Teamwork, Co-Regulation, and Socially Shared Regulation Skills within Engineering Education Studies: A GenAI-Assisted Scoping Review

Dr. Manish Malik SFHEA, MIET

Manish is an engineering education researcher who works within and outside technology enhanced learning environments. He is one of the founding members of the UK and Ireland Engineering Education Research Network since its inception in 2009. Currently, Manish is a visiting Professor at the Faculty of Engineering, at McGill University Canada in addition to his substantial post of Faculty Director of Teaching and Learning, Faculty of Engineering, Science and Social Sciences at Canterbury Christ Church University. His current research spans self, co, and socially shared regulation, Threshold Concepts, Computer Orchestration, Generative Artificial Intelligence for research and teaching and learning within engineering education. He also trains researchers in systematic reviews, meta-analysis and other research methods and has recently helped supported 250+ colleagues with their GenAI literacy through his signature mind-metaphors based framework for co-intelligence, co-inference and collaboration, allowing users to regain their agency when using GenAI models.

Dr. Julie-Ann Sime FHEA, MBPsS, Lancaster University, UK

Dr Julie-Ann Sime is an award-winning digital innovator, pioneer of online distance education, and academic. With a PhD in Artificial Intelligence in Education, she engages in multi-disciplinary research into learning with emerging technologies, inclusive education and research methods. In 2021, she received an international award from the British Council for Digital Innovation in Teaching for the CIELL mobile app, with a special commendation for its contribution to Equality, Diversity and Inclusion. For over 30 years, she has been teaching online postgraduate students and has supervised over 30 PhD students to completion. As an expert she has evaluated proposals and monitored progress of research funded by the European Commission. And she has worked with the European Institute of Innovation and Technology to advise on their Knowledge and Innovation Communities' activities and performance. She has extensive experience in European-funded collaborative research with industrial partners and SMEs to design innovative virtual learning environments that support individual and team training within science and engineering domains.

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Introduction

This research method, full paper, reports on a GenAI-assisted scoping review. Understanding and modelling team working skills in engineering education students is desirable from the point of view of employability, developing graduate attributes and in meeting standards set by accrediting professional bodies [1]-[3]. Due to the range of factors and challenges in developing team working skills, this is an area of interest to many academic staff working and researching in engineering education [4]-[5]. Borrego et. al highlighted the complexities in this area and have called for engineering education researchers to work with experts from other domains, such as industrial and organisational psychology to address some of the challenges faced by academic staff, students and engineering education researchers [5]. These challenges became even more prominent during and since the COVID pandemic, which needs capturing. This scoping review maps the extent and nature of research activity that has developed in the last three years and determines the value and feasibility of doing a full systematic review in this area as subsequent and future work [6]. In determining the scope of this scoping review, the authors wanted to include a related framework that is of interest, namely, self, co- and socially shared regulation of learning [7]-[9]. Earlier reviews have identified the benefits of encouraging self-regulation within teamwork settings [9], or looked at factors affecting teamwork skills development [4], however there is a need to synthesise findings from studies on co-, and socially shared regulation of learning within engineering education. The synergies here could benefit the community and help address the challenges related to team working [8]-[11].

An initial search on the ERIC database, restricted to just the last three years, revealed 329 records that met our search criteria as defined later in the paper. The number is large enough to test GenAI assisted automation in the shortlisting and selection process. This automation was carried out using Generative Artificial Intelligence (GenAI) tools such as ChatGPT® and NotebookLM®. The paper makes a methodological contribution in using a combination of: a novel approach of using synthetically generated abstracts for title and abstract shortlisting; use of NotebookLM® for extracting data; and also using GenAI developed code to remove duplicates in the search results. The PRISMA-ScR extension checklist [12] was followed for this scoping review and the primary research question, designed using the Population, Intervention, Comparator and Outcome (PICO) framework, focuses on teamwork related outcomes in higher education engineering student populations in the last three years [13]. The search clause, the inclusion and exclusion criteria were also guided by the PICO framework. A second research question focuses on the methodological contribution of this study:

1. What is the extent and nature of the research that has been carried out in higher engineering education, related to student teamwork, co and socially shared regulation of learning in the last three years?
2. How reliably can the use of GenAI be embedded in the process of carrying out a scoping review?

Scoping Review Method and Role of GenAI

Inclusion and exclusion criteria and search terms: The studies included in this work are only from a single database, namely ERIC. It takes a combined look at the last three years of English language (not other languages), full text articles (journal or conference papers, not books or dissertations) on different approaches to developing teamwork-related outcomes in engineering students (studies that only included non-engineering students were excluded). All reviews were excluded. Working with one database was considered sufficient for this proof of concept stage to test the novel methodology. Table 1 shows the population and the outcomes search terms, which were combined with AND and used when searching ERIC. The search feature of the ERIC database was first used on 25th November 2024 and the final version was run on 6th December 2024. We have included the link to the search results for replicability.

Table 1: PICO based search terms

Population based search terms	("Engineering student*" OR "Engineering Education" OR "engineering degree" OR "Engineering course" OR "Engineering programme")
Outcomes based search terms	("shared regulation of learning" OR "SSRL" OR "CoRL" OR "Co-regulat*" OR "Coregulat*" OR teamwork* OR transversal OR collaborative OR cooperative OR "team work*")

Selection of sources of evidence and data charting process: The first author developed a Google Apps script using ChatGPT's Canvas tool to help detect any duplicated titles in the search results. Both authors also performed this work manually for all 329 records for an objective comparison. After duplicate removal, the screening stage involved classification of the papers, done by both the authors and ChatGPT 4o programmatically through its API. To shortlist the papers checks for relevant population and outcomes were made in addition to using synthetically generated abstract examples. Shortlisted papers were read by the authors and synthetically using NotebookLM® to extract data. Disagreements were resolved by discussions between the authors at each stage. Discrepancies in authors and GenAI tools used were investigated jointly using the chat and evidence mapping feature in NotebookLM® and human discussion and verification.

Data items and synthesis of results: For the scoping review summary data fields were extracted, such as: Study type, type of data collected, number of participants, country, duration of study, number of studies, theoretical framework, study level, main findings. Comparison of human and machine results, in particular, the duplicate detection scores, the inter-rater reliability scores and accuracy scores at screening and detailed read stages, and the match between the extracted data by GenAI and humans are presented below in support of the methodological contribution.

Results

Human vs GenAI outcomes in duplicate detection and title and abstract screening: The list of 329 records were uploaded into a Google spreadsheet. Google Apps script (GAS) code to find duplicates in the list was generated in Canvas. Independently, the two authors sorted the list alphabetically and manually performed the duplicate removal. A 100% match (10 duplicates) between the two meant 319 records were kept. Some 130 of 319 (41%) titles and abstracts were independently read by the two authors, who divided this equally and checked each other's shortlisting based on the inclusion and exclusion criteria. The first author developed GAS code to use ChatGPT 4o via its API to get the same 130 records classified for keeping or rejecting

based on population and outcome and synthetically generated abstracts for objective comparison. To this end, Table 2 and Table 3 shows the confusion matrix and accuracy scores and Cohen's Kappa. Cohen's Kappa value (machine-human) for this stage of the process was 0.87, which is in the 'almost perfect' range of 0.8 to 1 [14], and is also above the average human-human figure of 0.82 (SD=0.11, n=12) in systematic literature reviews [15]. Based on these results, it was considered reasonable to use GenAI to classify the remaining records (n = 189 of 319). After cross-checking the classification of population and outcomes by GenAI, a total of 81 of 319 records were kept for the full text screening stage, which is a typical number at this stage.

Table 2. Human-machine confusion matrix (title and abstract screening)

Machine >> vs Human	Keep	Reject	Total
Keep	27	4	31
Reject	2	97	99
Total	29	101	**130**

Table 3. Human-machine inter-rater reliability (title and abstract screening)

Expected agreement by chance, Pr(e)	Accuracy or Observed agreement, Pr(a).	Cohen's Kappa, K
64.49%	95.38%	0.87

Human vs GenAI Full Text screening: A second step in a scoping review is to decide if a paper meets the inclusion or the exclusion criteria, after a full text read. Here, a sample of 36 of 81 randomly chosen papers (44%) were read by both authors and also synthetically read by NotebookLM® for an objective comparison. The authors manually and using NotebookLM®, extracted population, outcome and aims from these 36 articles, resulting in 108 data points to help with inclusion/exclusion. Table 4 shows the overall percentage match (88.89%) and the differences and similarities are captured in the confusion matrix, see Table 5.

Table 4. Human-machine percentage match (full-text read)

Data Extracted	Matches	Total	Percentage match
Aims, P and O	96	108	88.89%

Table 5: Human-machine confusion matrix (full-text read)

Machine >> vs Human	Keep	Reject	Total
Keep	21	1	22
Reject	2	12	14
Total	23	13	**36**

Cohen's Kappa value (machine-human) for the full text read stage was 0.82, see Table 6, which is in the 'almost perfect' range of 0.8 to 1 [14]. An average human-human figure for full text screening stage in systematic literature reviews is 0.77 (SD=0.18, n=14) [15]. After checking the 2 articles

that were rejected by humans but kept by NotebookLM®, we decided to include 1 of them. No other changes were made, making the number of papers kept from this stage to 22 of 36. Of 81 kept for full text screening, 8 were not accessible, 36 were processed by humans and machine (resulting in 22 kept). Given the 'almost perfect' performance of GenAI, the remaining 37 articles were processed using NotebookLM® alone to extract population, outcome and aims data (resulting in 26 kept). The classification done was helpful for verification as before, resulting in 48 of 81 keeps.

Table 6: Human-Machine inter-rater reliability (full-text read)

Expected agreement by chance, Pr(e)	Accuracy or Observed agreement, Pr(a).	Cohen's Kappa, K
53.09%	91.67%	0.82

Further Data extraction

Human and GenAI outputs: To objectively compare, further data extraction from 22 papers was done by the authors and the machine on the 'Keep' papers. Table 7 shows the fields and the percentage match of the extracted data fields between NotebookLM® and the authors. It indicates a high level of agreement (over 80%) between human and machine extracted data points, only for the fields number of studies, data collected and study type.

Table 7. Matched percentage - data extraction

| Data Extracted	Matches	Total	Percentage match
Number of studies	20	22	90.91%
Data collected	18	22	81.82%
Study type	18	22	81.82%
Main findings	17	22	77.27%
Number of participants	14	22	63.64%
Duration of study	14	22	63.64%
Study level	14	22	63.64%
Theoretical framework	13	22	59.09%
Country	11	22	50.00%

For the 48 of 81 ERIC records kept for the final summary in this review, see Appendix A, the data fields where the percentage match was high (over 80%) were extracted using NotebookLM® and the rest of the data was manually extracted.

Synthesis of results

This section presents the extent (date, country, number of studies, number of participants), and nature (study type, data collected, theoretical framework) of the research published in the last three years and found in this scoping review.

Extent: The extent of the review can be seen in the number of papers published over the last 3 years, the location where the studies were carried out, the number of studies reported in each

paper and the number of student participants involved in the research studies. In the last 3 years, there were 48 papers published on the ERIC database alone that fit the inclusion and exclusion criteria after full-text review. Of these, 12 papers were published in 2022, 21 in 2023 and 15 in 2024 (up to 6th December 2024 when the final search was conducted), see Figure 1 a. These studies were carried out in higher education institutions around the world with the vast majority (45.8%) arising out of USA (22), see Figure 1 c, with a few studies in other countries including: The Netherlands (5), Australia (2), China (2), Denmark (2), Finland (2), South Africa (2), Brazil (1), Chile (1), Columbia (1), Cuba (1), Cyprus (1), India (1), Mexico (1), New Zealand (1), Sweden (1), Turkey (1) and UK (1). Most papers reported on a single study (44) although one paper, from the USA, discussed 3 studies, and three papers gave accounts of 2 studies (including two from USA, and one from Cyprus). Within these studies, the number of student participants varied from 10 in a small, qualitative, case study based on interview data [16.pdf] (see Appendix A for a list of the 48 papers in this scoping review) to 3456 in a large quantitative study conducted over 2 years comparing team dynamics before and during emergency transition to virtual teamwork [22.pdf].
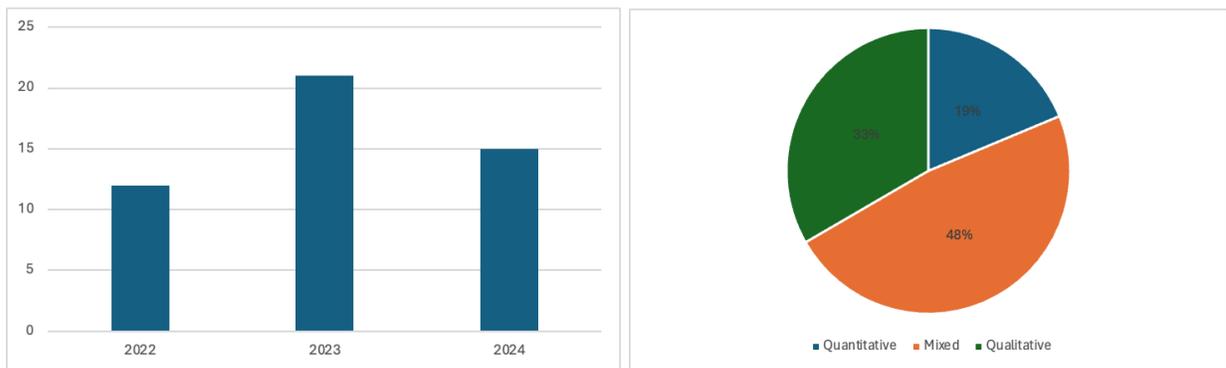
(a) Number of papers published in 2022, 2023 and 2024   (b) Type of study (qualitative, quantitative or mixed methods)
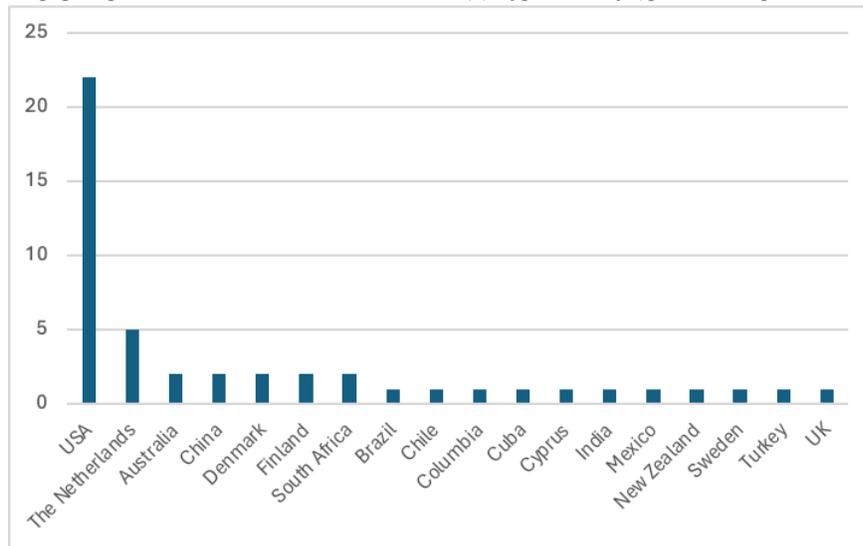
(c) Number of studies by country

Figure 1: Extent and nature of studies found

Nature: The investigation of the nature of the research reported in the papers found that the type of study that was most common was conducted by HE educators researching into their own

teaching practice, using their own courses as case studies, or evaluating the student experience of their courses through surveys. A few engaged in interventionist approaches like design-based research [08.pdf, 34.pdf] or action research [09.pdf] to improve their teaching practice through iterative changes and one adopted an ethnographic approach that reflected on past experiences over a number of years teaching at different institutions [13.pdf]. Data was collected primarily using mixed methods, to collect qualitative and quantitative data (23 papers or 48%), see Figure 1 b. In addition, 16 papers (33%) reported on qualitative studies typically involving student perceptions of teamwork which were gathered through individual and group interviews. The remaining 9 papers (19%) discussed experimental studies that tested hypotheses and typically analysed quantitative data to determine statistical analysis of variance between 2 groups, factor analysis or correlations. A wide range of research methods were used including surveys, interviews (individual and focus groups), observations, reflective notes or journals, network data on team performance and interactions (from video or online interactions). Most qualitative research utilised thematic analysis of interview transcripts or open survey questions and 3 analysed group discussions directly using discourse analysis to analyse marginalising language [74.pdf], or social network analysis of online group discussions [15.pdf, 73.pdf].

While all papers examined some aspect of teamwork, the theoretical framework of social regulation of learning is important as it extends understanding of motivational, social and psychological aspects of individuals to consider the meta-cognitive regulation of learning during collaboration. Out of 48 papers, only two focused on students' social regulation of learning. One was a small-scale qualitative case study of social regulation of learning (which encompasses co-regulation and socially shared regulation) within 3 inter-disciplinary group projects made up of postgraduate students [16.pdf]. The second was a 2-year, mixed methods study, examining the socially shared regulatory strategies that 871 undergraduate students (1st to 5th year) used to overcome team working issues [43.pdf]. Researching into social regulation of collaborative learning is complex as students are engaging in self-regulation and social regulation, however, it offers a promising avenue for improving understanding of teamwork and how it can be supported by academic staff.

Discussion

This section answers the two research questions.

1) What is the extent and nature of the research that has been carried out in higher engineering education, related to student teamwork, co and socially shared regulation of learning in the last three years? In the last 3 years, 48 papers were published in the ERIC database. Most studies were conducted in the USA (45.8%) and 17 other countries around the world. Studies varied from a small qualitative case study with 10 postgraduates [16.pdf] to a large, 2-year comparative study of 2 cohorts with 3456 undergraduates [22.pdf]. The nature of the research is that most papers were written by higher education educators researching their teaching practice using their courses as case studies and evaluating their students' experiences of teamwork through surveys. Both qualitative and quantitative data were collected in most studies (48%) using a wide variety of methods, such as questionnaires, interviews, focus groups. While the psychological and social aspects of learning and teamwork were considered in many papers, only two addressed the issue of social regulation of learning. Social regulation of learning is a promising new direction for

research as it can expand understanding of teamwork beyond self-regulation of learning into co-regulation and socially shared regulation of learning.

2) How reliably can the use of GenAI be embedded in the process of carrying out a scoping review? This work has highlighted the need for researchers to present a comparative evaluation of human and GenAI tool usage in all stages of the literature review. This was done using accuracy and Cohen's Kappa calculations and comparison with human benchmarks, where available. As each subject domain is different, these evaluation scores are critical and should be transparently presented as these may be very different depending on the domain specific data used (or lack of) when training the relevant GenAI models. Clearly, the code we used worked well to remove duplicates from the search results. It may be better to use this approach compared to cosine similarity, an embedding based method used in duplicate detection, which may produce sub 100% results [16]. Screening abstracts for relevant papers using GenAI performed better with Cohen's Kappa of 0.87 for human-machine versus 0.82 for human-human as reported in literature [15]. The results for the data extraction by NotebookLM®, needs further improvement for most fields extracted, however, it was useful to capture the aims, population and outcome (and some other fields but not all fields of interest), which helped in further shortlisting the papers at full-text read stage. In fact, GenAI performed better with Cohen's Kappa of 0.82 for human-machine vs 0.77 for human-human as reported in literature [15]. Since writing, NotebookLM® has undergone some upgrades and this may improve the results. Both GenAI tools required an initial investment in time spent on learning how to communicate effectively with the tools and to understand their capabilities and limitations. While GenAI tools can clearly be of help in the review process, humans play a crucial role in evaluating and shaping the contribution made by the GenAI tools.

Limitations

The first limitation of this work is using only one database (ERIC). Due to this the number of papers found that involved socially shared and co-regulation of learning was limited and by expanding the number of databases, this may improve. The second limitation was that we only used one approach and one GenAI model (ChatGPT 4o) to classify papers, and one GenAI tool (NotebookLM®) at the data extraction stage. Although we show where results are better than human only processes, other tools, models and approaches may be able to get better results than our work or in aspects where our results were sub-human performance.

Conclusions and future work

Given the findings of this scoping review, a full systematic review that includes additional databases such as SCOPUS or ACM Digital Library is feasible and likely to be valuable. This would enable a greater test of the methodology and help find papers on socially shared and co-regulation of learning. While the review is limited in scope, it has identified a gap in the research into teamwork particularly around social regulation of learning, including co-regulation and socially shared regulation of learning. In using GenAI tools (ChatGPT 4o and NotebookLM®) in this scoping review this research has demonstrated a novel methodology and identified two different tools, suitable for different stages of the review and for removing duplicates. Using ChatGPT and NotebookLM® was comparable, if not better, to human outcomes in most of the stages but there is a need to improve data extraction prompts when using

NotebookLM®. The review process and GenAI use described here is also applicable for full systematic reviews and meta-analyses. We recommend that in future reviews of different areas of interest, researchers document the accuracy of the GenAI models and tools they use at each stage alongside human results to allow trust in such tools to build within the research community.

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Appendix A - 48 Papers included in the review

[2.pdf] (Apostolellis et al., 2023), Creating effective project-based courses: personal relevance and its relations to successful group work.
[3.pdf] (Huijben et al., 2022), Networked learning to educate future energy transition professionals: Results from a case study.
[4.pdf] (Werth et al., 2022), Impacts on student learning, confidence, and affect in a remote, large-enrollment, course-based undergraduate research experience in physics.
[8.pdf] (Mielikäinen et al., 2024), Experiences of a project-based blended learning approach in a community of inquiry.
[9.pdf] (Serra et al., 2023), Using student-led tutorials to improve student performance in challenging courses.
[10.pdf] (Komp et al., 2023), C-HACK: A data science tutorial and hackathon for undergraduate students in chemical engineering.
[12.pdf] (Havenga & Swart, 2022), Preparing first-year engineering students for cooperation in real-world projects.
[13.pdf] (Secules, 2023), Reflections on problems of educational practice in a project course design.
[15.pdf] (Han et al., 2022), Social capital leveraging knowledge-sharing ties and learning performance in higher education.
[16.pdf] (O'Connell et al., 2024), Social regulation of learning in interdisciplinary groupwork.
[17.pdf] (D'Angelo & Ragarathinam, 2024), Speech analysis of teaching assistant interventions.
[18.pdf] (Crichton et al., 2022), Students' perceptions of problem-based learning.
[19.pdf] (Kapitsaki, 2024), Students' perceptions on adaptations and workload in a project-based scrum-variant course.
[20.pdf] (van Uum & Pepin, 2023), Students' self-reported learning gains in higher engineering education.
[21.pdf] (Magana et al., 2022), Teamwork facilitation and conflict resolution training in a HyFlex course.
[22.pdf] (Wei et al., 2024), The effect of the emergency shift to virtual instruction on student team dynamics.
[24.pdf] (Nuñez-Thompson et al., 2023), Participation in a team-based, first-year engineering design course.
[27.pdf] (Davies et al., 2023), Understanding the development of a design thinking mindset.
[30.pdf] (Jaworski & Cho, 2023), Implementation of an experiential service-learning course.
[31.pdf] (Taylor & Hernandez, 2022), Fostering community and inclusion in a team-based hybrid bioengineering lab course.
[34.pdf] (Lewis et al., 2023), Encouraging engineering design teams to engage in expert iterative practices.
[38.pdf] (Krab-Hüsken et al., 2023), Conceptual modelling enables systems thinking in sustainable chemistry and chemical engineering.
[39.pdf] (Pennes et al., 2023), A hands-on medical mechatronics exercise.
[40.pdf] (Du et al., 2023), A multimodal analysis of college students' collaborative problem solving.
[41.pdf] (Huerta et al., 2024), An exploration of psychological safety and conflict.

[43.pdf] (Werth et al., 2022), Assessing student engagement with teamwork in an online course.

[46.pdf] (Mesutoglu et al., 2024), Boundary interactions in a challenge-based learning course.

[48.pdf] (Magana et al., 2024), Characterizing team cognition within software engineering teams.

[49.pdf] (López-Reyes, 2022), Collaborative learning of differential equations.

[51.pdf] (Thite et al., 2024), Design of a simple rubric to peer-evaluate the teamwork skills of engineering students.

[53.pdf] (Ita et al., 2023), Designing a biomedical engineering course to develop entrepreneurial mindset in students.

[54.pdf] (Uotila et al., 2024), Developing engineering students' generic and professional skills through a consultative approach to project-based learning.

[55.pdf] (Zabala-Vargas et al., 2022), Didactic strategy mediated by games in the teaching of mathematics in first-year engineering students.

[56.pdf] (Sperling et al., 2024), Effects of a first-year undergraduate engineering design course: survey study of implications for student self-efficacy and professional skills.

[57.pdf] (Jiang et al., 2023), Engineering students' perception of learner agency development in an intercultural PBL team setting.

[58.pdf] (Clegorne et al., 2023), Engineering teamwork: Low stakes team building activities for high-impact undergraduate experiences.

[63.pdf] (Versfeld & Vinson, 2024), Exploring first-year engineering student perceptions of peer-led study groups in a global south context.

[64.pdf] (Hasan et al., 2024), Exploring students' conceptions of project-based learning: implications for improving engineering pedagogy.

[65.pdf] (Lyngdorf et al., 2023), First-year engineering students' learner agency sources in a systemic PBL environment: A Q study.

[66.pdf] (Kaygan, 2023), From forming to performing: Team development for enhancing interdisciplinary collaboration between design and engineering students using design thinking.

[67.pdf] (Kumar et al., 2022), Impact of AR-based collaborative learning approach on knowledge gain of engineering students in embedded system course.

[69.pdf] (Wendland & Worthington, 2024), Improv activities in an engineering classroom increase student self-perceptions of engagement, adaptability, and communication.

[71.pdf] (Avila et al., 2022), Improving teamwork in agile software engineering education: The ASEST+ framework.

[72.pdf] (Duarte et al., 2023), Information system development by using agile teamwork and service-learning.

[73.pdf] (Ouyang et al., 2023), Integration of artificial intelligence performance prediction and learning analytics to improve student learning in online engineering course.

[74.pdf] (Dickerson et al., 2024), Is Carla grumpy? Analysis of peer evaluations to explore microaggressions and other marginalizing behaviors in engineering student teams.

[76.pdf] (Fernandez-Fernandez et al., 2023), Mentoring for innovative design solutions (MINDS): Key design considerations and collaborative teamwork across universities for clinical translation.

[80.pdf] (Dutra & Calvão, 2024), Transmedia storytelling in materials selection design: an interdisciplinary experience with undergraduate engineering students.