

Relationship between Manufacturing Flexibility, AI adoption, E-Learning System and Manufacturing Operational Performance: Mediating Role of Mechanical Organization Learning Capability

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ABSTRACT

Purpose: In the current competitive and changing business environment, it is important to focus on the factors that can improve Manufacturing Operational performance. Therefore, the purpose of this research was to examine the effect of manufacturing flexibility, E-learning system, and AI-technology Adoption on Manufacturing Operational performance through the mediation of mechanical organization learning capability. **Design/ method/ approach:** The research adopted a quantitative research methodology. Data was gathered from employees using convenience sampling. Data was collected through a questionnaire developed from past literature review. The usable response rate was 59.19%. The gathered data was analyzed using Smart PLS. **Findings:** Results of the study revealed that manufacturing flexibility, E-learning system, and AI-technology Adoption have an effect on mechanical organization learning capability. Moreover, mechanical organization learning capability also has a positive significant effect on Manufacturing Operational performance. Findings also supported the mediating role of mechanical organization learning capability. **Originality:** This study adds to the body of literature by discussing the mediating role of mechanical organization learning capability.

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1. Introduction

Manufacturing operational performance is important to achieve long-term organizational success and sustainable competitiveness. It shows how effectively and efficiently the manufacturing system transforms inputs into products that are high quality while minimizing waste and costs (Bilal et al., 2026). Strong operational performance of an organization is affected by different external factors and internal capabilities. The external factors that contribute to operational performance include environmental dynamics and technological advancement. On the other hand, internal capabilities include resource utilization and innovation. The integration of innovative technologies into production enhances product quality, productivity, and flexibility (Rahman et al., 2025). Furthermore, effective production planning and a well-designed manufacturing system enable organizations to respond to market demands and meet performance targets. As a result, efficient manufacturing operational performance improves the efficiency and effectiveness of the organization. It also supports market expansion, drives the overall performance of organizations, and creates a competitive advantage (Adhaya et al., 2024).

Mechanical organizational learning capability is a vital organizational capability from a strategic point of view. Mechanical organizational learning capability is the system-driven and structured approach by which organizations ensure continuous improvement and adaptation in a turbulent operating environment (Jiang et al., 2026). This concept stresses routine-based learning processes, standardized training systems, and formalized procedures that enable employees to systematically apply, store, and acquire knowledge. Most of the time, organizations opt to improve their

learning capability by engaging external experts to challenge the assumptions of employees. Therefore, fostering key evaluation within controlled structures (Hosen et al., 2024). From a mechanical perspective, there are different key factors that operationalize organizational learning capability. These factors include alliance experience, technical expertise, and training availability. These factors function as inputs that later influence the successful achievement of alliance goals (Haile & Tüzüner, 2022).

Adoption of Artificial intelligence (AI) is not just the purchase of new technology. In fact, it is the adoption of a cultural shift that has a long-term impact on society and business (Venkatesh et al., 2024). Presently, AI contributes significantly to the global economy. Despite the transformative effect of AI on supply chains and customer services, a number of businesses still have to unlock the full potential of AI as they have not yet integrated AI into their operations. AI is widely used in retail, finance, and healthcare, facilitating diagnostic testing, personalized purchasing, and financial forecasting. The adoption rate of AI varies across industries and businesses. Some industries lead the way in the integration of AI, whereas others lag behind due to certain barriers. Successful adoption of AI policies thus focuses on enhancement irrespective of replacement. The usage of AI enhances human capabilities and their usage in business (Romeo & Lacko, 2026).

Recently, organizations have witnessed a major change in the training of manpower mainly due to the adoption and availability of digital technologies in the form of an e-learning system. Organizations at the global level are facing regular challenges to improve the capabilities of employees with the purpose of meeting the demands of the changing business environment. Traditional training methods are being replaced by scalable, flexible, and e-learning systems as they are more cost effective. An E-learning system is the usage of technologies and digital platforms to deliver educational content (Liu & Yu, 2023). Therefore, the e-learning system has become an important part of manpower training strategies in almost all industries. In some of the industries, the e-learning system has become a game changer, offering a more accessible, affordable, and efficient approach for both employees and managers (Ahmed, 2025).

Manufacturing Flexibility is one of the major factors in overcoming the challenges of the current competitive marketplace (Ujam, 2025). Manufacturing flexibility enables organizations to adjust their operational strategies in response to external pressures, regulations, and market conditions. Manufacturing flexibility allows organizations to adapt their production systems and processes to meet technological changes and fluctuating demands (Grefen et al., 2026). Furthermore, manufacturing flexibility helps in the adjustment of supply chain operations effectively and quickly. Manufacturing flexibility has become indispensable in the present global market where disruptions are more costly and frequent. Thus, the effect of manufacturing flexibility on this type of production system is an important parameter that must be well described and well known to ensure a sustainable manufacturing system. Ensuring a highly sustainable and efficient flexible manufacturing system is vital and can be obtained through flexible manufacturing (Tan et al., 2023). The aim of present study is to explore the effect of manufacturing flexibility, E-learning system, and AI-technology Adoption on Manufacturing Operational performance. Study also aims to explore the mediation of mechanical organization learning capability.

2. Literature Review

2.1 Mechanical Organization Learning Capability and Manufacturing Operational Performance

The managerial and organizational characteristics, factors, abilities or activities that promote the learning processes of organization of organization in the form of disseminating, obtaining and creating the knowledge enabling learning process of organization is referred as mechanical organization learning process (Odor, 2019). Learning capability of the mechanical organization is the subject of research as path of long-term cooperative performance and competitive advantage. The managerial and organizational traits that facilitate the learning process of organization are discussed as organizational learning capability. Organizational ability to absorb knowledge in the form of integration of knowledge, move the knowledge, obtain the knowledge and obtain the knowledge as the ability to enhance organizational capability of manufacturing organization (Eletu et al., 2021).

On the other hand, operational efficiency is discussed in studies as positive consequences in terms of comparison among outputs and inputs (Dilshani et al., 2019). Literature has defined efficiency as the relationships among the effects and inputs; thus, efficiency shows the effects regardless of resources and inputs that are being used to accomplish goals. Efficiency is referred as getting the outputs that are possible by using minimum inputs (Eletu et al., 2021). Operational efficiency involves improvement of the work that is performed across data, systems and people by using methods like predictive maintenance and lean six sigma to minimize nonvalue added time.

Literature has defined learning capability as organizational management qualities and features that are directed towards the support and promotion of a learning process. Learning capability is important resource that improves the performance, innovativeness and efficiency of the organization (Santos-Vijande et al., 2012). Learning capability

provides support to organization in new product delivery methods, minimization of cost, adjusting business activities, sensing market opportunities, and improving productivity. It shows the potential of mechanical firms to flourish, innovate and survive in the market. Mechanical organization learning capability drives operational performance by improving quality conformity, reduce lead time (Malik & Blumenfeld, 2012). Through utilization of different mechanisms like dialogue, risk taking, and knowledge sharing, mechanical firms improves process improvement that result in better competitive advantage, cost management and efficiency (Berndt et al., 2023).

The efficiency of the organization is enhanced through organizational technological capabilities in developing knowledge and innovative ideas from investment in R&D, application of innovative technology and continuous training to the process of problem solving that enables mechanical firms to achieve distinctive performance (Salisu & Abu Bakar, 2020). Thus, knowledge and learning are important factors that are responsible for significant improvement in efficiency. The study by Uğurlu and Kurt (2016) revealed that mechanical organization learning capability has positive effect on operational performance. Similar results were reported by Eletu et al. (2021) who established nexus among learning capability and operational efficiency of mechanical organization. Thus, we hypothesize that

H1: Mechanical Organization Learning Capability has positive significant effect on Manufacturing Operational Performance.

2.2 AI Technology Adoption and Mechanical Organization Learning Capability

AI technology adoption in manufacturing organization integration of AI in the form of IoT data, computer vision, and machine learning into processes of production to boost autonomy, quality and efficiency (Reference). AI technology adoption shifts organizational operations from reactive/ manual to optimize, reduce downtime and automated supply chains. AI technology adoption in manufacturing firms is driven and accelerating by the supply chain optimization, quality control, and predictive maintenance to improve competitiveness (Qudus, 2025). Organizations adopting these technologies most of the times outperform their competitors making AI as important to maintain competitive advantage rather (Huang et al., 2025).

The combination of mechanical organizational capability and AI technology highlights the important role that is played by technology to enhance competitiveness of business. As mechanical firms are integrating AI on regular basis into their operations, they have reflected significant effect of AI innovation, specifically for the improvement of market competitiveness, product development and improving efficiency (Lin & Wu, 2025). Dynamic capabilities of the organization are based in integration of resources but also involve restructuring mechanisms, formulating response strategies and external environment, highlighting the key role of technology, enhancing innovation capacity, and allocation of resources. From the perspective of digital transformation, AI technology provides a different perspective to enhance organizational learning capability. AI technology adoption improves organizational learning capability through real-time feedback and efficient data analysis while optimizing team learning capability (Ritala et al., 2024).

AI knowledge sharing system is developed to broaden the scope of interaction of knowledge to assimilate and acquire innovative resources of knowledge. It plays key role to enhance the capabilities by exploiting and transforming knowledge into innovation (Cui, 2025). AI plays very important role to boost operational efficiency and corporate innovation by playing the role of accelerator for organizational learning capability. AI technology adoption transforms workplaces into tasks that are automated by allowing to focus on creative work, strategic work and high value work (Anggraeni, 2025). Successful adoption of AI need integration of AI into culture of organization along with development of human capabilities for the management of these technologies. Past empirical studies analyzed the effect of AI technology adoption and organizational learning capability. Results of study Han et al. (2025) reported that AI technology adoption has positive effect on mechanical organization learning capability. So,

H2: AI Technology Adoption has positive effect on Mechanical Organization Learning Capability

The AI technology adoption has introduced automation and analytical capabilities into manufacturing environments. Whereas its impact on operational performance of the mechanical organization is not certain. The importance of AI driven benefits is dependent on the ability of organization to operationalize, adapt and interpret these technologies in mechanical systems (Hong et al., 2026). The learning capability of mechanical organizations plays key roles in this matter by enabling organizations to integrate AI into technical workflows and routine activities of production. It provides support to refinement of machine level operations, experiments and continuous learning that ensures application of AI that are aligned effectively with processes of manufacturing (Jamil et al., 2025).

By using this capability, mechanical organization can improve overall reliability of system, minimize inefficiencies and enhance precision. As a result, mechanical organization learning capabilities plays as a mechanism of transmission by which adoption of AI technology leads to improved manufacturing performance of operations (Leoni et al., 2022). The study of Kalmuk and Acar (2015) also discussed the mediating role of organizational learning

capability. So, we hypothesized that: Therefore, its mechanical organizational learning capability has the potential to play the role of mediator. So, we hypothesize that:

H3: Mechanical organizational learning capability mediates between AI-Technology adoption and manufacturing operational performance.

2.3 E-Learning System and Mechanical Organization Learning Capability

E-learning system is referred as usage of online technologies to provide professional training to employees working in manufacturing organization (Lee et al., 2011). E-learning system provides a number of benefits to the organization such as up-to-date training, consistency, flexibility and cost saving to a diverse workforce. Implementation of e-learning system can improve organizational learning along with different challenges such as engagement of learners, and development of effective content (Cavus et al., 2024). E-learning system provides approach of time and cost effectiveness. The success of mechanical organization is dependent on its capability to adapt to complex environments. The implementation of different measures is required based on technological concepts and organizational concepts enabling employees to fulfill different tasks efficiently. The organization will be successful if knowledge acquisition is higher than environmental challenges (Lalic et al., 2017).

Organizations that are knowledge driven are dependent on knowledge sharing and skill development. E-learning system provides technology enabled platforms, and flexible platforms that integrate collaborative learning, informal learning and formal learning approaches. These systems provide facilitation in real time application, sharing and acquisition of knowledge among organizational employees enhancing efficiency of organization (Zahari et al., 2024). Through alignment of learning process with practices and goals of organization, e-learning system improves adaptability and competence of employees. Furthermore, different advanced tools such as virtual environment and mobile learning further strengthen accessibility and engagement. As a result, e-learning systems play an important role in enhancing organizational capability to learn, enabling organizations to remain responsive and competitive to environmental changes (Giannakos et al., 2022).

The factor of cost effectiveness and just in time are considered as important antecedents of employee development. In context of manufacturing industry, e-learning system enhances learning capability of employees enabling technology driven training, real-time knowledge sharing and skill development improving adaptability, innovation and productivity in dynamic production environment (Giannakos et al., 2022). Moreover, e-learning systems in manufacturing organizations enhances organizational capability by providing up-to-date, consistent and flexible training leading to increased retention and reduced learning time (Cavus et al., 2024). E-learning systems facilitate flow of knowledge allowing employees to improve quality of production, fostering innovation and access training on demand (Soltani et al., 2020). So, e-learning system has the ability to develop high performance abilities and individual capabilities that ultimately result in enhanced organizational capability. Similarly, the study by Alzaabi and MALAYSIA (2021) revealed that e-learning systems has positive effect on mechanical organization learning capability. Thus, it is hypothesized that

H4: E-Learning system has positive effect on Mechanical organization Learning Capability.

E-learning system of organization provides its employees to disseminate knowledge and focus on development of skills. Whereas the effectiveness of improving operational performance of manufacturing organizations depends on the way knowledge is integrated in routine operations. The learning capability of mechanical organizations helps in the process by transforming knowledge that is digitally acquired within industrial and mechanical systems. It helps the employees to enhance process understanding, refine machine operations and internalize technical skills through structured learning mechanisms (Giannakos et al., 2022).

As a result, the knowledge collected from the systems of e-learning is applied effectively to optimize processes of production, reduce operational errors and improve efficiency. In the absence of such learning capability, e-learning initiatives may remain failed and underutilized to provide tangible performance outcomes. Thus, mechanical organizational learning capability may play the role of mediator. Furthermore, the study of Sancho-Zamora et al. (2022) also discussed the mediating role of organizational learning capability. So, we hypothesized that:

H5: Mechanical organizational learning capability mediates between E-learning system and manufacturing operational performance.

2.4 Manufacturing Flexibility and Mechanical Organization Learning Capability

Manufacturing flexibility in studies is discussed as the capacity of production system to maintain quality and adapt to changes while adjusting inputs and processes, enhanced through agile rules of manufacturing (Sarkar & Bhuniya, 2022). The concept of flexibility is multidimensional and complex that is very difficult to define. It is based on the

combination of different factors such as information, organizational design, technology of processes, organizational structure, and corporate culture. Manufacturing flexibility is a factor that is relevant to strategic context and operational context of Industrial framework. The manufacturing organizations having mass operations mostly need flexibility measures that are different from other organizations (Awais et al., 2023).

Environment is characterized by technological and demand uncertainty requiring organizations to exploit different activities (Min & Kim, 2022). Scholars mentioned that organizations having a great level of ambidexterity can develop new competencies, perfect existing resources and develop both through high manufacturing flexibility. This behavior of organization involves ability to change organizational production routes to alter the development of different activities that helps in management of organization. On the other hand, low manufacturing flexibility will cause problems in gaining knowledge (Maarof et al., 2022).

Manufacturing flexibility is important capability of organizations to support strategic intent of organization that look forward to outperforming competitors. The specific nature of flexibility is characterized by manufacturing organizations of different types on the basis of strategic goals of organization. firms that pursuit mass production will have different perspective of manufacturing (Dey et al., 2019). Flexibility plays very important role in improving organizational capability to manufacturing organization. Manufacturing flexibility plays key role to facilitate changes, expand usage of resources and shrink rigidity of resources that will lead to mechanical organization learning capability. Mechanical flexibility in terms of coordination flexibility, resources and planning has positive effect on mechanical organizational learning capability. Scholars revealed that mechanical organizational flexibility is one of the important predictor of organizational capability (Awais et al., 2023). So, it is hypothesized that

H6: Manufacturing Flexibility has positive effect on Mechanical Organization Learning Capability.

Studies mentioned that mechanical organizational learning capability may act as the mediator between manufacturing flexibility and manufacturing operational performance. Whereas manufacturing flexibility allows organizations to work effectively in response to alteration in process requirements, volume and design, its direct effect in performance can be constrained. Learning capabilities of the mechanical organizations facilitates the application, assimilation and acquisition of knowledge embedded in industrial and mechanical operations (Awais et al., 2023).

This capability operational efficiency is enhanced, coordination is improved and operational errors are reduced in manufacturing units. Therefore, organizations are in position to convert flexibility into operational performance of organization. If organizations do not focus on learning capability, the benefits of manufacturing flexibility cannot be used. Moreover, study of Oyewobi et al. (2021) mentioned the mediating effect of mechanical organizational learning outcomes. So, it is assumed that.

H7: Mechanical organizational learning capability mediates between manufacturing flexibility and manufacturing operational performance.

Based upon above discussion, this study has developed research framework as given in figure 1, showing that manufacturing flexibility, E-learning system, and AI-technology Adoption effects mechanical organization learning capability and Manufacturing Operational performance.

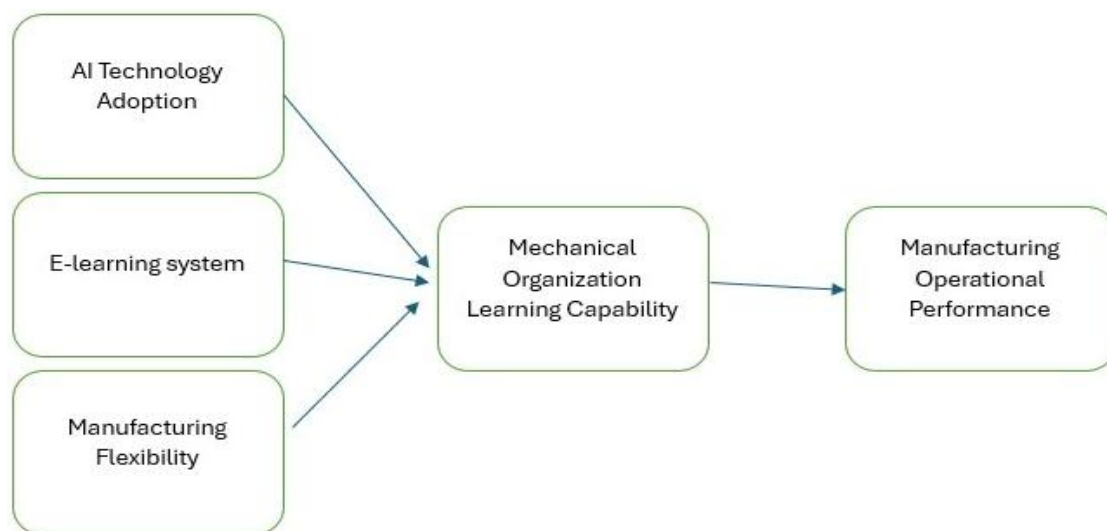


Figure 1: Framework

3. Methodology

Present study used descriptive quantitative methodology to meet the objectives mentioned earlier. This approach is used to examine the effect of independent variables on the dependent variables (Ghanad, 2023). Descriptive analysis is used to describe the understanding, presentation, processing and collection of information in percentage or quantitative way that can be present in the form of diagrams or charts. The employees working in the manufacturing organizations were the respondents of the study. This study used convenience sampling to reach these respondents. The questionnaire in Likert five-point scale was developed on the basis of past studies to reach the respondents. Questionnaire was distributed among 250 respondents. 59.19% of usable responses were received from the respondents. The questionnaire of the study was adapted from the literature review. The items of AI Technology Adoption were adapted from Chow et al. (2023), measurement scale of E-learning system was adapted from Soltani et al. (2020), questionnaire of Manufacturing Flexibility was adopted from Camison and Villar Lopez (2010), questionnaire of Mechanical Organization Learning Capability was used from the items of Migdadi (2021), and items of Manufacturing Operational Performance was adapted from Rahman et al. (2010). These questionnaires were initially examined in SPSS from demographic analysis of the respondents. Later, this study used Smart PLS for the analysis purpose and to explore the significant of proposed relationships.

4. Results

Initial analysis was carried out through SPSS for examination of demographic information of respondents. Findings revealed that 92.27% of respondents were male and remaining were female. Moreover, 64.25% of employees were married and 35.75% of employees mentioned their marital status as single. In terms of age, 39.11% employees had the age between 18 to 30 Years, 41.07% employees had the age between 31 to 45 years, whereas rest of the employees had the age of more than 45 years.

Later, Smart PLS was used for analysis purposes. 1st step of Smart PLS measurement analysis is assessment of measurement models that include testing of Cronbach Alpha, discriminant validity and convergent validity. To begin with analysis, the benchmark for factor loading is 0.70 (Hair Jr et al., 2017). Table 1 of the study showed that all items of the variables had a factor loading of more than 0.70.

Table 1: Factor Loading

	AITA	ELS	MF	MOLC	MOP
AITA1	0.839				
AITA2	0.832				
AITA3	0.815				
ELS1		0.818			
ELS2		0.873			
ELS3		0.870			
ELS4		0.872			
ELS5		0.845			
MF1			0.867		
MF2			0.865		
MF3			0.859		
MF4			0.857		
MOLC1				0.886	
MOLC2				0.851	
MOLC3				0.865	
MOLC4				0.735	
MOP1					0.823
MOP2					0.857
MOP3					0.887
MOP4					0.869

At this stage, this study examined Cronbach Alpha and AVE. Hair Jr et al. (2017) proposed the value of Cronbach Alpha must be 0.70 or more to be acceptable. Table 2 of the study showed that all values of Cronbach Alpha are higher than 0.70. Thus, the required criteria are fulfilled.

Table 2: Validity

	Cronbach's Alpha	AVE
AITA	0.773	0.687
ELS	0.909	0.733
MF	0.885	0.743
MOLC	0.855	0.699
MOP	0.881	0.738

Convergent validity was confirmed through AVE examination. Fornell and Larcker (1981) mentioned that required AVE figure is 0.50. Table 2 also shows the AVE values, where all of the figures of AVE are higher than 0.50, meeting the minimum requirement.

Discriminant validity is also an important test at the stage of measurement model. This test shows that all variables involved in the study are distinct from each other. Fornell and Larcker (1981) approach was used for this purpose. As per this approach, figures at the diagonal must be higher than the remaining figures. Table 3 shows that the statistical figures at the diagonal are higher than the remaining figures, meeting the criteria.

Table 3: Fornell and Larker

	AITA	ELS	MF	MOLC	MOP
AITA	0.829				
ELS	0.604	0.856			
MF	0.625	0.711	0.862		
MOLC	0.599	0.735	0.708	0.836	
MOP	0.655	0.714	0.760	0.820	0.859

Determinant of coefficient is the test that shows the effect of independent variables on the outcome variables. This test is also known as R square. The value of R square of 0.75 is considered as substantial, 0.50 is considered as moderate and that of 0.25 is considered as weak (Hair et al., 2019). As per the results of R square in Table 4, R square value is moderate.

Table 4: R Square

	R-Square
MOLC	0.622
MOP	0.673

After fulfilling all requirements of measurement model, this research explored the structural model to confirm the significance of hypothesis of the study proposed at the literature review stage. Significance of relationship was determined on the basis of t value and nature of relationship was determined on the basis of Beta value.

Table 5: Direct Results

	B	SD	T	P
AITA -> MOLC	0.146	0.059	2.461	0.007
ELS -> MOLC	0.422	0.061	6.871	0.000
MF -> MOLC	0.316	0.060	5.308	0.000
MOLC -> MOP	0.820	0.020	40.503	0.000

As per the statistics mentioned in Table 5 and Figure 2, AITA has positive effect on MOLC ($t=2.46$), accepting hypothesis. Likewise, ELS has significant effect on MOLC ($t=6.871$), accepting hypothesis, MF has significant positive impact on MOLC ($t=5.308$), and MOLC has positive effect on MOP ($t=40.503$).

Table 6: Mediating Results

	Beta	SD	T value	P
AITA -> MOLC -> MOP	0.120	0.049	2.447	0.007
ELS -> MOLC -> MOP	0.347	0.051	6.781	0.000
MF -> MOLC -> MOP	0.259	0.050	5.160	0.000

Table 6 shows the mediating results of the study. As per the statistics, MOLC mediates the relationship between AITA and MOP ($t=2.447$); MOLC mediates between ELS and MOP ($t=6.781$); and MOLC mediates between MF and

MOP ($t=5.160$).

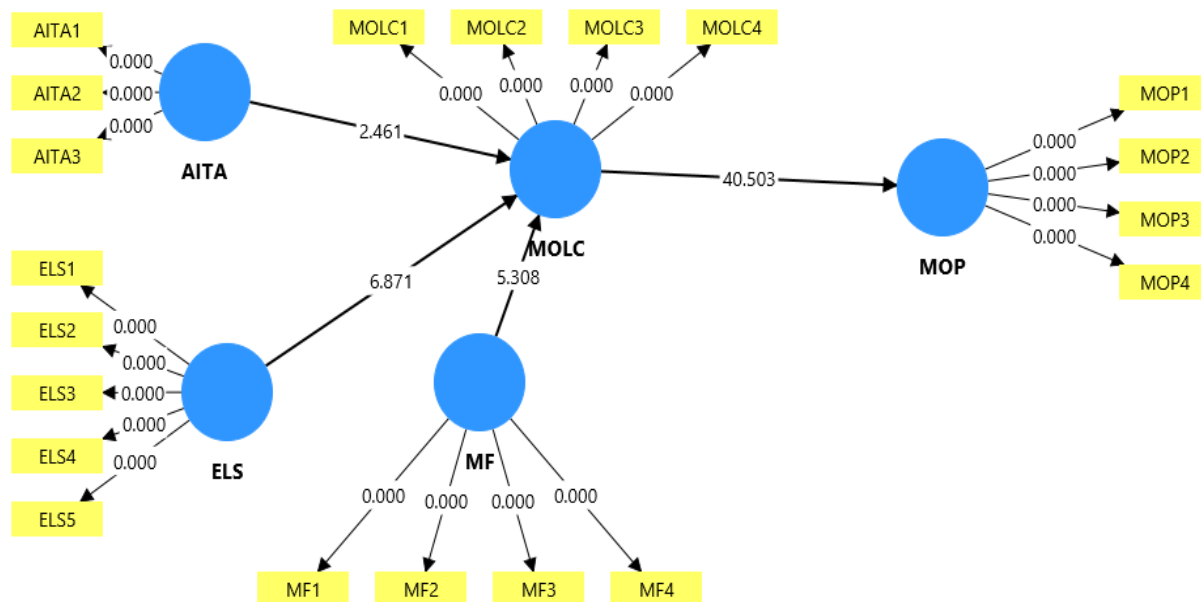


Figure 2: Structural Model

5. Discussion

Manufacturing operation performance is important to measure so the operations of the organization can be improved. This study explored the effect of different factors that can improve mechanical operation performance. Results demonstrated that Mechanical Organization Learning Capability has positive significant effect on Manufacturing Operational Performance. The possible reasons for these findings can be explained with the help of process standardization and knowledge integration. Mechanical organization learning capability focuses on systematic learning routines, codified knowledge and formalized procedures that improves consistency in activities of manufacturing. When mechanical organizational capability is integrated with organizational procedures, that ensures adherence, minimizes errors, and reduces process variability to establish production standards. Therefore, improving manufacturing operational performance.

Moreover, mechanical organization learning capability facilitate the transfer and accumulation of explicit knowledge within and across different departments of organizations. It enables employees to reuse and practice best practices in efficient way. This approach of structured learning enhances production efficiency, optimizes resource utilization and strengthen coordination. All these factors contribute to superior manufacturing operational performance. Furthermore, mechanical organization. Moreover, mechanical organization learning capability provides support to initiatives of continuous improvement by focusing on learning from past experiences which later leads to gain in manufacturing operational performance. Thus, regular application of mechanical organizational learning capability develops a stable operational environment that develop improvement in manufacturing operational performance. In past, Eletu et al. (2021) mentioned same findings in their study.

Findings also revealed that AI Technology Adoption has positive effect on Mechanical Organization Learning Capability as mentioned in the study of Han et al. (2025). These findings reflect the important role of advanced technologies that strengthen structured learning system within the organization. Opposite to traditional approaches, AI technology adoption enables predictive insights, pattern recognition and real time data processing, that later provide support to development of standardized knowledge systems and formalized procedures. Through AI technology adoption, organizations have the ability to codify learned knowledge into electronic and digital systems. Thus, AI technology adoption makes knowledge easier to disseminate, retrieve and store across operational units.

Furthermore, AI technology adoption improves decision-making accuracy of an employee by providing data driven recommendations and reducing human errors, that reinforces systematic nature of mechanical organization learning capability. As a result of this alignment, learning process within the organization becomes repeatable and consistent. Moreover, AI technology adoption promotes process optimization and automation by allowing organizations to follow best practices in effective way. So, the integration of AI technology provide strength to

mechanical organization learning capability by enabling organization to sustain standardization, efficiency and regular operational refinement.

Results also showed that E-Learning system has positive significant effect on Manufacturing organization Learning Capability (Alzaabi & MALAYSIA, 2021). The significant and positive association between e-learning systems and manufacturing organization learning capability can be explained from the lens of structured capability development and knowledge accessibility. The e-learning system of the organization transforms traditional training into continuously available and interactive learning environment, by allowing workers to get engage with standardized content at the desired pace. It is ensured through this capability that operational knowledge within all employees and departments of organization shared that strengthens manufacturing organization learning capability in all functional areas.

Additionally, e-learning system enables organizations to update training materials rapidly as a result of process changes and technological advancement in manufacturing settings. This capability ensures that organizational learning remains aligned and relevant with the needs of organizations, thus enhancing manufacturing organization learning capability. E-learning system also encourages self-learning of all stakeholders, that improves competence of employees and supports the knowledge accumulation. As employees of organizations interact with regular manner with digital content, the organization develops a more embedded and formalized learning culture, that ultimately reinforces manufacturing organization learning capability.

As per the results, Manufacturing Flexibility has positive effect on Organization Learning Capability as discussed by Awais et al. (2023). Manufacturing flexibility plays very important role to strengthen mechanical organization learning capability by enabling organization to respond to changing market conditions and production requirements. When process integrates manufacturing flexibility, organizations are able to introduce product variations, adjust volumes, and experiment with different production methods without significant disruption. Continuous opportunity of experimental learning and knowledge acquisition are created through this adaptability.

Engaged employee in flexible manufacturing system are likely to develop skills to solve the problems, refine operational practices, and share insights that collectively enhance mechanical organization learning capability. Furthermore, manufacturing flexibility minimizes rigidity in operational routines and allow organizations to transform and absorb new information into actionable knowledge. Cross functional collaboration is also encouraged by it as different team coordinate to manage varying demands of production. Therefore, organizations become proficient to learn from failures and success. So, manufacturing flexibility improves operational responsiveness. Additionally, it also acts as a important antecedent of mechanical organization learning capability by developing environment of knowledge integration and continuous improvement.

Mediating results are also supported in the statistical figures. Results postulate that mechanical organizational learning capability mediates between AI-Technology adoption and manufacturing operational performance. Results suggests that mechanical organizational learning capability has important mediating role to play in translating AI technology adoption into improved manufacturing operational performance. Whereas, AI technology adoption introduces automation, predictive analytics and data processing, its impact on performance may be limited without ability of organization to apply, interpret and absorb such knowledge. mechanical organization learning capability enable organizations to embed learning, standardize processes and AI driven insights into operational practices and routines. This structured learning mechanisms ensures that investment in technology is not under-utilized. In fact, they are transformed into actionable improvement in productivity, quality and efficiency. Furthermore, organizations having strong mechanical learning capability has the ability to align AI outputs with operational goals and reduce implementation errors. So, the mediation effect shows that Ai technology adoption is not enough for improvement in performance. It must be integrated by learning mechanisms to realize improvements in manufacturing operational performance.

Results also suggests that Mechanical organizational learning capability mediates between E-learning system and manufacturing operational performance. The findings show that mechanical learning capability is one of the critical transmission mechanisms by which an e-learning system contributes to manufacturing operational performance. E-learning systems of the organization helps in continuous training, skill development, and knowledge dissemination. Whereas, effectiveness of e-learning system is dependent on the way organization institutionalize the knowledge that is acquired. Mechanical organizational learning capability plays critical role to ensure that information that is collected from the platform of e-learning is codified into standardized workflows, manuals, and procedures. Knowledge loss is minimized through this structured conversion. Furthermore, it also promotes consistency in execution of tasks within the organization. Moreover, e-learning system allows different employees to apply different learning concepts repeatedly in operational setting. Therefore, variability is reduced and process reliability is enhanced. In absence of such learning mechanism, the benefits if e-learning system may remain individual specific and fragmented. Therefore,

the mediating role of enhanced manufacturing operational performance emerges not only from access to digital learning methods, but from the ability of organization to systematically operationalize and embed the knowledge into daily practices.

In the end, findings also demonstrate that Mechanical organizational learning capability mediates between manufacturing flexibility and manufacturing operational performance. In other words, results reveals that mechanical organizational learning capability plays the role of important linkage between manufacturing flexibility and manufacturing operational performance. It is achieved by converting adaptive capacity into outcomes on the regular basis. Although manufacturing flexibility enables the organization to respond quickly to customer requirements, volume and product design, such responsiveness cannot guarantee improved performance alone. Mechanical organization learning capability plays important role to ensure that experiences gained from operations that are flexible are systematically integrated, analyzed and documented into formal procedures. This process minimize ambiguity and convert temporary adjustment into repeatable best practices. Therefore, organizations are in position to stabilize performance despite regular alteration in operations. Furthermore, organizations are able to avoid inefficiencies in presence of structured learning that can be arisen from excessive flexibility, process variation and inconsistency. So, the mediation results of the study shows that manufacturing flexibility improves manufacturing operational performance when it is supported through strong mechanical learning framework that refines and institutionalizes operational knowledge. The mediating role of mechanical organization learning capability is supported by Oyewobi et al. (2021) in past.

6. Limitations and Directions

There are few limitations of the study that are mentioned in present section. This study discusses operational performance as the dependent variable of mechanical organization. It is proposed to extend the model and add the factor of sustainability in the proposed framework. The proposed model of the study is based on IVs, mediator and dependent variable. It is proposed that future studies may add moderating variable, when used by scholars in future studies. Furthermore, questionnaires are developed to collect responses from the respondents in this study. It is proposed that to used mixed methodology and add interviews from the respondents as part of methodology. Also, five-point Likert scale is used in present study to develop questionnaires. It is proposed that future studies may use six-point Likert scale, ranging from 1 to 6 to gather responses from the respondents. In the end, R square value shows that there is need of other variables as well to strengthen the impact of exogenous variables on outcome variables. Therefore, more variables related to technology should be added in future studies.

7. Theoretical and Managerial Contributions

This section highlights the managerial and theoretical contributions of the study. From the lens of theoretical contributions, present study extends the past literature on operations management and organizational learning by introducing mechanical organizational learning capability as important mediating variable. The study also explains the way manufacturing flexibility, e-learning systems and AI technology adoption are converted into enhanced manufacturing operational performance through knowledge integration, process standardization and structured learning. Therefore, existing technology driven and capacity based theoretical framework is enriched.

In terms of managerial contribution, the results shed light that managers of organization should not only rely on flexibility initiatives and technology adoption. Whereas, they should focus in development of mechanical organization learning capability by promoting continuous learning systems, codifying knowledge and formalizing procedures. The results of the study enable organizations to effectively translates flexible practices and technology investment into consistent improvements in manufacturing operational performance.

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