A Qualitative Exploration of Knowledge Sharing in Multidisciplinary Engineering Research Teams

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Abstract

This study aimed to explore how knowledge is shared, interpreted, and transformed among members of multidisciplinary engineering research teams in Muscat, Oman. A qualitative exploratory design was employed to examine the lived and practice-based experiences of researchers, engineers, project coordinators, and technical specialists working in multidisciplinary engineering research teams. Twenty-five participants were recruited through purposive sampling from university-based laboratories, research centers, and industry-linked engineering projects in Muscat. Data were collected exclusively through semi-structured interviews lasting 45–75 minutes. Interviews focused on participants' experiences of sharing technical knowledge, coordinating expertise, managing disciplinary differences, using digital platforms, and overcoming barriers to collaboration. Sampling continued until theoretical saturation was reached after 22 interviews, followed by three confirmatory interviews. All interviews were audio-recorded with consent, transcribed verbatim, anonymized, and analyzed using thematic analysis supported by NVivo software. The analysis generated five main categories: boundary translation and shared technical language, relational trust and psychological safety, digital and informal knowledge infrastructures, leadership-enabled expertise coordination, and tensions created by time pressure, ownership, and institutional silos. Participants described knowledge sharing as more than information exchange; it involved translating assumptions, negotiating meanings, clarifying dependencies, and developing shared problem representations. Effective knowledge sharing occurred when teams created psychologically safe spaces, used visual and digital artifacts, recognized distributed expertise, and established routines for cross-disciplinary sensemaking. Barriers included disciplinary jargon, publication competition, fragmented documentation, uneven participation, and insufficient time for reflective integration. Knowledge sharing in multidisciplinary engineering research teams is a socially embedded, technically mediated, and leadership-dependent process. The findings suggest that successful collaboration requires shared language, trust, documentation discipline, boundary-spanning leadership, and institutional incentives that reward collective knowledge creation. Strengthening these conditions can improve research integration, innovation quality, and team learning in engineering research environments.

Keywords: knowledge sharing; multidisciplinary teams; engineering research; qualitative study; thematic analysis; Muscat; expertise coordination; psychological safety.

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1. Introduction

Multidisciplinary engineering research has become increasingly central to solving complex technological, environmental, infrastructural, and industrial problems. Contemporary engineering challenges such as sustainable urban systems, renewable energy integration, smart infrastructure, artificial intelligence-enabled design, water security, and resilient transportation systems cannot be adequately addressed through isolated disciplinary expertise. Instead, they require collaboration among civil engineers, mechanical engineers, electrical engineers, computer scientists, environmental specialists, data analysts, project managers, and industry stakeholders. In this context, knowledge sharing becomes a core process through which distributed expertise is mobilized, combined, and transformed into innovative research outputs. However, while multidisciplinary teams are often formed to access diverse expertise, diversity alone does not guarantee integration. The value of such teams depends on whether members can communicate across knowledge boundaries, interpret one another's assumptions, and coordinate specialized contributions toward a shared research objective.

Knowledge sharing has long been recognized as a foundation of organizational learning and knowledge creation. Nonaka and Takeuchi (1995) argued that organizational knowledge creation involves dynamic interaction between tacit and explicit knowledge, where individual insights become collective knowledge through processes of socialization, externalization, combination, and internalization. In engineering research teams, this distinction is particularly important because much of the knowledge required for successful collaboration is tacit, experiential, and practice-based. For example, a senior structural engineer may understand design trade-offs through years of professional judgment, while a data scientist may rely on algorithmic assumptions that are not immediately visible to other team members. When such forms of expertise remain implicit, misunderstandings can emerge despite formal collaboration. Thus, knowledge sharing in engineering research involves not only transferring explicit data, documents, or models but also articulating assumptions, explaining constraints, and making tacit reasoning accessible to others.

The knowledge-based view of organizations suggests that knowledge is a strategic resource, yet it is difficult to transfer because it is embedded in people, tools, routines, and contexts (Argote & Ingram, 2000). This difficulty is intensified in multidisciplinary research teams because team members often differ in disciplinary language, methodological standards, epistemic values, and criteria for evidence. Carlile (2004) conceptualized knowledge boundaries as syntactic, semantic, and pragmatic. At syntactic boundaries, actors may need a shared vocabulary or information format. At semantic boundaries, they must interpret meanings differently attached to the same terms or models. At pragmatic boundaries, they must negotiate interests, priorities, and consequences when knowledge affects action. This framework is useful for understanding engineering research teams because knowledge sharing often begins with exchanging technical information but eventually requires translation and transformation. For example, a “model accuracy” requirement may have one meaning for a machine learning researcher and another for a safety engineer concerned with system reliability.

Multidisciplinary collaboration is also shaped by the social architecture of teams. Nahapiet and Ghoshal (1998) emphasized that social capital supports knowledge creation through structural, relational, and cognitive dimensions. Structural social capital concerns patterns of connection; relational social capital concerns trust, reciprocity, and identification; and cognitive social capital concerns shared language and narratives. These dimensions are highly relevant to engineering research because technical collaboration depends on both formal interaction and informal relational confidence. Team members are more likely to share incomplete ideas, admit uncertainty, or ask clarifying questions when they perceive that the team is safe for interpersonal risk taking. Edmondson (1999) introduced psychological safety as a shared belief that the team is safe for such risks, showing that it supports learning behavior in work teams. In multidisciplinary engineering teams, psychological safety may determine whether junior researchers challenge assumptions, whether industry engineers disclose practical constraints, and whether disciplinary experts expose limitations in their own models.

Expertise coordination is another critical component of knowledge sharing. Faraj and Sproull (2000) argued that effective teams do not merely possess expertise; they coordinate it by knowing where expertise is located, where it is needed, and how to bring it to bear. This insight is particularly relevant to research teams in which expertise is distributed across members and no individual possesses complete understanding of the project. Similarly, Wegner’s (1987) concept of transactive memory highlights the importance of knowing “who knows what” within a group. In engineering research teams, transactive memory may appear in practical forms such as knowing who understands simulation parameters, who can interpret field data, who manages regulatory requirements, and who can translate sponsor expectations into research tasks. Without such awareness, teams may duplicate work, overlook expertise, or delay decisions.

The literature on team science further shows that multidisciplinary collaboration is not simply a matter of assembling experts. Fiore (2008) argued that interdisciplinarity is fundamentally a form of teamwork, requiring processes that enable integration across knowledge domains. Stokols et al. (2008) emphasized that team science is influenced by contextual factors operating at interpersonal, organizational, institutional, and environmental levels. Likewise, the National Research Council (2015) emphasized that effective team science requires attention to communication, leadership, collaboration readiness, institutional support, and evaluation systems. These insights indicate that knowledge sharing in engineering teams should be studied as a situated process embedded in organizational conditions, professional identities, and project structures.

Research on scientific and engineering collaboration has also shown that cross-boundary work generates coordination costs. Cummings and Kiesler (2005) noted that scientific and engineering research increasingly involves multidisciplinary collaboration across disciplinary and organizational boundaries. Their later work showed that multi-university collaborations face higher coordination costs, partly because differences in geography, institutional norms, and disciplinary practices complicate communication and project outcomes (Cummings & Kiesler, 2007). Although the present study focuses on Muscat-based teams rather than multi-university international collaborations, similar coordination challenges may arise when teams include members from universities, research centers, and industry-linked engineering projects. These teams often work under funding deadlines, publication expectations, sponsor requirements, and technological uncertainty, all of which affect willingness and ability to share knowledge.

The role of weak and strong ties in knowledge sharing also requires attention. Hansen (1999) found that weak ties can help teams search for useful knowledge across organizational units but may be less effective for transferring complex knowledge. This distinction is useful in engineering research, where superficial information may be exchanged through weak ties, emails, or repositories, but complex technical knowledge often requires stronger relationships, repeated interaction, and shared problem-solving. Similarly, Wenger's (1998) theory of communities of practice suggests that learning occurs through social participation in shared practice. Engineering research teams may develop temporary or project-based communities of practice in which members learn from each other through meetings, prototypes, shared models, troubleshooting sessions, and informal conversations.

Despite these theoretical contributions, there remains a need for qualitative research that examines how knowledge sharing is experienced by members of multidisciplinary engineering research teams in specific institutional and regional contexts. Much of the literature on knowledge management and team science is conceptual or quantitative, and fewer studies provide detailed qualitative accounts of how engineers and researchers themselves describe the everyday practices, barriers, and enablers of knowledge sharing. Muscat, Oman, provides a relevant context for such inquiry because engineering research in the city is increasingly connected to national development priorities, infrastructure modernization, energy transition, water management, digital transformation, and university-industry collaboration. These conditions create a fertile environment for multidisciplinary projects, but they also intensify the need for effective knowledge integration among diverse experts.

Therefore, this study explores how knowledge sharing is practiced, enabled, and constrained in multidisciplinary engineering research teams in Muscat. By focusing on semi-structured interviews with participants directly involved in such teams, the study aims to generate a context-sensitive understanding of the social, technical, and organizational mechanisms that shape knowledge sharing. The aim of this study was to explore the experiences of members of multidisciplinary engineering research teams regarding the processes, facilitators, and barriers of knowledge sharing in Muscat-based research environments.

2. Methods and Materials

This study employed a qualitative exploratory design to investigate knowledge sharing in multidisciplinary engineering research teams. A qualitative approach was selected because the study sought to understand participants' experiences, meanings, perceptions, and interpretations rather than to measure predetermined variables. The research was conducted in Muscat, Oman, among engineering research teams affiliated with universities, research centers, and industry-linked innovation projects. The selected context was appropriate because Muscat hosts several engineering, technology, infrastructure, and applied research initiatives in which academics, engineers, postgraduate researchers, and industry professionals collaborate across disciplinary boundaries.

The study focused on multidisciplinary engineering teams, defined as project-based research groups involving members from at least two engineering or technology-related disciplines. These included, but were not limited to, civil engineering, mechanical engineering, electrical and electronics engineering, computer engineering, environmental engineering, energy systems, data analytics, and project management. The study did not include teams composed of members from only one discipline or teams whose work was primarily administrative rather than research-oriented.

Participants were selected using purposive sampling with maximum variation to capture diverse perspectives across disciplines, roles, experience levels, and institutional affiliations. Inclusion criteria were: being at least 21 years old, having direct experience in a multidisciplinary engineering research team in Muscat, participating in knowledge exchange or collaborative research activities, and being willing to take part in an audio-recorded semi-structured interview. Exclusion criteria were: lack of direct involvement in multidisciplinary research, purely administrative participation without technical or research contribution, or inability to provide informed consent.

The final sample consisted of 25 participants. The sample included 7 university faculty members, 4 postdoctoral or research fellows, 5 postgraduate research assistants, 6 industry-based engineers involved in collaborative research, and 3 project coordinators or technical managers. In terms of disciplinary background, participants represented civil and infrastructure engineering (n = 5), mechanical and manufacturing engineering (n = 4), electrical and electronics engineering (n = 4), computer engineering, artificial intelligence, and data analytics (n = 5), environmental and energy systems engineering (n = 4), and research/project coordination roles with cross-disciplinary responsibilities (n = 3). Participants' professional experience ranged from 2 to 21 years.

Theoretical saturation guided the final sample size. Saturation was considered achieved when additional interviews no longer generated substantially new codes, categories, or conceptual insights. Initial saturation was reached after 22 interviews, and three additional interviews were conducted to confirm the stability and adequacy of the emerging categories. This approach was consistent with qualitative sampling logic, in which adequacy is judged by depth, variation, and thematic completeness rather than statistical representativeness.

Data were collected exclusively through semi-structured interviews. No surveys, focus groups, observations, or document analysis were used as data collection methods. Semi-structured interviews were selected because they allowed participants to describe their experiences in depth while enabling the interviewer to probe emerging issues across cases. An interview guide was developed based on the study objective and relevant literature on knowledge sharing, multidisciplinary collaboration, expertise coordination, and team learning.

The interview guide included questions such as: "Can you describe how knowledge is usually shared in your research team?", "What makes it easier or harder for members from different disciplines to understand each other?", "How do team members identify who has the expertise needed for a specific problem?", "Can you describe a situation where knowledge sharing improved the project?", "Can you describe a situation where knowledge sharing failed or became difficult?", "What role do meetings, digital tools, documents, or informal conversations play in knowledge exchange?", and "What leadership practices support or hinder knowledge sharing?" Probing questions were used to clarify examples, explore meanings, and elicit concrete experiences.

Interviews lasted between 45 and 75 minutes. Interviews were conducted in private meeting rooms or through secure online platforms depending on participant availability. All interviews were conducted in English because English was the common working language in the participating research teams. Before each interview, participants received information about the study purpose, confidentiality, voluntary participation, and their right to withdraw. Written or recorded informed consent was obtained. With permission, interviews were audio-recorded and then transcribed verbatim. All transcripts were anonymized by replacing names, institutions, projects, and identifiable technical details with codes.

Data were analyzed using thematic analysis supported by NVivo software. The analysis followed an inductive logic, while remaining sensitized by existing concepts such as knowledge boundaries, psychological safety, social capital, and expertise coordination. The analysis proceeded through several stages. First, the researchers read the transcripts repeatedly to become familiar with the data and wrote analytic memos about early impressions. Second, initial codes were generated line by line and segment by segment. These codes captured actions, barriers, conditions, and meanings related to knowledge sharing. Examples of early codes included "disciplinary jargon," "visual explanation," "fear of exposing ignorance," "informal WhatsApp clarification," "unclear ownership of data," "senior engineer as translator," "meeting overload," "trust through previous collaboration," and "documentation gaps."

Third, related codes were grouped into candidate categories. NVivo was used to organize transcripts, retrieve coded segments, compare cases, and examine co-occurring codes. Fourth, candidate categories were reviewed against the full dataset to ensure that they were coherent, distinct, and grounded in participants' accounts. Fifth, the categories were refined and named to reflect the conceptual meaning of the data. The final analysis generated five main categories: boundary translation and shared technical language, relational trust and psychological safety, digital and informal knowledge infrastructures, leadership-enabled expertise coordination, and tensions of time pressure, ownership, and institutional silos.

Trustworthiness was enhanced through several strategies. Credibility was supported by prolonged engagement with the transcripts, peer debriefing among the research team, and member checking with six participants who reviewed a short summary of the preliminary findings. Dependability was strengthened by maintaining an audit trail of coding decisions, category development, and analytic memos. Confirmability was addressed through reflexive memo writing to identify potential researcher assumptions about engineering collaboration. Transferability was supported by providing detailed descriptions of the setting, sample, and analytic categories. Reporting was informed by qualitative reporting principles such as transparency of sampling, data collection, analysis, and reflexivity.

The study followed standard ethical principles for qualitative research involving human participants. Participation was voluntary, and participants were informed about the study purpose, procedures, expected interview duration, confidentiality measures, and their right to withdraw without consequence. Identifying details were removed from transcripts and reports. Audio files and transcripts were stored securely and were accessible only to the research team. Because participants discussed collaborative research teams and institutional practices, special care was taken to anonymize team names, project titles, and organizational identifiers. Direct quotations were edited only minimally for readability and to remove identifying information while preserving meaning.

3. Findings

The study included 25 participants from multidisciplinary engineering research teams in Muscat. Fourteen participants were male (56%) and eleven were female (44%). In terms of age, 6 participants were between 25 and 30 years old (24%), 9 were between 31 and 40 years old (36%), 7 were between 41 and 50 years old (28%), and 3 were older than 50 years (12%). Regarding professional role, 7 participants were university faculty members (28%), 4 were postdoctoral or research fellows (16%), 5 were postgraduate research assistants (20%), 6 were industry-based engineers involved in research collaboration (24%), and 3 were project coordinators or technical managers (12%). Participants' disciplinary backgrounds included civil and infrastructure engineering (n = 5, 20%), mechanical and manufacturing engineering (n = 4, 16%), electrical and electronics engineering (n = 4, 16%), computer engineering, artificial intelligence, and data analytics (n = 5, 20%), environmental and energy systems engineering (n = 4, 16%), and cross-disciplinary project coordination (n = 3, 12%). Professional experience ranged from 2 to 21 years, with 8 participants having fewer than 5 years of experience, 10 having 5–10 years, and 7 having more than 10 years.

The first category reflected participants' repeated emphasis that knowledge sharing in multidisciplinary engineering research teams required translation across disciplinary boundaries. Participants explained that team members often used the same words with different meanings or relied on discipline-specific assumptions that were not obvious to others. For example, terms such as "optimization," "efficiency," "risk," "validation," "model," and "performance" were interpreted differently by civil engineers, data scientists, environmental engineers, and industry engineers. Participants described effective knowledge sharing as the process of converting specialized explanations into shared technical language without oversimplifying the science. Visual artifacts such as diagrams, process maps, simulation outputs, prototypes, and annotated models were especially useful for creating common understanding. One participant stated, "When the computer engineer says the model is accurate, the civil engineer still asks, accurate for what condition? So we learned that every technical word needs a project meaning, not only a discipline meaning" (P08, civil engineer). Another participant noted, "The best meetings are not when everyone presents slides. The best meetings are when someone draws the system on the board and we all correct it together" (P14, project coordinator). Participants also reported that boundary translation was often performed by individuals with hybrid experience, such as engineers who had worked in both industry and academia or researchers trained in more than one field. These individuals acted as informal interpreters who clarified assumptions, connected methods, and reduced misunderstanding. However, the absence of shared language led to delays, rework, and frustration. As one participant explained, "Sometimes we thought we agreed, but after two weeks we discovered that each discipline understood the task differently" (P03, mechanical engineer).

The second category concerned the relational conditions that made knowledge sharing possible. Participants consistently described trust as a prerequisite for sharing incomplete ideas, admitting uncertainty, and asking questions outside one's expertise. In teams where members feared judgment, senior criticism, or loss of professional credibility, knowledge sharing became cautious and selective. Junior researchers in particular reported that they sometimes avoided asking basic questions because they did not want to appear incompetent. One research assistant explained, "In the beginning, I did not ask questions in meetings because everyone was senior and from different fields. Later, when the team leader said, 'There are no simple questions in this project,' people started speaking more openly" (P19, postgraduate researcher). Participants also emphasized that psychological safety was not created by friendliness alone; it depended on repeated respectful interactions, openness to alternative interpretations, and leaders' responses to mistakes. A faculty participant stated, "If someone shows a failed result and the first reaction is blame, then next time the result will be hidden until it is polished. That is dangerous in research" (P11, faculty researcher). Trust also shaped willingness to share tacit knowledge. Industry engineers noted that they were more willing to share practical constraints, field experiences, and operational lessons when they felt that academic researchers valued applied knowledge. Conversely, when academic and industry members perceived each other as dismissive, knowledge sharing became formal, minimal, and defensive. Participants described high-trust teams as spaces where members could say "I do not understand," "my model may be wrong," or "this assumption will not work in practice" without fear of embarrassment.

The third category showed that knowledge sharing depended on both formal digital platforms and informal communication channels. Participants reported using shared drives, cloud folders, email, project management platforms, version-controlled repositories, simulation files, spreadsheets, and messaging applications to exchange information. However, the effectiveness of these tools depended on documentation discipline and shared norms. Several participants complained that teams often had too many channels, resulting in fragmented knowledge. One participant observed, "The data is in one folder, the explanation is in an email, the decision is in WhatsApp, and the final number is in someone's laptop. This is not knowledge sharing; it is knowledge hunting" (P06, electrical engineer). Participants valued digital repositories when they were structured, updated, and linked to decisions. They also emphasized the importance of informal knowledge sharing through corridor conversations, quick calls, lab interactions, and peer-to-peer troubleshooting. Informal exchanges were especially useful for clarifying tacit details that were not captured in formal documents. A data analyst stated, "The report tells you what was done, but the short conversation tells you why it was done that way" (P21, data specialist). At the same time, participants warned that informal channels could exclude members who were not physically present or not part of social subgroups. Hybrid and distributed work arrangements increased the need for more deliberate documentation, especially for decisions made outside formal meetings. Effective teams combined informal responsiveness with formal traceability: they encouraged quick clarification but required important decisions, assumptions, data changes, and model versions to be documented in accessible shared spaces.

The fourth category reflected the role of leadership in identifying, connecting, and mobilizing expertise. Participants described knowledge sharing as more effective when team leaders understood the distribution of expertise and created routines for bringing the right knowledge into the right conversation. Leadership was not limited to formal principal investigators; it also included technical leads, senior engineers, project coordinators, and boundary spanners who helped align tasks. Participants appreciated leaders who clarified roles, mapped dependencies, invited quieter members to contribute, and prevented one discipline from dominating the project. One participant explained, "Our project moved faster when the coordinator started asking, 'Who needs this information before the next step?' That simple question changed the way we shared knowledge" (P04, environmental engineer). Another noted, "The leader does not need to know every technical detail, but they must know who knows it and when to involve them" (P16, industry engineer). Participants described poor expertise coordination as a major cause of inefficiency. In some teams, specialists were consulted too late, after design decisions had already been made. In others, meetings included too many people without clear purpose, leading to fatigue and superficial participation. Effective leadership created "knowledge checkpoints" at key project stages, where assumptions, data quality, design constraints, and disciplinary dependencies were reviewed collectively. Leaders also helped negotiate differences between academic priorities, such as publication and theoretical contribution, and industry priorities, such as feasibility, cost, and implementation. Participants indicated that knowledge sharing improved when leadership made integration an explicit responsibility rather than assuming that collaboration would happen naturally.

The fifth category captured tensions that constrained knowledge sharing. Participants reported that time pressure often reduced opportunities for reflection, explanation, and integration. Under deadline conditions, teams prioritized immediate task completion over deeper mutual understanding. While this sometimes improved short-term efficiency, it created long-term risks because assumptions remained unexamined. A participant stated, "When the deadline is close, people send results, not explanations. Later, when something fails, we realize the explanation was the missing part" (P12, computer engineer). Knowledge ownership was another barrier. Some participants hesitated to share early ideas, data, or methods because of concerns about authorship, intellectual property, publication credit, or misuse of information. This was especially evident in university-industry collaborations, where expectations around confidentiality and output ownership were not always clear. One faculty participant explained, "People say they believe in collaboration, but when the paper or patent is near, knowledge becomes sensitive" (P02, faculty researcher). Institutional silos also limited knowledge sharing. Participants described differences in reporting systems, approval procedures, software access, data policies, and performance incentives across organizations. These differences sometimes made it difficult to share files, align timelines, or involve external collaborators in technical discussions. Participants emphasized that silos were not only structural but also cultural: some departments valued individual expertise and disciplinary depth more than collaborative integration. As a result, team members sometimes protected their disciplinary territory rather than engaging in open knowledge exchange. Despite these barriers, participants believed that clear agreements, early authorship discussions, shared data protocols, and institutional recognition for team-based outputs could reduce defensive knowledge behavior.

4. Discussion

This study explored how members of multidisciplinary engineering research teams in Muscat experience knowledge sharing. The findings indicate that knowledge sharing is not a simple process of transmitting information from one expert to another. Rather, it is a complex social, technical, and interpretive process through which team members translate disciplinary assumptions, build relational trust, coordinate expertise, use formal and informal infrastructures, and negotiate institutional constraints. The five categories generated in this study show that effective knowledge sharing depends on the interaction between shared language, psychological safety, documentation practices, leadership routines, and incentive structures. These findings align with the broader knowledge management literature, which argues that knowledge transfer is difficult because knowledge is embedded in people, tools, routines, and contexts (Argote & Ingram, 2000). In multidisciplinary engineering research, this embeddedness is intensified because each discipline brings not only specialized information but also distinct methods, standards, and problem-solving logics.

The first main category, boundary translation and shared technical language, supports Carlile's (2004) argument that knowledge boundaries vary in complexity and require transfer, translation, or transformation depending on whether the challenge is syntactic, semantic, or pragmatic. Participants' accounts showed that engineering teams often began with syntactic issues, such as terminology and data formats, but quickly encountered semantic and pragmatic differences. For example, the same technical concept could carry different implications for design, computation, safety, sustainability, or implementation. This finding also aligns with Majchrzak et al. (2012), who argued that cross-functional teams must address knowledge differences when facing novelty. In the present study, boundary translation was facilitated by visual artifacts, shared models, diagrams, prototypes, and hybrid professionals who could interpret across disciplinary languages. This suggests that multidisciplinary engineering teams should treat shared language as an ongoing collaborative achievement rather than an initial condition. The finding also indicates that technical artifacts function as boundary objects when they allow different specialists to coordinate around a common representation while preserving their disciplinary perspectives.

The second category, relational trust and psychological safety, is consistent with Edmondson's (1999) theory that psychological safety enables learning behavior in teams. Participants reported that knowledge sharing improved when members felt safe to ask questions, reveal uncertainty, challenge assumptions, and discuss failed results. This is particularly important in engineering research because uncertainty is inherent in modeling, experimentation, prototyping, and field application. When team members hide uncertainty to protect professional image, the team may lose opportunities for early error detection and collective learning. The findings also support Nahapiet and Ghoshal's (1998) social capital perspective, especially the relational dimension of trust and reciprocity. Participants' accounts showed that trust was not merely interpersonal warmth; it was a functional condition for sharing tacit, incomplete, or sensitive knowledge. Industry participants were more willing to share practical field knowledge when they felt respected by academic researchers, while junior researchers were more willing to contribute when leaders normalized questioning. Thus, psychological safety in multidisciplinary engineering teams is both an ethical and epistemic condition: it affects whose knowledge becomes visible and usable.

The third category, digital and informal knowledge infrastructures, extends prior knowledge-sharing literature by showing that tools alone do not ensure knowledge integration. Participants used many digital platforms, but fragmented channels often made knowledge difficult to retrieve, interpret, or verify. This finding aligns with Nonaka and Takeuchi's (1995) distinction between tacit and explicit knowledge. Formal repositories may store explicit knowledge, but they often fail to capture the tacit reasoning behind decisions. Participants therefore relied on informal conversations to understand why certain assumptions, parameters, or design choices were made. At the same time, informal communication created risks of exclusion and knowledge loss when decisions were not documented. This finding suggests that multidisciplinary engineering teams require a dual infrastructure: informal channels for rapid clarification and formal systems for traceability. The issue is not whether teams should use digital tools, but whether they develop shared norms for naming, version control, decision logging, data ownership, and documentation. Without such norms, digital platforms become storage spaces rather than knowledge-sharing systems.

The fourth category, leadership-enabled expertise coordination, supports Faraj and Sproull's (2000) argument that team performance depends on coordinating expertise, not simply possessing it. Participants emphasized that effective leaders knew where expertise was located, when it was needed, and how to connect members across task dependencies. This finding is also consistent with Wegner's (1987) concept of transactive memory, which highlights the importance of shared awareness of "who knows what." In multidisciplinary engineering research teams, no single member can understand all technical details; therefore, the team requires mechanisms for locating and activating distributed expertise. Participants described effective leadership practices such as clarifying roles, creating knowledge checkpoints, inviting quieter members, and aligning academic and industry priorities. These practices transformed knowledge sharing from an informal expectation into a managed team process. The findings also resonate with team science literature, which emphasizes that interdisciplinary research requires deliberate leadership and collaboration structures rather than spontaneous cooperation (Fiore, 2008; National Research Council, 2015).

The fifth category, time pressure, knowledge ownership, and institutional silos, illustrates the organizational constraints that shape knowledge sharing. Participants reported that deadlines reduced explanatory communication and encouraged results-only exchanges. This finding is compatible with Cummings and Kiesler's (2007) work on coordination costs in collaborative research, where disciplinary and institutional boundaries complicate project outcomes. The present study adds qualitative detail by showing how such costs are experienced in everyday team practices: delayed consultation, fragmented documentation, unclear authorship expectations, restricted data access, and defensive knowledge behavior.

Participants' concerns about ownership also connect with Hansen's (1999) search-transfer problem. Weak ties may help researchers locate information, but complex knowledge sharing requires stronger relationships, trust, and clarity around use. When authorship, intellectual property, or institutional credit is ambiguous, team members may strategically withhold knowledge. Therefore, knowledge sharing is not only a communication issue but also an incentive and governance issue.

Overall, the findings suggest that knowledge sharing in multidisciplinary engineering research teams operates through five interdependent mechanisms. First, teams must translate disciplinary language into project-specific meaning. Second, they must create relational conditions that allow uncertainty and incomplete knowledge to be shared. Third, they must combine informal interaction with formal documentation systems. Fourth, they must coordinate expertise through leadership routines and transactive memory. Fifth, they must manage structural tensions related to time, ownership, and institutional boundaries. These mechanisms show that effective knowledge sharing is both emergent and designable. It emerges through repeated interaction, but it can also be supported through intentional team practices, leadership behaviors, and institutional policies.

5. Conclusion

This qualitative study explored knowledge sharing in multidisciplinary engineering research teams in Muscat. The findings show that knowledge sharing is a dynamic process shaped by disciplinary boundaries, relational trust, digital and informal infrastructures, leadership practices, and institutional constraints. Participants described effective knowledge sharing as a process of translating specialized knowledge into shared project meaning, coordinating distributed expertise, documenting decisions, and creating safe spaces for questioning and learning. The study highlights that multidisciplinary engineering collaboration requires more than technical competence. It requires shared language, psychological safety, leadership-enabled coordination, reliable knowledge infrastructures, and governance arrangements that reduce defensive knowledge behavior. By strengthening these conditions, engineering research teams can improve integration, reduce rework, enhance innovation, and produce more robust research outcomes. The findings provide practical implications for research managers, principal investigators, engineering faculty, industry partners, and policy makers seeking to improve the effectiveness of multidisciplinary engineering research.

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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