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# Do Young People Really Know How to Collaborate for Common Success? Study on Undergraduate Students' Perception of Collaborative Work in a Spanish University

## ABSTRACT

This paper studies undergraduate student attitudes towards team-based projects, connecting those attitudes to challenges and overall perception of this work. This study was conducted with 220 students in the context of three subjects taught at a Spanish University, that included collaborative projects as mandatory assignments to be developed over the course of the subject. The instrument was a Likert scale-based questionnaire. As a methodology, the Rasch model was used, making it possible to apply indirect measuring of students' development level of various skills. The findings point to the difficulty in solving specific communication needs and managing students' involvement and commitment to the project. The results obtained through Differential Item Functioning analysis (DIF) show that gender, year of study, students' age, academic degrees, and the context of curricular subjects influence significantly the acquisition of skills related to collaborative work, facilitating or hindering their development among university students. These results have practical implications for the design of collaborative projects within higher education academic programs. They also suggest that the way collaborative work is usually planned is not very effective and should be reconsidered.

## KEYWORDS

Collaborative work, educational research, Rasch model, higher education, interdisciplinary teams

## INTRODUCTION

Collaborative work is essential in tertiary education. Properly organized, it is fundamental for collaborative learning (Hoegl 2005). It is considered an innovative pedagogical tool for any type of training (Finkelstein et al. 2009; Thakral 2017). Collaboration, essential in many professional fields, is understood as the ability to work with other people, combining individual tasks with interactive teamwork, trying to resolve a problem conjointly, working on the same tasks simultaneously, assuming

responsibilities in a collective decision-making process, and producing a shared output (Heerwagen et al. 2004; Tuirán-Gutiérrez et al. 2019).

It is important to note that teamwork, in which the work is merely distributed through individual tasks among the participants, is not always collaborative. In fact, collaborative work is considered as a more advanced stage of teamwork with full cooperation during its development (Pollard and Collins 2005) and exposing students to real working environments (Hall and Buzwell 2013). True collaborative work implies that the participants voluntarily build a team that shares a common goal (Domingo 2008) and takes part in various activities of a different collaborative nature (Robillard and Robillard 2000). It requires each participant to be in charge of certain tasks and report on their completion. The team, in turn, must assess these results and extend or modify them to find a proper problem solution.

Due to its complexity, collaborative work should be properly structured to avoid any negative effects, such as a tendency by some team members to not contribute to the work (Hall and Buzwell 2013). There can also be friction because of the division of tasks, poor management of debates, scattered attention to the goals, and lack of responsibility (Algashaam 2015).

Positive effects of collaborative work include a better achievement of the common objectives and higher productivity of students compared to those working individually (Johnson and Johnson 1999; Layman 2006; Rodríguez-Zamora and Espinoza-Núñez 2017). In addition, it increases students' performance (Estébanez 2016), improves transferability of knowledge (Pfaff and Huddleston 2003), and workplace-related skills among the participants (Musa et al. 2011). Collaborative work is also important for improving learning processes that focus more on soft skills than on pure content, such as leadership, and communication skills (Barrick et al. 2007; Lu and Lin 2017). In addition, students can acquire diverse skills considered crucial for young people to succeed in the labor market (Alonso, Fernández, and Nyssen 2009; Youssef, Dahmani, and Omrani 2015).

In addition, certain critical factors stimulate collaborative work. Interaction is especially crucial for collaborative decision making. It is one of the main elements of collaborative work and as a social process, it implies much more effort from the participants than merely the individual contributions of each team member (Campbell, Roth, and Jornet 2019). In this regard, teams must effectively manage conflicts, as a part of human interaction, to avoid distraction from the goal of the conjoint work (Ayoko, Callan, and Härtel 2008). Not all conflicts are bad for collaborative work. For example, constructive conflicts, also called socio-cognitive conflicts, make the participants discover other points of view different from theirs and grow within the group. Because of this, constructive conflicts contribute to the group feeling, building greater confidence and engagement of team members (Näykki et al. 2014).

Increased communication and interaction are also considered essential in different professional environments. In this regard, the importance of internal communication, that consists of establishing a dialogue among the team participants, should be emphasized. This is especially meaningful for creation of a proper relational environment, in which the students can freely exchange their experience, ideas, and needs, actively listen to one another, and overcome conflicts successfully (Rodríguez-Zamora and Espinoza-Núñez 2017).

On the other hand, team-based work through interdisciplinary teams, comprised of members with different knowledge, experience, or skills, is very rewarding for students. This helps to create an improved learning environment (Fleischmann and Daniel 2010), develop critical thinking and open-

mindedness (Berasategi et al. 2020), generate new ideas from multiple perspectives (Foster and Yaoyuneyong 2016), improve decision making (Hjörne and Säljö 2014), learn about methodology of other fields, and exhibit higher responsibility (Marcos-Jorquera et al. 2016). Besides that, collaborative work is much more effective in small groups. This makes it possible to share different skills of each participant for the benefit of the group to find a proper solution to the problem (Cámara-Estrella, Díaz-Pareja, and Ortega-Tudela 2015).

In higher education, and more specifically, in Spanish universities that share the new European Higher Education Area (EHEA), it is absolutely essential to provide students with a strong basis focused not only on knowledge acquisition, but also on other important aspects to facilitate access to the labor market (Borrasca 2014). In this sense, collaborative work helps them in the acquisition of the needed skills. Therefore, it should be integrated within formal academic programs, according to the latest requirements of the Ministry of Education (ANECA 2014). Recently we have witnessed that collaborative work has been replacing traditional educational methods, transforming the higher education centers from instructor- to student-centered spaces. However, university students remain reluctant to use this work methodology (Clinton and Wilson 2019). Besides that, conservative educational methods are still prevalent in many universities (Estébanez 2016). Often, students fail to assume a greater responsibility to reach the objectives and teachers fail to create the appropriate environment that motivates and stimulates effective learning (Borrasca 2014).

In addition, the opportunistic character of some team members, internal conflicts, high cost related to the applied effort, and time constraints present serious barriers to the successful implementation of this methodology in a classroom (Foster and Yaoyuneyong 2016). These deficiencies, together with little knowledge of the proper techniques to organize collaborative work, prevent students from taking maximum advantage of the greater involvement of all the team members and, consequently, from obtaining better results from the collaborative experience. Therefore, it is important to measure the effectiveness of collaborative work as a pedagogical tool and its perception among students to understand the effect generated by this methodology (Layman 2006).

In light of the above, this research focuses on the analysis of certain factors considered fundamental for a successful collaborative work. Hence, the main objectives outlined in this study are the following:

- study undergraduate student attitudes towards team-based projects, connecting those attitudes to challenges and overall perception of this work, such as interdisciplinarity of the teams, internal communication, the participants' commitment to the work, their involvement, and maximization of human resources for a common goal;

- identify eventual differences in the development of skills related to collaborative work of undergraduate students classified under different criteria.

## MATERIALS AND METHODS

### Methodology and research context

This research took place at the University Europea del Atlántico (Santander, Spain) during the academic years 2017–2018 and 2018–2019. An online survey was used with a questionnaire administered after completing the projects. It was the moment when the students gained a full experience of collaborative work. The participation was voluntary and anonymous. The researchers

obtained informed consent from all the participants. The analysed sample comprised 220 students of different degrees, who developed collaborative projects within the framework of the following subjects:

-Advertising Campaign Design: taught from February to May 2018; required only for the students of publicity and public relations and elective for students of many other degrees, such as business management, audiovisual communication, journalism, psychology, and engineering;

-Market Research: taught from September to December 2018; required for students of business management and publicity and public relations, elective for students of psychology and engineering;

-Business Economy and Entrepreneurship: taught from February to May 2019; required for students of many different degrees and elective for students of sports sciences and human nutrition.

According to the university regulations, attendance to the classes for each of these subjects is mandatory; the total number of hours of face-to-face classes of each subject amounts to 60 teaching hours distributed across 15 weeks, which implies 90 additional hours of autonomous student work during this period. Prior to the development of the collaborative projects in each subject, a small workshop was held in which it was explained the relevance of working in interdisciplinary teams, highlighting increased communication, commitment of all members, and adjustment of the tasks according to the talents of each participant.

The questionnaire included several questions to collect demographic data of the participants such as gender, age, year of study, the subject within which the project was undertaken, degree in which students were enrolled, and the grade they obtained in the project. According to this information, the age of most of the students was between 20 and 21 years old (almost 83%), and half of the students were in their third year and the other half in their fourth year of study (see table 1).

**Table 1. Descriptive statistics: age and year of study.**

| Age | Students, n | Course | Students, n |
|---|---|---|---|
| 20 | 83 | 3rd year | 107 |
| 21 | 100 | | |
| 22 | 25 | 4th year | 113 |
| 23 | 8 | | |
| 24 | 4 | | |
| Total | 220 | Total | 220 |

The degrees in which the students were enrolled included business management (BM), audiovisual communication (ACOM), journalism (JOR), publicity and public relations (PPR), psychology (PSYCHO), IT engineering (IT), organizational engineering (OE), and sports sciences (SPORTS). Additionally, we also included a group of foreign students under Erasmus mobility program. The largest group of students belonged to PSYCHO (31%). Other representative groups were from BM (18%), PPR (17%), JOR (13%), and ACOM (12%). The respondents' profile counted with a predominant presence of women (61%), showing a preference to work in non-interdisciplinary teams (see table 2). In this study, interdisciplinary teams included members from at least two different academic degrees, while non-interdisciplinary teams included students from the same degree.

**Table 2. Descriptive statistics of the sample: degrees, teams' character, and gender.**

| Teams' character | | Students, n | | Teams, n | |
|---|---|---|---|---|---|
| Interdisciplinary | | 90 | | 24 | |
| Non-Interdisciplinary | | 130 | | 37 | |
| Total | | 220 | | 61 | |
| Degree | Students % | Men % | Women % | ITDR* % | Non-ITDR** % |
| BM | 18.2 | 11.4 | 6.8 | 7.3 | 10.9 |
| ACOM | 11.8 | 7.3 | 4.5 | 7.3 | 4.5 |
| JOR | 12.7 | 4.5 | 8.2 | 8.6 | 4.1 |
| PPR | 17.3 | 4.5 | 12.6 | 9.1 | 8.2 |
| PSYCHO | 30.5 | 8.2 | 22.3 | 2.7 | 27.7 |
| IT | 0.9 | 0.0 | 0.9 | 0.0 | 0.9 |
| OE | 1.4 | 1.4 | 0.0 | 1.4 | 0.0 |
| SPORTS | 0.5 | 0.5 | 0.0 | 0.5 | 0.0 |
| Erasmus | 6.8 | 0.9 | 5.9 | 4.1 | 2.7 |
| **Total** | **100** | **38.7** | **61.3** | **41.0** | **59.0** |

Note: *ITDR: interdisciplinary teams. **Non-ITDR: non-interdisciplinary teams.

Following Hoegl (2005) and Cámara-Estrella, Díaz-Pareja, and Ortega-Tudela (2015), who stated that smaller groups have a better performance than larger ones, the instructions provided for collaborative projects said that the teams should be a reduced size, with a minimum of three and a maximum of five members, and created by the students themselves. Each team had to develop a team-based project, according to the specific objectives set by each subject (see table 3).

**Table 3: Objectives and description of collaborative projects.**

| Subject | Project | Project's objectives and tasks |
|---|---|---|
| Market Research (MR) | Analysis of the preferences for cold breakfast cereals | Design and validate a questionnaire, collect information through a survey applied to a reduced sample, make a descriptive analysis, and suggest improvements in the questionnaire. |
| Advertising Campaign Design (ACD) | Design of advertising campaigns for real organizations (client-based projects) | Create advertising campaign for real-world local organizations, mainly for small and medium enterprises, but also for sports and cultural associations, and non-for-profit organizations. |
| Business Economy and Entrepreneurship (BEE) | Start-up/business proposal | Design a start-up/business proposal, write a business plan, and make a pitch. |

The distribution of the sample per subject is summarized in table 4.

**Table 4. Distribution of the sample per subject.**

| Subject | Students, n | Teams, n | ITDR* Teams, n | Non-ITDR** Teams, n |
|---|---|---|---|---|
| MR | 58 | 26 | 8 | 18 |
| ACD | 49 | 12 | 8 | 4 |
| BEE | 113 | 23 | 8 | 15 |
| Total | 220 | 61 | 24 | 37 |

Note: *ITDR: interdisciplinary teams. **Non-ITDR: non-interdisciplinary teams.

Additionally, the students had to evaluate nine statements through a four-point Likert scale, with categories from "totally disagree" as point one to "totally agree" as point four. The purpose of using a scale with no midpoint was to force the participants to define their position and avoid frequently adopted neutrality (Garland 1991). For this analysis seven statements, based on background literature previously mentioned, measured the students' perception of different aspects of collaborative work (see table 5). This measurement was aligned to the development of certain skills related to collaboration by the students. So this information was used for further analysis.

**Table 5. Statements to measure students' perception regarding collaborative work.**

| Item | Statement | Previous studies |
|---|---|---|
| P1 | During the project I understood the importance of working in an interdisciplinary team. | Berasategi et al. (2020); Marcos-Jorquera et al. (2016). |
| P2 | Communication among the members of my team was clear. | Berasategi et al. (2020); Domingo (2008); Knox, Gillis, and Dake (2019). |
| P3 | In my team everybody expressed conflicts openly by discussing differences. | Näykki et al. (2014) |
| P4 | In my team everybody was equally involved in the project. | Hall and Buzwell (2013); Knox, Gillis, and Dake (2019). |
| P5 | My team would obtain better results if communication among its members were more active. | Berasategi et al. (2020). |
| P6 | The potential of some participants was fully exploited during the project. | Hall and Buzwell (2013). |
| P7 | The members of my team were really committed to the success of the project. | Hall and Buzwell (2013); Knox, Gillis, and Dake (2019). |

| Descriptive statistics | | | | | | | |
|---|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 |
| Median | 4 | 3 | 3 | 2 | 2 | 3 | 3 |

*Validation through Rasch model*

The data was analyzed using the Rasch model, framed within the Item Response Theory, usually applied to the constructs that cannot be measured through an objective scale. The Item Response Theory (Latent Response Theory) assumes that the differences in the responses of the individuals to the

items of a test are due to their ability. The rest of the factors, for example, the difficulty of the items, that generate variability in the responses are considered to be constant. Using mathematical models, it focuses on latent traits, which are unobservable characteristics of the individuals, and tries to explain how they are related to the individuals' observed outcomes, such as responses or performance (Bichi and Talib 2018).

The collected data were specific, making their analysis more difficult to a certain extent. Firstly, we wanted to measure the level of acquisition of students' skills through their perception, which had no physical magnitude. Consequently, indirect measurement was applied through the evaluation of abstract aspects that create an underlying reality. In this regard, the Rasch model, which has been used in a number of studies in the field of education (Hadenfeldt et al. 2013; Herrmann-Abell and DeBoer 2018; Hoi 2020; Mursidi and Soeharto 2016), helps improve the precision of instruments construction and their quality monitoring (Boone 2016).

Secondly, data collection was done through an ordinal scale, so this kind of data generally does not have additive characteristics and should be treated as interval variables in further analysis (Bond and Fox 2007). At this point, a Rasch model ensures that the interval units are adjusted to the measurement requirements with categorical data (Sanchez-Ruiz and Blanco 2016; Sinkovics and Salzberger 2006). Besides that, the Rasch model complies with two other requirements: unidimensionality, which means that all the items refer to one construct, and invariance, that refers to the results obtained from the analysis are independent from the persons or items of the sample (Oreja-Rodríguez 2005). Detailed information on the Rasch model is offered in appendix A12.

The software used for data processing is Winsteps, version 4.8.0.0. Validation of the construct was done through the following tests:

(1) global reliability and validity of the measures;
(2) analysis of the dimensionality of the construct;
(3) analysis of response categories;
(4) item hierarchy;
(5) analysis of significant differences among different groups of participants.

The first analysis shows good persons' and items' reliability since the values are over 0.7 (Nunnally 1978). Considering the Wright's Test Reliability for persons, the index is even higher: 0.92, which complies with the requirement to be over 0.90. The indexes INFIT and OUTFIT are between the required 0.5 and 1.5, and the standardized fit statistics ZSTD tends to zero. Correlation, both for persons and items, is nearly 1 in absolute terms. These indexes, shown in table A1 in appendix, indicate optimal fit of items and persons (Febles 2008; Planinic et al. 2019).

The construct under analysis is unidimensional, that is, the items reflect a common latent variable. This is tested through the parameters that comply with the requirements of a Rasch model: the eigenvalue of non-explained variance of the first factor is <2 (1.9967), explained variance by items is greater than non-explained variance of the first factor (32.5%>16.1%) and explained variance by measures is >40% (43.4%). Besides that, the observed explained and non-explained variance corresponds to the expected one, which shows a balanced model (see table A2 in appendix).

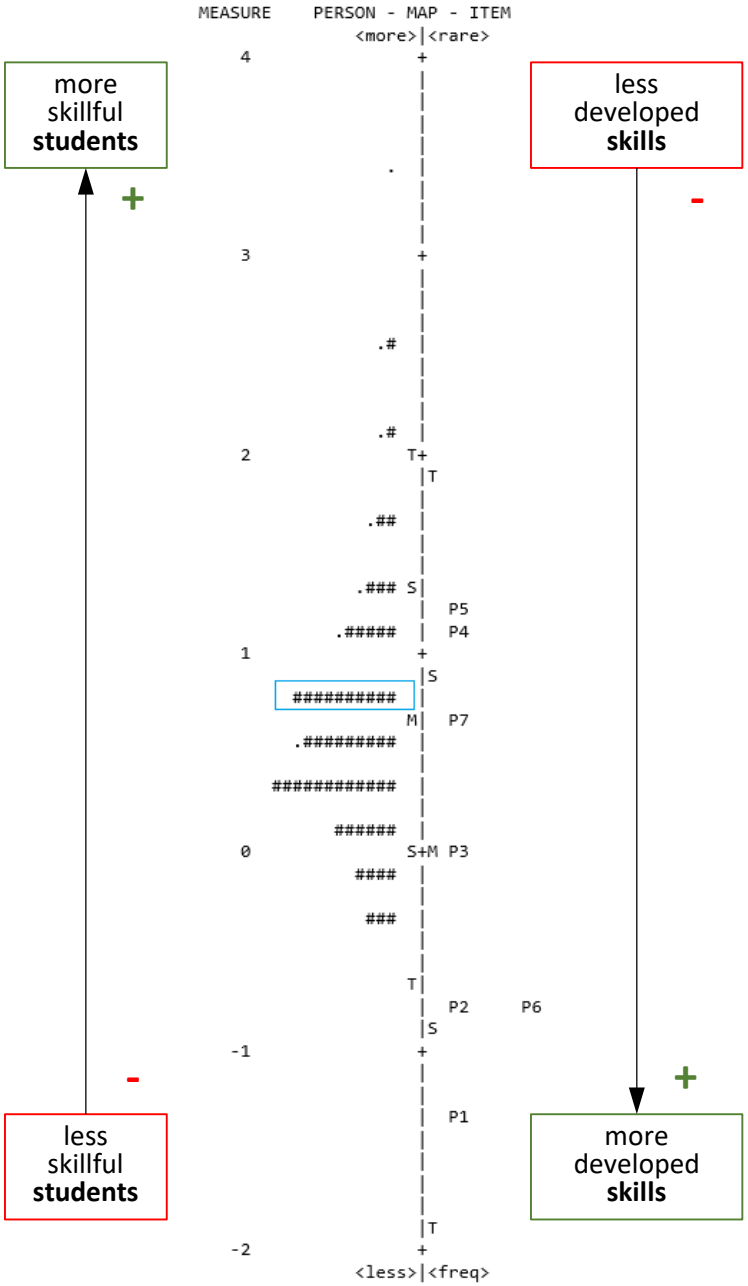
The structure of the scales used in this study is appropriate: the observed mean measures grow, keeping relation with the expected mean measures. MNSQ Infit and Outfit indexes are close to 1, which

validates the data in each category. Finally, the distribution of the categories is balanced, since the Andrich thresholds and the categories measures increase with each category (see table A3 in appendix).

## FINDINGS

The Wright map (see figure 1) shows a distribution of students according to their ability and of items according to their difficulty along the same scale. That is, it shows the students' ability and the level of development of the skills under analysis.

**Figure 1. The Wright map.**



The left side shows the distribution of students, represented by "#," equal to three individuals, and "." equal to one or two. Students are shown as a function of their ability, so the more able students are plotted at the top of the map and less able ones at the base. Each item, which in this analysis corresponds to a specific skill, is shown on the right side of the map, with the more developed skills at the base (easier to acquire) and less developed at the top (harder to acquire). The students located at the same level for an analyzed skill are likely to have a satisfactory level of its development. Following Planinic et al. (2019), when individuals are placed above the items, like the marked ones in a blue rectangle on figure 1, it means that the level of development of these skills is quite high for them. This is the case for the items P7, P3, P2, P6, and P1. When the students' position is below the skills, it indicates the contrary. In this example the marked students have less developed the skills identified as P4 and P5.

Two skills identified through the items P5 (increased communication for the projects' purpose) and P4 (balanced involvement in the project of the team members) are considered hard to acquire for many students of the sample, so they are less developed. The skill P7 (the members' commitment to the project) is situated lower, so it also presents certain challenges to many students. P3 (conflict solution through open debate) is located just in the mean item measure (M on the logit scale of the right side of the map), so the majority of students show good development of this skill. The remaining three items– P2 (clear communication within the team), P6 (unlocking the potential of team members), and P1 (the importance of working in an interdisciplinary team)–are located in the lower part of the map with no students below them. It means that all sampled students have a good level of acquisition and development of the above skills.

According to this, the students understand the importance of working in an interdisciplinary team in order to succeed in a collaborative project (P1), although the majority of the teams were non-interdisciplinary. Much more emphasis should be placed on execution and not only on the understanding of what should be the right thing to do. Regarding the internal communication (P2), the result is not surprising since the students built their teams on their own, trying to match themselves with those with whom they had a positive academic experience in the past or they got along best. Probably, due to their knowledge of each member, it was possible to take advantage of the potential of each of them for the benefit of the project (P6). This laid the groundwork for better conflict management by discussing the different points of view within the team (P3). Nevertheless, good internal communication is not enough for the purposes of the project, so, as seen previously (P5), the students might have realized that communication is critical for collaborative work and should be managed differently.

The skills' hierarchy, from the most developed to the least developed by the students of the sample, is the following: P1 – P2/P6 – P3 – P7 – P4 – P5.

### Additional results

Additionally, DIF analysis was applied to evaluate whether the items presented significant difficulties in different groups. The variables used for categorization were from the first block of the questionnaire as follows: gender (1) and year of study (2), following the research of Cleland, Foster, and Moffat (2005), who applied these criteria and found differences in students' attitudes to communication skills. Interdisciplinarity of the teams (3) was another criterion considered as relevant, since the students who work in interdisciplinary teams were expected to have a different approach to collaborative work (Marcos-Jorquera et al. 2016). Each of these categories generated two groups, so pairwise DIF analysis

was performed. The null hypothesis is that the items had the same difficulty for both groups (Linacre 2012); that is, that both groups had the same level of skills development under analysis (see tables A6–A7–A8 in appendix). The rule is to reject the null hypothesis when simultaneously the following three parameters are met: |DIF contrast| ≥ 0.5, |t-value| ≥ 1.98 and probability ≤ 0.05. DIF contrast, on its turn, corresponds to the level of |DIF influence|: i) with 0.43–0.64 logits it is from slight to moderate; ii) with >0.64 logits it is from moderate to high (Linacre 2018). In addition, positive DIF contrast of a particular skill indicates that the reference group has a lower development of that skill, while the negative sign indicates the contrary.

Besides that, this analysis used three other criteria: the age of the participants (4), degrees (5) and subject, within which collaborative projects were developed (6). They also correspond to the variables used in the demographic information block of the questionnaire. In this case in each category more than two groups were generated (see tables A9–A10–A11 in appendix). Here the null hypothesis is that each item had the same difficulty across all groups (Linacre 2012). In this analysis it means that all groups have the same level of development of the skills under analysis. To reject the null hypothesis the same statistics as previously are used. The summary of significant results of DIF analysis is shown in table A4 in appendix.

Significant differences were detected in all categories, so the brief interpretation is as follows:

-Gender (1): since DIF contrast is positive for the group of men, they were less familiar with the importance of working in interdisciplinary teams than the group of women (see table A5 in appendix for more details).

-The year of study (2): the third-year students were less familiar with the importance of working in interdisciplinary teams (P6) and could not exploit all the potential of the team members (P6) than the fourth-year students. These results are due to a positive DIF contrast for these skills. However, the third-year students were much more equally involved in the project than the fourth-year students, since DIF contrast for the skill P4 is negative for the first group (see table A5 in appendix for more details).

-Interdisciplinarity of the teams (3): the students of interdisciplinary teams were more aware of the importance of working in this heterogeneous environment than those who developed their projects in non-interdisciplinary teams. This is due to the DIF contrast with a negative sign for the skill P1. However, interdisciplinary teams' students were less committed to the projects than the other group. In this case DIF contrast is positive and slightly below 0,5. It means that the level of influence of DIF is moderate (see table A7 in appendix for more details).

-Students' age (4): 20-year-old students understood less about the importance of collaborating in interdisciplinary teams (P1) and were worse at managing the potential benefits of each team member for the project (P6) than the rest of age groups (positive DIF contrast in both cases). These results are aligned with those obtained in the category of the year of study. However, younger students managed their teams more successfully than the rest of the groups engaging equally in the project (P4 with negative DIF contrast). In contrast, 21-year-old students were less skilled in this area (P4 with positive DIF contrast). Nevertheless, this group was considered as the most prepared to exploit the potential of each team member to make the project a success (P6 with negative DIF contrast) (see table A8 in appendix for more details).

-Degree (5): the students who study journalism (JOR) and business management (BM) solved conflicts better than the rest of the groups (P3 with negative DIF contrast in both cases). In contrast, the

students of publicity and public relations (PPR) were the least skilled in this aspect (positive DIF contrast). However, this group of PPR was more equally involved in the project (P4 with negative DIF contrast) and the group of psychology (PSYCHO) (positive DIF contrast) was less involved than the rest of degree groups. Regarding exploitation of the talents of team members (P6), the students of BM and Erasmus performed worse (positive DIF contrast), while PSYCHO students performed better (negative DIF contrast) than the rest of the groups. Finally, Erasmus students were the most committed to the success of the project (P7 with negative DIF contrast), while JOR students were less committed (positive DIF contrast) (see table A9 in appendix for more details).

-Subject (6): the group of students who developed their projects within the context of Market Research (MR) were less prepared for working in interdisciplinary teams (P1), with weak communication skills required for team-based projects (P5) and little utilization of the potential of team members (P6), since DIF contrast in all these three is positive. However, these students were more involved in the project than the rest of the groups (P4) and committed to its success (P7), which is supported by negative DIF contrast. Curiously, the students of the subject Advertising Campaign Design (ACD) were also more equally involved in the project (P4 negative DIF contrast), but not committed to its success (P7 with positive DIF contrast). In addition, those who developed their projects in Business Economy and Entrepreneurship (BEE) showed themselves as less involved in the project (P4 with positive DIF contrast), but more skilled in leveraging the potential of the team members (P6 with negative DIF contrast) than the rest of subject groups (see table A10 in appendix for more details). These results seem to be related to the grades earned by the projects. They were much lower in Market Research than in the other two subjects. The results after applying F-test showed that these differences were significant at the 99% confidence level (see table A11 in appendix).

## CONCLUSIONS AND DISCUSSION

The study contributes to the literature by studying undergraduate student attitudes towards team-based projects, connecting those attitudes to challenges and overall perception of other aspects related to these projects. This allows us to detect the factors that support or constrain collaborative work. The study was conducted using the sample of 220 students from different faculties of the Spanish University Europea del Atlántico, who developed collaborative projects within the framework of three different subjects.

The most relevant results of this study, obtained through the application of Rasch methodology, show three main findings. The first one points out that the undergraduate students, despite being in their last two years of studies when they are expected to have acquired certain collaborative work skills, encounter difficulties that prevent them from effective collaboration.

Firstly, internal communication, although seen as good in general, is acknowledged as insufficient for the purpose of collaborative projects. This is evidenced by two facts. One is that some teams were inefficient in solving conflicts and avoided discussing them openly, like the students who study publicity and public relations. And two, the majority of the students had less developed specific communicative skills and acknowledged that interactions within a team should have been more intensive. This result is in line with the idea that communication is a complex and very critical factor that impacts greatly on the decisions of collaborative work. Usually, collective decision making requires increased levels of communication to ensure the success of the project (Finnegan and O'Mahony 1996).

In other fields, it is demonstrated that communication should also be collaborative, because it improves significantly the decision-making processes and helps in managing uncertainty, as stated by Politi and Street (2011) in their analysis of a communication model in medical environments or by Zenezini et al. (2019) in their proposal of business model for city logistics management.

Secondly, the undergraduate students point to unequal involvement of the participants in the projects and a lack of commitment as strong negative aspects of collaborative work they experienced. Poor involvement usually generates frustration and annoyance of those team members who try to achieve good results (Knox, Gillis, and Dake 2019). The problem is related to unequal distribution of effort, motivation, and contribution of the rest of the participants, and also to possible lack of confidence of certain team members, which is highly correlated with poor communication (Burdett 2003). This was observed most acutely among 21-year-old students and among those who studied psychology and developed their projects within the subject of Business Economy and Entrepreneurship regarding their involvement in the project. In this sense, we need to note that this subject was taught during the last semester of the last year of study. The students were not as motivated in this assignment since they were focused more on finishing their studies as soon as possible. So, apparently, timeframe is important as a factor in planning team-based projects.

Regarding commitment, the third-year students and those who formed part of interdisciplinary teams, studied journalism, and developed their projects within the subject of Advertising Campaign Design were rated as less skilled. It is necessary to remind that the projects within this subject were clearly client-oriented, which implied real interactions with clients and management of complex tasks. So those students were expected to show higher initiative and curiosity in this sense, but actually they were not offered additional training that could have prepared them better for the real working environment. In addition, much stress should be put on terms of motivation and leadership and effective collaboration among team members with different backgrounds and experiences.

Nevertheless, in other groups certain improvements were detected. For example, the third-year students, mainly 20-year-olds, were equally involved in team-based projects. The same result was shown by the students enrolled in the degree of publicity and public relations and by those who carried out their projects within the context of the subjects of Market Research and Advertising Campaign Design. Besides that, the students from the subject of Market Research and the Erasmus group were much more committed to the success of the project than the rest of the groups. A possible interpretation of the differences observed within the same groups regarding these two skills may be that involvement is more related to performing specific tasks assigned within a team. Meanwhile, commitment means going beyond this limitation trying to delve into certain questions and solve problems that may arise during the course of the project. This could be aligned with personal responsibility, which is diffused in large groups. In this study the teams were small, but probably it was impossible to completely eliminate this problem. This may be due to the common misunderstanding of what collaborative work really means, as stated previously.

The second finding shows that undergraduate students are quite aware that collaborative projects, which are complex, time-consuming, and demanding, should be carried out in interdisciplinary teams. However, the groups formed by men, 20-old-year students, in their third year of study and those who developed their projects in Market Research were less skillful in this regard. According to the sample distribution, the students preferred to build non-interdisciplinary teams, but they did it before

collaboration started. Upon completion of the work, they apparently changed their mind, as can be seen in the Wright map shown previously, in which the readiness to work in interdisciplinary teams of all the students is very high. This falls in line with what other studies have highlighted. Interdisciplinary collaboration, although challenging and even frustrating, is essential to achieve meaningful results from cooperation among the participants (Foster and Yaoyuneyong 2016) and to address complex problems in many other fields (Armstrong and Jackson-Smith 2013; Klein and Falk-Krzesinski 2017). This is probably in consonance with the need for good communication among the team members. In this sense, the students of the sample are also aware that a really good collaborative environment is due to clear and smooth communication among team members.

The third finding points to the differences found among the groups formed according to the following criteria: (1) gender, (2) year of study, (3) interdisciplinary character of the team, (4) students' age, (5) degree, and (6) subject, within which the team-based projects were developed. All of them can be considered as factors that influence the development of skills related to collaborative work. In this regard, significant differences were detected on similar aspects: (i) interdisciplinary character of the team, (ii) equal involvement in the project, (iii) poor commitment to the success of the project, and (iv) communication.

In view of these results, the specific context generated by the degrees should be taken into account, because the subjects, depending on their more practical or theoretical focus, favor or limit different aspects of collaborative work. Besides that, specific training prior to collaborative projects, focused on team-skills proposed by Prichard, Stratford, and Bizo (2006), may be needed. This training proves to be very successful since it pursues many different objectives, such as problem solving, decision making, time management, and cooperation. Additionally, instructors can help students become more cooperative through increased interaction, motivating them to openly debate their ideas (Molinillo et al. 2017). It would be also appropriate to design a course with real-world experience, integrating real professionals and dealing with complex interactions, as suggested by Foster and Yaoyuneyong (2016), who used a cross-disciplinary client-based project flipped classroom. This real environment enables students to work in interdisciplinary teams forcing them to adopt a different frame of thinking to solve real problems.

Other researchers, such as Marcos-Jorquera et al. (2016), recommend the creation of interdisciplinary project-based learning programs with a flexible curriculum, similar to real-work environments. This approach allows including professional orientation for university students within any subject without additional schedules. Berasategi et al. (2020), on the other hand, share their experience in an interdisciplinary environment using the case study methodology through which they detect significant increased participation of the team members and improved communication skills.

It may also be helpful to rely on specific tools or procedures to monitor the effectiveness of collaborative work, so that an instructor can intervene in time with proper guidance, or that the students themselves can see what they can improve. Here, an observational register and student field diary may be useful to check critical incidents as well as the acquisition of certain skills. This initiative proved to be especially successful during the pandemic-induced lockdown in 2020, as stated by Domínguez-Lloria et al. (2021). A difficulty for an instructor is that the students may generate no input, which is usually related to group cohesion problems. In this regard, a teacher should count with observational support that catches not only students' interactions but also actions that may explain social and cognitive

processes. A good example is Intelligent Tutoring System (GISMO, CAMera, CAM, and similar) that creates specific indicators enabling the instructor to follow up students' activities (Salihoun, Guerouate, and Sbihi 2017).

From a broader perspective and taking into account that nowadays university students tend to replace face-to-face meetings by digital communication (Koch 2010, cited by Borg et al. 2021), it is highly recommended to include technological solutions to support collaborative work since the digital environment also shapes collaborative context (Heerwagen et al. 2004). In this sense, there are different tested proposals on the usage of collaborative environments, that include virtual and augmented reality, emulating copresence and enhancing the feeling of collaboration. They are considered as very effective since they improve many skills needed for complex tasks. The reduced cost of these tools and a better access to high-speed internet connection increase the adoption of this technology in the university setting (Papanastasiou et al. 2019). Regarding the study presented in this paper, we are considering the inclusion of new technologies in the next editions of collaborative projects undertaken by undergraduate students.

## Limitations and future work lines

Limitations of this work are related to the targeted population, which was restricted to undergraduate students of a single university. We find it necessary to extend the analysis to other universities, including postgraduate students, and also to companies and organizations to compare and contrast the various perspectives and try to analyze the cause of eventual differences. In our next research study, we plan to include other factors that shape collaborative work, such as motivation, leadership, role assignment, and creativity, to name a few. This might require the application of other research methods, such as group or personal interviews, which would be of great help to obtain deeper insight into the research topic. This will help create more realistic contexts for collaborative projects carried out within the university to foster higher involvement and commitment of undergraduate students, and to better prepare them for the labor market.

## Ethics Review

The administration of the surveys was anonymous and to adults who were informed about the purpose of the same. It was not necessary to carry out any special procedure in relation to the management of authorizations through the Research Ethics Committee of the University Europea del Atlantico, nor does it represent any responsibility with regard to the Organic Law on Data Protection as far as the custody of data and ARCO rights are concerned.

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## SUPPLEMENTARY DATA (APPENDIX)

**Table A1. Global validity of the construct.**

| | INFIT | | OUTFIT | | Reliability | Correlation |
|---|---|---|---|---|---|---|
| | MNSQ | ZSTD | MNSQ | ZSTD | | |
| Persons | 1.01 | 0.05 | 0.98 | 0.05 | 0.82 | 0.99 |
| Items | 0.98 | -0.25 | 0.9 | -0.15 | 0.99 | -1.00 |

**Table A2. Abbreviated analysis of the dimensionality of the construct.**

| | Eigenvalue | Observed, % | Expected, % |
|---|---|---|---|
| Total variance of the observed values | 12.3698 | 100.0 | 100.0 |
| Explained variance by measures | 5.3698 | 43.4 | 43.2 |
| Explained variance by persons | 1.3463 | 10.9 | 10.8 |
| Explained variance by items | 4.0234 | 32.5 | 32.4 |
| Total non-explained variance | 7.0000 | 56.6 | 56.8 |
| Non-explained variance of the 1st factor | 1.9967 | 16.1 | |

**Table A3. Summarized structure of response categories.**

| Category | Distribution% | Observed measures | Expected measures | Infit MNSQ | Outfit MNSQ | Andrich thresholds | Measures |
|---|---|---|---|---|---|---|---|
| 1 | 11 | -0.63 | -0.59 | 0.90 | 0.83 | NONE | -2.31 |
| 2 | 20 | -0.02 | -0.08 | 1.08 | 1.05 | -0.94 | -0.73 |
| 3 | 36 | 0.65 | 0.69 | 1.14 | 1.11 | -0.28 | 0.64 |
| 4 | 32 | 1.55 | 1.54 | 0.95 | 0.97 | 1.22 | 2.46 |

**Table A4. Significant items in DIF analysis for dichotomous and polytomous variables, summary.**

| Category | Item | Statement | DIF contrast | t-value | Probability | Groups |
|---|---|---|---|---|---|---|
| Gender (1) | P1 | During the project I understood the importance of working in an interdisciplinary team. | 0.57 | 2.14 | 0.03 | Group 1 (men) vs. Group 2 (women) |
| Year of study (2) | P1 | During the project I understood the importance of working in an interdisciplinary team. | 0.69 | 2.63 | 0.00 | Group 1 (3$^{d}$ year) *vs.* Group 2 (4$^{th}$ year) |
| | P4 | In my team everybody was equally involved in the project | -1.79 | -8.59 | 0.00 | |
| | P6 | The potential of some participants was fully exploited during the project. | 1.22 | 5.33 | 0.00 | |
| Interdisciplinarity (3) | P1 | During the project I understood the | -0.58 | -2.02 | 0.04 | Group 1 (ITDR* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | importance of working in an interdisciplinary team. | | | | teams) vs. Group 2 (Non-ITDR** teams) |
| | P7 | The members of my team were really committed to the success of the project. | 0.46 | 2.50 | 0.01 | |
| Age (4) | P1 | During the project I understood the importance of working in an interdisciplinary team. | 0.50 | 2.34 | 0.02 | 20 |
| | P4 | In my team everybody was equally involved in the project | -1.00 | -5.81 | 0.00 | 20 |
| | | | 0.61 | 4.14 | 0.00 | 21 |
| | P6 | The potential of some participants was fully exploited during the project. | 0.71 | 3.98 | 0.00 | 20 |
| | | | -0.45 | -2.63 | 0.01 | 21 |
| Degree*** (5) | P3 | In my team everybody expressed conflicts openly by discussing differences. | -0.74 | -2.18 | 0.04 | JOR |
| | | | 0.53 | 2.34 | 0.02 | PPR |
| | | | -0.69 | -3.05 | 0.00 | BM |
| | P4 | In my team everybody was equally involved in the project. | -0.64 | -2.80 | 0.00 | PPR |
| | | | 0.69 | 3.87 | 0.00 | PSYCHO |
| | P6 | The potential of some participants was fully exploited during the project. | 0.62 | 2.51 | 0.01 | BM |
| | | | 1.29 | 3.46 | 0.00 | Erasmus |
| | | | -0.72 | -3.17 | 0.00 | PSYCHO |
| | P7 | The members of my team were really committed to the success of the project. | -1.11 | -2.45 | 0.03 | Erasmus |
| | | | 0.65 | 2.41 | 0.02 | JOR |
| Subject**** (6) | P1 | During the project I understood the importance of working in an interdisciplinary team. | 0.75 | 2.69 | 0.01 | MR |
| | P4 | In my team everybody was equally involved in the project. | -1.00 | -4.24 | 0.00 | MR |
| | | | -0.90 | -4.77 | 0.00 | ACD |
| | | | 0.86 | 5.76 | 0.00 | BEE |
| | P5 | My team would obtain better results if communication among | 0.45 | 2.29 | 0.02 | MR |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | its members were more active. | | | | |
| | P6 | The potential of some participants was fully exploited during the project. | -0.57 | -3.38 | 0.00 | BEE |
| | | | 1.31 | 6.10 | 0.00 | MR |
| | P7 | The members of my team were really committed to the success of the project. | 0.85 | 4.47 | 0.00 | ACD |
| | | | -0.99 | -3.76 | 0.00 | MR |

Note: *ITDR: interdisciplinary teams. **Non-ITDR: non-interdisciplinary teams. ***Grades: BM – Business Management, Erasmus – Erasmus group, JOR – Journalism, PPR – Publicity and Public Relations, PSYCHO– Psychology. ****Subjects: MR – Market Research, ACD – Advertising Campaign Design, BEE – Business Economy and Entrepreneurship.

**Table A5. Pairwise DIF analysis of the groups by GENDER**

| Person class[1] | DIF Contrast | t-value | Probability | Skill |
|---|---|---|---|---|
| 1 | 0.57* | 2.14* | 0.0343* | P1 |
| 1 | -0.23 | -0.97 | 0.3318 | P2 |
| 1 | 0.05 | 0.27 | 0.7844 | P3 |
| 1 | -0.15 | -0.81 | 0.4173 | P4 |
| 1 | -0.32 | -1.70 | 0.0907 | P5 |
| 1 | 0.33 | 1.46 | 0.1477 | P6 |
| 1 | 0.07 | 0.39 | 0.6992 | P7 |
| 2 | -0.57* | -2.14* | 0.0343* | P1 |
| 2 | 0.23 | 0.97 | 0.3318 | P2 |
| 2 | -0.05 | -0.27 | 0.7844 | P3 |
| 2 | 0.15 | 0.81 | 0.4173 | P4 |
| 2 | 0.32 | 1.70 | 0.0907 | P5 |
| 2 | -0.33 | -1.46 | 0.1477 | P6 |
| 2 | -0.07 | -0.39 | 0.6992 | P7 |

Note:[1]categorization by gender: 1 = male students, 2 = female students. *Significant differences for items (skills)with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A6. Pairwise DIF analysis of the groups by the YEAR of STUDY**

| Person class[1] | DIF Contrast | t-value | Probability | Skill |
|---|---|---|---|---|
| 1 | 0.69* | 2.63* | 0.0094* | P1 |
| 1 | -0.10 | -0.44 | 0.6607 | P2 |
| 1 | 0.30 | 1.56 | 0.1198 | P3 |
| 1 | -1.79* | -8.59* | 0.0000* | P4 |
| 1 | 0.07 | 0.36 | 0.7223 | P5 |
| 1 | 1.22* | 5.33* | 0.0000* | P6 |
| 1 | 0.24 | 1.32 | 0.1882 | P7 |
| 2 | -0.69 | -2.63* | 0.0094* | P1 |

| | | | | |
|---|---|---|---|---|
| 2 | 0.10 | 0.44 | 0.6607 | P2 |
| 2 | -0.30 | -1.56 | 0.1198 | P3 |
| 2 | 1.79 | 8.59* | 0.0000* | P4 |
| 2 | -0.07 | -0.36 | 0.7223 | P5 |
| 2 | -1.22 | -5.33* | 0.0000* | P6 |
| 2 | -0.24 | -1.32 | 0.1882 | P7 |

Note: [1]categorization by the year of study: 1 = 3[d] year of study, 2 = 4[th] year of study. *Significant differences for items (skills) with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A7. Pairwise DIF analysis of the groups by INTERDISCIPLINARITY of the teams**

| Person class[1] | DIF Contrast | t-value | Probability | Skill |
|---|---|---|---|---|
| 1 | -0.58* | -2.02* | 0.0459* | P1 |
| 1 | -0.02 | -0.09 | 0.9279 | P2 |
| 1 | 0.00 | 0.00 | 1.000 | P3 |
| 1 | -0.33 | -1.79 | 0.0750 | P4 |
| 1 | -0.11 | -0.60 | 0.5527 | P5 |
| 1 | 0.37 | 1.61 | 0.1091 | P6 |
| 1 | 0.46* | 2.50* | 0.0136* | P7 |
| 2 | 0.58* | 2.02* | 0.0459* | P1 |
| 2 | 0.02 | 0.09 | 0.9279 | P2 |
| 2 | -0.00 | -0.00 | 1.000 | P3 |
| 2 | 0.33 | 1.79 | 0.0750 | P4 |
| 2 | 0.11 | 0.60 | 0.5527 | P5 |
| 2 | -0.37 | -1.61 | 0.1091 | P6 |
| 2 | -0.46* | -2.50* | 0.0136* | P7 |

Note:[1]categorization by the character of the team: 1 = interdisciplinary teams, 2 = non-interdisciplinary teams. *Significant differences for items (skills) with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A8. DIF analysis of the groups by AGE**

| Person class (age) | DIF Contrast | t-value | Probability | Skill |
|---|---|---|---|---|
| 20 | 0.50* | 2.34* | 0.0225* | P1 |
| 21 | -0.24 | -1.24 | 0.2178 | P1 |
| 22 | -0.06 | -0.14 | 0.8904 | P1 |
| 23 | -1.28 | -1.23 | 0.2749 | P1 |
| 24 | -0.26 | -0.24 | 0.8529 | P1 |
| 20 | -0.14 | -0.63 | 0.5294 | P2 |
| 21 | 0.12 | 0.82 | 0.4128 | P2 |
| 22 | -0.11 | -0.34 | 0.7402 | P2 |
| 23 | -0.22 | -0.38 | 0.7229 | P2 |
| 24 | -0.85 | -0.78 | 0.5791 | P2 |
| 20 | 0.08 | 0.49 | 0.6290 | P3 |
| 21 | 0.00 | 0.00 | 1.000 | P3 |

| | | | | |
|---|---|---|---|---|
| 22 | 0.11 | 0.41 | 0.6871 | P3 |
| 23 | -0.91 | -1.57 | 0.1769 | P3 |
| 24 | -0.05 | -0.07 | 0.9537 | P3 |
| 20 | -1.00* | -5.81* | 0.0000* | P4 |
| 21 | 0.61* | 4.14* | 0.0001* | P4 |
| 22 | 0.15 | 0.55 | 0.5912 | P4 |
| 23 | 0.93 | 1.72 | 0.1470 | P4 |
| 24 | 0.22 | 0.32 | 0.8017 | P4 |
| 20 | 0.14 | 0.91 | 0.3681 | P5 |
| 21 | -0.11 | -0.83 | 0.4106 | P5 |
| 22 | 0.00 | 0.00 | 1.000 | P5 |
| 23 | 0.27 | 0.58 | 0.5897 | P5 |
| 24 | -0.38 | -0.57 | 0.6717 | P5 |
| 20 | 0.71* | 3.98* | 0.0002* | P6 |
| 21 | -0.45* | -2.63* | 0.0100* | P6 |
| 22 | -0.31 | -0.85 | 0.4055 | P6 |
| 23 | -0.17 | -0.29 | 0.7842 | P6 |
| 24 | 0.69 | 0.95 | 0.5171 | P6 |
| 20 | 0.11 | 0.69 | 0.4911 | P7 |
| 21 | -0.11 | -0.83 | 0.4085 | P7 |
| 22 | 0.03 | 0.10 | 0.9227 | P7 |
| 23 | 0.25 | 0.57 | 0.5936 | P7 |
| 24 | 0.22 | 0.33 | 0.7981 | P7 |

Note: *Significant differences for items (skills) with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A9. DIF analysis of the groups by DEGREE**

| Person class[1] | DIF Contrast | t-value | Probability | Skill |
|---|---|---|---|---|
| BM | 0.11 | 0.33 | 0.7412 | P1 |
| ACOM | -0.42 | -1.01 | 0.3235 | P1 |
| ACOM/PPR | 1.48 | 1.18 | 0.4480 | P1 |
| SPORTS | -0.37 | -0.19 | 0.8813 | P1 |
| ERASMUS | 0.64 | 1.33 | 0.2119 | P1 |
| IT | 1.04 | 0.91 | 0.5299 | P1 |
| OE | 1.48 | 1.18 | 0.4480 | P1 |
| OE/IT | 0.76 | 0.38 | 0.7678 | P1 |
| JOR | -1.13 | -1.86 | 0.0787 | P1 |
| PPR | -0.31 | -0.83 | 0.4117 | P1 |
| PSYCHO | 0.23 | 1.15 | 0.2566 | P1 |
| BM | 0.18 | 0.67 | 0.5089 | P2 |
| ACOM | -0.21 | -0.65 | 0.5238 | P2 |
| ACOM/PPR | -0.72 | -0.36 | 0.7778 | P2 |
| SPORTS | -0.97 | -0.49 | 0.7100 | P2 |

| | | | | |
|---|---|---|---|---|
| ERASMUS | 0.26 | 0.57 | 0.5791 | P2 |
| IT | -0.97 | -0.51 | 0.7017 | P2 |
| OE | 0.90 | 0.71 | 0.6051 | P2 |
| OE/IT | 1.77 | 1.40 | 0.3943 | P2 |
| JOR | -0.16 | -0.47 | 0.6453 | P2 |
| PPR | -0.07 | -0.26 | 0.8001 | P2 |
| PSYCHO | 0.04 | 0.23 | 0.8203 | P2 |
| BM | 0.37 | 1.62 | 0.1167 | P3 |
| ACOM | 0.18 | 0.68 | 0.5031 | P3 |
| ACOM/PPR | 0.20 | 0.16 | 0.8994 | P3 |
| SPORTS | -0.03 | -0.03 | 0.9836 | P3 |
| ERASMUS | -0.06 | -0.16 | 0.8798 | P3 |
| IT | -1.68 | -0.87 | 0.5439 | P3 |
| OE | 0.20 | 0.16 | 0.8994 | P3 |
| OE/IT | -0.53 | -0.27 | 0.8345 | P3 |
| JOR | -0.74* | -2.18* | 0.0424* | P3 |
| PPR | 0.53* | 2.34* | 0.0265* | P3 |
| PSYCHO | -0.26 | -1.55 | 0.1276 | P3 |
| BM | -0.69* | -3.05* | 0.0050* | P4 |
| ACOM | 0.08 | 0.30 | 0.7712 | P4 |
| ACOM/PPR | -0.90 | -0.72 | 0.6037 | P4 |
| SPORTS | 1.61 | 0.86 | 0.5465 | P4 |
| ERASMUS | -0.56 | -1.51 | 0.1627 | P4 |
| IT | -1.35 | -1.18 | 0.4473 | P4 |
| OE | -0.90 | -0.72 | 0.6037 | P4 |
| OE/IT | -1.64 | -0.83 | 0.5596 | P4 |
| JOR | 0.50 | 1.79 | 0.0895 | P4 |
| PPR | -0.64* | -2.80* | 0.0091* | P4 |
| PSYCHO | 0.69* | 3.87* | 0.0003* | P4 |
| BM | -0.14 | -0.61 | 0.5447 | P5 |
| ACOM | -0.48 | -1.85 | 0.0800 | P5 |
| ACOM/PPR | -1.05 | -0.83 | 0.5576 | P5 |
| SPORTS | -1.31 | -1.04 | 0.4877 | P5 |
| ERASMUS | 0.07 | 0.20 | 0.8484 | P5 |
| IT | 0.90 | 1.06 | 0.4803 | P5 |
| OE | 0.32 | 0.27 | 0.8344 | P5 |
| OE/IT | -0.17 | -0.14 | 0.9127 | P5 |
| JOR | 0.28 | 1.00 | 0.3306 | P5 |
| PPR | 0.17 | 0.74 | 0.4632 | P5 |
| PSYCHO | 0.06 | 0.38 | 0.7021 | P5 |
| BM | 0.62* | 2.51* | 0.0179* | P6 |
| ACOM | 0.04 | 0.13 | 0.8972 | P6 |
| ACOM/PPR | 2.32* | 1.96 | 0.3006 | P6 |
| SPORTS | -0.92 | -0.46 | 0.7232 | P6 |

| | | | | |
|---|---|---|---|---|
| ERASMUS | 1.29* | 3.46* | 0.0061* | P6 |
| IT | 2.22 | 2.70 | 0.2260 | P6 |
| OE | 0.95 | 0.75 | 0.5887 | P6 |
| OE/IT | 1.82 | 1.44 | 0.3863 | P6 |
| JOR | 0.88 | -1.97 | 0.0643 | P6 |
| PPR | 0.14 | 0.49 | 0.6274 | P6 |
| PSYCHO | -0.72* | -3.17* | 0.0025* | P6 |
| BM | -0.15 | -0.65 | 0.5194 | P7 |
| ACOM | 0.52 | 1.97 | 0.0637 | P7 |
| ACOM/PPR | -0.47 | -0.37 | 0.7735 | P7 |
| SPORTS | 2.07 | 1.10 | 0.4692 | P7 |
| ERASMUS | -1.11* | -2.45* | 0.0341* | P7 |
| IT | -0.91 | -0.80 | 0.5723 | P7 |
| OE | -2.07 | -1.05 | 0.4842 | P7 |
| OE/IT | 0.42 | 0.33 | 0.7957 | P7 |
| JOR | 0.65* | 2.41* | 0.0270* | P7 |
| PPR | 0.06 | 0.27 | 0.7894 | P7 |
| PSYCHO | -0.18 | -1.16 | 0.2504 | P7 |

Note: [1]Degrees:BM–Business Management; ACOM–Audiovisual Communication; JOR–Journalism; PPR–Publicity and Public Relations; PSYCHO–Psychology; IT–IT Engineering; OE–Organizational Engineering; SPORTS–Sports Sciences; ERASMUS–a group of foreign students under Erasmus mobility program. *Significant differences for items (skills) with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A10. DIF analysis of the groups by SUBJECT**

| Person class[1] | DIF Contrast | t-value | Probability | Item |
|---|---|---|---|---|
| ACD | 0.14 | 0.54 | 0.5896 | P1 |
| BEE | -0.30 | -1.65 | 0.1030 | P1 |
| MR | 0.75 | 2.69* | 0.0107* | P1 |
| ACD | -0.21 | -0.89 | 0.3795 | P2 |
| BEE | 0.04 | 0.26 | 0.7992 | P2 |
| MR | 0.16 | 0.57 | 0.5735 | P2 |
| ACD | 0.39 | 2.11 | 0.0412 | P3 |
| BEE | -0.13 | -1.01 | 0.3172 | P3 |
| MR | -0.18 | -0.72 | 0.4730 | P3 |
| ACD | -0.90* | -4.77* | 0.0000* | P4 |
| BEE | 0.86* | 5.76* | 0.0000* | P4 |
| MR | -1.00* | -4.24* | 0.0001* | P4 |
| ACD | -0.32 | -1.75 | 0.0875 | P5 |
| BEE | -0.03 | -0.24 | 0.8140 | P5 |
| MR | 0.45* | 2.29* | 0.0281* | P5 |
| ACD | 0.10 | 0.46 | 0.6477 | P6 |

| | | | | |
|---|---|---|---|---|
| BEE | -0.57* | -3.38* | 0.0011* | P6 |
| MR | 1.31* | 6.10* | 0.0000* | P6 |
| ACD | 0.85* | 4.47* | 0.0001* | P7 |
| BEE | -0.10 | -0.87 | 0.3889 | P7 |
| MR | -0.99* | -3.76* | 0.0006* | P7 |

Note: [1]Subjects: ACD–Advertising Campaign Design; BEE–Business Economy and Entrepreneurship; MR–Market Research.*Significant differences for items (skills) with |DIF contrast|> 0.5, |t-value|> 1.98 and probability < 0.05. Level of |DIF influence|: i) 0.43–0.64 from slight to moderate; ii) >0.64 from moderate to high (Linacre 2018).

**Table A11. Grades obtained for the projects.**

| | ACD | BEE | MR |
|---|---|---|---|
| Mean (grades) | 7.6 | 7.3 | 5.9 |
| SD | 0.85 | 0.72 | 1.73 |
| n | 49 | 113 | 58 |
| F value = 38.69 p-value < 0,0001 (***) | | | |

## A12. RASCH MODEL, SOME EXPLANATIONS

### Formula

The Rasch model is used to estimate the response to a given item from the difference between the level of the person according to his/her ability and the level of the item according to its difficulty. Using the equation given in Andricht (2010), we can express the following:

$$Pr\{X_{ni} = x\} = (exp\ x(\beta_n - \delta_i))/\gamma_n \quad (1)$$

where $X_{ni} = x \in \{1, 2, 3, 4\}$ is a entire random vector of responses $y$; $\beta_n$ and $\delta_i$ are the parameters of $n_{th}$ person and $i_{th}$ item. $\gamma_n = 1+exp(\beta_n - \delta_i)$ is a vector that serve to standardize (1) and ensures that the two probabilities sum to 1.

### Some assumptions of the Rasch model

The approach established by the Rasch model is different from that of other statistical models, such as regression. Regression models are often used to describe a data set. Thus, the parameters of these models can be adapted to present a better fit to the data. However, the Rasch model is just the opposite, the data are intended to fit the model (Andrich 2004). That is, the first thing that is done when starting a Rasch analysis is to check that the data fit the model and those that do not meet this requirement should be eliminated from the sample (as was done at the beginning of the analysis). Briefly, some of the assumptions of the Rasch model are stated as follows:

### Unidimensionality and independence in the response

Equation (1) shows that, since there is only one parameter per person, the model is unidimensional and defined on a continuum. This also implies that the response of a single person to an item is independent of the responses to the rest of the items in the sense that:

$$Pr\{X_{ni} = x_{ni}\} = \prod_{i=1}^{I} (exp\ x_{ni}(\beta_n - \delta_i))/\gamma_n \quad (2)$$

where $x_{ni}$ denotes the response vector of a person $n$ to items $i = 1, \ldots, I$. This implies that the greater the person's ability, the greater the positive response to that item and vice versa. Some correlation between

an individual's responses to different items may be expected, but the functional form in (2) ensures local independence, i.e., the probability of responding correctly to a set of items is the product of the probabilities of responding correctly to each item separately.

The property that specifically differentiates Rasch models from the models of Impulse Response Theory (IRT) is that of invariant comparison. Rasch defined the principle as follows: the comparison between two stimuli should be independent of which particular individuals were central to the comparison; and also, it must be independent of what other stimuli within the class under consideration were or could also have been compared. Symmetrically, a comparison between two individuals should be independent of which particular stimuli within the class under consideration were central to the comparison; and it should also be independent of which other individuals were also compared, on the same or another occasion (Rasch 1961).

As established in Rasch (1980), the adequacy of the statistic used for the $n_{th}$ person's parameter $\beta_n$ is simply the sum of its responses $r_n = \sum_{i=1}^{I} x_{ni}$. Given a vector of responses of the $n_{th}$ person to the I items,

$$Pr\left\{\mathrm{X}_{ni} = \mathrm{x}_{ni} | \mathrm{r}_n\right\} = \frac{1}{\gamma_r} exp(\mathrm{x}_{ni} \sum_{i=1}^{I} (-\delta_i)) \quad (3)$$

where $\gamma_r = \sum_{((x_{ni})|\mathrm{r}_n)} exp(\mathrm{x}_{ni} \sum_{i=1}^{I} (-\delta_i))$ is the sum of all possible responses of the $n_{th}$ person given the response vector $r_n$. As can be seen in (3), the probability of the responses is independent of the person parameters, $\beta_n$, where $n = 1, \ldots, N$ is the number of people in the study. Rasch model incorporates this principle because its formal structure allows for the algebraic separation of the person and item parameters, in the sense that the person parameter can be removed during the process of statistical estimation of the item parameters. This result is achieved by using conditional maximum likelihood estimation, in which the response space is divided according to the total person scores. The implication is that a single person's score is the statistic sufficient for the item or person parameter.

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