Encouraging Teamwork after the Pandemic

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Abstract

The Accreditation Board for Engineering and Technology (ABET) proposes that one of the student outcomes that engineers must have is "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" [1]. Project-based learning is one of the teaching methodologies used in engineering education to promote teamwork [2; 3]. Cornerstone courses are first-year engineering design courses mostly using project-based learning methodologies [4], where students work in teams to solve real-world problems [5]. During COVID-19, students had to work remotely in teams using different platforms, such as Teams, ZOOM, and Google Drive. Today, most universities have returned to face-to-face classes. After meeting with students to discuss their projects, the faculty team realized that despite the face-to-face classes, some teams still use different technologies to do their teamwork and have never met in person outside lecture time. The faculty team has noticed a need for more empathy between team members, less engagement with the course, and a feeling of being burdened by working in teams. These observations led to our research question: How do face-to-face and remote work experiences outside classroom settings influence undergraduate students' perceptions of teamwork in the context of a cornerstone course in Engineering? This WIP explores students' perceptions regarding teamwork, considering whether they have worked face-to-face or remotely outside classes. A survey was conducted at the semester's end to understand the students' perceptions concerning teamwork, considering how their team worked. This WIP contributes to engineering education by exploring how the post-pandemic generations have challenged face-to-face teamwork and its consequences for achieving teamwork as a student outcome.

Introduction

Accreditation agencies worldwide consider the ability to work in teams to be highly relevant. The Accreditation Board for Engineering and Technology (ABET) finds it essential that engineers possess "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" [1].

Active learning is one of the ways to encourage teamwork in engineering education [6]. Several active learning approaches exist, such as Project-, Cooperative-, Problem-, Team-, Competence-, and Challenge-based learning [6]. Of all of them, the most commonly used in Engineering education are problem- and project-based learning [7]. Capstones and cornerstone courses are usually taught following a project-based learning approach where students work in teams solving real-world problems [7] in a face-to-face setting [8].

Collective empathy (empathy with team members) is key to effective teams [9]. It promotes creativity, team members' understanding, a constructive working environment, and diminishing conflict [9].

Several studies have found different results regarding face-to-face and online teamwork. For example, Goñi et al. [10] found insignificant differences regarding personal goals, regulation strategies, and team challenges. Nevertheless, online students revealed that they discussed less in teams than face-to-face students. However, the study occurred during COVID-19, when not only the students' courses were online, but their lives were remote [10]. Other studies have found significant differences between working remotely and face-to-face in teams. Garrat-Reed et al. [11] suggest that working in teams remotely did not present the students with an equivalent face-to-face learning experience.

Even though most universities have returned to face-to-face teaching and learning, students still use different platforms, such as Teams, Zoom, and Google Drive, to work in teams. This way of working involves face-to-face, online synchronic, and/or asynchrony interactions.

These observations led to our research question: How do face-to-face and remote work experiences outside classroom settings influence undergraduate students' perceptions of teamwork in the context of a cornerstone course in Engineering?

Research Context

This research is conducted at a highly selective university in Latin America. During the COVID-19 pandemic lockdown between 2020 and the first semester of 2021, this institution and much of the country adopted an online education modality, later transitioning to a hybrid model that combined in-person and remote instances [12].This lockdown period coincided with a significant proportion of their secondary education for most of the cohort analyzed in this study. Because of this period, crucial aspects of their formative process differed greatly from the norm.

During the second semester, students from the Natural Science and Math College are enrolled in this cornerstone course offered by the Engineering School. The course had 209 students enrolled who worked in three different sections. Each section divided students into ten teams, with six to eight students per team. There were a total of 30 teams. Appendix A presents this cornerstone course summary [13].

Methodology

To answer our research question: how do face-to-face and remote work experiences outside classroom settings influence undergraduate students' perceptions of teamwork in the context of a cornerstone course in Engineering? Students were asked to answer a survey at the end of the semester. Of the 209 students enrolled in the course, 95 (45% of the student body) signed the consent form and answered the survey.

The survey was designed using five-point Likert scales and involved four theoretical constructs. The constructs were:

1- Empathy: Empathy questions were based on Pérez-Albéniz et al. [14] adaptation to Spanish of the Interpersonal Reactivity Index IRI. According to Davis's 1983 definition, the Interpersonal Reactivity Index considers empathy as "reactions of one individual to the observed experiences of another" as a set of constructs and not as a one-dimensional concept [14]. The following four questions were used in this study from the Perspective Taking- PT (*Toma de Perspectiva*) construct. This decision was made because these questions show the ability or tendency of participants to adopt others' perspectives [14], a relevant issue when working in teams.

2- How team members work is defined as the specific collaborative actions carried out by students while developing their projects. These actions include task division, joint task development, collective decision-making, and individual progress review.

3- How team meetings developed: This construct explores how students engage in collaborative work outside of the classroom setting. It is not derived from a theoretical perspective but developed inductively based on the specific course context. The objective is to understand the significance students attribute to synchronous instances (such as face-to-face meetings or video conferences) and asynchronous work (like written communication channels or collaborative platforms).

4- How students felt while working in teams: This dimension delves into personal feelings regarding the teamwork experience during the semester. It explores how tasks are distributed among team members and how collective responsibility develops both in decision-making and in reviewing the work accomplished.

These three items were developed specifically to measure constructs according to course design. See the survey in Appendix B.

All scales were analyzed through Exploratory Factor Analysis (EFA) to understand how latent dimensions emerge from the data and which theoretical constructs can be inferred. Polychoric correlations were used to estimate the factor model given ordinal items, with Ordinary Least Squares as the extraction method.

Subsequently, to identify how students perceive their teamwork skills and experiences, items with significant effects in factor analysis were used to classify cases in clusters using K Means. This algorithm produces a classification that maximizes differences between groups and minimizes them within the group [15], making this technique ideal for exploring the diversity of positions in a semantic space such as teamwork. Finally, latent dimensions that emerged in EFA describe clusters founded by the classification model.

Preliminary Results

The average on a scale from one to five was calculated for each item. Figure 1 presents the survey results for the Empathy Scale regarding team members.

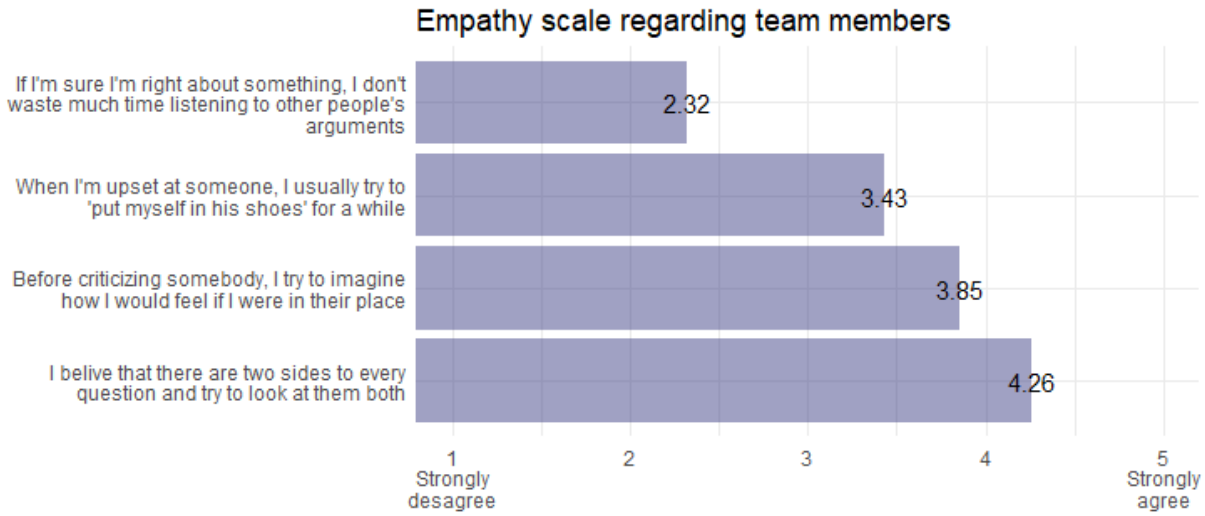

Figure 1: Empathy Scale Regarding Team Members

Figure 1 shows the only empathy result below three (middle) is: *If I am sure I am right about something, I do not waste much time listening to other people's arguments.*

Students were asked about the type of working instance they perceived most relevant to their teamwork. Figure 2 shows these results.

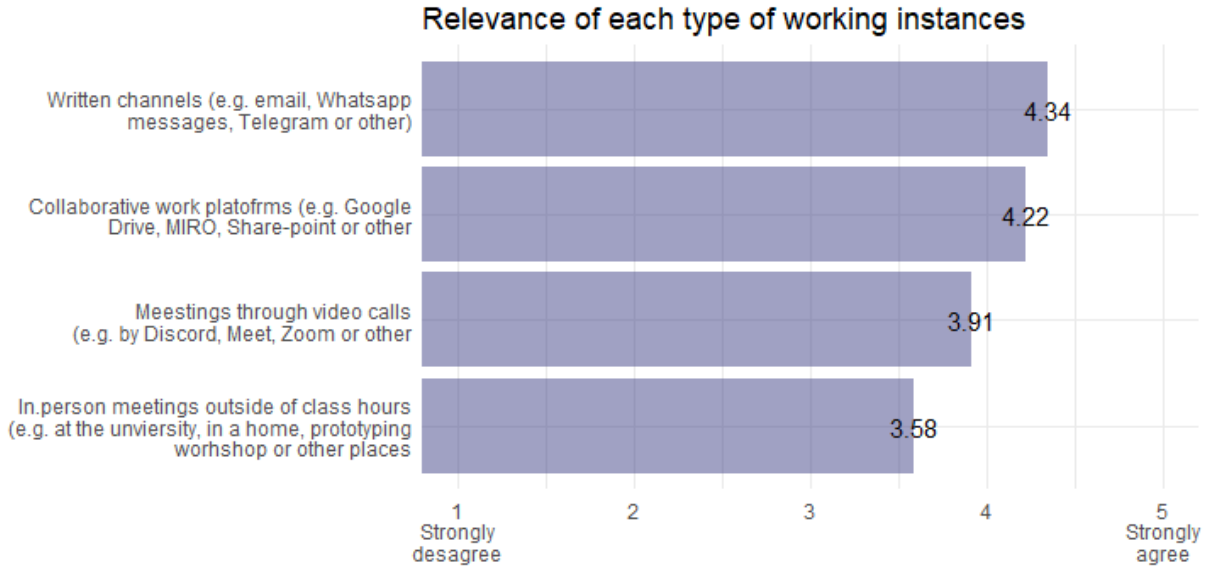

Figure 2: relevance of each type of working instance

As shown in Figure 2, the four types of instances, asynchrony (written channels and collaborative work platforms) and synchronic (Meetings through video calls and In-person meetings outside of class hours), were considered relevant as all scored over three.

Two levels of questions on team dynamics were asked. The first asked how students felt about working in teams during the semester. These results are presented in Figure 3.

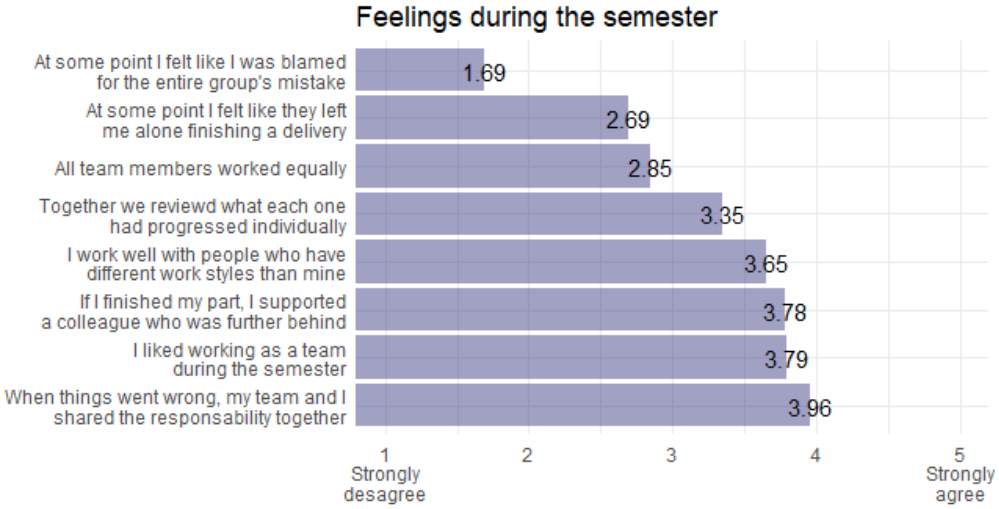

Figure 3: Feelings during the semester

As shown in Figure 3, the one with the lowest results is: *At some point, I felt I was blamed for the entire group's mistake.* This statement is followed by: *At some point, I felt like they left me alone finishing a delivery,* and *All team members worked equally.* The three of them are under three points.

The second question regarding teams' dynamics concerned how their team meetings developed. Figure 4 shows these results.

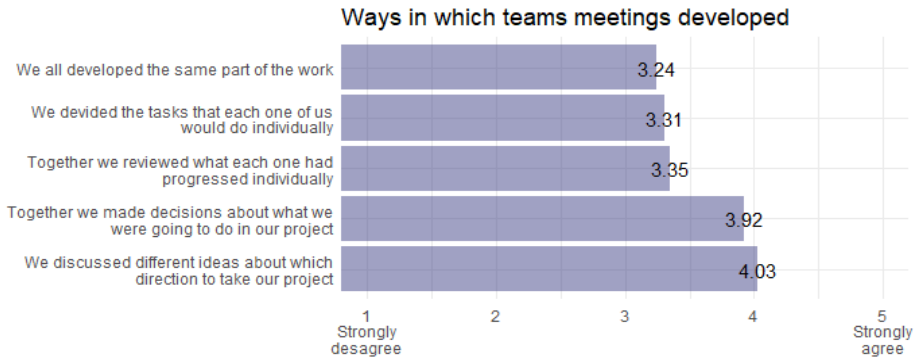

Figure 4: Ways in which team meetings developed

Figure 4 shows that all the statements were graded over three, with the highest being: *We discussed different ideas about which direction to take our project.*
An exploratory factor analysis was conducted. Figure 5 shows the results and loadings of latent emerged dimensions on measured items.

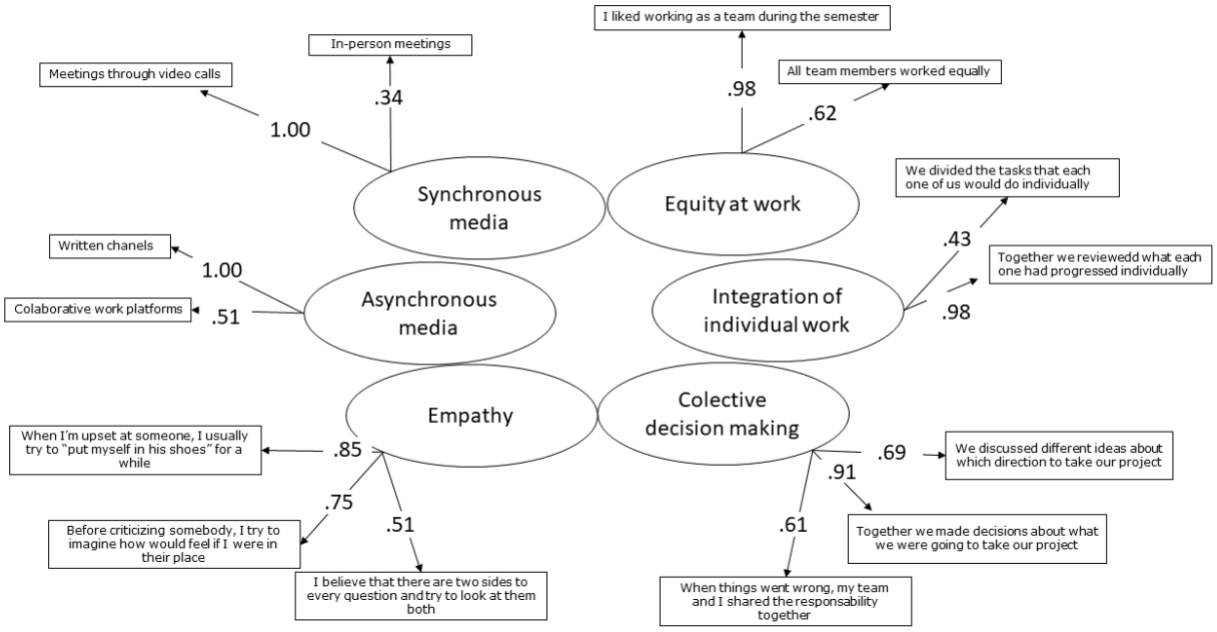

Figure 5: Exploratory Factor Analysis

K Means cluster found five groups that can be described through latent variables that emerged in EFA. Figure 6 presents the five groups.

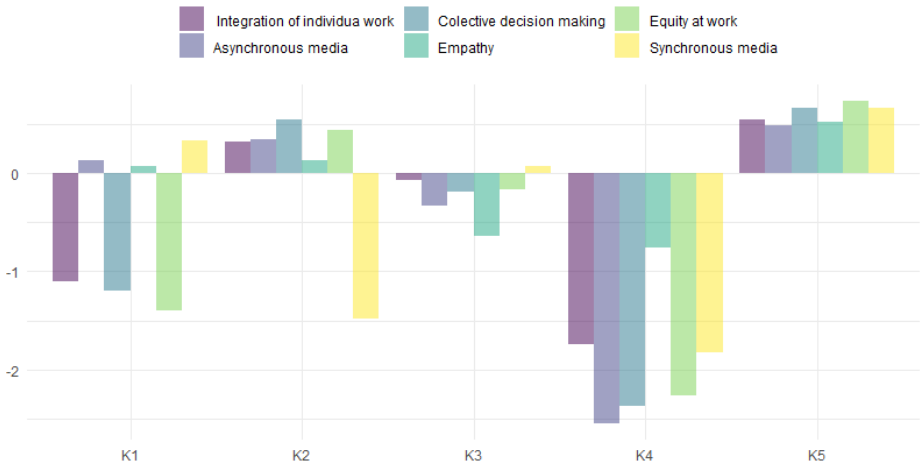

Figure 6: Clusters

As seen in Figure 6, the following five clusters were found in the students' responses:

1. Cluster K1 (n=12): For these students, it was important to use synchronous media, but they declared having problems with equity at work, to integrate their work, and to make decisions together as a team.
2. Cluster K2 (n=14): These students found the use of synchronous means to be irrelevant. Nevertheless, they have all the other five variables positive.
3. Cluster K3 (n=28): The empathy scale is the lower value for these students. They have all other variables negative except for using synchronous media, which is low-positive.
4. Cluster K4 (n=5): These students have all the variables negative. They have a low value on the empathy scale, and their perception of teamwork is negative.
5. Cluster K5 (n=36): These students have everything positive. They are the ones with higher empathy scores. They could integrate their work, have equity at work, and make decisions together. Regarding the type of meeting instances, they value asynchrony and synchronic meetings.

Figure 7 presents how these clusters are distributed within the thirty teams.

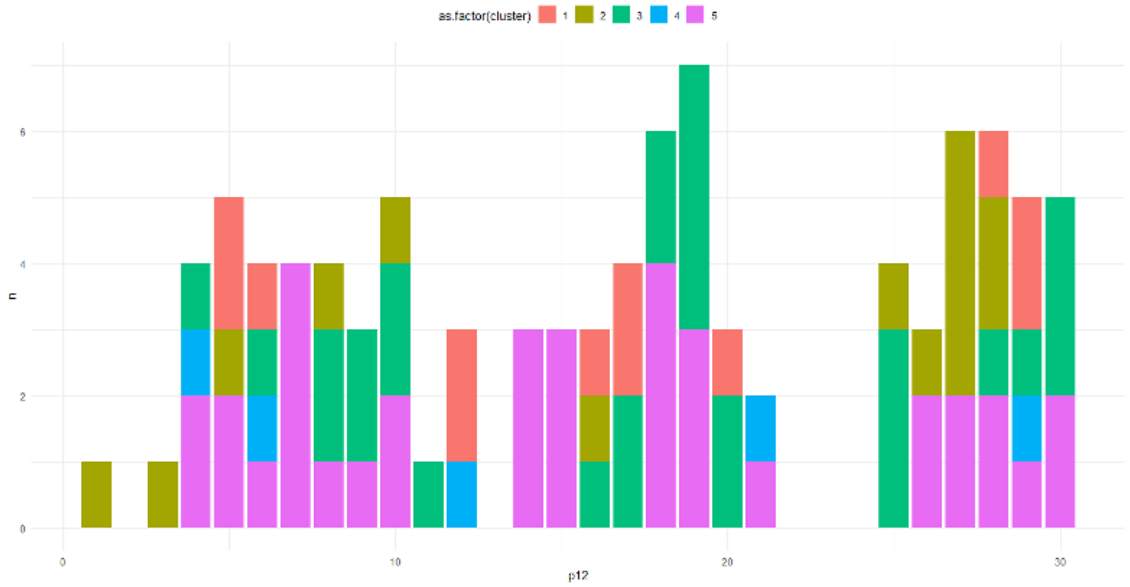

Figure 7: Students per group and cluster

From Figure 7, we can see how the students from each cluster are distributed within teams.

The four people who responded from team seven belong to cluster K5. From this, we can deduce that they had a good perception of their teamwork and were empathetic. The same is true for teams fourteen and fifteen. In team 21, only two people responded to the questionnaire, but one belonged to cluster K5, let us say effective teamwork, and the other to cluster K4, where every variable was negative.

Conclusion, Limitation, and Future Work

In this work-in-progress article, we present the preliminary results of a survey conducted to answer the following research question: How do face-to-face and remote work experiences

outside classroom settings influence undergraduate students' perceptions of teamwork in the context of a cornerstone course in Engineering?

We presented five clusters to which students belonged, considering their responses. These clusters are diverse, and the one with the highest number of responses (n=36) is cluster K5. This cluster shows that students did have a good perception of teamwork at the end of the course. Nevertheless, these results are inconclusive because it is still necessary to understand whether the differences between variables are significant.

This WIP presents a series of limitations, such as only 45% of the student body responding to the survey, and we have teams with no representation in the responses. It is important to consider this when analyzing the preliminary results.

Our next step in this research is to conduct it in the first semester of 2024, from March to July, with a cohort of 800 students to get a larger sample. We will contrast the students' perceptions and the type of meeting they find important (synchronic or asynchrony) with their team performance (final grade) to understand if they correlate. Conducting interviews with students to understand their perceptions regarding teamwork fully is also relevant.

Appendices

Appendix A: Cornerstone Course Summary [13]

Teaching Methods	Project-based Learning Flipped Classroom In-class teamwork activities and workshops
Course content	Engineering Design Process (know, define, ideate, prototype, test), Data analysis (qualitative and quantitative), Pitch.
Learning Outcomes	1. Solve a real-world problem. Apply a user-centered design methodology to an engineering problem. Produce a device that responds to a specific group's social, economic, or environmental vulnerability inequalities. 2. Articulate individual contributions to teamwork to develop a joint project.
Assessment Methods	1. Individual assessment: In-class contribution to teamwork activities, homework assignments, and workshop assistance. 2. Team assessment: Oral presentations on the design process (research and prototype). 3. Peer assessment after each team deliverable.
Evaluation Criteria	1. Professor: During the semester, the professor and the teaching assistants assess the design process. 2. Stakeholders: The final deliverable is presented at a technology fair, where stakeholders assess it.

Appendix B: Survey

1. Based on your experience this semester and your relationship with your team members, indicate to what degree you identified with the following statements (0 = strongly disagree, 5 = strongly agree).

    a. When I am upset at someone, I usually try to "put myself in his shoes" for a while (PT item 25).
    b. Before criticizing somebody, I try to imagine how I would feel if I were in their place (PT item 28).
    c. I believe every question has two sides, and I try to consider both(PT item 21).
    d. If I am sure I am right, I do not waste much time listening to other people's arguments (PT item 15).

2. To meet to work with your team, on a scale from 1 ("Not at all important") to 5 ("Very important"), how important were the following means or working instances?

    a. In-person meetings outside class hours (e.g., at the university, in a home, prototyping workshop, or elsewhere).
    b. Meetings through video calls (e.g., by Discord, Meet, Zoom, or other).
    c. Written channels (e.g., email, WhatsApp messages, Telegram, or others).
    d. Collaborative work platforms (e.g., Google Drive, MIRO, SharePoint, or others).
    e. Other (specify)_____

3. The following statements describe different ways to develop team-building meetings. Considering your experience in meetings with your team, mark your level of agreement with each of them (0 = strongly disagree, 5 = strongly agree).

    a. We divided the tasks that each one of us would do individually.
    b. We discussed different ideas about which direction to take our project.
    c. Together, we made decisions about what we were going to do in our project.
    d. We all developed the same part of the work.
    e. Together, we reviewed how each one had progressed individually.

4. Thinking about how you felt during this semester when working with your team, how much do you agree or disagree with the following statements?

    a. I liked working as a team during the semester.
    b. All team members worked equally.
    c. At some point, I felt they left me alone finishing a delivery.
    d. At some point, I felt blamed for the entire group's mistake.
    e. When things went wrong, my team and I shared the responsibility.
    f. If I finished my part, I would support a colleague further behind.
    g. I work well with people who have different work styles than mine.

References

[1] ABET. 2022. Criteria for Accrediting Engineering Programs, 2022–2023

[2] N. Ismail, N. A. Aziz, C. K. Hong, M. Z. Zainal, *Assessing Teamwork Value in Project-Based Learning of Capstone Project Course.* Atlantis Press, 2020. https://doi.org/10.2991/assehr.k.200921.025

[3] Hung, W., Dolmans, D. H. J. M., & van Merriënboer, J. J. G. (2019). A review to identify key perspectives in PBL meta-analyses and reviews: trends, gaps, and future research directions. Advances in Health Sciences Education, 24(5), 943–957. https://doi.org/10.1007/s10459-019-09945-x

[4] Phillips, A., Kecskemety, K. M., & Kajfez, R. L. (2019, October). Identifying Student Team Leaders and Social Loafers in a First-Year Engineering Cornerstone Robotics Design Project. In 2019 IEEE Frontiers in Education Conference (FIE) (pp. 1-5). IEEE. https://doi.org/10.1109/FIE43999.2019.9028610

[5] Wengrowicz, N., Dori, Y. J., & Dori, D. (2017). Meta-assessment in a project-based systems engineering course. Assessment & Evaluation in Higher Education, 42(4), 607-624. https://doi.org/10.1080/02602938.2016.1173648

[6] Hernández-de-Menéndez, M., Vallejo Guevara, A., Tudón Martínez, J.C. et al. (2019)Active learning in engineering education. A review of fundamentals, best practices, and experiences. Int J Interact Des Manuf 13, 909–922. https://doi.org/10.1007/s12008-019-00557-8

[7] Reis, A. C. B., Barbalho, S. C. M., & Zanette, A. C. D. (2017). A bibliometric and classification study of Project-based Learning in Engineering Education. Production, 27.

[8] Kuladinithi, K., Fisser, L., Fuger, K., Stolpmann, D., Vatandas, Z., Timm-Giel, A., & Dürkop, A. (2020, August). Online teaching of project-based learning courses: issues, challenges, and outcomes. In ACM SIGCOMM 2020. ACM Special Interest Group on Data Communication (SIGCOMM).

[9] Hess, J. L., Carrillo-Fernandez, A., Fila, N. D., & Schimpf, C. T. (2021, July), Exploring How Empathy Manifests with/for Teammates in a Junior-Level Biomedical Engineering Course Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. https://peer.asee.org/37143

[10] Goñi, J., Cortázar, C., Alvares, D., Donoso, U., & Miranda, C. (2020). Is Teamwork Different Online Versus Face-to-Face? A Case in Engineering Education. Sustainability. 12. 1-18. 10.3390/su122410444.

[11] Garratt-Reed, D.; Roberts, L.D.; Heritage, B. Grades, Student satisfaction and retention in online and face-to-face introductory psychology units: A test of equivalency theory. Front. Psychol. 2016, 7.

[12] Astudillo, G., Hilliger, I., Rodríguez, F., & Baier, J. (2022, September). Towards Effective Blended Learning Through the Eyes of Students: A Survey Study in Transition into Face-to-Face

Education. In European Conference on Technology Enhanced Learning (pp. 492-499). Cham: Springer International Publishing.

[13] Cortázar. C., Nussbaum, M., Harcha, J., Alvares, D., López, D., Goñi, J., & Cabezas V. (2021). Promoting critical thinking in an online, project-based course. Computers in Human Behavior. 119. https://doi.org/10.1016/j.chb.2021.106705.

[14] Pérez-Albéniz, A., De Paúl, J., Etxeberría, J., Montes, M. P., & Torres, E. (2003). Adaptación de interpersonal reactivity index (IRI) al español. Psicothema, 267-272.

[15] Bock, HH. (2007). Clustering Methods: A History of k-Means Algorithms. In: Brito, P., Cucumel, G., Bertrand, P., de Carvalho, F. (eds) Selected Contributions in Data Analysis and Classification. Studies in Classification, Data Analysis, and Knowledge Organization. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-73560-1_15