contexts outside of project management.

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