Challenges of Communication Across Engineering Disciplines: A Qualitative Inquiry

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Abstract

This study aimed to explore the major communication challenges experienced by engineers working across disciplinary boundaries in multidisciplinary engineering projects. A qualitative inquiry design was used to examine how engineers from different disciplinary backgrounds interpret, negotiate, and manage communication challenges in collaborative project environments. Participants were selected through purposive sampling from engineering firms, consulting companies, construction projects, technology organizations, and industrial project teams in Tehran, Iran. Data were collected through semi-structured individual interviews with 22 engineers representing civil, mechanical, electrical, software/computer, industrial, and chemical/process engineering disciplines. Interviews continued until theoretical saturation was reached, with saturation identified after the twentieth interview and confirmed through two additional interviews. All interviews were audio-recorded with participant consent, transcribed verbatim, and analyzed using thematic analysis. NVivo software was used to organize transcripts, develop initial codes, compare emerging categories, and support systematic retrieval of coded segments. Analysis generated five main categories: disciplinary language and epistemic framing, ambiguity at technical interfaces, coordination pressure under time and hierarchy, fragmentation of digital communication tools, and relational trust and boundary-spanning competence. Participants reported that communication problems often emerged not from unwillingness to collaborate but from differences in terminology, design assumptions, risk priorities, documentation habits, and expectations regarding decision authority. Cross-disciplinary misunderstanding was most visible at interfaces between design, implementation, safety, software, and project management functions. The findings suggest that communication across engineering disciplines is a socio-technical process shaped by professional language, disciplinary identity, organizational routines, project constraints, and the quality of boundary-spanning practices. Improving interdisciplinary communication requires more than formal meetings or documentation templates; it requires shared interpretive spaces, explicit interface management, translation-oriented leadership, and a project culture that supports questioning, clarification, and mutual learning.

Keywords: engineering communication; interdisciplinary collaboration; qualitative inquiry; boundary objects; project coordination; Tehran; thematic analysis

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1. Introduction

Contemporary engineering work is rarely confined to a single technical discipline. Large-scale infrastructure, energy, manufacturing, software, transportation, health technology, construction, and industrial systems increasingly require civil, mechanical, electrical, software, chemical, industrial, and systems engineers to coordinate their expertise within shared project environments. These projects are technically complex, temporally constrained, and organizationally distributed. As a result, engineering communication is not simply the exchange of information; it is a central mechanism through which technical meaning, design intent, risk interpretation, project priorities, and professional accountability are negotiated. The success of engineering projects therefore depends not only on the technical competence of individual specialists but also on their capacity to communicate across disciplinary boundaries.

The problem of interdisciplinary communication in engineering is rooted in the nature of engineering knowledge itself. Engineering disciplines differ in their objects of analysis, preferred representations, methods of validation, design constraints, and assumptions about what counts as an acceptable solution. For example, civil engineers may prioritize structural integrity, regulatory compliance, and site feasibility; mechanical engineers may focus on performance, tolerances, maintainability, and material behavior; electrical engineers may attend to power distribution, control systems, safety, and signal reliability; software engineers may emphasize architecture, scalability, integration, and iterative testing; and industrial engineers may foreground process optimization, productivity, and system flow. These differences are valuable because they allow complex problems to be approached from multiple expert perspectives. However, they can also create misunderstanding when specialists assume that other disciplines interpret technical terms, drawings, schedules, constraints, or risks in the same way.

The literature on engineering practice has increasingly emphasized that coordination and communication are not peripheral “soft skills” but core components of professional engineering work. Trevelyan (2007) argued that technical coordination is a major aspect of engineering practice and that engineers frequently achieve results by influencing, aligning, and coordinating the work of others. This view challenges narrow models of engineering competence that frame engineering primarily as individual technical problem solving. In actual project environments, engineers spend substantial time explaining design requirements, negotiating changes, resolving discrepancies, clarifying responsibilities, and translating disciplinary concerns into forms that others can understand and act upon. Thus, communication across engineering disciplines should be understood as a technical, relational, and organizational process.

The interdisciplinary character of engineering projects also raises questions about knowledge boundaries. Carlile (2002, 2004) explained that knowledge boundaries become more difficult to manage as novelty, dependence, and difference increase. When tasks are routine and terminology is shared, knowledge can be transferred relatively easily. However, when disciplines depend on each other while holding different assumptions, knowledge must be translated and transformed. This distinction is highly relevant to engineering projects, where the meaning of a design decision may change across disciplinary interfaces. A change in equipment layout, for instance, may appear minor from one disciplinary perspective but may significantly affect structural loads, electrical routing, safety clearance, maintenance access, procurement schedules, or software-control logic. Communication failure occurs when the implications of such decisions are not translated across the full project system.

Boundary objects provide one influential way to understand how communication across disciplines may be supported. Star and Griesemer (1989) introduced the concept of boundary objects to describe artifacts that are sufficiently adaptable to local use while maintaining enough common identity across communities. In engineering projects, drawings, BIM models, specifications, interface control documents, schedules, prototypes, dashboards, and test reports may function as boundary objects. Henderson (1991) showed the importance of visual representations in design engineering, while Carlile (2002) demonstrated how boundary objects can support knowledge sharing in product development. However, boundary objects do not automatically solve communication problems. Their effectiveness depends on how they are used, interpreted, updated, and embedded in collaborative practices. A model, drawing, or document may facilitate shared understanding when it is actively discussed, but it may also become a source of confusion when different disciplines read it through incompatible assumptions.

Communication challenges across engineering disciplines are also connected to occupational communities. Bechky (2003) showed that engineers, technicians, and assemblers often interpret work through situated occupational understandings, and that common ground is created through interaction rather than assumed in advance. Similarly, Boland and Tenkasi (1995) argued that knowledge-intensive organizations require both perspective making within communities and perspective taking across communities. In engineering contexts, each discipline develops its own perspective through education, tools, standards, and professional routines. Interdisciplinary communication requires engineers not only to defend their own disciplinary perspective but also to understand how other disciplines frame problems, evidence, constraints, and acceptable trade-offs.

The challenge becomes particularly important in design and project environments where interdependence is high. Dym et al. (2005) described engineering design as complex, iterative, and difficult to teach because it involves problem framing, modeling, decision making, and trade-off evaluation. Design decisions are rarely isolated; they produce consequences across technical subsystems. Kleinsmann and Valkenburg (2008) found that shared understanding in co-design is shaped by barriers and enablers related to actors' differences, project organization, and communication practices. This suggests that engineering communication problems are not merely interpersonal issues; they are embedded in project structures, disciplinary routines, documentation systems, and organizational cultures.

Interdisciplinary engineering communication is also affected by hierarchy and authority. Project teams often include senior discipline leads, junior engineers, project managers, consultants, contractors, clients, and external regulators. These actors may not have equal power to question assumptions, delay decisions, or request clarification. Communication may therefore become compressed under schedule pressure, especially when project milestones, budget constraints, and client expectations dominate technical dialogue. In such contexts, engineers may avoid raising uncertainties because they do not want to appear incompetent, obstructive, or slow. However, unspoken uncertainty can later reappear as rework, interface conflict, safety concerns, or implementation failure. This makes the quality of communication climate, psychological safety, and leadership particularly important in multidisciplinary engineering work.

Digitalization has further transformed communication across engineering disciplines. Engineering teams now rely on email, messaging platforms, document management systems, BIM environments, simulation tools, enterprise resource planning systems, issue trackers, and virtual meetings. These tools can increase speed and traceability, but they may also fragment communication when different disciplines use different platforms, file versions, naming conventions, or documentation practices. A technical decision may be discussed in a meeting, partially recorded in email, reflected in a drawing revision, and implemented through an informal message. When communication is distributed across multiple channels, the risk of misalignment increases. Digital tools therefore do not eliminate communication challenges; they reconfigure them.

Despite extensive discussion of interdisciplinarity, collaboration, and engineering design, there remains a need for qualitative studies that examine how engineers themselves experience communication challenges across disciplines in real project contexts. Much of the existing literature addresses engineering education, product development, systems design, or organizational knowledge boundaries, but fewer studies explore the lived communication experiences of engineers working across multiple disciplines in local professional contexts such as Tehran. Engineering organizations in Tehran often operate within conditions of rapid urban development, infrastructure complexity, technology adoption, resource constraints, regulatory demands, and multi-actor project delivery. These conditions make communication across engineering disciplines especially consequential.

A qualitative inquiry is appropriate because the phenomenon involves meaning, interpretation, interaction, and situated experience. Quantitative measures may identify the frequency of communication problems, but they are less able to explain how engineers interpret disciplinary misunderstanding, how they negotiate interface ambiguity, why certain communication routines fail, and what practices help them develop shared understanding.

Semi-structured interviews allow participants to describe concrete experiences, explain disciplinary tensions, and reflect on the organizational conditions that shape communication.

Accordingly, the aim of this study was to explore the challenges of communication across engineering disciplines among engineers working in multidisciplinary project environments in Tehran.

2. Methods and Materials

This study used a qualitative inquiry design to explore engineers' experiences of communication challenges across disciplinary boundaries. A qualitative approach was selected because the study sought to understand how participants interpreted communication problems, how these problems emerged in everyday project work, and how engineers made sense of cross-disciplinary interaction. The study was guided by an interpretive orientation, assuming that communication challenges are socially constructed through professional language, disciplinary norms, organizational routines, and project-specific interactions. The purpose was not to test predetermined hypotheses but to generate a thematic understanding of the phenomenon based on participants' accounts.

Participants were selected through purposive sampling from Tehran-based engineering organizations, including consulting engineering firms, construction and infrastructure companies, industrial project organizations, technology companies, and multidisciplinary design teams. Inclusion criteria were: holding an academic degree in an engineering discipline, having at least three years of professional engineering experience, participating in multidisciplinary engineering projects, and having direct experience communicating with engineers from other disciplines. Engineers who worked only in single-discipline roles with no cross-disciplinary interaction were excluded.

A total of 22 engineers participated in the study. The sample included civil, mechanical, electrical/electronics, software/computer, industrial, and chemical/process engineers. The exact number of participants was determined by theoretical saturation. Initial interviews generated a wide range of codes related to terminology, documentation, interface management, project hierarchy, digital tools, and trust. By the twentieth interview, no substantially new conceptual categories were emerging. Two additional interviews were conducted to confirm the stability of the categories and ensure that saturation had been reached.

Data were collected only through semi-structured individual interviews. An interview guide was developed based on the study aim and the literature on interdisciplinary collaboration, engineering communication, boundary objects, and project coordination. The interview guide included open-ended questions such as: "Can you describe a situation in which communication with another engineering discipline was difficult?" "What types of misunderstandings commonly occur between disciplines?" "How do drawings, models, or documents help or hinder communication?" "How do time pressure and project hierarchy affect communication?" and "What practices help engineers from different disciplines understand each other better?"

Interviews were conducted in a private setting or through secure online meetings, depending on participant availability. Each interview lasted between 45 and 75 minutes. With participant consent, interviews were audio-recorded and transcribed verbatim. Field notes were written after each interview to record contextual impressions, repeated concepts, and emerging analytical ideas. Data collection continued until theoretical saturation was achieved.

Data were analyzed using thematic analysis. The analysis followed a systematic process of familiarization, initial coding, category development, theme refinement, and interpretation. First, transcripts were read several times to gain an overall understanding of participants' experiences. Second, meaningful units related to communication challenges, disciplinary interaction, documentation, coordination, and boundary-spanning practices were identified and coded. Third, similar codes were grouped into subcategories. Fourth, subcategories were compared across participants and integrated into broader main categories. Fifth, the themes were reviewed in relation to the full dataset to ensure that they accurately represented the interviews.

NVivo software was used to manage the data, organize transcripts, store codes, compare coded segments, and retrieve quotations. Coding was both inductive and conceptually informed. Although the analysis was open to participants' own meanings, concepts from the literature—such as shared understanding, boundary objects, knowledge boundaries, and technical coordination—were used sensitively during interpretation. To enhance trustworthiness, the study used prolonged engagement with transcripts, peer debriefing, memo writing, constant comparison across interviews, and an audit trail of coding decisions. Credibility was strengthened by returning brief summaries of interpreted meanings to selected participants for confirmation. Transferability was supported by providing detailed contextual descriptions of participants, project settings, and communication situations.

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 interviews. Personal names, company names, project titles, and identifying technical details were removed from transcripts. Participants were assigned codes such as P1, P2, and P3. Audio files and transcripts were stored securely and accessed only for research purposes.

3. Findings

The study included 22 engineers working in Tehran-based multidisciplinary project environments. Of the participants, 14 were men (63.6%) and 8 were women (36.4%). In terms of age, 9 participants (40.9%) were between 25 and 34 years old, 8 participants (36.4%) were between 35 and 44 years old, and 5 participants (22.7%) were 45 years old or older. Regarding educational level, 6 participants (27.3%) held a bachelor's degree, 14 participants (63.6%) held a master's degree, and 2 participants (9.1%) held a doctoral degree. The disciplinary distribution included civil engineering (n = 4, 18.2%), mechanical engineering (n = 4, 18.2%), electrical/electronics engineering (n = 4, 18.2%), software/computer engineering (n = 4, 18.2%), industrial engineering (n = 3, 13.6%), and chemical/process engineering (n = 3, 13.6%). Participants' professional roles included project engineers (n = 6, 27.3%), design engineers (n = 5, 22.7%), discipline leads (n = 5, 22.7%), project managers (n = 4, 18.2%), and systems or integration engineers (n = 2, 9.1%). In terms of professional experience, 5 participants (22.7%) had 3–7 years of experience, 11 participants (50.0%) had 8–15 years, and 6 participants (27.3%) had more than 15 years of experience.

The first category concerned differences in disciplinary language, technical vocabulary, and problem-framing assumptions. Participants reported that engineers from different fields often used the same words with different meanings or used specialized terms that were not transparent to other disciplines. Misunderstandings frequently occurred when one discipline assumed that another discipline understood implicit technical constraints. For example, a mechanical engineer explained, "When I say access space, I am thinking about maintenance, replacement, and safety clearance, but the civil team may only see unused physical space in the plan" (P7). Similarly, a software engineer stated, "For us, integration means data flow and system behavior, but for some colleagues integration only means that the hardware is physically connected" (P12). Participants emphasized that each discipline carried its own way of defining problems, evaluating evidence, and prioritizing risks. Civil engineers often described communication in terms of site conditions, structural limitations, and regulations, while software and electrical engineers emphasized control logic, compatibility, versioning, and testing. These differences created what participants described as "hidden assumptions." One participant noted, "The problem is not that people do not communicate; the problem is that they communicate from inside their own discipline and think the meaning is obvious" (P3). This category shows that cross-disciplinary communication challenges often begin before any disagreement appears; they are embedded in the interpretive frames that engineers bring to project conversations.

The second category related to ambiguity at technical interfaces between disciplines. Participants described interfaces as the points where responsibilities, data, drawings, calculations, equipment, software, and schedules intersect. These interfaces were often the most vulnerable locations for communication breakdown. Engineers reported that problems emerged when responsibility for interface decisions was unclear or when one discipline changed a design element without fully communicating its consequences to others. An electrical engineer stated, "A small change in the panel location can affect cable length, ventilation, access, and sometimes even civil work, but if it is sent only as a drawing revision, people may not understand the reason or the impact" (P9). Several participants explained that interface documents existed but were not always updated, reviewed, or interpreted consistently. A civil engineer said, "We had interface control documents, but they were treated like formal paperwork. The real coordination happened in calls, and sometimes the document was updated after the decision had already moved forward" (P2). Participants also reported that ambiguity increased when contractors, consultants, and client representatives interpreted the same technical requirement differently. In these cases, drawings and specifications did not automatically produce shared understanding. One project manager explained, "A drawing is useful only when everyone knows what decision it represents. Otherwise, each discipline reads its own part and misses the system effect" (P18). This category demonstrates that interdisciplinary communication is especially difficult where technical responsibilities overlap and where project artifacts are not actively used as shared interpretive tools.

The third category concerned how time pressure, cost constraints, and hierarchical decision-making shaped communication. Participants repeatedly stated that communication problems intensified near project deadlines, tender submissions, client reviews, installation stages, and commissioning. Under pressure, engineers shortened explanations, skipped clarification, relied on assumptions, or communicated only with discipline leads rather than directly with affected specialists. One industrial engineer said, "When the schedule is normal, people ask questions. When the deadline is close, everyone sends messages quickly and expects others to understand immediately" (P15). Participants also described hierarchical barriers. Junior engineers sometimes hesitated to challenge senior engineers or project managers, even when they noticed inconsistencies. A young electrical engineer explained, "Sometimes you see that another discipline has misunderstood your requirement, but if the decision came from a senior meeting, you think twice before questioning it" (P10). Senior participants also acknowledged that hierarchy could reduce communication quality. A discipline lead stated, "If the culture is only command and approval, engineers report completion, not uncertainty" (P5). Cost pressure created another challenge because communication was often framed as a delay rather than as risk prevention. Participants argued that early clarification meetings were sometimes cancelled to save time, but the same issues later produced rework. One participant summarized, "The cheapest communication is before construction, but organizations often understand this after the mistake becomes visible" (P21). This category indicates that communication challenges are not merely linguistic or technical; they are shaped by organizational priorities and power relations.

The fourth category referred to fragmented digital communication and inconsistent documentation practices. Participants described using multiple platforms, including email, messaging applications, shared drives, CAD/BIM systems, issue trackers, spreadsheets, and project management software. While these tools increased speed, they also dispersed information across channels. A software engineer stated, "A decision may start in a meeting, continue in WhatsApp, appear in Jira, and then be reflected in a document. Later nobody knows which one is the official source" (P13). Participants explained that some disciplines relied heavily on formal drawings and document revisions, while others used agile boards, informal messages, or direct calls. This created uneven visibility. A mechanical engineer explained, "If something is not in the drawing register, our team may not treat it as official, but the software team may think the issue tracker is enough" (P6). Version control was another repeated problem. Participants described situations in which teams worked from outdated drawings, specifications, or calculation sheets because updates were not clearly communicated. A project manager noted, "The problem is not lack of tools; the problem is too many tools without rules about what each tool means" (P17). Participants suggested that digital communication worked best when projects defined a single source of truth, clear revision protocols, and explicit responsibilities for updating shared artifacts. This category shows that digitalization can support interdisciplinary engineering communication only when technological tools are integrated into disciplined communication routines.

The fifth category involved relational trust and the role of boundary spanners. Participants consistently stated that communication improved when engineers trusted each other enough to ask questions, admit uncertainty, and explain disciplinary constraints without defensiveness. Trust was built through repeated interaction, previous successful collaboration, informal conversations, and respect for other disciplines' expertise. One civil engineer stated, "When I know the electrical engineer personally, I ask before assuming. When there is no relationship, I just write a comment and wait" (P4). Participants also identified certain individuals who were especially effective at translating between disciplines. These boundary spanners understood enough of multiple disciplines to recognize misunderstandings and connect people before problems escalated. A systems engineer explained, "My role is not to know everything deeply. It is to know where misunderstanding can happen and bring the right people into the same conversation" (P20). Boundary-spanning competence included the ability to simplify without distorting, ask clarifying questions, interpret drawings and data across disciplines, and identify downstream consequences of technical decisions. Participants believed that these skills were often learned informally through experience rather than systematically taught. One senior engineer noted, "The best interdisciplinary communicators are not always the most senior technically; they are the ones who can listen to another discipline without immediately defending their own" (P11). This category highlights that effective communication across engineering disciplines depends on relational and interpretive capacities as much as formal technical procedures.

4. Discussion

The first finding showed that disciplinary language and epistemic framing create hidden barriers to communication across engineering disciplines. Participants did not describe communication problems simply as failures of speaking or listening; rather, they emphasized differences in how disciplines define problems, interpret terms, and prioritize evidence. This finding aligns with Boland and Tenkasi's (1995) argument that knowledge-intensive organizations require both perspective making and perspective taking. Engineers must develop strong disciplinary perspectives, but interdisciplinary collaboration requires them to make these perspectives understandable to others. The finding also supports Bechky's (2003) work on occupational communities, which showed that misunderstandings emerge because professional groups interpret work through situated knowledge. In the present study, civil, mechanical, electrical, software, industrial, and process engineers entered communication with different assumptions about risk, feasibility, and design adequacy. These results suggest that communication problems cannot be solved merely by asking engineers to "communicate more." Instead, communication must involve explicit translation of assumptions, constraints, and criteria. This is particularly important in engineering projects because technical terms often appear precise while carrying discipline-specific meanings. Therefore, interdisciplinary communication training should focus not only on presentation skills but also on epistemic awareness: the ability to recognize how one's own discipline frames reality and how other disciplines may interpret the same issue differently.

The second finding indicated that ambiguity at technical interfaces is a major source of interdisciplinary communication difficulty. Participants repeatedly described interface points as locations where responsibility, documentation, and technical consequences became unclear. This finding is strongly consistent with Carlile's (2002, 2004) theory of knowledge boundaries. When knowledge is shared across boundaries marked by difference, dependence, and novelty, simple information transfer becomes insufficient; knowledge must be translated and sometimes transformed. Engineering interfaces are precisely such boundary zones because a decision made in one discipline produces consequences for other disciplines. The finding also corresponds with Star and Griesemer's (1989) concept of boundary objects and Henderson's (1991) analysis of visual communication in design engineering. Drawings, models, schedules, and specifications may support collaboration, but the present findings show that these artifacts do not automatically generate shared understanding. They must be actively interpreted through dialogue. This supports Levina and Vaast's (2005) distinction between designated boundary objects and boundary objects-in-use. A document may be formally designated as an interface tool, yet it becomes effective only when engineers use it to negotiate meaning and coordinate action. Thus, engineering organizations should treat interface management not as a documentation formality but as an ongoing communicative process.

The third finding showed that time pressure, cost pressure, and hierarchy intensify communication challenges. Participants explained that under project pressure, engineers shorten explanations, rely on assumptions, and hesitate to raise concerns. This finding aligns with Okhuysen and Bechky's (2009) integrative view of coordination, which emphasizes that coordination depends on accountability, predictability, and common understanding. When deadlines compress communication, these coordination conditions are weakened. The finding also corresponds with Edmondson and Nembhard's (2009) argument that project teams face challenges related to complexity, cross-functionality, temporary membership, and embeddedness in organizational structures. Multidisciplinary engineering teams are often temporary, deadline-driven, and dependent on hierarchical decisions. These conditions may reduce opportunities for reflective communication. In addition, participants' concerns about questioning senior decisions suggest that psychological and organizational safety are important for engineering communication. When engineers fear that clarification will be interpreted as incompetence or resistance, uncertainties remain hidden until they become technical problems. This finding implies that project leaders should actively legitimize clarification, encourage early escalation of ambiguity, and distinguish constructive technical questioning from opposition. In engineering, silence can be costly because unresolved ambiguity often becomes rework, delay, or safety risk.

The fourth finding revealed that digital communication tools can both support and fragment interdisciplinary communication. Participants did not reject digital tools; rather, they criticized the absence of shared rules regarding which platform, document, or revision should be considered authoritative. This finding extends the boundary-object literature by showing that digital artifacts can lose integrative value when they are dispersed across uncoordinated platforms. It also aligns with Hinds and Mortensen's (2005) work on distributed teams, which highlighted the importance of shared context and spontaneous communication in reducing conflict. Even when teams are located in the same city or organization, digital fragmentation can create a form of cognitive and procedural distance. Engineers may technically have access to information but still lack clarity about its status, meaning, or relevance. The findings suggest that interdisciplinary communication requires not only digital availability but also digital governance. A shared drive, BIM model, issue tracker, or project management system becomes useful only when teams agree on revision protocols, naming conventions, approval authority, and the relationship between informal and formal communication. Without such rules, technology accelerates message exchange while weakening collective interpretation. Engineering organizations should therefore evaluate communication tools not by the number of platforms adopted but by whether they create traceable, shared, and actionable technical understanding.

The fifth finding emphasized relational trust and boundary-spanning competence as critical enablers of communication across engineering disciplines. Participants described trust as the condition that allows engineers to ask questions, reveal uncertainty, and seek clarification before errors occur. This finding aligns with Kleinsmann and Valkenburg's (2008) study of shared understanding in co-design, which showed that collaborative understanding is shaped by both barriers and enablers within project interaction. The finding also supports Levina and Vaast's (2005) concept of boundary-spanning competence, where individuals develop the capacity to relate practices across fields. In the present study, boundary spanners were not necessarily those with the deepest expertise in every discipline; rather, they were individuals capable of recognizing possible misunderstanding, translating between vocabularies, and bringing the right experts into conversation. This suggests that interdisciplinary communication is a professional competence that can be developed intentionally. Engineering education and organizational training often emphasize technical specialization, but the findings indicate that engineers also need skills in translation, facilitation, systems thinking, and cross-disciplinary listening. In complex projects, the boundary spanner functions as a socio-technical integrator who protects the project from hidden assumptions and fragmented decisions.

Overall, the findings show that communication across engineering disciplines is a layered phenomenon involving language, knowledge boundaries, interface ambiguity, organizational pressure, digital systems, and relational dynamics. The study contributes to the literature by showing how these factors appear in the lived experiences of engineers working in Tehran-based multidisciplinary projects. It also suggests that interdisciplinary communication should be treated as an engineering management capability rather than as an individual personality trait. Communication quality depends on how organizations structure meetings, define interface responsibilities, govern documents, support clarification, and cultivate boundary-spanning roles. The findings therefore have implications for engineering education, project management, organizational design, and professional development.

This study has several limitations. First, the participants were selected from Tehran-based engineering organizations, which may limit the transferability of the findings to other regions, countries, or industrial contexts. Communication challenges in engineering are shaped by local organizational cultures, regulatory environments, labor markets, and project delivery systems. Second, the study relied only on semi-structured interviews. Although interviews provided rich accounts of participants' experiences, the study did not include direct observation of meetings, document flows, design reviews, or digital communication practices. Third, the sample included multiple engineering disciplines, but some subfields and specialized industries may not have been fully represented. Fourth, because the study focused on engineers' perceptions, it did not measure the direct effect of communication challenges on project cost, safety, schedule performance, or technical quality.

Future research should examine communication across engineering disciplines using multiple qualitative data sources, including observation of project meetings, analysis of design documents, review of digital communication records, and interviews with clients, contractors, and project managers. Comparative studies could explore whether communication challenges differ across industries such as construction, energy, manufacturing, software, transportation, or healthcare technology. Future studies may also compare public-sector and private-sector engineering organizations or examine differences between traditional project management and agile or integrated project delivery models. Quantitative research could develop and validate scales for measuring interdisciplinary engineering communication quality, interface clarity, boundary-spanning competence, and documentation reliability. Longitudinal studies would also be valuable for understanding how communication problems emerge, escalate, or are resolved across different phases of engineering projects.

Engineering organizations should develop explicit protocols for interdisciplinary communication, especially at technical interfaces. Project leaders should define a single source of truth for documents, clarify revision authority, and ensure that drawings, models, and specifications are discussed as shared decision tools rather than treated as passive records. Regular interdisciplinary interface meetings should be held before major design freezes, procurement decisions, and construction or implementation stages. Organizations should also identify and train boundary spanners who can translate between disciplines, detect hidden assumptions, and facilitate clarification. Communication training for engineers should include disciplinary perspective taking, technical explanation for non-specialists, questioning practices, documentation discipline, and conflict resolution. Finally, managers should create a culture in which asking for clarification is viewed as professional responsibility rather than weakness.

5. Conclusion

This qualitative inquiry explored the challenges of communication across engineering disciplines among engineers working in multidisciplinary project environments in Tehran. The findings revealed five main categories: disciplinary language and epistemic framing, ambiguity at technical interfaces, coordination pressure under time and hierarchy, fragmentation of digital communication tools, and relational trust and boundary-spanning competence. The study shows that communication across engineering disciplines is not merely a matter of transmitting information; it is a process of translating assumptions, coordinating interdependent decisions, managing artifacts, and building shared understanding across professional boundaries. Engineering projects require specialists, but specialization alone can create interpretive gaps. These gaps become especially problematic when technical interfaces are unclear, digital tools are fragmented, and organizational pressure discourages clarification. The findings suggest that improving interdisciplinary communication requires intentional organizational practices, including interface governance, disciplined documentation, psychologically safe communication climates, and the development of boundary-spanning roles. By recognizing communication as a core engineering capability, organizations can reduce rework, improve collaboration, and support more reliable project outcomes.

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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