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Research article

A Pilot Study: Assessing the Synergy of Student Multidisciplinary Teamwork in Collaborative Projects

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Abstract

This pilot study delves into the efficacy of a novel scale, combining established measurements, to evaluate student teamwork in mixed collaborative environments. The article is split into two parts: the creation of the new scale and its application in evaluating four small heterogeneous groups' teamwork. Upon utilizing this newly developed scale to assess the diverse working teams, statistical analysis shows no significant differences in the three new dimensions, namely in communication skills (F=1.10, p=0.38), teamwork skills (F=0.20, p=0.89), or management skills (F=1.04, p=0.41). These findings suggest that despite variations in nationality, educational specializations, and gender, the teams displayed comparable competency in teamwork capabilities. The non-significant disparities underscore the potential effectiveness and equity of the new scale in appraising teamwork in diverse groups, emphasizing its utility in assessing cross-cultural and interdisciplinary collaborations. This research contributes with insights into evaluating and enhancing multidisciplinary teamwork, offering a possible instrument for fostering successful collaboration in varied student groups.

Keywords:
teamwork; assesment; multidisciplinary design collaboration; project based learning.

Zusammenfasung

Diese Pilotstudie befasst sich mit der Wirksamkeit einer neuartigen Skala, die etablierte Messungen kombiniert, um die Teamarbeit von Studierenden in gemischten kollaborativen Umgebungen zu bewerten. Der Artikel ist in zwei Teile gegliedert: die Erstellung der neuen Skala und ihre Anwendung bei der Bewertung der Teamarbeit von vier kleinen heterogenen Gruppen. Bei Verwendung dieser neu entwickelten Skala zur Bewertung der vielfältigen Arbeitsteams zeigt die statistische Analyse keine signifikanten Unterschiede in den drei neuen Dimensionen, nämlich bei den Kommunikationsfähigkeiten (F=1,10, p=0,38) und den Teamfähigkeiten (F=0,20, p=0,89). oder Managementfähigkeiten (F=1,04, p=0,41). Diese Ergebnisse deuten darauf hin, dass die Teams trotz unterschiedlicher Nationalität, Bildungsspezialisierung und Geschlecht eine vergleichbare Kompetenz in der Teamarbeit zeigten. Die nicht signifikanten Unterschiede unterstreichen die potenzielle Wirksamkeit und Gerechtigkeit der neuen Skala bei der Bewertung der Teamarbeit in verschiedenen Gruppen und unterstreichen ihren Nutzen bei der Bewertung interkultureller und interdisziplinärer Zusammenarbeit. Diese Forschung liefert Einblicke in die Bewertung und Verbesserung multidisziplinärer Teamarbeit und bietet ein mögliches Instrument zur Förderung einer erfolgreichen Zusammenarbeit in verschiedenen Studentengruppen.

Schlüsselworte:
Zusammenarbeit; Beurteilung; multidisziplinäre Designzusammenarbeit; Projekt basiertes lernen.

1. Introduction

In the dynamic landscape of education, the cultivation of essential skills extends far beyond individual academic prowess. Collaborative skills, teamwork, and collective problem-solving abilities have emerged as pivotal competencies for success in the modern world (Luk & Chan, 2022; Poole et al., 2021; Yang, 2023). The significance of teamwork in educational projects cannot be overstated, as it not only enhances academic learning but also nurtures social, emotional, and cognitive development.

Multidisciplinary settings show a confluence of diverse expertise, perspectives, and skills that are to be used in actual teamwork. Within this milieu, theories and models of teamwork stand as guiding lines, setting the path toward cohesive and effective collaboration. The imperative for successful multidisciplinary teamwork is underscored by the need to synthesize insights from various domains, fostering innovation and comprehensive problem-solving. This article embarks on an exploration of the theories, models, and fundamental factors that contribute to effective teamwork within multidisciplinary collaborative projects. By dissecting the core principles that underpin successful collaboration across disciplines, we seek to unveil the pivotal elements that propel teams towards collective achievement in multifaceted professional environments.

2. Theories and models of teamwork

Research emphasizes the significance of small, dedicated teams and their role in achieving success (Hoegl & Parboteeah, 2003; Poole et al., 2021; Sidorenkov & Borokhovski, 2023). Exploration of the prerequisites for establishing and managing effective teams underscores the significance of team composition, clear objectives, resource allocation, leadership, and external support. These fundamental insights serve as a cornerstone for comprehending and fostering successful teamwork.

Katzenbach and Smith's (1993) define a team as "a small group of people with complementary skills and a shared purpose and approach, which hold themselves mutually accountable for the team's success". The two researchers underline the importance of teams in achieving results that go beyond the capabilities of individual members. They emphasize the collective performance of a team that has a common goal that unites the members. They argue that this common objective is essential for creating a strong team identity. The authors also suggest that smaller groups are more agile, have clearer communication, and can focus better on tasks, fostering a higher level of camaraderie and mutual trust. Therefore, teamwork is regarded as "a social strategy built upon knowledge, attitudes, skills, and the ability to combine cognitive appreciation from all team members" (Jorgensen et al., 2019).

Hackman (2002) emphasizes the importance of designing teams deliberately. He suggests that a team's structure, composition, and tasks significantly impact its effectiveness. Hackman (2002) argues that teams work best when they have a compelling direction and a shared purpose. The author also stresses the importance of creating an environment where team members feel safe to express themselves. Teamwork also implies that the opinions of others are respected and the differences are handled so that the group can use the complementary experiences and knowledge (Chan & Luk, 2022).

3. The importance of teamwork in multidisciplinary settings

Teamwork is considered as an important soft skill for the workforce of industry 4,0 and 5,0 enterprises (Jorgensen et al., 2019, Polakova 2023). There are domains that see teamwork not only as a well-appreciated soft skill, but a fundamental capability that sets the ground of field competencies. Leading and participating in multidisciplinary teams is seen as a main task for food engineering (FE) (Saguy 2016). The Accreditation Board for Engineering and Technology (ABET) gives accreditations to engineering programs primarily in the United States. In their 2019 criteria, one of the mandatory learning outcomes they specified was "the capability to operate efficiently as a valuable member of a technical team." Moreover, team-oriented design projects develop engineering students' collaboration skills and are appreciated in a capstone course context (Leonard, 2023).

As a result, teamwork competencies are considered highly relevant for the higher education in chemical engineering and related fields like food engineering and agricultural engineering (Tobajas 2019) and in ICT (Barr, 2019; Assayne 2022; Kokkoniemi 2023). There are program studies such as Chemical Engineering at University of Sao Paolo Brasilia or Monash University Malaysia that require specific competencies like the ability to work in multidisciplinary and transdisciplinary teams that are based also on transdisciplinary competencies like teamwork (Oliveira, 2023; Yan, 2022). These programs, in the discussion of developing future engineers, stress the need for the following elements as parts of competences: entrepreneurship, time/project management, thinking and acting reflectively, analysis and decision making, design thinking, leadership skills (or empathy), knowledge/lifelong learning, self-reliance, sustainability and the environment, internationality, teamwork, communication and cooperation. These elements are considered to be intrinsic to the engineering field.

Similarly, an attempt to align the learning objectives of the graduated Global Engineering study programs at the North American universities, MacDonald (2022) includes in his learning objectives Multidisciplinary Teamwork and Leadership. The graduates should use this ability to create a collaborative and inclusive environment for a diverse team and to establish goals, plan tasks and meet objectives in collaboration with the other member of this team

A review on studies on multidisciplinary design collaboration (i.e. how members of diverse teams that intend to produce creative outputs act, interact and collaborate) revealed that the key elements are communication and social interactions (Nguyen, 2022):

1. Communication. The process of design, as highlighted by Bucciarelli & Bucciarelli in 1994, is

inherently social. Social interactions play a crucial role in design activities, constituting about 21% of the time spent on conceptual design. Conversations and exchanges among individuals involved in design can aid in uncovering diverse perspectives, fostering the establishment of personal connections. The effectiveness of collaboration and corresponding the quality of design are very much influenced by the way in which tensions and emotions are handled during the collaborative design sessions (Detienne et al., 2012). Notably, cultural diversity holds as much importance as disciplinary diversity, as suggested by Jutraz and Zupancic (2017).

2. Knowledge and diversity, as the different disciplinary backgrounds generate the diversity of knowledge and experience.

3. Trust and context. The team members can create shared understanding only if they can establish a mutual agreement based on the contextual knowledge convergence.

4. Barrier and design communication. The visual representation are the essential tools for facilitating multidisciplinary communication.

5. Jargon and roles. Discussion should be encouraged in a context that stimulates imagination and idea exchange by team members assuming the role of collaboration facilitator so that jargon conflicts are avoided or overcome.

4. Key factors that contribute to effective teamwork in collaborative projects

Effective student teamwork in collaborative projects relies on several key factors that contribute to success. These factors include various elements that promote cohesion through communication skills, productivity through actual teamwork skills, and learning outcomes in terms of teamwork results.

Students need a clear understanding of the project's goals, their roles, and the expected outcomes. Establishing clear objectives helps in aligning efforts and focusing on the end goals (Yang, 2023). Studies show that a diverse team brings varied perspectives, skills, and strengths. Combining individuals with different backgrounds, expertise, and experiences can lead to innovative problem-solving and a rich learning environment (Bell et al., 2011). Open and effective communication is essential. Encouraging active and respectful dialogue among team members fosters collaboration and knowledge sharing (da Silva et al., 2015; Johnson & Johnson, 2009). These aspects transcend the possible barriers of language and move into a more intimate zone of communication.

Establishing ground rules and setting clear roles and responsibilities are also key factors to effective student teamwork (Alsaleh, 2020; Johnson & Johnson, 2009; Mead & Scharmann, 1994). Setting team norms and guidelines helps in structuring interactions and managing conflicts. It ensures that everyone understands the expectations, timelines, and behavioral standards within the team. Clearly defining individual roles and responsibilities within the team avoids ambiguity and ensures accountability. When everyone knows their specific tasks, it prevents duplication of efforts and ensures progress. Also, mentorship of peers that passed the course can positively influence the teamwork performance and reduce the team dysfunctionalities (Iacob, 2020).

Conflicts are inevitable in group work, especially when team members don't speak their native language. Teaching students how to manage conflicts constructively, listen actively, and find common ground is essential for successful collaboration. Sometimes, not using the mother tongue language helps in giving time to comprehend the possible conflict situations (De Dreu & Weingart, 2003). Also, incorporating peer feedback and evaluation allows students to assess their own and others’ contributions. It encourages accountability, fairness, and improvement in teamwork (Falchikov, 2005). Diverse team members' backgrounds can offer a fresh perspective when giving feedback.

The efficacy of student teamwork in collaborative projects depends upon a comprehensive integration of multifaceted elements. Establishing a conducive environment where clear communication, structured roles, and diversified perspectives intersect is vital. The factors presented enhance the learning experience and nurture essential skills. Recognizing the significance of these factors and their interconnectedness is decisive for teachers aiming to cultivate a dynamic and productive collaborative learning environment. As the landscape of education continues to evolve, fostering these elements will remain pivotal in preparing students for the challenges within specific work domains.

5. Methodology

In this study, it is important to note that the research undertaken serves as a pilot investigation, laying the foundation for future, more extensive research endeavors. Our primary objective was to develop and validate a novel scale for assessing teamwork characteristics by combining two previously verified scales (Kiesewetter & Fischer, 2015a; Liu et al., 2022). By conducting this pilot study, we aimed to measure the efficacy of the new scale while also identifying any potential refinements required for its successful implementation in future research. The use of established scales provided a robust starting point for our assessment of multidisciplinary student teamwork, ensuring that the new scale maintained the reliability and validity. The results of this pilot study contribute to the ongoing effort to enhance the precision and applicability of teamwork measurement tools for this specific pilot study that aimed to also answer to the following research questions:

Can the combination of two established scales, one measuring team coordination, team cooperation, information exchange, team adjustment behaviors and the other assessing constructive controversy, helping behaviors, spontaneous communication and team creativity, yield a more cohesive and effective scale for evaluating teamwork performance in a mixed collaborative work environment?

How does the composition of multidisciplinary teams, in terms of members' diverse culture, study backgrounds and language, impact the efficiency and quality of teamwork?

5.1. Participants

The study comprised a diverse group of 17 participants, with 6 individuals hailing from Norway and 11 from Romania. The participants were predominantly female, with 10 women contributing to the study, while 5 participants identified as male, and 2 individuals opted not to declare their gender. This age range was between 19 and 27 years old. 13 of the participants had specialized in the field of Information Technology (IT), while the remaining 4 participants specialized in Food-related disciplines.

Prior to their involvement in the research, all participants were provided with a comprehensive explanation of the study's objectives, procedures, and benefits. Additionally, participants were informed about the measures taken to protect their privacy and confidentiality, including the secure handling of their data. Only after participants had an opportunity to ask questions and express their willingness to participate by signing the consent forms did the data collection process begin.

Participants were mixed and grouped in 4 heterogeneous teams, as described below.

Team 1

In this first team, 2 students were from Norway and 2 from Romania. Within this group, there were 3 males and 1 female. In terms of their academic specialization, the participants were evenly divided, with 3 studying Information Technology (IT) and 1 focusing on Food-related disciplines.

Team 2

In the second team, 1 student was from Norway and 2 from Romania. Within this group, there were 1 male and 2 did not declare the gender. In terms of their academic specialization, the participants were evenly divided, with 1 studying Information Technology (IT) and 1 focusing on Food-related disciplines.

Team 3

In the third team, 2 students were from Norway and 3 from Romania. Within this group, there were 3 males and 2 females. In terms of their academic specialization, the participants were evenly divided, with 4 studying Information Technology (IT) and 1 focusing on Food-related disciplines.

Team 4

In the fourth team, 1 student was from Norway and 4 from Romania. Within this group, there were 3 males and 2 females. In terms of their academic specialization, the participants were evenly divided, with 4 studying Information Technology (IT) and 1 focusing on Food-related disciplines.

5.2. Educational context

The students were participating in the second Summer school organized in the framework of the MAPIoT program (MAPIOT 2021). The purpose of the project is to develop the needed capabilities for the adoption of digital technologies in the Agrofood businesses especially in small and medium businesses (Florea 2023). The summer schools were designed as testbeds for methods to teach the digital skills for the workforce of this business. The lack of such a workforce is one of the main causes of the slow adoption of digital technologies in the agrifood sector. The development of suitable teaching methods that should form the digital competencies but also the transversal competencies as teamwork and working in a multidisciplinary environment required for the implementation and use of the digital technologies in agrifood was identified as a need that should be solved by the project (Berntzen 2022).

During the two weeks of the summer school the students had a mix of practical courses and field visits in IT business producing equipment and technologies for the digitalisation of the agri- food sectors and in agrifood business implementing or intending to implement digital technologies. The main approach was that the students have hands-on contact with technologies during the courses, see the process of developing the technologies in the IT business and know the real needs and problems of agrifood business implementing digitalisation. At the end of the school the students developed using the technologies they learned during the summer school - in a Hackathon manner - an IT solution for a problem they identified in the visits.

The learning unit "C4 Digital design of food manufacturing processes – theory and applications" was selected for the pilot study for multiple reasons:

- it introduces a modeling and simulation tool that:
  - o utilizes a simple graphical language which eases the development of models;
  - o allows a description of the systems that the students have encountered in their visits giving them a common ground for discussions and reasoning;
  - o supports the rapid designs of multiple solution.
- it was at the end of the second week, so:
  - o the team members had the time to know each other and to develop teamwork and multidisciplinary skills;
  - o the students had done the visits on field, so they had examples of potential agrifood systems in which to implement their solution;
  - o it was before the final Hackathon when the students would develop an IT based solution for a problem they encountered in their visits on field.

The learning unit was divided in two parts - one dedicated to learning the modeling and the other to simulation methods and tools. This was performed through learning by doing. The teacher models one component of an agrifood production system (like reservoirs, machines, transport systems, robots, workers) and the teams had to reproduce this modeling and simulation example and then they received the task to model a component of the same type. An example of how to connect the models of components in the model of a production systems was also presented and reproduced by the students.

In the second part, each team developed a model of the systems that were relevant for the implementation of the IT solution in the final Hackathon. They selected the relevant components, they modeled them and connected them in the model of the complete system. They verified and validated the model through simulation using data from the enterprises they visited.

The four modeled system were:

- Tomato sauce producing plant (Team 3)
- Wine producing plant (Team 2)
- Internet of things (IoT) monitored farm (Team 1)
- Drone monitored farm (Team 4)

5.3. Instruments

The Teamwork Assessment Scale (Kiesewetter & Fischer, 2015b) is a specialized instrument developed to evaluate the quality of teamwork among undergraduate medical students during simulated ward rounds. The scale likely includes a set of well-defined and structured items or criteria designed to measure various aspects of teamwork. These criteria could encompass elements such as effective communication, collaboration, leadership, task distribution, and adaptability. Each item within the scale would likely be rated on a standardized scale, allowing observers to assess the extent to which students exhibit these teamwork behaviors.

The Taiwanese Team Interactions and Team Creativity Instrument (TITC-T) (Liu et al., 2022) is a particular assessment tool designed to measure team interactions and creativity within the context of nursing education. The scale likely encompasses a set of structured items or criteria that are carefully crafted to evaluate team interactions and creativity among nursing students. The items may focus on various facets of teamwork, such as communication, cooperation, leadership, and problem-solving skills, which are particularly crucial in the healthcare setting. Moreover, the scale is likely to assess the students' ability to generate innovative solutions and ideas, which is essential in nursing practice.

In the context of evaluating teamwork aspects in heterogeneous working groups, characterized by the inclusion of members from diverse countries, diverse educational specializations, and genders, the previously employed scales fell short in capturing the intricate dynamics at play. Notably, none of the team members, when collaborating, utilized their native languages; instead, they relied on English as the lingua franca. This language dynamic introduced an additional cultural layer of complexity, as the scales might not have been designed to account for the potential communication challenges, subtle cultural nuances. Furthermore, the diverse composition of these groups, encompassing individuals from various academic backgrounds and cultural contexts, rendered it essential to assess how well the scales adapted to these heterogeneous settings. The limitations of the existing scales in accommodating these variables underscore the necessity of developing a more contextually relevant assessment tool capable of effectively measuring teamwork in diverse and globally integrated work environments.

5.4. Procedure

The procedure for this pilot study is divided into two sections: first, generating the new scale, and second verifying the scale in an actual teamwork with the 4 heterogeneous groups.

Generating the new scale

For creating a new scale, we used factor analysis, which has suggested three new dimensions labeled as "Communication Skills," "Teamwork Skills," and "Management Skills”.

6. Results

In this study, Cronbach’s Alpha was use to assess the internal consistency of the Communication, Teamwork and Management skills. The resulting coefficients where 0.881 for the Communication skills, 0.857 for the Teamwork skills and 0.776 for the Management skills.

The overall reliability for the 18 items scale was 0.894.

For the management skills dimension, in order to gain more structure, item Q7 was removed from scale.

Verifying the scale in an actual teamwork

After applying the newly developed scale to assess the four heterogeneous working teams, the results from the analysis of variance (ANOVA) revealed that there were no statistically significant differences among the teams in terms of their communication skills ($F=1.10$, $p=0.38$), teamwork skills ($F=0.20$, $p=0.89$), or management skills ($F=1.04$, $p=0.41$) (Table 1).

Table 1. ANOVA for group skills

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
comm_skills	Between Groups	44,568	3	14,856	1,100	,384
	Within Groups	175,550	13	13,504		
	Total	220,118	16			
teamwork_skills	Between Groups	10,913	3	3,638	,207	,890
	Within Groups	228,617	13	17,586		
	Total	239,529	16			
man_skills	Between Groups	1,532	3	,511	1,046	,405
	Within Groups	6,350	13	,488		
	Total	7,882	16			
skillstotal	Between Groups	52,348	3	17,449	,304	,822
	Within Groups	747,417	13	57,494		
	Total	799,765	16			

7. Discussions

For generating the new scale, we begin by compiling a comprehensive list of 17 items that pertain to teamwork aspects, starting from the two cited scales. These items were designed to cover a broad range of behaviors and competencies within each dimension. We administered the initial set of items to the sample of participants, grouped in 4 teams. This testing phase aims to evaluate the clarity and relevance of the items and gather preliminary data for factor analysis.

We collected responses and performed an EFA to identify the underlying factor structure of the scale. Based on the results of the EFA, to choose the items that load most strongly on each other, the Rotated Component Matrix suggested the 3 dimensions. After finalizing the items, conduct a CFA to validate the factor structure. CFA confirmed that the selected items align well with the proposed dimensions, namely "Communication Skills," "Teamwork Skills," and "Management Skills”. Using these dimensions, we tested the new scale with the four teams.

The results indicate that the teams, despite their diversity in nationality, education specializations, and gender, demonstrated comparable levels of competence in these essential teamwork skills. The non-significant differences also highlight the potential effectiveness and fairness of the new scale in evaluating teamwork performance in diverse working groups, underscoring its utility as a valuable instrument for assessing cross-cultural and interdisciplinary collaboration.

8. Limitations

One of the primary limitations of this article is the relatively small number of participants included in the study. The sample size of participants, which was limited to 17 students, may constrain the generalizability of the findings to a broader population. A larger and more diverse sample would provide a more comprehensive representation of the diversity inherent in heterogeneous working groups, thereby enhancing the study's external validity. This limitation underscores the need for further research with larger sample sizes to confirm the robustness of the newly developed scale and to explore potential variations in teamwork skills across a more extensive range of contexts and participants.

9. Conclusions

This study provides affirmative answers to the two fundamental research questions. Firstly, the combination of two established scales measuring diverse teamwork dimensions, including team coordination, cooperation, information exchange, team adjustment behaviors, constructive controversy, helping behaviors, spontaneous communication, and team creativity, indeed yielded a more cohesive and effective scale for evaluating teamwork performance in a mixed collaborative work environment. The amalgamation of these scales allowed for a more comprehensive assessment, addressing various facets of teamwork, thereby providing a more cohesive perception of teamwork dynamics.

Secondly, this study highlights that despite the significant influence of multidisciplinary team composition, characterized by members from diverse cultural backgrounds, study specializations, and language proficiency, the efficiency and quality of teamwork was not affected. It underscores that diverse teams, while offering unique perspectives and experiences, can perform with remarkable uniformity, as evidenced by the non-significant differences in teamwork skills across groups. This study contributes to our understanding of teamwork evaluation in diverse work environments and emphasizes the applicability of the new scale in such settings, thus supporting its utility in cross-cultural, multidisciplinary collaborations.

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References

Accreditation Board for Engineering and Technology. (2019). *Criteria for Accrediting Engineering Programs*. ABET, pp. 2020–2021.

Alsaleh, N. J. (2020). Teaching Critical Thinking Skills: Literature Review. *TOJET: The Turkish Online Journal of Educational Technology,* 19 (1).

Assyne, N., Ghanbari, H., Pulkkinen, M. (2022). The essential competencies of software professionals: A unified competence framework. *Information and Software Technology*, 151, 107020, ISSN 0950-5849, https://doi.org/10.1016/j.infsof.2022.107020.

Barr, M., Parkinson, J. (2019). Developing a work-based software engineering degree in collaboration with industry. In: *Proceedings of the 2019 Conference on United Kingdom & Ireland Computing Education Research*. pp. 1–7.

Bell, S. T., Villado, A. J., Lukasik, M. A., Belau, L., & Briggs, A. L. (2011). Getting specific about demographic diversity variable and team performance relationships: A meta-analysis. *Journal of Management*, 37(3), pp. 709–743. https://doi.org/10.1177/0149206310365001

Berntzen, L., Florea A. (2022). Design Thinking Applied to the Internet of Things - A Project on Technological Innovation in Agriculture and Food Processing, *ICDS 2022, The Sixteenth International Conference on Digital Society*, Porto, Portugal, pp. 44-49, ISSN: 2308-3956

Chan, C.K.Y., Luk, L.Y.Y. (2022). Studies in Educational Evaluation Academics' beliefs towards holistic competency development and assessment: a case study in engineering education. *Stud. Educ. Eval.* 72, 101102 https://doi.org/10.1016/j. stueduc.2021.101102.

da Silva, F. M., Neto, F. M. M., Burlamaqui, A. M. F., Demoly, K. R. do A., & Pinto, J. P. de F. (2015). Providing an Extension of the SCORM Standard to Support the Educational Contents Project for t-Learning. *Creative Education*, 06 (11), pp. 1201–1223. https://doi.org/10.4236/CE.2015.611118

De Dreu, C. K. W., & Weingart, L. R. (2003). Task Versus Relationship Conflict, Team Performance, and Team Member Satisfaction: A Meta-Analysis. https://doi.org/10.1037/0021-9010.88.4.741

Falchikov, N. (2005). *Improving assessment through student involvement: practical solutions for aiding learning in higher and further education*. RoutledgeFalmer. https://www.routledge.com/Improving-Assessment-thr

Florea, A., Popa, D. I., Morariu, D., Maniu, I., Berntzen, L., & Fiore, U. (2023). Digital farming based on a smart and user-friendly IoT irrigation system: A conifer nursery case study. *IET Cyber-Physical Systems: Theory & Applications*. 1–19, https://doi.org/10.1049/cps2.12054

Hackman, J. R. (2002). *Leading teams: setting the stage for great performances*. https://books.google.com/books/about/Leading_Teams.html?hl=ro&id=wkgxCgAAQBAJ

Hoegl, M., & Parboteeah, K. P. (2003). Goal Setting and Team Performance In Innovative Projects: Http://Dx.Doi.Org/10.1177/1046496402239575, 34 (1), pp. 3–19. https://doi.org/10.1177/1046496402239575

Iacob, C., & Faily, S., (2020). The Impact of Undergraduate Mentorship on Student Satisfaction and Engagement, Teamwork Performance, and Team Dysfunction in a Software Engineering Group Project. *SIGCSE '20: Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, pp. 128–134, https://doi.org/10.1145/3328778.3366835

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, 38 (5), pp. 365–379. https://doi.org/10.3102/0013189X09339057

Jorgensen, S., Arce-Trigatti, A., Allen Mathende, S. B., Cain, A. H., Sanders, J. R., Arce, P. E. (2019). *An Activity to Illustrate Teamwork: An Introduction to the Renaissance Foundry Model Through Mindful Abstraction*

Katzenbach, J., & Smith, D. K. (1993). *The discipline of teams.* Harvard Business Review.

Kiesewetter, J., & Fischer, M. R. (2015). The Teamwork Assessment Scale: A Novel Instrument to Assess Quality of Undergraduate Medical Students' Teamwork Using the Example of Simulation-based Ward-Rounds. GMS Zeitschrift Fur Medizinische Ausbildung, 32 (2). https://doi.org/10.3205/ZMA000961

Kokkoniemi, M., Isomöttönen, V.. (2023). A systematic mapping study on group work research in computing education projects. *Journal of Systems and Software*. 204. 111795. 10.1016/j.jss.2023.111795.

Leonard, A., Guanes, G., & Dringenberg, E. (2023). Undergraduate students' beliefs about diverse approaches to making engineering design decisions: Exploring change during a capstone course. *International Journal of Technology and Design Education*, pp. 1–31.

Liu, H. Y., Sung, S. C., Chao, C. Y., Chen, N. H., Chen, H. F., & Wu, S. M. (2022). Development and Psychometric Testing of a Taiwanese Team Interactions and Team Creativity Instrument (TITC-T) for Nursing Students. *International Journal of Environmental Research and Public Health*, 19 (13). https://doi.org/10.3390/IJERPH19137958

Modernizing Agricultural Practice using Internet of Things (MAPIOT) project site https://digifof.omilab.ulbsibiu.ro/psm/content/mapiot/info?view=activities

Mead, J. M., & Scharmann, L. C. (1994). Enhancing Critical Thinking Through Structured Academic Controversy. *American Biology Teacher*, 56 (7), pp. 416–419. https://doi.org/10.2307/4449872

MacDonald, L., Thomas, E., Javernick-Will, A., Austin-Breneman, J., Aranda, I., Salvinelli, C., Klees, R., Walters, J., Parmentier, M., Schaad, D., Shahi, A., Bedell, E., Platais, G., Brown, J., Gershenson, J., Watkins, D., Obonyo, E., Oyanedel-Craver, V., Olson, M., Linden, K. (2022). Aligning learning objectives and approaches in global engineering graduate programs: *Review and recommendations by an interdisciplinary working group. Development Engineering*. 7. 100095. 10.1016/j.deveng.2022.100095.

Nguyen, M., Mougenot, C.A. (2022). Systematic review of empirical studies on multidisciplinary design collaboration: Findings, methods, and challenges, *Design Studies*, 81, 101120, ISSN 0142-694X, https://doi.org/10.1016/j.destud.2022.101120.

Oliveira, R., Hipólito, G., Pontes, R., Ferreira, P., Moreira, R., Plácido, J., Silva, C., Tovar, L. (2023). Transdisciplinary Competency-based Development in the Process Engineering Subjects: A Case Study in Brazil. *Education for Chemical Engineers*. 44. 10.1016/j.ece.2023.05.007.

Poláková, M, Horváthová Suleimanová, J., Madzík, P., Copuš, L., Molnárová, I., Polednová, J. (2023). Soft skills and their importance in the labour market under the conditions of Industry 5.0, *Heliyon,* 9 (8), e18670, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2023.e18670.

Poole, M. S., Dobosh, M. A., Keyton, J. (2021). Group Communication Theory: New Theories and Perspectives. *The Emerald Handbook of Group and Team Communication Research*, 45–52. https://doi.org/10.1108/978-1-80043-500-120211005

Reyes, L., Reedy, A., Guerrero Farías, M., Pradilla, D. (2020). Improving employability skills through non-placement work-integrated learning in chemical and food engineering: A case study. *Education for Chemical Engineer*s. 33. 10.1016/j.ece.2020.09.002.

Saguy, I. S.,Cohen, E. (2016). Food engineering: Attitudes and future outlook, *Journal of Food Engineering,* 178, pp. 71-80, ISSN 0260-8774, https://doi.org/10.1016/j.jfoodeng.2016.01.009.

Sidorenkov, A. V., & Borokhovski, E. F. (2023). The Role of Cohesion and Productivity Norms in Performance and Social Effectiveness of Work Groups and Informal Subgroups. *Behavioral Sciences*, 13(5). https://doi.org/10.3390/BS13050361

Tobajas, M., Molina, C.B., Quintanilla, A., Alonso-Morales, N., Casas, J.A. (2019). Development and application of scoring rubrics for evaluating students' competencies and learning outcomes in Chemical Engineering experimental courses. *Educ. Chem. Eng*. 26, 80–88

Yang, X. (2023). A Historical Review of Collaborative Learning and Cooperative Learning. *TechTrends*, 67(4), 718–728. https://doi.org/10.1007/S11528-022-00823-9/TABLES/2

Yap, J.S., Tan, J. (2022). Lifelong learning competencies among chemical engineering students at Monash University Malaysia during the COVID-19 pandemic. *Educ. Chem. Eng*. 38, 60–69. https://doi.org/10.1016/j.ece.2021.10.004.