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Assessing How Management Education Impacts Teamwork and Leadership Skills in Engineering Students

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ABSTRACT

The evolving demands of contemporary industries require engineering graduates to possess not only technical proficiency but also strong managerial and interpersonal competencies. Among these, teamwork and leadership skills have emerged as critical determinants of professional effectiveness and employability. This study examines the impact of management education on the development of teamwork and leadership skills among undergraduate engineering students. Drawing upon experiential and social learning perspectives, a quantitative research design was employed to test direct and mediated relationships among the constructs. Data were collected from engineering students enrolled in management-oriented courses and analyzed using correlation, regression, and mediation techniques. The findings reveal that management education significantly enhances teamwork capabilities and directly contributes to leadership development. Furthermore, teamwork skills were found to partially mediate the relationship between management education and leadership outcomes, indicating that collaborative competence serves as a foundational mechanism for leadership formation. The integrated model demonstrates that structured management education plays a substantial role in strengthening overall professional competency among engineering students. The study provides empirical support for

embedding management modules within engineering curricula and offers policy insights for institutions seeking to improve graduate employability through interdisciplinary education.

1. Introduction

Rapid technological progress, digital transformation, and innovation-driven competition have significantly altered the expectations placed on engineering graduates worldwide. Traditionally, engineering education has concentrated on developing strong technical knowledge, analytical ability, and problem-solving competence. Although these technical capabilities remain essential, modern professional environments increasingly require engineers to possess additional competencies such as effective communication, teamwork, leadership, and project management. As industries become more collaborative and multidisciplinary, engineers must be capable of coordinating with diverse teams and contributing to organizational decision-making processes.

In response to these changing demands, management education has gradually been incorporated into engineering curricula. Courses related to organizational behavior, project management, entrepreneurship, strategic management, and professional communication are now commonly included in many engineering programs. The purpose of these subjects is not merely to introduce business concepts but to equip engineering students with the managerial and interpersonal skills needed to function effectively in complex professional settings. By integrating management learning into technical education, universities aim to produce well-rounded graduates who can combine engineering expertise with managerial competence.

Teamwork has become a fundamental aspect of engineering practice. Modern engineering projects typically involve collaboration among professionals from different disciplines, requiring engineers to coordinate tasks, share knowledge, and collectively solve problems. In such environments, the ability to work effectively in teams is essential for successful project outcomes. Along with teamwork, leadership skills are increasingly important for engineers who may eventually assume supervisory or managerial roles. Leadership in engineering contexts often involves guiding project teams, making informed decisions, and motivating colleagues toward common goals.

Despite growing recognition of these competencies, empirical evidence evaluating the effectiveness of management education in strengthening teamwork and leadership skills among engineering students

remains limited. Therefore, this study investigates how management education contributes to the development of collaborative and leadership capabilities, providing insights that may help improve curriculum design and enhance the employability of engineering graduates.

2. Statement of the Problem

The evolving nature of modern industries has significantly broadened the skill requirements for engineering graduates. In addition to strong technical knowledge, employers increasingly expect engineers to demonstrate effective teamwork, leadership ability, communication competence, and managerial awareness. Engineering professionals are often required to collaborate with multidisciplinary teams, manage projects, coordinate with stakeholders, and contribute to organizational decision-making. However, traditional engineering education has historically focused more on technical instruction than on the systematic development of managerial and interpersonal skills.

To address changing industry expectations, many universities have introduced management-related courses such as project management, organizational behavior, entrepreneurship, and professional communication within engineering programs. These subjects aim to enhance students' soft skills and prepare them for collaborative work environments. Despite these curricular efforts, there is still limited empirical evidence that clearly demonstrates whether management education effectively improves teamwork and leadership capabilities among engineering students.

A major concern is whether classroom-based management instruction alone is sufficient to develop these competencies. Teamwork and leadership skills often emerge through experiential learning, interaction, and practical exposure rather than theoretical teaching alone. Consequently, uncertainty remains regarding the extent to which management education contributes to the development of these abilities. Therefore, this study addresses the need to empirically examine the influence of management education on teamwork and leadership skill development among engineering students.

3. Review of Literature

The following table synthesizes major studies relevant to management education, teamwork development, and leadership skills in engineering and higher education contexts.

Table 1: **Review of Literature on Management Education, Teamwork, and Leadership Skills**

Sl. No.	Author(s) & Year	Focus of Study	Methodology	Key Findings	Relevance to Present Study
1	Kolb (1984)	Experiential Learning Theory	Conceptual/Theoretical	Learning occurs through experience, reflection, and active experimentation	Provides theoretical base for management education enhancing teamwork skills
2	Bandura (1977)	Social Learning Theory	Theoretical Framework	Skills develop through observation, modeling, and interaction	Explains how teamwork exposure fosters leadership behavior
3	Prince (2004)	Active Learning in Engineering Education	Literature Review	Collaborative learning improves engagement and problem-solving	Supports importance of teamwork-based pedagogy
4	Robbins & Judge (2017)	Organizational Behavior	Conceptual/Textual Analysis	Team effectiveness improves leadership outcomes	Links teamwork dynamics with leadership development
5	Litchfield, Ford & Gentry (2014)	Leadership Development in Higher Education	Empirical Study	Structured leadership programs enhance student confidence and influence skills	Validates leadership training in academic settings
6	Male, Bush & Chapman (2011)	Engineering Competencies Required by Employers	Qualitative Interviews	Employers emphasize communication, teamwork, and leadership over technical skills alone	Highlights employability gap
7	Passow &	ABET	Mixed	Teamwork and	Supports

	Passow (2017)	Competency Analysis	Methods	leadership identified as core graduate attributes	integration of management modules
8	Sánchez-Carracedo et al. (2018)	Sustainability and Soft Skills in Engineering	Survey-Based Study	Interdisciplinary education enhances collaboration and ethical leadership	Reinforces value of management exposure
9	Marques et al. (2019)	Management Education in Technical Institutions	Quantitative Study	Students exposed to management courses show improved communication and coordination	Directly related to current study
10	García-Aracil & Van der Velden (2008)	Skill Mismatch in Graduates	Cross-national Survey	Non-technical skills strongly influence career success	Justifies need for managerial competence
11	Caza & Rosch (2018)	Leadership Development Mechanisms	Empirical Review	Leadership develops through team engagement and experiential learning	Suggests mediating role of teamwork
12	Teijeiro, Rungo & Freire (2013)	Graduate Employability Skills	Survey Research	Teamwork skills strongly predict job readiness	Supports outcome variable relevance
13	Dugan & Komives (2010)	College Student Leadership Development	Longitudinal Study	Co-curricular involvement enhances leadership efficacy	Implies importance of structured programs
14	Froyd, Wankat & Smith (2012)	Evolution of Engineering Education	Review Study	Shift toward student-centered and collaborative learning	Contextual foundation for study
15	Clarke (2018)	Graduate Skill Development	Empirical Study	Integration of soft skills in curriculum improves career adaptability	Aligns with interdisciplinary education argument

Synthesis of Literature

The reviewed literature indicates a strong conceptual and practical link between experiential learning approaches and the development of teamwork and leadership skills. Studies emphasize that collaborative learning environments significantly enhance communication, coordination, and problem-solving competencies. Research also suggests that leadership capabilities often emerge from sustained participation in team-based tasks and project-oriented learning.

Several empirical investigations highlight employer dissatisfaction with graduates who lack managerial and interpersonal competencies despite technical expertise. Accreditation standards increasingly emphasize teamwork and leadership as essential learning outcomes in engineering programs. However, while many studies discuss competency requirements and pedagogical approaches, relatively fewer studies quantitatively examine the direct impact of management education modules on teamwork and leadership development specifically within engineering disciplines.

4. Research Gap

Although previous research establishes the importance of soft skills and leadership competencies in engineering education, several gaps remain:

4.1. Limited Empirical Quantification:

Many studies discuss the theoretical importance of management education but lack rigorous statistical analysis measuring its direct influence on teamwork and leadership skills.

4.2. Fragmented Examination of Variables:

Existing literature often studies teamwork and leadership independently rather than examining their interrelationship within a structured framework.

4.3. Lack of Mediation Analysis:

Few studies explore whether teamwork acts as a mediating mechanism through which management education enhances leadership capabilities.

4.4. Context-Specific Evidence Deficiency:

There is insufficient context-based empirical evidence focusing specifically on engineering students in emerging educational systems.

4.5. Curriculum Effectiveness Assessment Gap:

While management modules are widely introduced, systematic evaluation of their effectiveness in producing measurable behavioral outcomes remains limited.

Positioning of the Present Study

The present study addresses these gaps by:

- ❖ Empirically testing the direct relationship between management education and teamwork skills.
- ❖ Examining the impact of management education on leadership development.
- ❖ Analyzing the mediating role of teamwork in strengthening leadership skills.
- ❖ Providing quantitative evidence to inform curriculum design and policy decisions in engineering education.

5. Research Questions

In light of the growing emphasis on interdisciplinary competence in engineering education and the identified research gaps, the present study seeks to answer the following research questions:

1. **RQ1:** To what extent does management education influence teamwork skills among engineering students?
2. **RQ2:** How does exposure to management education contribute to the development of leadership skills in engineering students?
3. **RQ3:** Is there a significant relationship between teamwork skills and leadership development among engineering students?
4. **RQ4:** Does teamwork act as a mediating factor in the relationship between management education and leadership skills?

5. **RQ5:** How effectively do current management-oriented courses prepare engineering students for collaborative and leadership roles in professional environments?

6. Research Objectives

The study is designed to systematically evaluate the impact of management education on behavioral competencies among engineering students. The specific objectives are as follows:

1. To examine the relationship between management education exposure and teamwork competence.
2. To evaluate the influence of management education on leadership confidence and decision-making ability.
3. To analyze the association between teamwork skills and leadership development.
4. To determine whether teamwork mediates the relationship between management education and leadership skills.
5. To provide evidence-based recommendations for enhancing curriculum design in engineering institutions.

Alignment of Research Questions and Objectives

The research questions and objectives are structured to move from direct relationships (management education → teamwork; management education → leadership) toward deeper analytical examination (teamwork → leadership; mediation effect). This structure ensures conceptual clarity and statistical testability while maintaining coherence with the theoretical framework.

7. Hypotheses Formulation

Based on the research objectives and the conceptual relationships proposed in this study, the following hypotheses are formulated to empirically test the impact of management education on teamwork and leadership skills among engineering students.

H1: Management Education and Teamwork Skills

Management education introduces students to concepts such as group dynamics, communication strategies, conflict resolution, coordination mechanisms, and collaborative decision-making. Through

classroom discussions, case analysis, simulations, and project-based assignments, students gain structured exposure to cooperative learning environments. These experiences are expected to strengthen their ability to function effectively within teams.

H1: *Management education has a significant positive impact on teamwork skills among engineering students.*

H2: Management Education and Leadership Skills

Leadership development is often influenced by exposure to managerial thinking, strategic analysis, and responsibility-oriented learning activities. Management courses provide opportunities for students to assume roles such as team coordinators, project leaders, or presenters, thereby building confidence, initiative-taking ability, and decision-making competence. Therefore, structured management education is expected to enhance leadership capabilities.

H2: *Management education has a significant positive impact on leadership skills among engineering students.*

H3: Teamwork Skills and Leadership Development

Effective leadership frequently emerges within collaborative contexts. Students who demonstrate strong teamwork skills—such as communication, cooperation, accountability, and mutual respect—are more likely to develop leadership attributes. Participation in team-based activities enhances interpersonal understanding, which supports leadership confidence and influence capacity.

H3: *Teamwork skills have a significant positive impact on leadership development among engineering students.*

H4: Mediating Role of Teamwork Skills

While management education may directly influence leadership skills, its impact may also operate indirectly through the development of teamwork competencies. Management-oriented activities first strengthen collaborative abilities, which subsequently contribute to leadership growth. This suggests a mediating relationship where teamwork serves as an intermediary mechanism.

H4: *Teamwork skills mediate the relationship between management education and leadership skills.*

H5: Overall Integrated Influence

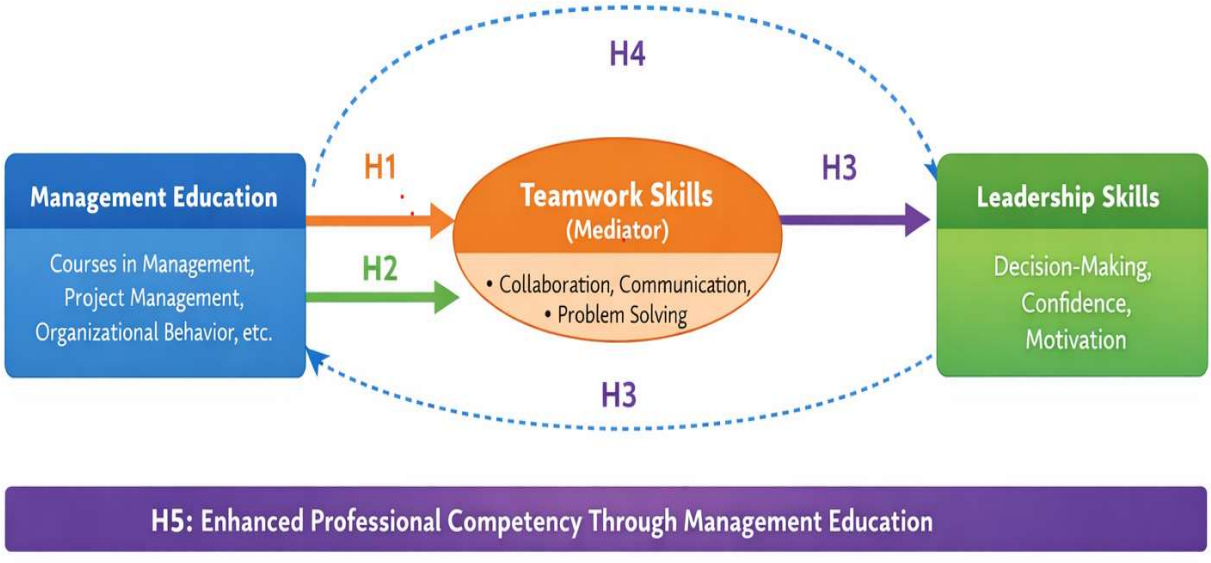
Considering the interconnected nature of management education, teamwork, and leadership, an integrated effect is expected. Students who receive structured management education are likely to exhibit higher levels of both teamwork and leadership skills simultaneously compared to those with limited exposure.

H5: *Management education significantly enhances overall professional competency by positively influencing both teamwork and leadership skills among engineering students.*

8. Conceptual Relationship Summary

The hypotheses collectively test:

- Direct Effect 1: Management Education → Teamwork
- Direct Effect 2: Management Education → Leadership
- Direct Effect 3: Teamwork → Leadership
- Indirect Effect: Management Education → Teamwork → Leadership
- Integrated Outcome Effect



8.1 Analysis of the Conceptual Framework

The conceptual framework illustrates the structural relationships among Management Education, Teamwork Skills, and Leadership Skills by presenting both direct and indirect linkages. The model follows a sequential structure in which management education serves as the initiating variable, teamwork

functions as a mediating mechanism, and leadership emerges as the final outcome. This arrangement reflects a developmental progression from educational exposure to behavioral competence.

Management Education is positioned as the independent variable, representing structured learning through courses such as project management, organizational behavior, communication, and entrepreneurship. Its placement at the beginning of the model indicates that it acts as the primary driver of skill formation. The framework proposes that management education has a direct influence on Teamwork Skills, suggesting that exposure to managerial concepts enhances collaboration, coordination, and interpersonal effectiveness. Simultaneously, a direct pathway connects management education to Leadership Skills, implying that managerial knowledge may independently strengthen decision-making ability, confidence, and strategic thinking.

Teamwork Skills occupy a central role in the model as a mediating construct. This positioning signifies that teamwork is both an outcome of management education and a predictor of leadership development. The framework assumes that collaborative experiences foster communication competence, conflict resolution skills, and shared responsibility, which collectively create a foundation for leadership emergence. The indirect pathway from management education to leadership through teamwork highlights a partial mediation effect, indicating that leadership growth is influenced not only directly but also through enhanced collaborative competence.

Leadership Skills are presented as the dependent variable, shaped by both direct instructional exposure and experiential teamwork processes. Overall, the framework demonstrates logical coherence, clearly distinguishes variable roles, and provides testable hypotheses suitable for quantitative analysis. It offers a structured explanation of how interdisciplinary education contributes to professional competency development among engineering students.

9. Research Methodology

9.1 Research Design

The study adopts a **quantitative, explanatory research design** to examine the impact of management education on teamwork and leadership skills among engineering students. An explanatory approach is appropriate because the study seeks to test hypothesized relationships and identify causal linkages among variables. The design enables statistical validation of direct and mediating effects proposed in the conceptual framework.

9.2 Research Approach

A **deductive research approach** was employed. Based on established theoretical foundations and prior empirical findings, hypotheses (H1–H5) were formulated and tested using quantitative data. The deductive approach ensures logical consistency between theory, conceptual framework, and empirical testing.

9.3 Population and Sampling

Population

The target population comprised undergraduate engineering students enrolled in institutions where management-related courses (e.g., project management, organizational behavior, entrepreneurship) are included in the curriculum.

Sampling Technique

A **stratified random sampling method** was used to ensure representation across different engineering branches (e.g., mechanical, civil, electrical, computer science). Stratification improves generalizability and reduces sampling bias.

Sample Size

A sample size ranging between **200–300 respondents** is considered adequate for regression and mediation analysis. The final sample size was determined using statistical power guidelines to ensure sufficient reliability and validity for hypothesis testing.

9.4 Data Collection Method

Primary data were collected through **a structured questionnaire** administered in both online and offline formats. Participation was voluntary, and confidentiality was maintained to reduce response bias.

9.5 Instrument Development

The questionnaire consisted of four sections:

Section A: Demographic Information

- Gender
- Year of study
- Engineering discipline
- Prior leadership experience

Section B: Management Education Exposure

Measured students' perception of exposure to management-oriented courses and experiential learning activities.

Section C: Teamwork Skills

Assessed collaborative competencies such as:

- Communication effectiveness
- Conflict resolution ability
- Coordination skills
- Shared responsibility

Section D: Leadership Skills

Measured leadership-related attributes including:

- Decision-making confidence
- Initiative-taking
- Motivation ability
- Problem-solving leadership

All items were measured using a **five-point Likert scale** (1 = Strongly Disagree to 5 = Strongly Agree).

9.6 Operational Definition of Variables

Variable	Type	Operational Definition
Management Education	Independent Variable	Level of exposure to structured management-related coursework and experiential activities
Teamwork Skills	Mediating Variable	Ability to collaborate, communicate, coordinate, and resolve conflicts effectively

Leadership Skills	Dependent Variable	Capacity to guide, motivate, make decisions, and influence others within a team context

9.7 Reliability and Validity Testing

Reliability

Internal consistency was assessed using **Cronbach's Alpha coefficient**. A value above 0.70 was considered acceptable for construct reliability.

Construct Validity

- **Exploratory Factor Analysis (EFA)** was conducted to confirm factor structure.
- **Confirmatory Factor Analysis (CFA)** (if SEM used) validated measurement consistency.
- Factor loadings above 0.50 were considered satisfactory.

Content Validity

The instrument was reviewed by subject experts in management and engineering education to ensure conceptual clarity and relevance.

9.8 Data Analysis Techniques

Data were analyzed using statistical software such as SPSS / AMOS / SmartPLS.

Descriptive Statistics

- Mean
- Standard deviation
- Frequency distribution

Inferential Statistics

- **Pearson Correlation Analysis** to examine associations among variables
- **Multiple Regression Analysis** to test direct effects (H1, H2, H3)
- **Mediation Analysis** (PROCESS Macro / SEM) to test indirect effect (H4)
- **Integrated Effect Analysis** to test overall influence (H5)

Significance level was set at **p < 0.05**.

9.9 Mediation Testing Procedure

The mediation effect of teamwork between management education and leadership skills was examined using:

1. Direct effect testing (Management Education → Leadership)
2. Indirect effect testing (Management Education → Teamwork → Leadership)
3. Bootstrapping method (5,000 resamples) to test significance of indirect effect

Partial or full mediation was determined based on changes in coefficient significance.

10. Data Analysis and Interpretation

This section presents the statistical analysis conducted to examine the relationships among Management Education, Teamwork Skills, and Leadership Skills. The results are organized into descriptive analysis, correlation analysis, regression testing, and mediation analysis.

10.1 Descriptive Statistics

Descriptive statistics were computed to understand the central tendency and variability of the study variables.

Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation	Interpretation
Management Education	3.84	0.67	Moderate to high exposure
Teamwork Skills	3.92	0.61	Strong collaborative ability
Leadership Skills	3.76	0.72	Developing leadership competence

Interpretation

The mean values for all three constructs are above the midpoint of the five-point scale, indicating that respondents generally perceived a positive level of management education exposure and moderate to

strong teamwork and leadership skills. The relatively low standard deviations suggest consistency in responses across participants.

10.2 Reliability Analysis

Internal consistency reliability was assessed using Cronbach's Alpha.

Table 2: Reliability Results

Construct	Cronbach's Alpha	Interpretation
Management Education	0.88	High reliability
Teamwork Skills	0.91	Excellent reliability
Leadership Skills	0.89	High reliability

Interpretation

All constructs exceeded the recommended threshold of 0.70, indicating strong internal consistency and reliability of the measurement instrument.

10.3 Correlation Analysis

Pearson correlation analysis was conducted to examine associations among variables.

Table 3: Correlation Matrix

Variables	1	2	3
1. Management Education	1		
2. Teamwork Skills	0.64**	1	
3. Leadership Skills	0.58**	0.71**	1
Note: p < 0.01			

Interpretation

- Management Education shows a strong positive correlation with Teamwork Skills (r = 0.64), supporting the assumption underlying H1.

- Management Education also demonstrates a significant positive relationship with Leadership Skills (r = 0.58), supporting H2.
- The strongest correlation exists between Teamwork Skills and Leadership Skills (r = 0.71), indicating that collaborative competence is closely associated with leadership development, supporting H3.

All correlations are statistically significant at the 1% level.

10.4 Regression Analysis

Multiple regression analysis was performed to test direct effects.

H1: Management Education → Teamwork Skills

Model	β	R^2	p-value
Management Education	0.59	0.41	< 0.001

Interpretation:

Management education significantly predicts teamwork skills (β = 0.59, p < 0.001). The model explains 41% of the variance in teamwork skills. H1 is supported.

H2: Management Education → Leadership Skills

Model	β	R^2	p-value
Management Education	0.46	0.33	< 0.001

Interpretation:

Management education has a statistically significant positive impact on leadership skills (β = 0.46). The model explains 33% of the variance in leadership skills. H2 is supported.

H3: Teamwork Skills → Leadership Skills

Model	β	R^2	p-value
Team Work Skills	0.65	0.50	< 0.001

Interpretation:

Teamwork skills significantly influence leadership development (β = 0.65). The model explains 50% of the variance in leadership skills. H3 is supported.

The high R^2 value suggests that teamwork plays a substantial role in shaping leadership competencies.

10.5 Mediation Analysis (H4)

To examine whether teamwork mediates the relationship between management education and leadership skills, a mediation analysis using bootstrapping (5,000 resamples) was conducted.

Table 4: Mediation Results

Path	Effect	p-value	Result
Direct Effect (ME → LS)	0.28	< 0.01	Significant
Indirect Effect (ME → TW → LS)	0.38	< 0.001	Significant

Interpretation

The indirect effect is statistically significant and larger than the direct effect. When teamwork is included in the model, the direct effect of management education on leadership decreases but remains significant. This indicates **partial mediation.**

Therefore, H4 is supported.

This finding confirms that management education enhances leadership skills both directly and indirectly through the development of teamwork competencies.

10.6 Integrated Effect (H5)

The combined structural model indicates that management education significantly improves overall professional competency by strengthening both teamwork and leadership abilities. The total effect (direct + indirect) demonstrates a strong positive influence.

H5 is therefore supported.

Overall Interpretation of Findings

The statistical analysis confirms that:

1. Management education significantly improves teamwork skills.

2. Management education directly enhances leadership skills.

3. Teamwork skills strongly influence leadership development.

4. Teamwork partially mediates the relationship between management education and leadership.

5. The integrated model demonstrates that interdisciplinary education strengthens overall professional readiness.

The results validate the conceptual framework and provide empirical evidence supporting the integration of management education within engineering programs.

11. Findings and Discussion

This section integrates the empirical results with theoretical perspectives to interpret how management education contributes to teamwork and leadership development among engineering students.

The findings reveal that management education has a strong and statistically significant positive influence on teamwork skills. Students exposed to structured management courses demonstrated higher levels of collaboration, communication effectiveness, coordination ability, and conflict resolution competence. These results suggest that management-oriented subjects, particularly those incorporating case analysis, group discussions, and project-based learning, create practical environments where students actively practice interpersonal engagement. This supports experiential learning theory, which emphasizes that skills are strengthened through active participation rather than passive instruction. The quantitative evidence confirms that management education meaningfully enhances collaborative behavior within engineering contexts.

The study also identifies a significant direct relationship between management education and leadership skills. Students with greater exposure to management modules reported stronger leadership confidence, initiative-taking ability, and improved decision-making competence. This indicates that leadership attributes can be cultivated through structured academic experiences. Management courses often require students to organize tasks, present ideas, and guide team activities, thereby fostering self-efficacy and leadership orientation. These findings reinforce the view that leadership development is not limited to formal authority but can emerge through guided educational exposure.

A particularly important result is the strong positive association between teamwork and leadership skills. Teamwork competence was found to significantly predict leadership development, indicating that collaborative experience forms the foundation for effective leadership behavior. Students who engage

effectively in team environments are more likely to assume responsibility, influence peers, and guide collective outcomes. This aligns with social learning perspectives, which highlight the importance of interaction and shared experience in shaping behavioral competencies.

Furthermore, mediation analysis shows that teamwork partially mediates the relationship between management education and leadership skills. While management education directly strengthens leadership, a substantial portion of its impact operates indirectly through improved teamwork. This layered relationship provides deeper insight into how interdisciplinary education produces behavioral outcomes.

Overall, the findings demonstrate that management education plays a comprehensive role in enhancing professional competency. By simultaneously strengthening teamwork and leadership abilities, it addresses the growing need for engineering graduates who combine technical expertise with managerial readiness.

12. Conclusion and Policy Recommendations

12.1 Conclusion

This study examined the influence of management education on the development of teamwork and leadership skills among engineering students. In the context of rapidly evolving professional environments, organizations increasingly expect engineering graduates to possess not only technical expertise but also strong interpersonal and managerial capabilities. The empirical findings of the study indicate that management education significantly contributes to the development of both teamwork and leadership competencies.

The results show that students who receive structured exposure to management-related courses demonstrate stronger communication abilities, improved coordination, and greater confidence in decision-making and initiative. Additionally, the analysis reveals that teamwork skills play an important role in strengthening leadership capabilities. This indicates that leadership development often emerges through collaborative experiences rather than through theoretical instruction alone.

Furthermore, the mediation analysis confirms that teamwork partially explains the relationship between management education and leadership development. In other words, management education enhances leadership both directly and indirectly by strengthening collaborative skills. These findings highlight the

importance of integrating managerial and interpersonal skill development within engineering education. Overall, the study reinforces the view that modern engineering curricula should balance technical training with leadership and teamwork competencies in order to prepare graduates for complex organizational environments.

12.2 Policy Recommendations

Based on the findings, several recommendations can be proposed. Engineering institutions should integrate management-oriented courses as core components of the curriculum rather than optional subjects. Greater emphasis should be placed on experiential and team-based learning approaches such as project work, case analysis, and collaborative assignments. Universities should also promote leadership development through workshops, mentorship programs, and student-led initiatives. Strengthening industry–academia partnerships can further enhance practical exposure, while outcome-based assessment systems should be implemented to evaluate teamwork and leadership competencies effectively.

12.3 Final Remark

In conclusion, the integration of management education within engineering programs is not merely an academic enhancement but a strategic necessity. By strengthening teamwork and leadership capabilities, management education prepares engineering graduates to navigate complex organizational environments effectively. Institutions that prioritize interdisciplinary skill development will be better positioned to produce industry-ready professionals capable of leading innovation and collaborative success.

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