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Reimagining Engineering Teamwork Education: A Literature-Based Analysis of Academic and Industry Alignment

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ABSTRACT

BACKGROUND & CONTEXT

Teamwork is a vital graduate attribute in engineering education; yet, a persistent disjuncture exists between academic instruction and workplace practices. Although engineering programmes integrate team-based projects, these often lack the interdisciplinary dynamics, emergent leadership, and adaptive problem-solving required in professional engineering environments. Prior research reveals inconsistencies in teamwork pedagogy and assessment, with a limited focus on communication, conflict resolution, and reflective practice.

PURPOSE OR GOAL

This study systematically reviews literature published between 2020 and 2024 to examine how teamwork is conceptualised, taught, and assessed in engineering education, and to identify contradictions between academic models and industry requirements.

APPROACH OR METHODOLOGY

A systematic literature review was conducted in accordance with the PRISMA 2020 guidelines. Peer-reviewed articles were retrieved from Scopus, Web of Science, and ERIC using defined search terms. A total of 28 studies were selected for analysis. Cultural-Historical Activity Theory (CHAT) provided a lens for examining systemic contradictions, while the Five Cs framework (Contextualisation, Collaboration, Communication, Conflict Resolution, and Continuous Reflection) guided pedagogical synthesis.

OUTCOMES

The analysis identified systemic contradictions such as rigid academic structures versus fluid workplace practices, nominal versus emergent leadership, and assessment focused on fairness rather than outcomes. The thematic synthesis highlighted underdeveloped competencies in communication, conflict resolution, and reflective practice, which industry stakeholders highly value.

CONCLUSIONS

The study underscores the need for curriculum renewal that embeds authentic teamwork scenarios, industry collaboration, and reflective pedagogy. By integrating CHAT and the Five Cs, the paper offers a framework for reimagining teamwork education as a developmental and adaptive process aligned with professional practice.

KEYWORDS

Engineering education, teamwork competence, Cultural-Historical Activity Theory, Five Cs, systematic review.

Introduction

Teamwork competence is widely recognised as a core attribute of engineering graduates and is typically developed through group projects, capstone courses and other collaborative modules. However, despite these efforts, employers continue to point out persistent gaps in graduates' collaboration, leadership, adaptability, and communication skills (Kimpton & Maynard, 2024; Visser & Terblanche, 2025). Evidence from South Africa reinforces this concern: Visser and Terblanche (2025) found that Generation Z employees in particular struggle with teamwork and interpersonal soft skills. International research supports this trend, with studies reporting that while employers consistently value teamwork, they remain unconvinced that universities are producing graduates who are ready for the fast-paced, interdisciplinary challenges of professional practice (Tushar et al., 2023; Fleming, 2024). Collectively, these insights highlight a troubling disconnect between how teamwork is taught in higher education and how it is actually experienced in engineering workplaces.

The challenge does not lie in the absence of teamwork training, but rather in how poorly it aligns with the realities of professional practice. In academic contexts, teamwork is often framed in terms of fairness, accountability, and structured procedures. By contrast, industry settings prize more fluid qualities, emergent leadership, adaptability, and collaboration that is sensitive to context. Several recent studies highlight this mismatch. For instance, Popli (2024) shows how internships and industry-based projects better equip students by embedding authentic workplace experiences. Similarly, Tushar et al. (2023) and Fleming (2024) argue that universities struggle to keep pace with the rapidly evolving demands of modern workplaces. Challenges in embedding employability and teamwork skills into higher education curricula are not unique to one country. For example, Mainga et al. (2022), working in Papua New Guinea, found that academics struggle to integrate employability skills, particularly teamwork and adaptability, into their teaching. Similarly, in South Africa, Nudelman et al. (2022) observed that students are acutely aware of the socio-cultural dimensions that shape teamwork, which complicates efforts to align academic preparation with industry expectations. Taken together, these findings suggest that while universities in both developing and developed contexts are addressing teamwork, they often do so in ways that fall short of preparing graduates for the flexibility and complexity demanded in real-world engineering teams.

The problem, therefore, lies not in the absence of teamwork training but in its misalignment with professional expectations. Academic teamwork often emphasises fairness, accountability, and procedural structures, while industry teamwork requires emergent leadership, adaptability and context-sensitive collaboration.

To investigate this misalignment, the study adopts Cultural-Historical Activity Theory (CHAT). CHAT is uniquely suited because it examines teamwork as a systemic, socially situated activity, where contradictions between components (subjects, tools, rules, communities, division of labour and outcomes) become drivers of learning and change (Engeström, 1987, 2001). Unlike narrower competency models, CHAT enables a holistic analysis of how teamwork is mediated, regulated and enacted across academic and professional contexts. This makes it particularly effective for identifying the systemic sources of the disjuncture between classroom and workplace teamwork.

This study responds by conducting a systematic literature review of engineering teamwork education research published between 2020 and 2024. It pursues three aims:

1. To synthesise how teamwork is conceptualised, taught and assessed in recent scholarship.
2. To identify dominant theoretical and pedagogical approaches informing teamwork education.
3. To reveal contradictions between academic teamwork models and industry practices.

CHAT provides the analytical structure, while the Five Cs framework offers pedagogical categories for interpreting the findings and proposing curriculum renewal.

Research Questions

The following research questions (RQs) guide the study:

- RQ1: How is teamwork conceptualised, taught and assessed in undergraduate engineering programmes according to recent literature (2020–2024)?
- RQ2: What are the dominant theoretical and pedagogical approaches to teamwork instruction in engineering education?
- RQ3: What are the key contradictions between academic teamwork models and professional engineering teamwork practices?

Theoretical Framework

Cultural-Historical Activity Theory (CHAT)

The conceptual basis for this study is Engeström's third-generation Cultural-Historical Activity Theory (CHAT), which conceptualises activity as a system of interacting elements. Originally developed to investigate expansive learning in work settings, CHAT enables the analysis of complex human practices through interconnected activity systems (Engeström, 2001). Each system comprises interrelated components: the subject, the object, mediating artefacts (tools), rules, the community, and the division of labour. In the third-generation model, two or more activity systems share a partially common object, forming a network of interactions (see Figure 1).

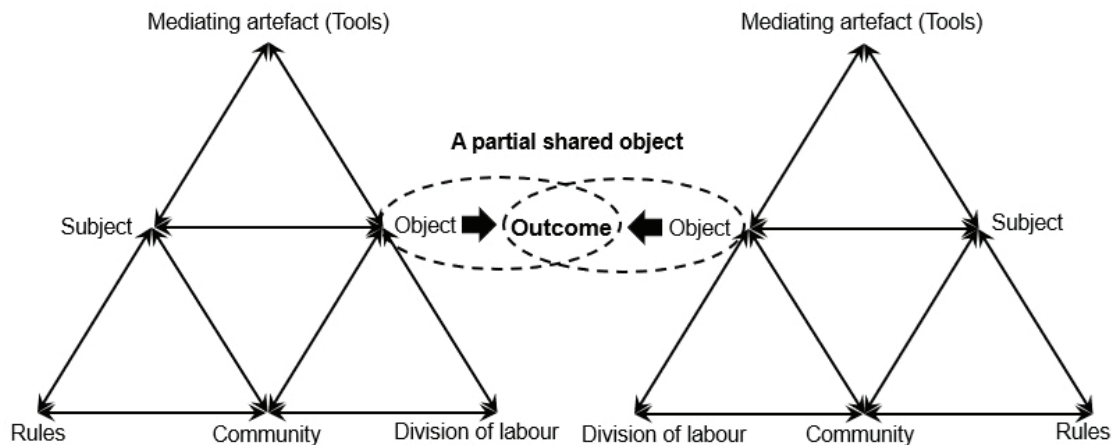


Figure 1: Engeström's CHAT model (Adapted from Engeström, 2001)

This framework supports the mapping of teamwork education processes onto systemic elements such as tools, rules, and community, further detailed in Table 1.

CHAT Constructs Applied to Teamwork

To illustrate CHAT's relevance to teamwork, Table 1 outlines its constructs, definitions and examples in both academic and industry contexts.

Table 1: CHAT constructs and their application to teamwork (Adapted from Engeström, 2001)

CHAT Construct	Definition	Academic teamwork	Industry teamwork
Subject	Actor(s) involved in the activity	Students in team-based learning	Engineers in collaborative teams
Object	Goal or purpose of the activity	Complete academic projects/tasks	Delivering engineering solutions
Tools (Mediating artefacts)	Instruments or signs mediating the activity	Rubrics, team templates, and LMS platforms	CAD software, communication tools, and project management systems
Rules	Norms, conventions, or guidelines	Grading policies, role assignments	Project timelines, quality standards, safety protocols
Community	Social context or group involved	Class peers, instructors, tutors	Team members, departments, and external stakeholders
Division of Labour	Distribution of tasks, roles, responsibilities	Assigned or rotated by the instructor	Emergent, based on expertise and negotiation
Outcome	Result or transformation achieved	Learning outcomes, grades	Product delivery, innovation, performance metrics

This mapping enables systematic identification of contradictions within and between teamwork activity systems, illustrated in Figure 2.

Contradictions in Activity Systems

Contradictions are understood as drivers of change and development, arising when existing structures or practices fail to meet new demands and challenges. CHAT categorises contradictions into four types (Engeström, 2001):

- C1 – Primary contradictions: tensions within a single element (e.g., conflicting rules or values in the academic environment).
- C2 – Secondary contradictions: tensions between components (e.g., misalignment between assessment tools and teamwork expectations).
- C3 – Tertiary contradictions: tensions between the current system and an innovative model (e.g., student-led teams introduced into a traditionally instructor-led course).
- C4 – Quaternary contradictions: tensions between the central activity system and neighbouring systems (e.g., differences between academic teamwork and industry practices).

These contradictions provide a lens for examining systemic misalignments between engineering education and professional practice, and for identifying potential pathways for transformation and curriculum innovation.

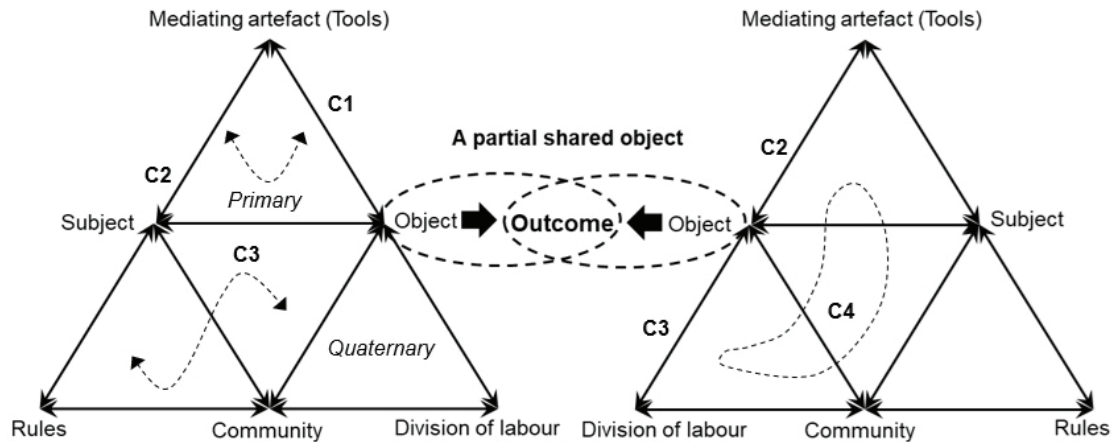


Figure 2: CHAT contradictions (C1–C4) across academic and industry teamwork systems (Adapted from Engeström, 2001)

They highlight the areas where tensions in teamwork education emerge, forming the analytical foundation for the literature review findings.

Methodology

This study employed a systematic literature review (SLR) methodology to identify, screen and synthesise research on teamwork education in engineering published between 2020 and 2024. To ensure transparency and reproducibility, the review adhered to the PRISMA 2020 guidelines (Page et al., 2021).

Search and Selection

The review focused on peer-reviewed journal articles and conference proceedings. Databases searched included Scopus, Web of Science and ERIC. Search strings combined keywords such as “*engineering teamwork*,” “*collaborative learning*,” “*team-based projects*,” “*graduate attributes*,” “*industry expectations*,” and “*Cultural-Historical Activity Theory (CHAT)*.”

The initial search identified 523 records. After removing 83 duplicates, 440 records remained for title and abstract screening. Of these, 312 were excluded because they were either not undergraduate-focused or not engineering-related. The remaining 128 full-text articles were assessed for eligibility, of which 100 were excluded as they did not address undergraduate teamwork or fell outside the 2020–2024 period. Ultimately, 28 studies met all criteria and were included in the final dataset. The selection of studies followed the PRISMA 2020 process, as shown in Figure 3. This transparent process ensured that only studies meeting the criteria for relevance and quality were included, with details summarised in Table 2.

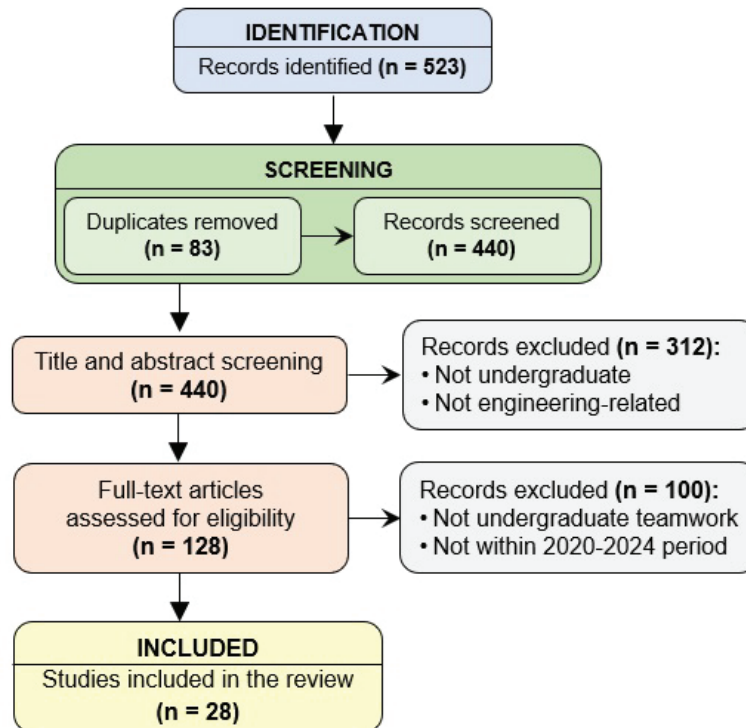


Figure 3: PRISMA 2020 flow diagram of study selection process (Adapted from Page et al., 2021)

Data Extraction and Coding

For each study, the following data were extracted:

- Author(s) and year of publication.
- Title and thematic focus.
- Research context.
- Key contributions to teamwork pedagogy or theory.

The analysis proceeded in two stages:

1. CHAT-based coding (deductive). Each study was mapped against CHAT constructs (subject, object, tools, rules, community, division of labour and outcomes). This allowed the identification of systemic contradictions (C1–C4).
2. Thematic synthesis using the Five Cs (inductive–deductive). The studies were then analysed for how they addressed or neglected Contextualisation, Collaboration, Communication, Conflict Resolution and Continuous Reflection. This stage combined deductive use of the Five Cs framework with inductive identification of themes emerging from the dataset. Coding was cross-checked between authors to enhance validity and reduce bias.

Limitations and Critical Reflection

As a literature-based review, this study is limited by the scope and quality of the included articles. While PRISMA ensured transparency in the selection process, some relevant studies may have been excluded due to limitations in database coverage or publication language. Furthermore, the reliance on published studies introduces publication bias, as unsuccessful or less visible interventions are underrepresented. The interpretation of contradictions through CHAT is necessarily contextual, and while this provides valuable insights, it may not capture all the nuances of diverse educational settings. These limitations suggest caution in generalising findings universally, while still affirming the value of the integrated framework for guiding curriculum renewal.

Descriptive Summary of Reviewed Studies

To provide a descriptive overview of the reviewed studies, Table 2 lists the authors, year, focus, context and key contribution of each article.

Table 2: Descriptive summary of reviewed studies (2020–2024)

Author(s)	Year	Title/Focus	Research Context	Key Contribution
Auckaili & Al-Rawi	2020	Effective teamwork and team diversity	Engineering classrooms	Identified diversity challenges in teamwork
Chowdhury & Murzi	2020	Evolution of teamwork to Industry 4.0	Evolution of teamwork to Industry 4.0	Reviewed teamwork evolution; identified shifting skills and workplace expectations
Garousi et al.	2020	Closing the gap between education and industry	Software engineering (global)	SLR of industry needs vs education
Chowdhury & Murzi	2021	Teamwork in interdisciplinary classrooms	Interdisciplinary engineering	Highlighted teamwork challenges across fields
Fouché & Müller	2021	Formative assessment for teamwork discourse	First-year engineering	Built teamwork discourse with peer/self-assessment
Kirkman et al.	2021	Feedback and reflection in team training	Workplace training	Demonstrated transfer of teamwork competencies
Mentz & de Beer	2021	CHAT in mixed-methods SDL	Higher education	Applied CHAT; examined contradictions in self-directed learning
Bayer et al.	2022	Teamwork in senior capstone	Political science capstone	Teamwork built across formats, boosting readiness
Havenga & Swart	2022	Cooperative learning integration in the engineering introduction course	First-year engineering (South Africa)	Applied cooperative learning to prepare students for teamwork
Magana et al.	2022	Conflict resolution in HyFlex teamwork	Blended engineering teamwork	Conflict resolution training improved teamwork
Nudelman et al.	2022	Teamwork perceptions in South Africa and Spain	Professional programmes (South Africa and Spain)	Socio-cultural factors shape teamwork in South Africa
Picard et al.	2022	Professional skills in team-based projects	Undergraduate engineering (EPFL; team projects)	Identified professional skills gained in team projects; informed curriculum design
Bergman	2023	Intercultural group work experiences	Master's engineering programs	Explored experiences in intercultural teamwork

Author(s)	Year	Title/Focus	Research Context	Key Contribution
Brown et al.	2023	Teamwork performance in the capstone during remote teaching	Engineering capstone (online due to pandemic)	Analysed teamwork in remote capstone; found reduced collaboration
Kimpton & Maynard	2023	Holistic approach to teamwork skills development	Tertiary engineering education	Proposed framework for effective teamwork
Rodríguez-Simmonds et al.	2023	Inclusion in engineering teaming	First-year engineering teams	Identified skills from team projects; guided curriculum
Rennie et al.	2023	Emergent leadership in virtual teams	Virtual team teleconferencing task	Communication style predicted leader emergence
Schibelius et al.	2023	Teamwork, conflict and industry readiness	Interdisciplinary capstone	Training improved teamwork and readiness
Van Helden et al.	2023	Collaborative learning in design education	Engineering design education	Follow-up SLR on collaborative learning
Bhaduri et al.	2024	Industry-informed teamwork practices	Interdisciplinary engineering	Recommendations for aligning classrooms with industry
Deveci & Bedirhanoğlu	2024	Coping with underperforming peers	Engineering teamwork	Documented peer strategies for conflict
Doulougeri et al.	2024	CBL implementation in engineering—systematic review	HE engineering; 48 studies (2010–2021); spider-web framework	Maps: CBL overview, variations, and challenges; alignment and program-level scaling guidance.
Fleming et al.	2024	Employer skills in engineering job ads	Engineering job advertisements	Identified technical and professional skills demanded by the industry
Karabulut-İlgu et al.	2024	Teamwork skill development in a flipped course	Civil engineering (flipped learning)	Demonstrated how flipped delivery enhances teamwork skill development
Kimpton & Maynard	2024	SLR on teamwork skill development	Global HE teamwork contexts	Synthesised recent teamwork education studies
Mesutoglu	2024	Multidisciplinary teamwork in the CBL course	Applied physics and mechanical engineering undergraduates	Examined teamwork in challenge-based learning
Qadri et al.	2024	Aligning education with industry	Cross-functional teamwork	Industry-informed cross-functional teamwork
Vega et al.	2024	Preparing PhD students for jobs in industry	Doctoral education and industry workforce preparation (USA)	Stressed communication and professional skills for PhD employability

This descriptive mapping establishes the breadth of contexts examined and sets the stage for the thematic analysis presented in the Findings section.

Findings

The analysis of the 28 studies revealed recurring tensions between academic teamwork practices and professional engineering workplaces. Using CHAT, these tensions were

interpreted as contradictions (C1–C4). The Five Cs framework highlighted pedagogical areas where teamwork instruction was underdeveloped or misaligned.

- C1 – Primary contradictions: Ambiguities within assessment rubrics.
- C2 – Secondary contradictions: Conflicts between tools, rules and outcomes.
- C3 – Tertiary contradictions: Resistance when new teamwork models challenge entrenched practices.
- C4 – Quaternary contradictions: Disjunctures between academic and workplace teamwork norms.

Thematic analysis through the Five Cs showed:

- Contextualisation is often limited to capstones, lacking authentic industry engagement.
- Collaboration is frequently assumed rather than scaffolded.
- Communication is underdeveloped across curricula.
- Conflict Resolution is addressed in only a few studies, with strong benefits when included.
- Continuous Reflection is rarely embedded systematically.

Synthesis Framework

To synthesise insights from CHAT and the Five Cs, Figure 4 presents an integrated framework for reimagining teamwork education. This framework bridges the gap between identifying contradictions and proposing pedagogical responses, guiding the interpretation in the Discussion section.

Discussion

The findings confirm that teamwork in engineering education is frequently constrained by systemic contradictions that limit competence development. CHAT surfaced structural tensions, while the Five Cs revealed underutilised pedagogical levers.

Figure 4 serves as both a conceptual synthesis and a practical tool. It demonstrates that contradictions, such as rigid assessment rules or a lack of conflict resolution, can be addressed by embedding the Five Cs into curricula. For example, Conflict Resolution directly targets interpersonal tensions, while Continuous Reflection supports adaptive learning.

The implications are clear:

1. Curriculum renewal is needed to embed authentic teamwork experiences across all levels.
2. Pedagogical development should scaffold collaboration, communication and conflict resolution.
3. Assessment reform must reflect adaptability, leadership and collective outcomes rather than only fairness.

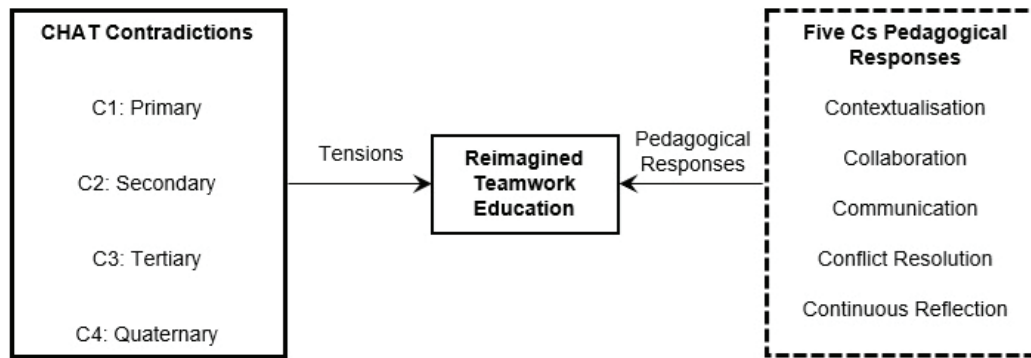


Figure 4: Integrated framework combining CHAT contradictions (C1–C4) with Five Cs pedagogical principles

Conclusions

This study systematically reviewed 28 recent studies on teamwork education in engineering. Using CHAT, it identified systemic contradictions, and with the Five Cs, it highlighted practical strategies for addressing them. Current teamwork education often reproduces tensions that hinder competence development, particularly in areas such as communication, conflict resolution, and reflective practice.

Recommendations

- Embed authentic teamwork throughout curricula, not just in capstones.
- Scaffold teamwork pedagogy systematically, with explicit focus on communication, conflict resolution and reflection.
- Reform assessment practices to align with the industry's emphasis on adaptability and collective performance.

By combining CHAT's structural analysis with the Five Cs' pedagogical insights, the study offers an integrated framework for aligning academic teamwork with professional practice.

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