Exploring Engineers' Experiences of Interdisciplinary Collaboration in Multidisciplinary Engineering Projects: A Qualitative Study

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Abstract

This study aimed to explore engineers' lived experiences of interdisciplinary collaboration in multidisciplinary engineering projects and to identify the relational, communicative, organizational, and learning processes that shape effective cross-disciplinary work. This qualitative study was conducted using a conventional thematic analysis approach. Participants were 24 engineers working in multidisciplinary engineering projects in Tehran, Iran. They were selected through purposive sampling to ensure variation in engineering discipline, professional experience, organizational role, and project type. Data were collected exclusively through semi-structured interviews, each lasting approximately 45–75 minutes. Interviews focused on participants' experiences of working with engineers and professionals from other disciplines, perceived facilitators and barriers to collaboration, communication practices, conflict management, leadership support, and learning outcomes. Data collection continued until theoretical saturation was achieved. All interviews were audio-recorded with participants' consent, transcribed verbatim, and analyzed using NVivo software. The analysis followed iterative coding, category development, constant comparison, memo writing, and theme refinement. Five main categories emerged from the analysis: negotiating disciplinary languages and mental models; coordination through boundary objects and integrative routines; relational trust and psychological safety; leadership and project governance as collaboration scaffolds; and interdisciplinary learning and professional identity development. Participants described interdisciplinary collaboration as both necessary and challenging. While disciplinary diversity improved problem-solving and project innovation, it also created misunderstandings, delays, jargon-related confusion, and conflicts over priorities. Effective collaboration depended on shared project goals, early clarification of roles, structured coordination meetings, use of common design documents, respectful communication, and leaders who actively mediated disciplinary boundaries. The findings suggest that interdisciplinary collaboration in engineering projects is not merely a technical process but a socially negotiated practice requiring communication competence, trust, boundary-crossing capacity, integrative leadership, and reflective learning. Multidisciplinary projects benefit when organizations create formal and informal structures that enable engineers to translate disciplinary knowledge, manage conflict constructively, and develop shared ownership of complex project outcomes.

Keywords: interdisciplinary collaboration; multidisciplinary engineering projects; engineers' experiences; qualitative study; semi-structured interviews; thematic analysis

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1. Introduction

Contemporary engineering projects increasingly require collaboration across multiple disciplinary, professional, and organizational boundaries. Infrastructure systems, smart cities, energy transition projects, industrial automation, transportation networks, digital manufacturing, environmental remediation, and complex construction programs rarely belong to a single engineering specialty. Instead, they require the coordinated contribution of civil, mechanical, electrical, software, industrial, environmental, chemical, architectural, managerial, and financial expertise. This shift has changed the meaning of professional engineering practice. Engineering is no longer limited to the application of specialized technical knowledge within a stable disciplinary domain; rather, it is increasingly performed through interdependent work in which specialists must communicate, negotiate, integrate knowledge, and jointly solve complex socio-technical problems (National Academy of Sciences et al., 2005; Trevelyan, 2007).

Interdisciplinary collaboration can be broadly understood as a process in which individuals from different disciplinary backgrounds interact to address a problem that cannot be adequately solved from a single disciplinary perspective. The emphasis is not simply on placing multiple experts beside one another, but on creating meaningful integration across knowledge domains, methods, assumptions, values, and problem framings (Aboelela et al., 2007; Borrego & Newswander, 2010; Klein, 2010). In engineering projects, this distinction is especially important. A project may be multidisciplinary in composition, meaning that several disciplines are represented, but still fail to become genuinely interdisciplinary if each discipline works in isolation and merely submits its own technical deliverable. Interdisciplinary collaboration requires translation, mutual adjustment, shared decision-making, and integration of disciplinary contributions into a coherent project outcome.

The growing importance of interdisciplinary collaboration in engineering is linked to the complexity of modern socio-technical systems. Problems such as energy efficiency, urban resilience, transportation safety, sustainable construction, water management, digital transformation, and industrial productivity involve technical, environmental, economic, regulatory, human, and organizational dimensions. The National Academies have argued that complex scientific and technological problems often cross disciplinary borders and require institutional conditions that support integration across fields (National Academy of Sciences et al., 2005). Similarly, the literature on team science emphasizes that complex problem-solving depends not only on the individual competence of experts but also on the quality of interaction among them (Fiore, 2008; Stokols et al., 2008). For engineers, this means that technical excellence must be accompanied by the ability to coordinate with others, understand different knowledge traditions, and translate specialized expertise into forms that other professionals can use.

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Engineering education and engineering practice research have also emphasized the centrality of teamwork, communication, and coordination. Trevelyan's (2007) empirical work on engineering practice showed that technical coordination is a major part of what engineers actually do in professional settings. Engineers spend considerable time securing cooperation, aligning schedules, clarifying requirements, resolving interdependencies, and ensuring that technical work is performed in relation to broader project needs. This observation challenges narrow views of engineering as an individual analytical activity and instead positions engineering as a distributed, collaborative, and socially organized practice. In multidisciplinary projects, coordination becomes even more complex because each discipline may define problems, risks, evidence, quality, and feasibility differently.

One of the main challenges in interdisciplinary engineering collaboration is the presence of disciplinary languages and mental models. Disciplines differ not only in terminology but also in assumptions about what counts as a valid solution, acceptable risk, adequate documentation, and efficient decision-making. For example, a civil engineer may prioritize structural safety and regulatory compliance, while a software engineer may focus on system adaptability, user requirements, and iterative development. A mechanical engineer may frame a problem through performance and reliability, while an environmental engineer may emphasize long-term ecological impact. These differences can enrich project outcomes, but they can also create misunderstanding and conflict if not explicitly addressed. Richter and Paretti (2009) described disciplinary egocentrism as a barrier to interdisciplinarity, referring to the difficulty individuals may have in recognizing the value of perspectives outside their own field.

Boundary theory provides a useful lens for understanding these processes. Carlile (2002, 2004) argued that knowledge boundaries become difficult when actors differ in knowledge, interests, and dependence. In such situations, knowledge must be transferred, translated, and sometimes transformed. Engineering projects often require all three processes. Some information can be transferred directly through drawings, specifications, schedules, and calculations. Other information must be translated because different disciplines interpret the same artifact differently. In more complex cases, knowledge must be transformed through negotiation and joint problem-solving, especially when technical requirements conflict or when project constraints require compromise. Boundary objects such as drawings, BIM models, prototypes, specifications, simulations, risk registers, design reviews, and shared dashboards can support collaboration because they provide common reference points across disciplinary communities (Akkerman & Bakker, 2011; Carlile, 2002; Star & Griesemer, 1989).

However, tools and documents alone do not ensure collaboration. Interdisciplinary work also depends on relational conditions such as trust, openness, psychological safety, and mutual respect. Edmondson (1999) introduced psychological safety as a shared belief that a team is safe for interpersonal risk-taking. In engineering settings, psychological safety may influence whether engineers ask questions outside their expertise, admit uncertainty, challenge assumptions, or raise concerns about design decisions. When psychological safety is low, engineers may avoid speaking up, especially if they are junior, belong to a less dominant discipline, or fear being judged as technically weak. In contrast, psychologically safe teams are more likely to engage in learning behaviors, error reporting, and constructive conflict, all of which are essential for complex project performance (Edmondson, 1999; Edmondson & Lei, 2014).

Leadership and project governance are also central to interdisciplinary collaboration. Multidisciplinary engineering projects require leaders who can define shared goals, clarify roles, manage interfaces, balance disciplinary priorities, and create spaces for integration. Cross-boundary teaming research suggests that collaboration across knowledge boundaries requires leaders to frame the work, create shared understanding, and support interaction among diverse specialists (Edmondson & Harvey, 2018). In engineering projects, poor governance may lead to fragmented decision-making, duplicated work, delayed approvals, and unresolved conflicts between disciplines. Conversely, effective governance can create alignment through integrated planning, interface management, design coordination meetings, collaborative review processes, and transparent decision protocols.

Although prior research has examined interdisciplinary learning in engineering education (Borrego & Newswander, 2010; Lattuca et al., 2013, 2017; Richter & Paretti, 2009), team effectiveness in engineering student projects (Borrego et al., 2013), and multidisciplinary design collaboration (Nguyen & Mougenot, 2022), less attention has been paid to the everyday lived experiences of practicing engineers working in multidisciplinary projects, particularly in urban and industrial contexts outside North America and Western Europe. The experiences of engineers in Tehran are especially relevant because large engineering projects in this context often involve dense organizational hierarchies, regulatory complexity, resource constraints, time pressure, contractor–consultant interactions, and coordination among public and private actors. These conditions may intensify the challenges of interdisciplinary collaboration and reveal context-specific mechanisms through which engineers manage knowledge boundaries.

A qualitative approach is appropriate for this topic because interdisciplinary collaboration is experienced through meanings, interactions, tensions, and situated practices that cannot be fully captured through quantitative indicators alone. Semi-structured interviews enable engineers to describe how collaboration unfolds in real project settings, how they interpret disciplinary differences, what barriers they encounter, and which strategies they consider effective. By focusing on engineers' own accounts, this study contributes to a more practice-oriented understanding of interdisciplinary collaboration in multidisciplinary engineering projects. Therefore, the aim of this study was to explore engineers' experiences of interdisciplinary collaboration in multidisciplinary engineering projects in Tehran.

2. Methods and Materials

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This study used a qualitative research design based on thematic analysis. A qualitative design was selected because the purpose of the study was to explore engineers' subjective experiences, interpretations, and meanings regarding interdisciplinary collaboration in multidisciplinary engineering projects. The study did not seek to test predetermined hypotheses; rather, it aimed to develop an in-depth understanding of how engineers experience collaboration across disciplinary boundaries, how they interpret barriers and facilitators, and how interdisciplinary interaction shapes project work. Thematic analysis was used because it provides a flexible yet systematic approach for identifying, organizing, and interpreting patterns of meaning within interview data (Braun & Clarke, 2006).

Participants were 24 engineers working in multidisciplinary engineering projects in Tehran, Iran. Purposive sampling was used to recruit participants who had direct experience of collaboration with engineers or professionals from other disciplines. Inclusion criteria were: having at least three years of professional engineering experience; being involved in at least one multidisciplinary engineering project during the previous three years; working in Tehran-based organizations, consulting firms, contractor companies, design offices, technology firms, or project management units; and willingness to participate in an interview. Engineers who had only academic or single-discipline work experience and no direct involvement in multidisciplinary project teams were excluded.

The sample included engineers from civil, mechanical, electrical, software/computer, industrial, chemical/process, and environmental engineering backgrounds. Participants held different roles, including project engineer, design engineer, site engineer, project manager, technical coordinator, systems engineer, and senior consultant. Sampling continued until theoretical saturation was achieved, meaning that additional interviews no longer generated substantially new categories or conceptual insights.

Data were collected exclusively through semi-structured interviews. An interview guide was developed based on the research aim and the literature on interdisciplinary collaboration, engineering teamwork, project coordination, and knowledge integration. The guide included open-ended questions such as: "Can you describe your experience of working with engineers from other disciplines?" "What makes interdisciplinary collaboration effective in engineering projects?" "What kinds of misunderstandings or conflicts occur between disciplines?" "How are technical disagreements usually resolved?" "What role do project managers or senior engineers play in supporting collaboration?" and "How has interdisciplinary work influenced your professional learning?"

Interviews were conducted individually in a private setting or through secure online platforms, depending on participants' availability. Each interview lasted approximately 45–75 minutes. All interviews were audio-recorded with participants' informed consent and transcribed verbatim. Field notes were written after each interview to document contextual observations, initial analytic impressions, and emerging ideas. Data collection and analysis occurred concurrently, allowing early codes and categories to inform subsequent interviews.

Data were analyzed using thematic analysis with the support of NVivo software. First, the researchers read the transcripts several times to become familiar with the data. Second, initial codes were generated line by line and assigned to meaningful segments of text. Third, related codes were compared and grouped into preliminary categories. Fourth, categories were reviewed and refined through constant comparison across interviews. Fifth, main themes were developed by identifying broader patterns that captured the central meanings of participants' experiences. NVivo was used to organize transcripts, manage codes, retrieve coded segments, compare cases, and support analytic memo writing.

To enhance trustworthiness, several strategies were applied. Credibility was supported through prolonged engagement with the data, member checking with selected participants, and peer debriefing among the research team. Dependability was strengthened by maintaining an audit trail of coding decisions, category development, and theme refinement. Confirmability was supported through reflexive memo writing to identify possible researcher assumptions. Transferability was enhanced by providing detailed descriptions of participants, project contexts, and analytic categories.

Participants were informed about the purpose of the study, voluntary participation, confidentiality, and their right to withdraw at any stage. Written informed consent was obtained before each interview. Participants' names and organizational identifiers were removed from transcripts, and codes such as P1, P2, and P3 were used in reporting quotations. Audio files and transcripts were stored securely and were accessible only to the research team.

3. Findings

A total of 24 engineers participated in the study. Fifteen participants were male (62.5%) and nine were female (37.5%). Participants' ages ranged from 27 to 52 years; six participants (25.0%) were aged 25–30 years, eight (33.3%) were aged 31–40 years, seven (29.2%) were aged 41–50 years, and three (12.5%) were older than 50 years. In terms of educational level, 10 participants (41.7%) held a bachelor's degree, 12 (50.0%) held a master's degree, and two (8.3%) held a doctoral degree. Regarding disciplinary background, five participants (20.8%) were civil engineers, four (16.7%) mechanical engineers, four (16.7%) electrical engineers, four (16.7%) software or computer engineers, three (12.5%) industrial engineers, two (8.3%) chemical or process engineers, and two (8.3%) environmental engineers. Professional experience ranged from 4 to 26 years, with seven participants (29.2%) having 3–7 years of experience, nine (37.5%) having 8–15 years, and eight (33.3%) having more than 15 years. Participants had worked in construction, infrastructure, energy, manufacturing, automation, ICT, and environmental engineering projects.

Participants described interdisciplinary collaboration as a process of continuous translation between disciplinary languages, assumptions, and priorities. Many engineers stated that misunderstandings often occurred not because team members lacked technical competence but because each discipline interpreted project problems through its own

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professional lens. Civil engineers tended to emphasize physical feasibility, structural safety, and regulatory approval, while software and electrical engineers often focused on system functionality, flexibility, and integration. Mechanical and process engineers emphasized performance, efficiency, and operational reliability. These differences created tension when decisions required trade-offs. One participant explained, "When we say 'risk,' every discipline hears something different. For the civil team, risk means safety and legal responsibility; for the software team, it means system failure or user dissatisfaction. We use the same word, but we are not always talking about the same thing" (P7). Participants emphasized that effective collaboration required patience, questioning, and willingness to explain disciplinary reasoning in accessible language. As one senior engineer noted, "The best meetings were not the ones where everyone defended their own calculation. They were the ones where people explained why that calculation mattered for the whole project" (P14).

The second category concerned the importance of shared artifacts and structured routines for integrating disciplinary work. Participants repeatedly referred to drawings, BIM models, technical specifications, Gantt charts, interface matrices, design review checklists, risk registers, and shared dashboards as practical tools that helped different disciplines coordinate their contributions. These artifacts functioned as common reference points, but participants emphasized that their usefulness depended on collective interpretation. A project document could reduce confusion when it was updated, accessible, and discussed in joint meetings; however, it could also create conflict when disciplines worked with different versions or interpreted requirements differently. One participant stated, "The model itself does not solve the collaboration problem. It becomes useful when all disciplines sit around it and say, 'This is my constraint, this is your constraint, and here is where they collide'" (P3). Participants also highlighted the value of weekly coordination meetings, interdisciplinary design reviews, early interface mapping, and technical workshops. These routines allowed engineers to identify dependencies before they became costly errors. As one participant said, "Most problems became serious when coordination was late. If electrical, mechanical, and civil teams met early, the project moved smoothly. If they met after construction started, every discussion became a claim or a delay" (P18).

The third category reflected the relational and emotional conditions that shaped collaboration. Participants reported that interdisciplinary collaboration improved when engineers felt respected, trusted, and safe to ask questions or express uncertainty. Junior engineers and engineers from less dominant disciplines sometimes hesitated to challenge decisions made by senior or more institutionally powerful groups. Participants stated that fear of embarrassment, blame, or professional judgment reduced openness and delayed problem identification. One participant explained, "Sometimes you see a problem, but you are not sure if you should say it because maybe the other discipline will think you do not understand their work. In good teams, asking is normal. In weak teams, asking becomes risky" (P11). Trust developed through repeated interaction, reliability, responsiveness, and recognition of each discipline's contribution. Participants valued colleagues who responded quickly, explained constraints honestly, and did not use technical complexity to dominate discussions. As one engineer stated, "Trust is built when someone says, 'I do not know, let us check together.' That sentence saves projects because it opens the door for real collaboration" (P21).

The fourth category focused on the role of leadership and project governance. Participants emphasized that interdisciplinary collaboration did not occur automatically; it required leaders who could organize communication, clarify responsibilities, manage conflict, and align disciplines around shared project goals. Effective project managers were described as translators and integrators rather than merely schedule controllers. They created structures for early coordination, ensured that all relevant disciplines were present in decision-making meetings, and prevented one discipline from dominating the project. One participant said, "A good project manager does not need to know every formula, but must know when two disciplines are not understanding each other. They must stop the meeting and make the hidden conflict visible" (P5). Participants also identified weak governance as a major barrier. Ambiguous roles, delayed decisions, unclear approval authority, and fragmented communication channels often intensified interdisciplinary tensions. As another participant stated, "When responsibility is unclear, every discipline protects itself. People stop thinking about the project and start thinking about how to avoid blame" (P16).

The fifth category showed that interdisciplinary collaboration contributed to engineers' professional learning and identity development. Participants reported that working with other disciplines expanded their understanding of project complexity, improved their communication skills, and helped them move beyond narrow disciplinary thinking. Some participants described this as a transition from being a discipline-based engineer to becoming a project-oriented professional. One participant said, "At the beginning of my career, I thought being a good engineer meant defending my technical solution. Now I think it means understanding how my solution affects everyone else" (P9). Participants also noted that interdisciplinary collaboration developed practical judgment, especially the ability to recognize trade-offs between technical ideality, cost, time, safety, and constructability. However, learning was not automatic; it depended on reflection, feedback, and exposure to real project problems. As one senior consultant explained, "You learn interdisciplinarity when you experience the consequences of not collaborating. A small misunderstanding in design can become a huge problem on site" (P22).

4. Discussion

The aim of this study was to explore engineers' experiences of interdisciplinary collaboration in multidisciplinary engineering projects. The findings revealed that interdisciplinary collaboration is a complex socio-technical process shaped by disciplinary language, coordination routines, relational trust, leadership, governance, and professional learning. Participants did not describe collaboration as a simple matter of placing different

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experts in the same project team. Instead, they experienced it as a negotiated process requiring continuous translation, alignment, conflict management, and shared sense-making. This finding is consistent with the broader literature on interdisciplinarity, which emphasizes integration across knowledge domains rather than mere coexistence of multiple disciplines (Aboelela et al., 2007; Borrego & Newswander, 2010; Klein, 2010). The results also support the argument that engineering practice is inherently collaborative and coordination-intensive, rather than purely individual or technical (Trevelyan, 2007).

The first main category showed that engineers frequently struggled with disciplinary languages and mental models. Participants emphasized that terms such as risk, quality, efficiency, feasibility, and completion often carried different meanings across disciplines. These findings align with Richter and Paretti's (2009) discussion of disciplinary egocentrism, in which individuals may find it difficult to connect other disciplinary perspectives to their own field of expertise. The findings also support Carlile's (2004) view that knowledge boundaries become difficult when actors have different knowledge bases, interpretive frameworks, and interests. In this study, disciplinary diversity was not viewed negatively; participants recognized that it improved problem-solving. However, diversity became productive only when engineers were able to explain the logic behind their disciplinary judgments. This suggests that interdisciplinary collaboration requires communicative competence, epistemic humility, and the ability to make tacit assumptions explicit.

The second category demonstrated the importance of boundary objects and integrative routines. Participants described drawings, models, technical specifications, interface matrices, and coordination meetings as essential mechanisms for aligning disciplinary contributions. This finding is strongly consistent with boundary object theory, which argues that shared artifacts can support cooperation across social worlds while allowing different groups to interpret them according to local needs (Star & Griesemer, 1989). Carlile (2002) similarly emphasized that boundary objects support knowledge transfer, translation, and transformation in new product development. In the present study, however, participants made clear that artifacts were not sufficient by themselves. A BIM model, schedule, or specification became useful only when engineers collectively discussed its implications. This finding aligns with Akkerman and Bakker's (2011) argument that boundary crossing involves interaction, interpretation, and learning. Therefore, engineering organizations should not treat collaboration tools as technical substitutes for interdisciplinary dialogue.

The third category concerned trust and psychological safety. Participants reported that collaboration improved when engineers felt able to ask questions, admit uncertainty, challenge assumptions, and raise concerns without fear of humiliation or blame. This finding is consistent with Edmondson's (1999) theory of psychological safety, which identifies interpersonal safety as a condition for learning behavior in teams. In multidisciplinary engineering projects, psychological safety may be especially important because engineers must often ask questions outside their own discipline. Without psychological safety, disciplinary boundaries become defensive boundaries, and team members may conceal doubts or avoid difficult conversations. Edmondson and Lei (2014) also emphasized that psychological safety is important in knowledge-intensive work because uncertainty and interdependence require open communication. The present findings extend this argument by showing how psychological safety operates specifically in engineering collaboration: it allows engineers to identify interface problems earlier, learn from other disciplines, and prevent technical errors from becoming project failures.

The fourth category highlighted leadership and project governance as scaffolds for collaboration. Participants described effective project leaders as translators, facilitators, and integrators who clarified roles, made conflicts visible, and aligned disciplinary work around shared project goals. These findings are consistent with cross-boundary teaming research, which argues that leaders must actively support coordination and knowledge integration across expertise boundaries (Edmondson & Harvey, 2018). The findings also correspond with team effectiveness theory in engineering project contexts, where coordination, shared goals, communication, and leadership are central to performance (Borrego et al., 2013). Importantly, participants distinguished between administrative project management and integrative leadership. Administrative control over schedules and deliverables was necessary but insufficient. What engineers valued most was leadership that created conditions for early coordination, fair participation, transparent decisions, and constructive conflict resolution. This suggests that multidisciplinary engineering projects require leaders with boundary-spanning competence, not only technical authority.

The fifth category showed that interdisciplinary collaboration contributed to professional learning and identity development. Participants described a shift from discipline-centered thinking toward project-centered thinking. This finding is consistent with research on interdisciplinary competence, which emphasizes the ability to recognize disciplinary perspectives, integrate knowledge, communicate across fields, and reflect on the limitations of one's own expertise (Lattuca et al., 2013, 2017). The findings also support Fiore's (2008) argument that interdisciplinarity should be understood as teamwork requiring specific collaborative competencies. Engineers in this study learned interdisciplinarity through experience, especially through exposure to real project interdependencies and consequences of poor coordination. This indicates that interdisciplinary competence is not only a cognitive skill but also a situated professional practice developed through participation in complex projects, reflective learning, and interaction with diverse experts.

Overall, the findings suggest that interdisciplinary collaboration in engineering projects should be understood as a dynamic process of boundary negotiation. Engineers must cross boundaries of language, knowledge, role, authority, responsibility, and professional identity. These boundaries can produce friction, but they can also generate innovation when managed constructively. The results support prior literature showing that multidisciplinary collaboration can improve creativity and problem-solving while also introducing barriers such

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as jargon, trust deficits, coordination difficulty, and conflicting priorities (Nguyen & Mougenot, 2022). The contribution of this study lies in its qualitative focus on practicing engineers' lived experiences in Tehran-based projects. It shows that collaboration is influenced not only by technical project complexity but also by organizational hierarchy, communication culture, leadership practices, and the practical need to prevent delays, rework, and blame.

This study has several limitations. First, the participants were engineers working in Tehran, and their experiences may reflect the organizational, regulatory, cultural, and project-management conditions of this specific context. Therefore, the findings should be transferred to other contexts with caution. Second, the study relied exclusively on semi-structured interviews. Although interviews provided rich accounts of engineers' experiences, the study did not include direct observation of project meetings, document analysis, or longitudinal tracking of collaboration processes. Third, the sample included engineers from several disciplines, but some fields were represented by a small number of participants. Finally, because the study focused on engineers' perspectives, it did not include the experiences of architects, project owners, clients, contractors, policymakers, or non-engineering professionals who may also influence multidisciplinary project collaboration.

Future research could examine interdisciplinary collaboration in engineering projects using multi-method designs that combine interviews, observations, meeting recordings, and analysis of project documents. Longitudinal studies would be especially valuable for understanding how collaboration evolves from project initiation to design, implementation, and delivery. Comparative studies across cities, industries, and organizational types could identify how context shapes collaboration practices. Future research could also compare the experiences of junior and senior engineers, examine gendered dynamics in interdisciplinary project teams, and investigate the role of digital collaboration platforms such as BIM, project management software, and shared data environments. In addition, quantitative studies could develop and test models linking psychological safety, boundary-spanning leadership, communication quality, and project performance.

Engineering organizations should intentionally design structures that support interdisciplinary collaboration. Project managers should organize early-stage coordination meetings, clarify disciplinary interfaces, and ensure that all relevant disciplines participate in key decisions. Teams should develop shared glossaries, interface matrices, integrated design review routines, and version-controlled project documents. Leaders should create psychologically safe environments where engineers can ask questions, challenge assumptions, and raise concerns without fear of blame. Training programs should include communication across disciplines, conflict management, systems thinking, and boundary-spanning skills. Organizations should also recognize and reward collaborative behavior, not only individual technical performance. By treating interdisciplinary collaboration as a core engineering capability, organizations can reduce rework, improve innovation, and strengthen project outcomes.

5. Conclusion

This qualitative study explored engineers' experiences of interdisciplinary collaboration in multidisciplinary engineering projects in Tehran. The findings showed that interdisciplinary collaboration is a complex process requiring more than technical expertise. Engineers must negotiate disciplinary languages, align different mental models, use shared artifacts effectively, build trust, participate in psychologically safe communication, and work under leadership structures that support integration. Five main categories emerged: negotiating disciplinary languages and mental models; coordination through boundary objects and integrative routines; relational trust and psychological safety; leadership and project governance as collaboration scaffolds; and interdisciplinary learning and professional identity development.

The study suggests that effective collaboration depends on the ability of engineers and project leaders to transform disciplinary diversity into integrated project knowledge. Multidisciplinary teams become truly interdisciplinary when members do not merely contribute separate technical outputs but actively translate, question, adjust, and combine their expertise. For engineering organizations, this means that collaboration should be treated as a professional competence and a project-management priority. Structured coordination, shared documents, respectful dialogue, conflict mediation, and reflective learning are essential to improving performance in complex engineering projects. The findings provide practical insight for engineering managers, educators, consultants, and organizations seeking to strengthen interdisciplinary collaboration in project-based engineering work.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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