

Mechanical Knowledge Networks and Innovation Capability: A Mixed-Methods Approach

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ABSTRACT

Purpose: The performance of organizations depends on the factor of innovation capability. Organizations with innovation capability mostly compete effectively in the evolving market. Therefore, this research aims to explore the effect of engineering cross-cultural collaboration, mechanical knowledge networks, digital knowledge infrastructure, and leadership support on enhancing innovation capability. Design/ method/ approach: Quantitative and qualitative research methods are used in this research. Interviews were conducted with 25 respondents and quantitative data were collected from 280 respondents. Quantitative data were analyze using One-Way ANOVA through SPSS. Qualitative data were analyze using thematic analysis supported by a three-stage coding technique open, axial, and selective coding adapted from grounded theory principles. Findings: The results from both quantitative and qualitative approaches confirm that mechanical knowledge network is an important predictor of Innovation capability. Moreover, engineering cross-cultural collaboration, digital knowledge infrastructure, and leadership support also affect innovation capability. Originality: The originality of the paper lies in introducing mechanical knowledge network as an important factor to enhance innovation capability. This study used quantitative and qualitative approaches simultaneously to ensure the role of cross-cultural collaboration, mechanical knowledge networks, digital knowledge infrastructure, and leadership support in enhancing innovation capability.

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1. Introduction

Mechanical engineering is changing at a rapid pace due to the introduction of different technologies such as Internet of Things (IoT), big data, robotics, machine learning, and artificial intelligence (AI) (Rana et al., 2025). These technologies are changing how mechanical organizations produce, develop, design, and improve processes and products. Machine learning and AI can help engineers develop products faster, improve efficiency, reduce errors, predict performance, and test different designs. In the present changing environment, it is very important for mechanical organizations to focus on their innovation capability. The term innovation capability reflects the ability of a mechanical organization to adopt, develop, create, and apply new processes, products, technologies, and ideas (Balagopal, 2024). Strong innovation capability helps mechanical organizations respond to changing market and customer requirements, increase productivity, reduce costs, and improve product quality. The importance of innovation capability has further increased due to the growth of Industry 4.0, as organizations need better approaches and new skills to utilize advanced technologies (Odai et al., 2026). However, success cannot be ensured for mechanical organizations through technology alone. Mechanical organizations also need to focus on innovation capability so that they can effectively use technologies, organizational resources, employee skills, and knowledge. Thus, the development of innovation capabilities is important for solving complex mechanical problems, maintaining competitiveness in increasingly competitive industrial environments, supporting productivity, and improving

sustainability (Febrianto & Rufaidah, 2026).

Since the dawn of the Industrial Revolution, progress in mechanical engineering is closely linked to the exchange of ideas, experience, and knowledge among professionals and organizations. In the present competitive market, mechanical organizations depend on different forms of collaboration to solve complex engineering problems, improve manufacturing processes, and develop new products (Olodu et al., 2026). Mechanical knowledge networks provide a structured means for mechanical organizations, industry partners, suppliers, researchers, and engineers to apply, share, create, and identify mechanical knowledge (Ali, 2024). These networks facilitate the exchange of information regarding engineering practices, machinery, materials, methods, production, design, and technologies. The growing use of Industry 4.0 technologies has increased the importance of mechanical knowledge networks because mechanical organizations need to quickly share and access knowledge across external partners and different organizational functions (Sousa et al., 2025). Mechanical organizations can develop efficient and flexible manufacturing systems, respond to technological changes, support innovation, and improve learning through mechanical knowledge networks. In other words, mechanical knowledge networks can play a vital role in strengthening competitiveness, innovation capability, knowledge sharing, and collaboration within mechanical organizations (Ryalat et al., 2024).

Mechanical organizations are operating in global environments where engineers from different cultures and countries work together on various projects. Mechanical organizations are enabled through cross-cultural engineering collaboration to combine diverse problem-solving approaches, experiences, and technical knowledge across engineering activities, maintenance, quality, production, and design (Beagon & Morgan, 2026). As systems of manufacturing organizations become connected through cross-cultural engineering collaboration, advanced technologies, and knowledge sharing across geographically dispersed teams, these collaborations provide support through continuous improvement, innovation, joint learning, and better communication. Cross-cultural engineering collaboration also helps mechanical organizations understand different technical perspectives and practices that enable teams to develop effective solutions (Loweth et al., 2025).

Digital transformation is reshaping the way mechanical organizations share, access, store, and create technical knowledge (Angelopoulos & Alexopoulos, 2026). Digital knowledge infrastructure is particularly important in the context of mechanical organizations that are dependent on operational expertise, production records, technical information, and engineering data. Digital knowledge infrastructure includes knowledge repositories, maintenance records, computer-aided design systems, databases, and digital platforms that help employees efficiently share and manage knowledge (Mishra et al., 2026). By linking different digital technologies with organizational knowledge, mechanical organizations are enabled through digital knowledge infrastructure to respond effectively to technological changes, optimize manufacturing processes, develop better products, and improve collaboration (Cheng et al., 2026).

Organizational learning is a relational and social process by which mechanical organizations apply, share, and acquire knowledge on a continuous basis. In mechanical organizations, organizational learning provides support for operational activities, maintenance, manufacturing, and engineering (Al Doghan & Vui, 2026). It also enables employees to transfer expertise and technical knowledge to new employees of mechanical organizations. Organizational learning helps employees in responding to Industry 4.0 requirements, artificial intelligence, robotics, automation, advanced machinery, and technological changes. Employees working in mechanical organizations can develop better designs, production solutions, and manufacturing methods through organizational learning (YUNUSA et al., 2026). Another important factor for the success of mechanical organizations is leadership support because successful adoption of knowledge-based practices, new processes, and technologies depends on active leadership involvement. Furthermore, leadership support includes creating an environment, promoting knowledge sharing, encouraging employee participation, and providing adequate resources to support innovation and learning. Supportive leaders can motivate employees and engineers to adopt advanced manufacturing technologies, enhance workplace safety, solve technical problems, and improve production processes. Leadership support can encourage continuous improvement, increase team morale, improve productivity, and strengthen organizational culture (Vasumathi et al., 2025).

Furthermore, external knowledge integration is also an important capability for mechanical organizations as they increasingly depend on industry partners, technology providers, research institutions, customers, expertise from suppliers, technologies, and knowledge. External knowledge integration enables mechanical organizations to develop innovative engineering solutions, improve production methods, understand customer needs, and identify emerging technologies. External knowledge integration access to specialized expertise that maybe available internally. Thus, objective of this study is to examine the role of mechanical knowledge networks, engineering cross cultural collaboration, digital knowledge infrastructure, and leadership support to enhance innovation capability.

2. Literature Review

2.1 Innovative Capability

Innovation capability is discussed in literature as the ability of the organization to generate new business models, new processes, new products, and new ideas that help the organization to adapt in changing market conditions and stay competitive (Osiyevskyy et al., 2025). Innovation capability is considered as the basic competence of the organization that enable it to effectively implement, take up, and generate innovative solutions. This capability is beyond the technical factor to develop new services or products to organizational strategic orientation, culture, and processes with purpose to support continuous transformation and improvement. Organizations having strong innovation capability mostly outperform their competitors with their resources like collaboration networks, R&D investments, and skilled personnel (Trizotto et al., 2025).

In literature, innovation capability is considered as important capability of the firm by which it transforms organizational resources, information, expertise, and knowledge into improved or new managerial practices, services, processes and products (Mayorga et al., 2026). Irrespective of considering innovation only as one of the outcomes, studies have discussed innovation capability as the capacity of the organization to implement improvement, develop solutions, generate ideas, and identify opportunities (Trizotto et al., 2025). Studies discussed that innovation capability is important for organizations to compete at global and local market.

Studies also discussed that collaborations and external partnerships play key role to improve innovation capability. Different external stakeholders such as research institutes, suppliers, and customers provide organizations with new technologies and knowledge, that later foster innovation (Zhang, 2025). As a result, external networking helps in developing ecosystem of innovation where organizations offer ideas and resources to each other with purpose to create new solutions. Studies also mentioned issues related to technological perspective including role of technology to shape innovation capability. Organizations having advanced technologies like data analytics, artificial intelligence and digital platforms have the ability to innovate better. Moreover, usage of technology in practices of organization help them to minimize operational cost, accelerate product development and respond to changes in market (Ahmed et al., 2026).

2.2 Mechanical Knowledge Networks and Innovation Capability

Mechanical knowledge network has the ability to link machinery design and physical components of machine to the structural flow of information (Su et al., 2025). In studies related to innovation, mechanical knowledge network is treated as combination of knowledge pieces or technological components, that show the way knowledge network shape creativity and learning. Knowledge network has the ability to enhance sharing between organizations, groups, and individuals in formal and informal ways. One of the biggest challenges that is being faced by scholars is to find way to successfully deploy and design knowledge network on the basis of research of past decade.

In literature, mechanical knowledge network is discussed as network of the organization by which technical and mechanical knowledge is applied, stored, integrated, exchanged, and generated in all mechanical related functions (Schaffland & Schöning, 2023). Studies identified external knowledge integration, leadership support, organizational learning, and knowledge repositories as important elements of mechanical knowledge network.

Studies empirically provide the evidence to support the proposition that innovation is supported by mechanical knowledge networks (Maula, 2024). Scholars suggested that Knowledge networks are vital enabler of organizational competitiveness and commercialization. Studies reported that mechanical knowledge network structure has very important role to improve innovative performance (Fang et al., 2017). These results show that innovation is dependent on multiple factors including network relationships. Likewise, Wang et al. (2018) also found that knowledge network has positive role to influence innovation performance of high tech organization.

2.3 Engineering Cross-Functional Collaboration and Innovation Capability

Studies have referred engineering cross functional cooperation as the process in which engineering or mechanical department has the ability to coordinate and collaborate with other departments to improve the quality of their outcomes and performance (John, 2022). Efficiency of the engineering project can be significantly enhanced by the integration of IoT technologies and cross functional collaboration. Cross functional collaboration promote synergy among members of the team who belong to diverse background, fostering innovation, decision making, and open communication, while ensuring that all mechanical and engineering processes are aligned to organizational goals (Sultana, 2026). Cross functional collaboration is important for innovation success. It brings together people of different teams to work with members of other departments. The key component of mechanical knowledge network is the cross functional collaboration among R&D, quality, maintenance, production and engineering and other related departments of organization. Studies categorise problems of engineering through interdependence because solutions

often need technical knowledge from different functional areas (Silva et al., 2026). Therefore, innovation is negatively affected when knowledge remain isolated within specialized departments.

Studies referred to previous commercial systems and research work that provide solutions for collaborative product development. They also noted that practical applications in the field of engineering are becoming more advanced and common. Therefore, they have referred collaboration as factor that is based in intelligent coordination mechanism and logical mechanism to facilitate human computer and human-human relationship (Varela et al., 2022). Empirical studies supported the importance of cross functional knowledge sharing among different department. Scholars empirically reported that mechanical responsibilities and roles can be important for coordination in different departments of the organization. Moreover, organizational innovativeness has a link with performance of organization and cross functional knowledge (Ahmad et al., 2023). In other words, relationships and communication across functional boundaries has the ability to create mechanism by which specialized knowledge is combined and later transformed into organizational innovation.

2.4 Digital Knowledge Infrastructure and Innovation Capability

Digital knowledge infrastructure is the discussed in literature as the network combination of human expertise, digital repositories, software standards, and physical hardware that are used to share, curate, store, and create information at the global level (Kaur, 2026). Studies mentioned that digital infrastructure are not fully coherent or engineered processes. In fact, they are best understood as complex or adaptive systems. They consist of a number of parts that has the ability to interact through technical processes and social processes, with different level of success. Digital knowledge infrastructure include distributed access, collaboration, learning, intellectual activity and technology for the documentation of information and human expertise (Patterson et al., 2023). Digital libraries are mostly considered as information collection system that provide support to numeric data, images, and text. They are an important factor of knowledge infrastructure. They can be used at all staged of research lifecycle from gathering observation through stewardship of research product, curation, management, interpretation of data, analysis of data, and cleaning of data (Sanbein, 2026).

Different engineering and mechanical organizations generate large amount of technical information through lessons learned production information, maintenance records, project reports, design documents, and engineering database. Without proper digital systems, it is not possible to assess valuable knowledge. Digital systems play the role of memory for the organization that enable engineers to look for solutions of problems faced in past (Wittenborg, 2025). Scholars indicated that digital system helps in solving problems with more personal experience and convenience (Sen et al., 2023).

Studies have reported digital knowledge infrastructure to effect technological innovation in positive way among mechanical organization by providing strength to innovation ability, adaptability, and absorptive capacity (Xia & Johar, 2024). Studies suggests that digital knowledge management systems help organizations to apply, share, integrate and acquire knowledge in effective way. Therefore, studies proposed identification of future research directions and implementation road man in adaptive innovation ecosystems, human AI collaboration, and intelligent knowledge systems. Studies also discussed that digital knowledge infrastructure must not be considered as source of information technology. Whereas digital knowledge systems can become important factor of organizational knowledge network by supporting the recombination of knowledge for innovation, accelerating knowledge retrieval, and preserving technical memory.

2.5 Organizational Learning and Innovation Capability

Organizational learning is one of another factors that links mechanical knowledge network with innovation capability of the firm. Sustainable innovation is not created within the organization only on the basis of technical knowledge. The decision makers of the organization must learn from previous technical changes, customer feedback, experiments, failures, and projects (Dani & Gandhi, 2022). Organizational learning help organizations to convert experience into form of knowledge that can be used in new problem solving. Learning capability of mechanical organizations impacts operational performance by improving quality and minimizing lead time. By using different techniques like knowledge sharing, risk taking, and dialogues, mechanical organizations can improve their processes with purpose of enhance efficiency, cost management, and competitive advantage (Berndt et al., 2023). It is assumed that learning capability of the organization impacts its ability to implement and initiate innovative practices faster than competing organizations. Studies focused on analysing impact of learning capability on the mechanical organization as a factor of competitive advantage and financial performance. The organizational and managerial traits that facilitates the process of learning within the organization are mentioned in literature as organizational learning capability (Ferreira et al., 2021). The ability of organizations to absorb knowledge as integration of knowledge, obtain the knowledge, and move the knowledge as ability to enhance organizational capability within a manufacturing

organization (Seraj & Sundram, 2026). The management of mechanical firm can provide support to organizational learning by allocating the important resources and removing the obstacles that can negatively affect process of learning. It also encourages employees to share, gather and experiment with fresh ideas to enhance organizational learning capability and eventually ability of organization to innovate. Studies determined that organizational efficiency is enhanced through technological capabilities in developing innovative ideas and knowledge by investing in R&D, continuous training regarding the process to solve the problem, and application of innovative technology that enable mechanical organization to improve performance (Salisu & Abu Bakar, 2020). Scholars examined organizational learning capability, organizational performance and innovation, and reported that organizational learning capability effect innovation that later effect organizational performance (Gomes et al., 2022).

2.6 Leadership Support and Innovation Capability

Studies view leadership as vital factor to improve innovation at the organizational level. Leadership that promotes learning, collaboration, recognition, and trust can encourage employees to exchange their expertise (Iqbal et al., 2025). It is vital that leaders create climate that enable communication among employees of the organization and encourage culture of innovation. Therefore, adding leaders of the organization must focus on developing mechanism that promote innovation culture within organization. With the evolution of mechanical organization, leaders should have technical knowledge so they can guide their followers and other employees (Verawati & Hartono, 2020). In other words, leaders of the mechanical organizations must possess managerial and technical skills. This combination of leadership ability and expertise are important for the success of mechanical organizations, affecting everything from project outcomes to team dynamics. Mechanical organizations need more than innovation and technical skills from the leaders because they play vital role in managing projects, pushing the boundaries of what can be achieved, and inspiring team members (Chukwunweike & Salaudeen, 2025).

Studies in past mentioned that leadership plays very important role to drive service, manufacturing, and IT industries. Scholars emphasized that some firm mostly rely on leadership with purpose to sustain digital innovation. Scholars also demonstrated that leadership promotes green innovation practices in SMEs when it is combined with learning mechanism of the organization (Kaiser, 2026). The effect of leadership on the innovation is operated through three interlinked mechanism, namely psychological safety, cognitive simulation, and visionary influence. The factor of psychological safety is used as individualized consideration that minimize failure and enhance risk taking. Moreover, factor of cognitive simulation deals with the leader who encourage questions related to problem solving and creativity. Whereas, visionary leader is the one who provides employees with sense of reasoning to innovate (Sharma et al., 2025). Results show that leaders who understand the importance of transparency, teamwork, empowerment, and communication promote innovation within their organization (Subramanian & Banihashemi, 2026).

2.7 External Knowledge Integration and Innovation Capability

In context of innovation management within a mechanical firm, external knowledge integration is regarded as vital factor. The idea to integrate external sources of the process of innovation has been focused frequently in past studies on innovation because organizational innovation does not depend on internal knowledge generation (Basit, 2021). Organizations acquire knowledge from industrial associates, competitors, consultants, universities, suppliers, and customers on regular basis. All these factors in literature are considered as external factors. Organizations can achieve technological development when they are exposed to external knowledge factors.

As the technological environment is going through rapid changes, therefore usage of external factors is increased in mechanical organizations. Studies reported that external knowledge effects the innovation capability while network embeddedness and technological proximity impacts the strength of relationship (Weissenberger-Eibl & Hampel, 2021). Scholars determined that different external sources such as workshops, new employees, consultants, competitors and customers contribute significantly towards innovation. External knowledge networks are important for organizations that need to integrate internal technical expertise with knowledge from market actors, institutions, suppliers and customers (Shi et al., 2020).

In other words, external knowledge boosts the innovation capacity of the mechanical organization. Network embeddedness and technological proximity have altered the effect of this relationship. Different external sources like workshops, new employees, consultants, competitors, and customers helps the mechanical firms to create innovation. Scholars empirically explored that intraorganizational networks and external knowledge impacts innovation within high technology organizations (Yu & Chen, 2020). They also reported that exploratory innovation is significantly affected by diversity of external knowledge. More importantly, intraorganizational network provide is strengthened by external knowledge diversity. The findings of Li and Gao (2023) also show that external knowledge plays important roles to create innovation by integrating knowledge. Studies also show that new products (innovation capability) can

be enhanced through external alliances of R&D.

3. Methodology

3.1 Research Design

In current study researcher applied an explanatory sequential research design for the examination of relationship between innovative capability (INC) and Mechanical Knowledge Networks (MCKN) in organizations. Purpose of selecting this design is to enable explanation and enrichment of quantitative findings through qualitative inquiry. This approach is guided through pragmatic research philosophy. The current study integrated interpretivist and positivistic perspectives for the provision of comprehensive knowledge about how programmed knowledge networks influence innovation performance.

In the quantitative phase researcher examined that whether organization having different levels of Mechanical Knowledge Networks differ significantly in Innovation Capability with the help of One-Way ANOVA (Analysis of Variance). Successively, in qualitative section interviews were conducted with conveniently selected managers, supervisors, and professionals of research and development, for the explanation of statistical results and identification of organizational mechanisms containing the hypothesized relationships.

3.2 Sample and Population

Target population includes medium-size organizations. Stratified sampling technique was adopted on the quantitative phase to ensure the inclusion of all sections of organizations like maintenance, production, research and quality assurance department.

350 respondents selected from the organizations for the quantitative section after the collection of data researcher conducted the data cleaning and missing values analysis. Consequently, after the removal of missing values and the outlier's researcher retained only 280 responses for further analysis. while 25 respondents selected for the qualitative interviews.

For the categorization of the organization as high, average and low maturity of Mechanical Knowledge Network.

3.3 Instrument Development

For the collection of quantitative study data, a well-structured instrument was used. It consisted of three sections. Respondents' demographics were included in first section, Second section consisted of items measuring MCKN (Mechanical Knowledge Networks), adapted by Vătămănescu et al. (2023), having good reliability and validity at five points Likert scale for the assessment of collaboration cross functional, sharing of knowledge, organizational learning and digital system of knowledge. Third section contained the items of Innovation capability developed by Calik and Bardudeen (2016) at five points Likert scale having good validity and reliability. It covers process improvement, product innovation, continuous improvement and creativity. Five-point Likert scale used, with 1-strongly disagree to 5-strongly agree. For the establishment of content validity, the instrument was reviewed by 7 experts and pilot-tested with 50 respondents. The values of Cronbach's alpha exceeded the required threshold of 70%, which confirms internal consistency satisfactory.

3.4 Collection of Data and Analysis

Data collection process was completed through self-administered questionnaires. Firstly, researcher calculated descriptive statistics for the demonstration of overall characteristics of respondents and the distribution of the construct. Convergent validity and reliability of construct, AVE, and composite reliability were calculated. Assumptions of variance homogeneity and normality were assessed prior to the One-Way ANOVA. After having significant results of ANOVA, specific group differences were identified by Tukey's HSD post hoc test. For the analysis of qualitative data open coding, axial coding, and selective coding, at the end both quantitative and qualitative strands were integrated and joint analysis displayed.

4. Quantitative Data Analysis

4.1 Respondent's Profile

The final data comprised of the responses of 280 respondents the organizations. The largest group comprise of mechanical engineers followed by production managers and then specialists of R&D. Greater than 85% of respondents possessed minimum five years professional experience thus, have sufficient familiarization with innovative activities and organizational collaborations.

Table 1: Demographic Characteristics of Respondents

Characteristic	Category	Frequency	Percentage
Gender	Male	210	75%
	Female	70	25%
Positions	Engineers	105	37.5%
	Manager Production	73	26.1%
	Specialist R&D	61	21.7%
	Supervisors (technical)	41	14.6%

Demographics Table 1 demonstrates that the mechanical engineers are significantly involved in the data collection process and decision making. 37.5% of the respondents were engineers, 26.1% were manager production, 21.7% were research and development specialists and 14.6% were technical supervisors. Consequently, enhancing the credibility and relevancy of research findings. 75% respondents were male while 25% were female.

4.2 Descriptive Statistics

For the assessment of initial information about the perceptions of respondents regarding innovative capability and MCKN, descriptive statistics calculated using SPSS.

Table 2: Descriptive Statistics

Variable	N	Mean	SD
MCKN	280	3.78	0.55
INC	280	3.51	0.72

Average score of Mechanical Knowledge Networks is Mean = 3.78 and SD = 0.55, indicating that included organizations demonstrate moderate knowledge sharing practices. Organizations' innovative capability also exhibited relatively high mean i.e. Mean = 3.51 and Standard deviation 0.72. However, a high value of standard deviation shows greater variation in the innovative performance of an organization. Subsequently, respondents were classified of high, moderate and low MCKN with the help of a composite score threshold for the facilitation of comparative analysis.

4.3 Construct Validity and Reliability

Before testing the hypothesis measurement psychoanalytical properties were

Table 3: Convergent Validity and Reliability

Variable	α	AVE	CR
MCKN	0.92	0.66	0.94
INC	0.88	0.63	0.90

Table 3 shows the values of Cronbach's alpha 0.92 and 0.88 for the mechanical knowledge networks and innovative capability are higher than the threshold level of greater than 0.70, which confirms the good internal consistency. While the values of Composite Reliability are .94 and 0.90 respectively. Values of AVEs are 0.66 and 0.63 which are above the threshold level of 0.50 according to the criteria defined by Fornell and Larcker (1981), demonstrating good convergent validity, indicating that intended theoretical concepts are adequately measured by the construct.

4.4 Statistical Assumptions Assessment

Before conducting ANOVA, homogeneity and normality assumptions were tested.

Table 4: Test of Normality

Groups	Skew	Kurt	Shapiro–Wilk (p)
Low MCKN	-0.33	-0.20	.082
Moderate MCKN	-0.26	-0.17	.093
High MCKN	-0.18	-0.31	.066

Table 4, The values of kurtosis and skewness fell within the acceptable range i.e. between -1 to +1, while Shapiro–Wilk statistics is insignificant because its values are higher than 0.05 indicating INC approximately normally distributed.

Table 5: Levene's Test of Homogeneity

Statistic	df1	df2	p
1.85	2	277	.149

Homogeneity of variance confirmed by Insignificant values of Levene's statistic. Which supports the use of one-way ANOVA.

4.5 One-Way ANOVA

According to the maturity of MCKN, respondents were grouped for the determination whether Capability of Innovation differed significantly among organizations.

Table 6: Innovation Capability Across MCKN Groups

Group	n	Mean	SD
Low MCKN	90	2.83	0.51
Moderate MCKN	100	3.45	0.47
High MCKN	90	4.17	0.43

According to the descriptive statistics table#6 there is a clear progress in INC across groups with organization having stronger MCKN consistently performing at high innovation level.

Table 7: One-Way ANOVA Results

Source	SS	df	MS	F	p
Between Groups	88.41	2	44.20	105.23	0.000
Within Groups	116.85	277	0.42		
Total	205.26	279			

According to the results Table #7, there is a significant difference in capability of innovation among knowledge networks $F(2, 277) = 105.23$, significant at 1%. effect size corresponding is ($\eta^2 = .42$) indicating that approximately 42% of the variance in capability of Innovation is associated with differences in maturity of MCKNs, that represent a significant practical effect. Findings of the study provides the support to the assumption that organizations having mature knowledge sharing networks will demonstrate significant high innovative capability than the organization with weak knowledge networks.

Table 8: Tukey HSD Post Hoc Comparisons

Comparison	Mean Difference	P-Value
Low vs Moderate	-0.61	0.000
Low vs High	-1.33	0.000
Moderate vs High	-0.71	0.000

Significant difference between all groups is demonstrated by the Table#8 test of Tukey's HSD. The magnitude of the difference is highest among low Vs high MCKN groups. It suggests Mechanical Knowledge Networks, collaborative practices of engineering, that systematic sharing of knowledge sharing, and organizational learning significantly improves the innovation capability. Quantitative results established a foundation for the qualitative research, that demonstrate that the processes of organizations are responsible for the statistical difference among them.

4.6 Qualitative Analysis

After completing the quantitative analysis, the researcher moved to the qualitative inquiry for the observation of the difference among the organizations based on the maturity of the Mechanical Knowledge Network. Twenty-five respondents having technical and managerial positions were selected purposively to ensure the representation of low, moderate, and high MCKN. Semi-structured interviews were conducted exploring the experience of participants regarding collaboration, sharing of knowledge, technology and problem solving, organizational learning and practices of innovation. A three-stage coding process was used for the analysis of Interview transcripts adapted from grounded theory principles. Analysis advanced through open, axial, and selective coding. Facilitating the researcher to integrate progressively into overarching themes and categories.

4.6.1 Open Coding

It is the first stage of analysis at which a line-by-line examination of interview transcripts was conducted. starting

concepts explained the experience of the respondents and without predetermined labelling of theoretical categories. From the interview data, overall, 86 initial codes emerged, resulting in 27 refined open codes.

Exemplary open codes are

- informal technical discussions
- collaborative troubleshooting
- sharing engineering expertise
- supplier collaboration
- digital engineering documentation
- knowledge repositories
- interdepartmental meetings
- design review sessions
- Experimentation
- Engineering mentorship
- continuous improvement culture
- learning from production failures
- customer feedback integration
- technology adaptation
- engineering communities of practice

Respondents emphasized that frequent interactions generate innovation rather than differentiated technical expertise.

According to a respondent “Whenever you face an issue related to production, its solution is rarely designed by a single engineer. It develops with the help of discussion involving production, maintenance design and team quality” (Respondent R 05)

According to another participant

“A lot of innovative ideas start from the informal discussions during meetings, which eventually are converted to formal improved initiatives (participant R12)

These statements demonstrate that knowledge of engineering is socially constructed by mutual interactions rather than individually.

4.6.2 Axial Coding

After conceptually grouping the related open codes, axial coding was formulated. For the identification of patterns researcher examined the relationships among the constructs explaining how MCKNs impact Innovation Capability.

As a result, 6 categories emerged

First Category: Engineering Collaboration cross-functional

Related Open codes

- engineering teamwork
- collaborative troubleshooting
- technical consultation
- interdisciplinary meetings

It was described by the respondents that cross functional collaboration is a basic mechanism by which technical knowledge and skill were integrated cross organizational department.

According to an engineering manager stated:

"Innovation quality based on the effective communication of engineering design with production team prior to the implementation." (R 07)

Second Category: infrastructure of Digital Knowledge

Related Open codes:

- CAD knowledge libraries
- engineering databases
- digital collaboration
- knowledge retrieval
- document repositories

Respondents emphasized that digital systems improve the problem-solving capability and preserved organizational memory.

According to the production supervisor:

"Engineers simply retrieve the prior solution from the technical data base rather than the solving repeatedly same problem “(R 23)

Third Category: Organizational Learning

Related Open codes:

- project reviews
- continuous learning
- technical reflection
- lessons learned
- failure documentation

Respondents emphasized that innovation is a process of learning process which is supported by previous engineering experiences review and systematic documentation.

Another respondent described

"Every failure teaches us something and these lessons eventually guides the future projects." (R17)

Forth Category: Leadership Support

Related Open codes:

- strategic vision
- innovation rewards
- management encouragement
- employee recognition
- knowledge-sharing culture

Respondents focused that the behavior of leadership significantly impact willingness to employees to exchange technical expertise.

As one innovation manager explained:

"After senior management rewarded collaborative behavior the sharing of knowledge became routine rather than individual achievements." (R19)

Fifth Category: External Knowledge Integration

Related Open codes are

- university collaboration
- customer interaction
- industrial networking
- supplier partnerships
- technology benchmarking

It was highlighted by the respondents that external ordination enhanced organizational learning.

According to a respondent:

"Most of our best ideas of engineering were generated through collaborative discussions (R11)

Sixth Category: Development of Innovation Capability

Open codes:

- process innovation
- rapid prototyping
- product improvement
- operational flexibility
- technological adaptation

It was consistently emphasized by the respondents that there is a strong link between knowledge networks, innovation performance and improved organizational responsiveness.

4.6.3 Selective Coding

In this section, the researcher integrated the axial categories into related explanatory framework explaining the link between Mechanical Knowledge Networks and Innovation Capability.

Theme 1: Innovation capability Accelerated by Cross-Functional Collaboration

It was consistently emphasized by the respondents that collaboration among production, engineering, quality, and maintenance departments is the basic driver of innovation.

"When different departments of engineering work together on the same problem innovation begins rather than separately." (R13)

Theme 2: Organizational Innovation Capability Preserved by Digital Knowledge Infrastructure/ Repositories

It was reported by the respondents that innovation capability will be improved significantly by centralized digital knowledge infrastructure (systems), enabling technical knowledge rapid retrieval.

"When employees leave the organization our digital repository/ infrastructure protects the valuable experience

from disappearing." (R 07)

Theme 3: Transforms Experience into Innovation through Organizational Learning

According to participants, systematic reflection on previous projects is necessary for continuous innovation.

"Completion of every project is a foundation to start and improve the other project and bring innovation to the upcoming projects" (R 06)

Theme 4: Knowledge Sharing Conditions Created by Leadership

According to respondents, innovation flourished when organizational leaders actively promoted trust, openness, and collaboration that later enhance innovation capability within mechanical organization.

"Technical ideas are shared willingly by employees because management promotes and encourages collaborative activities rather than competition, enhancing innovation capability" (R17)

Theme 5: Innovation Opportunities enhanced by External Knowledge Networks

Respondents indicated that customers, suppliers, industrial associations, and universities introduced diverse perspectives that stimulate technological innovation.

"Working with universities opened new avenues for us to understand new technologies which can never be comprehended in isolation." (R02)

These themes explained collectively the quantitative findings of the study by describing how strong networks can develop innovation capability by the approach of interconnections of leadership, organizational learning, digital knowledge management and external engagement.

Overarching core category is

Organizational Capability for Innovation is affected by Mechanical Knowledge Networks

The present category depicts the perceptions of the participants about the constitution of organizational structure by knowledge networks by which technical expertise is generated, integrated, shared, and transformed into capability of innovation. Thus, it is not only the possession of skilled workers that leads towards innovation capability but rather based on the ability of the organization to coordinate differentiated expertise by structured learning, collaboration, communication, leadership support and digital knowledge system. These mechanisms support one another for the creation of a dynamic organizational capability which continuously improves innovation performance.

5. Discussion

The overall results show that mechanical knowledge networks has central role to develop organizational capability for innovation within mechanical organizations (Maula, 2024). This result suggests that there are multiple factors that lead to innovation capability. It is not dependent only on experienced employees, technicians, and skilled engineers. Instead, a structure is provided by mechanical knowledge network through which different types of expertise and technical knowledge can be transformed, integrated, shared, and connected into useful organizational capability. The knowledge network bring together knowledge from organizational functions, maintenance, quality, production, and engineering, that allow employees to get knowledge from one another and address technical issues jointly. The results further show that mechanical knowledge networks are strengthened through digital knowledge infrastructure, leadership support, cross functional collaboration, and organizational learning. These elements do not work independently, infact they work together to achieve a goal. Therefore, mechanical knowledge networks create an environment where knowledge is moved across all boundaries of organisation and contribute to innovation. Consequently, mechanical knowledge networks have the potential to strengthen innovation capability by enabling mechanical organizations to sustain continuous innovation, improve processes, develop new solutions, retain valuable knowledge and coordinate diverse expertise.

Results indicate that in mechanical organizations innovation capability is supported significantly through cross sectional collaboration. Participant revealed that innovation capability is developed in a mechanical organization when employees from maintenance, quality, engineering, and production departments work together rather than focusing on solving problems separately. The possible reason for these results can be that each department provides different experience and knowledge. Employees working in mechanical organizations understand operational challenges, maintenance employees understand equipment reliability and performance, quality staff identify quality problems, and engineering provide technical solutions. Combination of these perspectives provide strength to innovation capacity by helping organizations to understand problems from different angles and develop practical solutions. The results further show that when different departments of mechanical organization work together on the same problem, innovation capability get stronger as employees get chance to develop better solutions, identify causes, and share ideas collectively. Moreover, cross functional collaboration also encourages continuous improvement, joint problem solving, and knowledge sharing. Respondents also mentioned that innovation capability within mechanical organization depends technical expertise of employees along with organizational ability to connect different functional

knowledge. Strong innovation capability also helps mechanical organizations to develop innovative engineering solutions, solve technical problem faster, and improve processes. These findings are aligned to the empirical results of Ahmad et al. (2023).

The results also suggest that within mechanical organization digital knowledge infrastructure has important role to play in order to strengthen innovation capability. Participants emphasized that employees are enabled through digital knowledge infrastructure to access quickly operational experience, previous solutions, maintenance data, engineering records, and access technical information. This rapid access is vital as mechanical organizations depend on specialized knowledge that is developed through practical experience. Digital knowledge infrastructure also minimizes the loss of valuable knowledge in case experienced employees leave the firm. Through strong knowledge in centralized digital repositories, employees are allowed to build and access existing knowledge through digital knowledge infrastructure. This will reduce repeated problem solving, improve technical decision making, and support learning. The results indicate that digital knowledge infrastructure not only preserve only organizational knowledge but also provide strength to innovation capability. Mechanical organizations can develop new engineering solutions, support continuous improvement, solve technical problem solving, and improve knowledge sharing through digital knowledge infrastructure, thus improving innovation capability.

The results show that organizational learning is important to transform previous experiences into innovation and develop innovation capability within a mechanical organization. Respondents mentioned that completed projects provide knowledge that is valuable for the organization in order to improve future performance. systematic reflection on project outcomes allows employees to find the way similar issues can be avoided in future, what problems occurred in past and what worked well for the mechanical organization. This process helps mechanical organizations to convert practical experience into better engineering solutions, improved methods, and new ideas. By this way, organizational learning provide support to continuous innovation that later strengthen innovation capability of the mechanical organization.

The results show that leadership support play key role to create that support knowledge sharing and provide strength to innovation capability within mechanical organizations (Subramanian & Banihashemi, 2026). Participants revealed that leadership support encourages collaboration, openness, and trust making employees willing to share ideas and technical knowledge. This is vital because mechanical organizations are heavily dependent on experience of employees and engineering knowledge. Unhealthy competition can be reduced among employees through strong leadership support and employees are encouraged to exchange suggestions openly, exchange experiences, and technical support. This kind of leadership support will also create a safe environment where employees can share ideas with others without fearing criticism. With increase in knowledge sharing, employees can learn from others and address operational and engineering problems. Therefore, results suggest that leadership support play key role to strengthen innovation capability by encouraging continuous learning and collaboration.

Results also indicate innovation capability within a mechanical firm is significantly effected through external knowledge integration (Li & Gao, 2023). As a result, employees who are working mechanical organization get multiple opportunities for innovation. Participants revealed that universities, industrial associations, suppliers, and customers provide expertise, technical knowledge, and new perspectives that are unavailable within a mechanical organization. Mechanical organizations are enabled through external knowledge integration to identify news approaches to solve production and engineering problems, understand changing requirements of customers, and access emerging technologies. Collaboration with external stakeholders is valuable as integration of external knowledge provides access to new technological developments, specialized expertise, and research findings. The results also suggest that mechanical organization is also enabled to expand its knowledge base with the help of external knowledge integration that is hard to find out independently. Effective external knowledge integration also provide support in exchange of knowledge between external partners and mechanical organizations that encourages technical innovation and continuous learning. In other words, external knowledge integration can play integral role to strengthen innovation capability by helping mechanical organizations respond effectively to technological changes, support new process and product development, and improve problem solving.

The quantitative results show that mechanical knowledge networks, organizational learning, systematic knowledge sharing, and collaborative engineering practices improve innovation capability in mechanical organizations. The findings suggest that innovation capability cannot be developed only through technical expertise but using structured interaction that allows employees to apply, combine, and exchange knowledge. Mechanical networks has the ability to connect employees from different functional groups, production teams, technicians, and engineers, and enable them to develop solution of complex problems and share technical experience. Likewise, collaborative engineering practices also create opportunities for employees to work together, improve existing processes, and learn from different perspectives. Furthermore, systematic knowledge sharing ensure that valuable technical knowledge remain available in all departments of mechanical organization, whereas organizational learning help employees to convert past

experience into new ideas and improved practices. Together these mechanisms provide strength to ability of organization to implement and generate innovation. Thus, the quantitative results show the vital role of knowledge based organizational mechanism to develop innovation capability. These quantitative results are aligned with the qualitative results depicting that mechanical knowledge networks support continuous innovation, learning, knowledge sharing, and collaboration.

6. Limitations and Future Directions

This research has few limitations that provide different opportunities for upcoming research. Initially, the outcomes of the study are based on mechanical organizations that may not be generalized to other industrial sectors. Secondly, present research mainly focuses on external knowledge integration, cross-functional collaboration, digital knowledge infrastructure, leadership support, organizational learning, and knowledge sharing as factors that impact innovation capability. Upcoming studies should explore additional organizational, cultural, and technological factors to enhance innovation capability. Thirdly, upcoming studies should develop proper research framework having multiple independent variables, mediators and moderators that play their role to enhance innovation capability of the organization. In the end, future studies should also analyze the role of emerging technologies like industry 5.0 and industry 4.0 to strengthen innovation capability and mechanical knowledge networks.

7. Theoretical and Managerial Contribution

Present study extend literature regarding innovation capability by introducing mechanical knowledge networks as mechanism of the organization by which technical knowledge is transformed, integrated, and shared into innovation capability. The results also show that external knowledge integration, digital knowledge infrastructure, leadership support, organizational learning, and cross functional collaboration integration strengthening innovation capability. Therefore, present research provides a more detailed and integrated explanation of the way knowledge-based mechanisms develop innovation capability in mechanical organization. From the perspective of managerial contribution, managers working in mechanical organizations should strengthen mechanical knowledge networks by focusing on leadership support, organizational learning, knowledge sharing and cross functional collaboration. The decision makers should also invest in external knowledge integration and digital knowledge infrastructure with universities, customers, and suppliers to develop effective engineering solutions and improve innovation capability.

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