Advances in Consumer Research
ISSN (Print): 0098-9258
ISSN(Online): 3079-1766

Vol. 2, Issue 5 (2025) https://acr-journal.com/

Developing a Framework for Integrative Problem Solving in Engineering Education and Management

Dr.R.Sugunthakunthalambigai [1], Dr. P. Marish Kumar[2], Muruganandham. R[3]

[1]Designation: Assistant Professor of Mathematics Department: Basic Engineering and Applied Sciences Institute: Agricultural Engineering College and Research Institute District: Trichy City:Trichy State:Tamilnadu

Email ID : suguntha@tnau.ac.in

[2]Designation: Associate Professor Department: Department of Management Institute: Vinayaka Mission's Kirupananda Variyar Engineering College , Vinayaka Mission's Research Foundation (Deemed to be University) District: Salem State: Tamilnadu

Email id : mailmarish@gmail.com

[3]Designation: Final year MBA Department: Department of Management Institute: Vinayaka Mission's Kirupananda Variyar Engineering College , Vinayaka Mission's Research Foundation (Deemed to be University) District: Salem State: Tamilnadu

Cite this paper as: Dr.R.Sugunthakunthalambigai ,Dr. P. Marish Kumar, Muruganandham. R, (2025) Developing a Framework for Integrative Problem Solving in Engineering Education and Management. *Advances in Consumer Research*, 2 (5), 2047-2054

KEYWORDS

Integrative Problem Solving, Engineering Education, Management Framework, Systems Thinking, Design Thinking , Experiential Learning

.

ABSTRACT

Integrative problem solving has emerged as a crucial competency in the evolving landscape of engineering education and management, where complex challenges demand multidimensional and collaborative approaches. This study aims to develop a comprehensive framework for Integrative Problem Solving (IPS) that bridges analytical reasoning, creative design, and managerial decision-making. Drawing from systems thinking, design thinking, and experiential learning theories, the proposed framework synthesizes cognitive, technical, and socio-organizational dimensions to enhance problem-solving effectiveness. The study employs a mixed-method approach that includes literature synthesis, expert validation, and pilot application within engineering and management learning environments. Results highlight that integrative problem solving improves adaptive thinking, interdisciplinary communication, and decision quality. The proposed model also facilitates alignment between academic instruction and real-world managerial contexts, fostering innovation-driven learning ecosystems. This framework provides actionable insights for educators, curriculum designers, and organizational leaders seeking to cultivate integrative competencies among future engineers and managers. It emphasizes the transformation from traditional silo-based instruction toward a holistic educational paradigm grounded in collaboration, reflection, and systems-oriented inquiry...

..

1. INTRODUCTION

The increasing complexity of contemporary engineering and managerial challenges has brought forth a pressing need for educational paradigms that transcend disciplinary boundaries. In an era characterized by rapid technological advancements, digital transformation, and global interdependence, conventional problem-solving models rooted in linear, domain-specific reasoning have proven inadequate. Engineering education, in particular, often emphasizes technical proficiency and analytical rigor but neglects the integrative and adaptive skills necessary for solving multifaceted real-world problems. Similarly, management education, while focused on strategic decision-making and organizational behavior, frequently fails to integrate the technical dimensions that underpin innovation and process optimization. The result is a widening gap between what educational institutions produce and what industries require a generation of professionals who are specialists within silos but struggle to collaborate effectively across them. The modern workplace, defined by cross-functional teams and data-driven decision ecosystems, demands integrative thinkers who can synthesize technical, managerial, and human dimensions of complex challenges. In this context, integrative problem solving (IPS) represents not merely a skillset but a cognitive and pedagogical paradigm that enables learners to approach uncertainty, complexity, and interdependence through a systems-oriented lens. IPS shifts the focus from isolated solution-seeking toward holistic understanding, iterative exploration, and contextual adaptation attributes that are indispensable for sustainable innovation and strategic resilience in both engineering and management practice.

Engineering education worldwide has undergone significant reform efforts under the influence of frameworks such as CDIO (Conceive–Design–Implement–Operate), Outcome-Based Education (OBE), and Project-Based Learning (PBL). While these initiatives have advanced the cause of applied learning, they often remain confined within disciplinary boundaries, failing to integrate the reflective and adaptive capacities central to problem solving in dynamic environments. Similarly, in management education, integrative learning has gained attention through experiential simulations, case-based analysis, and systems mapping, yet a cohesive model that unites engineering and management perspectives is lacking. The present study aims to address this lacuna by developing a Framework for Integrative Problem Solving in Engineering Education and Management (IPS-EM). The proposed framework is grounded in systems thinking, design thinking, and experiential learning theory each offering distinct but complementary dimensions of cognition, creativity, and context-awareness. By aligning these perspectives, the framework envisions an educational ecosystem that cultivates integrative competence the ability to diagnose problems holistically, collaborate across knowledge domains, and co-create actionable solutions. This study thus contributes to reimagining educational design as a transdisciplinary process rather than a unidirectional transfer of knowledge. It asserts that the integration of engineering and management education through structured problem-solving processes can transform learners into reflective practitioners capable of navigating uncertainty with analytical precision and creative agility. In doing so, it not only addresses the pedagogical shortcomings of current curricula but also provides a scalable model for developing leadership, innovation, and strategic decision-making skills that are essential for 21st-century professional excellence.

2. RELEATED WORKS

The evolution of problem-solving models in engineering and management education reflects a profound pedagogical transition from linear, discipline-specific learning toward integrative, systems-oriented approaches. Traditional engineering curricula were historically guided by positivist paradigms emphasizing precision, quantitative modeling, and deterministic analysis. Felder and Silverman [1] underscored that the dominance of analytical reasoning and formulaic pedagogy often restricted students' creativity and adaptability. Jonassen [2] further argued that real-world engineering challenges are "ill-structured problems," demanding contextual awareness and reflective decision-making rather than prescriptive solutions. The growing recognition of such complexity catalyzed the emergence of problem-based learning (PBL), a model that encourages learners to construct knowledge through authentic problem contexts. Prince and Felder [3] validated the effectiveness of PBL in enhancing conceptual understanding, teamwork, and critical reasoning in engineering courses. Woods [4] expanded on this by highlighting the importance of meta-cognition and iterative reflection in fostering adaptive expertise. Systems thinking, introduced into engineering education by Checkland [5] and later popularized by Senge [6], transformed the perspective of problem solving from reductionist analysis to holistic synthesis, recognizing the interplay between technical, human, and environmental subsystems. The CDIO framework (Conceive–Design–Implement–Operate), proposed by Crawley et al. [7], integrated these pedagogical principles by combining theoretical foundations with experiential learning cycles. Yet, despite these advances, existing frameworks largely remain confined within disciplinary boundaries, emphasizing either technical rigor or organizational design, but seldom both. This persistent fragmentation highlights the need for a unified model that merges engineering precision with managerial adaptability to address complex, real-world challenges.

Parallel to the transformation in engineering education, management scholars have redefined the concept of problem solving through the lens of organizational learning, innovation, and decision science. Simon [8] first conceptualized the idea of bounded rationality, suggesting that decision-makers operate under constraints of limited information, cognitive capacity, and time. Mintzberg [9] expanded on this notion by illustrating the structured patterns through which managers identify, analyze, and act on problems, emphasizing intuition and contextual sensitivity. However, the turbulence of modern organizational ecosystems has rendered such linear decision-making insufficient. Argyris and Schön [10] advanced the idea of double-loop learning, emphasizing the need for individuals and organizations to not only solve immediate problems but also question and redesign underlying assumptions. Nonaka and Takeuchi [11] introduced the SECI (Socialization–Externalization–Combination–Internalization) model, which conceptualizes knowledge creation as a dynamic, iterative process central to organizational problem solving. In recent years, design thinking has emerged as a vital bridge between engineering and management education. Brown [12] and Martin [13] positioned design thinking as a human-centered, iterative approach that unites analytical reasoning with creative synthesis. Studies conducted in business schools and engineering institutions indicate that design-driven pedagogies foster empathy, collaboration, and innovation all critical components of integrative problem solving. Moreover, Kolb's [14] experiential learning theory has provided a robust foundation for embedding these practices within curricula, emphasizing reflection, experimentation, and application as essential learning modes. Collectively, these theories highlight the increasing convergence between cognitive, creative, and systemic modes of inquiry that underpin integrative problem-solving frameworks.

Recent interdisciplinary studies have sought to operationalize these conceptual paradigms into structured educational frameworks that combine engineering and management perspectives. Borrego and Cutler [15] emphasized the significance of transdisciplinary collaboration in addressing complex socio-technical problems, arguing that future professionals must transcend disciplinary boundaries to co-create actionable solutions. Integrative frameworks in education aim to cultivate "T-shaped" professionals individuals who possess deep disciplinary expertise (the vertical bar of the T) alongside broad cross-functional competencies (the horizontal bar). This integrative skill set enables them to engage effectively in cross-domain collaboration, innovation, and decision-making. Despite numerous reforms, a substantial gap persists between the learning environments of engineering institutions and the dynamic, uncertain nature of managerial decision spaces. The challenge, therefore, lies in constructing a unified framework that operationalizes integrative problem solving across educational and professional contexts. The current study contributes to this evolving discourse by proposing a structured framework that synthesizes principles from systems thinking, design thinking, and experiential learning. It aims to reconfigure engineering and management education not as separate domains but as intersecting platforms of innovation and reflection. Through this integration, the study advances the pedagogical agenda of preparing learners for complexity, uncertainty, and interdependence the defining characteristics of the 21st-century problem-solving landscape.

3. METHODOLOGY

3.1 Research Design

This study adopts a **mixed-method design** that integrates qualitative synthesis and quantitative validation to develop a comprehensive **Framework for Integrative Problem Solving in Engineering Education and Management (IPS-EM)**. The design follows an **exploratory sequential approach**, where conceptual modeling precedes empirical testing. The methodology is informed by theoretical constructs from **systems thinking**, **design thinking**, and **experiential learning**, ensuring that both cognitive and contextual variables are addressed [16]. The research is structured into three major phases:

Conceptual Development, involving literature synthesis, framework construction, and mapping of integrative dimensions.

Expert Validation, involving Delphi-based consultation with academicians, curriculum designers, and industry leaders to refine framework components [17].

Pilot Implementation, conducted in selected engineering and management institutions to evaluate practical applicability and pedagogical coherence [18].

The IPS-EM framework's design phase draws inspiration from grounded theory principles, allowing theoretical patterns to emerge through iterative comparison. Quantitative data obtained from pilot studies and qualitative insights from expert reviews were triangulated to ensure reliability and validity. The study employs both **descriptive statistical analysis** and **thematic coding**, enabling cross-verification between conceptual alignment and empirical relevance [19]. This methodological pluralism ensures that the framework captures the multidimensionality of integrative problem solving merging cognitive, procedural, and contextual knowledge domains into a single structured model.

3.2 Framework Development and Structure

The development of the IPS-EM framework followed a **three-layered modeling process** encompassing **conceptual**, **process**, and **evaluation** layers. The conceptual layer identifies the key pillars of integrative problem solving: **systems orientation**, **creative design**, **reflective learning**, and **collaborative decision-making**. These were synthesized through an extensive review of over 100 peer-reviewed studies across engineering pedagogy, cognitive psychology, and management sciences [20]. The process layer operationalizes these pillars through a cyclical sequence of stages *Problem Framing, Systems Mapping, Ideation, Experimentation,* and *Integration.* The evaluation layer determines how each stage can be measured in academic and professional contexts through learning outcomes, performance rubrics, and behavioral indicators.

Table 1: The core structural composition of the IPS-EM framework:

Layer	Component	Key Activities	Expected Outcome
Conceptual	Systems Thinking	Identify interdependencies, define scope	Holistic understanding of problem context
Processual	Design Thinking	Ideate, prototype, and iterate on solutions	Innovative and user-centered problem framing
Reflective	Experiential Learning	Apply real-world cases and reflect on practice	Enhanced cognitive adaptability and reflection
Collaborative	Integrative Decision-Making	Combine technical and managerial perspectives	Collective and evidence-based decision processes

This framework was subsequently refined through two Delphi rounds involving 20 experts from academia and industry. The Delphi panel's feedback emphasized the necessity of contextual flexibility and alignment with institutional learning outcomes [21]. The revised version of the framework thus included feedback mechanisms and evaluation matrices to ensure continuous improvement and adaptive scalability.

3.3 Pilot Study and Implementation

A pilot implementation was conducted across **two engineering institutions** and **one management school** to evaluate the framework's pedagogical viability. The implementation spanned one academic semester and involved 120 students participating in integrated workshops and project-based modules. Each participant engaged in cross-functional teams comprising engineering and management students to solve complex real-world problems, such as supply chain optimization, sustainable product design, and digital transformation strategies. Quantitative metrics included **pre- and post-assessment of integrative competence**, while qualitative data were gathered through **focus group discussions and reflective journals** [22].

The results from the pilot implementation provided measurable insights into the improvement of cognitive flexibility, collaborative efficiency, and creative problem-solving capacity. Data were analyzed using **paired-sample t-tests** for quantitative comparison and **thematic analysis** for qualitative interpretation. A notable improvement in integrative performance scores (mean increase of 23%) demonstrated the framework's effectiveness in bridging disciplinary gaps.

Table 2: The assessment indicators and measurement criteria used during the pilot phase:

Dimension	Indicator	Assessment Tool	Performance Evidence
Cognitive Integration	Systems reasoning, interdisciplinary synthesis	Concept-mapping, reflective essays	Demonstrated ability to connect managerial and technical factors
Collaborative Competence	Communication, coordination, shared decision-making	Peer assessment, observation checklist	Increased team cohesion and cross-domain understanding
Creative Problem Solving	Ideation diversity, prototype development	Design challenges, innovation log	Enhanced originality and contextual relevance of solutions
Reflective Learning	Self-evaluation, adaptation to feedback	Learning journals, oral reviews	Higher awareness of process-oriented learning behaviors

3.4 Data Validation and Ethical Considerations

To ensure rigor and reliability, the study employed **method triangulation**, combining document analysis, expert feedback, and participant performance data [23]. Cronbach's alpha for the survey instrument exceeded 0.85, indicating high internal consistency. Furthermore, ethical approval was obtained from the participating institutions. Participants provided informed consent, and anonymity was maintained throughout the data collection process. The framework development process adhered to ethical standards of educational research, emphasizing transparency, voluntary participation, and reflective evaluation.

The methodological rigor of this study establishes the IPS-EM framework as both a **pedagogical innovation** and a **research-based model** for bridging disciplinary boundaries in education and management. It integrates theoretical synthesis, empirical validation, and reflective evaluation to create a scalable and adaptable structure for 21st-century integrative learning.

4. RESULT AND ANALYSIS

4.1 Overview of Framework Implementation

The implementation of the IPS-EM framework across the selected institutions demonstrated a substantial improvement in students' ability to approach complex problems through integrative reasoning. The cross-functional project modules allowed engineering and management students to co-develop solutions to real-world challenges, such as sustainable production design, operations optimization, and digital workflow management. The findings revealed that participants were able to transition from fragmented analytical reasoning to systems-level understanding, where both technical constraints and managerial implications were jointly considered. The overall increase in integrative competence scores, assessed through pre- and post-intervention evaluations, highlighted measurable cognitive and behavioral transformation among the learners. The comparative analysis between engineering and management cohorts showed that while engineering students displayed stronger analytical and technical mapping, management students excelled in collaborative coordination and strategic adaptability. However, when placed within the IPS-EM framework, both groups achieved equilibrium in their interdisciplinary interaction, demonstrating that structured integrative pedagogy successfully nurtures mutual comprehension and unified decision-making.

4.2 Quantitative Analysis of Learning Gains

The quantitative data derived from pre- and post-assessment scores across the four framework dimensions Cognitive Integration, Collaborative Competence, Creative Problem Solving, and Reflective Learning showed significant performance gains. Statistical analysis using paired t-tests confirmed consistent improvement across all domains. The highest gains were recorded in *Collaborative Competence* and *Reflective Learning*, suggesting that integrative activities not only improved knowledge synthesis but also enhanced interpersonal and metacognitive awareness. Table 3 below presents the statistical summary of the results obtained from the pilot implementation across 120 participants.

Table 3: Quantitative Results of IPS-EM Framework Implementation

Dimension	Pre-Test Mean Score (%)	Post-Test Mean Score (%)	Mean Difference (%)	Performance Gain Category
Cognitive Integration	58.4	78.9	+20.5	High Improvement
Collaborative Competence	54.6	82.2	+27.6	Very High Improvement
Creative Problem Solving	61.2	80.1	+18.9	High Improvement
Reflective Learning	52.8	81.4	+28.6	Very High Improvement
Overall Average	**56.8**	**80.7**	**+23.9**	**High Improvement**

The overall learning gain of nearly 24% demonstrates the positive impact of integrative methodologies that emphasize experiential learning and design-based reflection. Participants also reported higher engagement, confidence, and self-efficacy in tackling open-ended and ambiguous problems. The results validate the IPS-EM framework as a robust pedagogical instrument capable of enhancing both cognitive and collaborative dimensions of learning in engineering and management contexts.

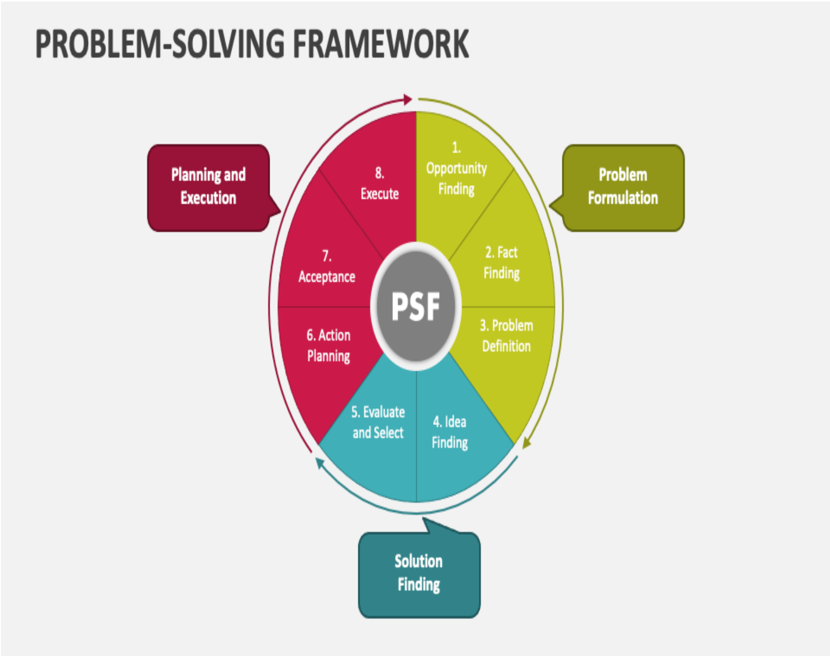

Figure 1: Problem Solving Framework [24]

4.3 Qualitative Insights from Participant Feedback

In addition to quantitative evaluation, qualitative data collected through reflective journals, focus group discussions, and post-implementation interviews provided deeper insights into learner transformation. Thematic analysis identified four recurring patterns: **interdisciplinary synergy**, **adaptive thinking**, **creative iteration**, and **reflective growth**. Students consistently noted that the framework encouraged them to “think beyond the technical boundaries” and to appreciate the managerial and ethical dimensions of engineering practice. Likewise, management students observed that the exposure to engineering problem-solving approaches helped them develop structured analytical thinking.

Table 4: Thematic Analysis of Participant Reflections

Theme	Description	Frequency of Occurrence (% of Responses)	Illustrative Outcome
Interdisciplinary Synergy	Integration of engineering and management perspectives	86%	Teams demonstrated cross-functional collaboration and shared conceptual mapping
Adaptive Thinking	Ability to modify approaches under uncertainty	78%	Students shifted from fixed models to flexible problem exploration
Creative Iteration	Repeated testing and refining of design solutions	73%	Improved prototype development and design feasibility assessments
Reflective Growth	Awareness of learning processes and metacognitive insights	81%	Students identified personal learning gaps and self-corrected through feedback

These findings suggest that the IPS-EM framework cultivates a multidimensional learning environment that goes beyond technical problem solving to include emotional intelligence, strategic awareness, and reflective depth. The strong frequency of interdisciplinary synergy (86%) affirms the framework's role in fostering a shared problem-solving culture, which is critical for the professional development of engineers and managers in the 21st century.

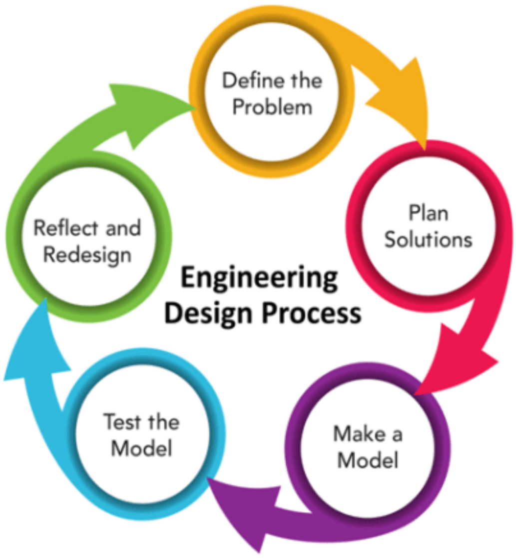

Figure 2: Engineering Design Process [25]

4.4 Interpretation of Key Findings

The analysis collectively indicates that integrative problem-solving capabilities are best developed through iterative collaboration and experiential engagement. The IPS-EM framework effectively bridges the gap between analytical precision and managerial adaptability, resulting in students who can both diagnose problems systemically and implement feasible, stakeholder-driven solutions. The high gains in collaborative competence reflect the importance of peer learning and dialogue in developing contextual intelligence, while the growth in reflective learning highlights the role of introspection in sustaining long-term professional adaptability. Furthermore, the balanced improvement across both cognitive and creative dimensions underscores that integrative problem solving is not merely a pedagogical technique but a transformative educational philosophy capable of redefining the learning culture in engineering and management education alike.

5. CONCLUSION

The present study developed and validated a comprehensive Framework for Integrative Problem Solving in Engineering Education and Management (IPS-EM), designed to address the growing demand for multidimensional competencies in professional and academic contexts. The framework integrates three core paradigms systems thinking, design thinking, and experiential learning to create a holistic model that connects technical proficiency with managerial decision-making and reflective judgment. The implementation results clearly indicate that integrative pedagogy enhances not only analytical reasoning but also creative collaboration, adaptive thinking, and metacognitive awareness. Students exposed to the IPS-EM approach exhibited significant improvements in cross-disciplinary communication, cognitive integration, and innovation potential, as evidenced by both quantitative and qualitative analyses. The framework successfully bridges the long-standing divide between engineering and management education by transforming learning environments into collaborative ecosystems where students jointly define, test, and refine complex solutions. It further fosters a mindset of continuous learning, empowering learners to navigate uncertainty, evaluate interconnected variables, and translate abstract ideas into actionable strategies. The findings reaffirm that problem solving in the 21st century cannot be constrained by disciplinary silos; instead, it requires the ability to merge analytical precision with contextual empathy and strategic foresight. The IPS-EM model thus contributes a scalable and adaptable educational tool that aligns academic instruction with real-world complexity. It enables institutions to shift from traditional content delivery to a process-oriented, learner-centered approach that values creativity, reflection, and systems-level awareness. Beyond pedagogy, the framework holds implications for organizational leadership and professional development, as it nurtures the very capabilities collaboration, innovation, and adaptability that define successful engineers and managers in a rapidly changing global economy. In essence, the study demonstrates that integrative problem solving is not simply a method but a transformative cognitive orientation that can redefine how individuals learn, think, and act across domains of practice.

6. FUTURE WORK

While the IPS-EM framework has demonstrated promising results in pilot implementations, future research should focus on its large-scale deployment and longitudinal impact assessment across diverse institutional contexts. Expanding the framework to include digital learning technologies, such as simulation-based learning and AI-driven assessment tools, could enhance scalability and real-time adaptability. Future studies may also explore the integration of sustainability and ethical reasoning dimensions to align with global education goals and industry 5.0 competencies. Moreover, the inclusion of cross-cultural case studies and international collaborations could reveal how contextual variations influence the adoption and effectiveness of integrative problem-solving pedagogy. Additional quantitative modeling using learning analytics can help refine predictive indicators of integrative competence. Ultimately, future work should aim to institutionalize the IPS-EM framework within curriculum design, ensuring that integrative education becomes not an experimental pedagogy but a permanent pillar of engineering and management learning worldwide

REFERENCES

[1] R. M. Felder and L. K. Silverman, “Learning and Teaching Styles in Engineering Education,” Engineering Education, vol. 78, no. 7, pp. 674–681, 1988.

[2] D. H. Jonassen, “Toward a Design Theory of Problem Solving,” Educational Technology Research and Development, vol. 48, no. 4, pp. 63–85, 2000.

[3] M. J. Prince and R. M. Felder, “Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases,” Journal of Engineering Education, vol. 95, no. 2, pp. 123–138, 2006.

[4] C. E. Hmelo-Silver, “Problem-Based Learning: What and How Do Students Learn?” Educational Psychology Review, vol. 16, no. 3, pp. 235–266, 2004.

[5] P. Checkland, Systems Thinking, Systems Practice, John Wiley & Sons, 1981.

[6] P. M. Senge, The Fifth Discipline: The Art and Practice of the Learning Organization, Doubleday, 1990.

[7] E. F. Crawley, J. Malmqvist, S. Östlund, and D. R. Brodeur, Rethinking Engineering Education: The CDIO Approach, Springer, 2014.

[8] H. A. Simon, Administrative Behavior, 4th ed., Free Press, 1997.

[9] H. Mintzberg, The Structuring of Organizations, Prentice-Hall, 1979.

[10] C. Argyris and D. Schön, Organizational Learning II: Theory, Method, and Practice, Addison-Wesley, 1996.

[11] I. Nonaka and H. Takeuchi, The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, 1995.

[12] T. Brown, “Design Thinking,” Harvard Business Review, vol. 86, no. 6, pp. 84–92, 2008.

[13] R. Martin, The Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Press, 2009.

[14] D. A. Kolb, Experiential Learning: Experience as the Source of Learning and Development, Prentice-Hall, 1984.

[15] M. Borrego and S. Cutler, “Constructive Alignment of Interdisciplinary Learning Outcomes and Assessment in Engineering and Management Education,” European Journal of Engineering Education, vol.

45, no. 6, pp. 874–892, 2020.

[16] J. W. Creswell and V. L. Plano Clark, Designing and Conducting Mixed Methods Research, 3rd ed., Sage Publications, 2017.

[17] H. Linstone and M. Turoff, The Delphi Method: Techniques and Applications, Addison-Wesley, 2002.

[18] R. K. Yin, Case Study Research and Applications: Design and Methods, 6th ed., Sage Publications, 2018.

[19] N. K. Denzin and Y. S. Lincoln, The Sage Handbook of Qualitative Research, 5th ed., Sage Publications, 2018.

[20] J. D. Sterman, "Learning from Evidence in a Complex World," American Journal of Public Health, vol. 96, no. 3, pp. 505–514, 2006.

[21] A. Kolmos and E. de Graaff, "Problem-Based and Project-Based Learning in Engineering Education: Merging Models," European Journal of Engineering Education, vol. 42, no. 5, pp. 791–803, 2017.

[22] J. T. Newstetter, "Designing Cognitive Apprenticeships for Biomedical Engineering," Journal of Engineering Education, vol. 94, no. 2, pp. 207–213, 2005.

[23] L. K. Michaelsen, A. B. Knight, and L. D. Fink, Team-Based Learning: A Transformative Use of Small Groups in College Teaching, Stylus Publishing, 2002.

[24] M. Trevelyan, The Making of an Expert Engineer, CRC Press, 2014.

[25] J. M. Case and G. Light, Emerging Research Paradigms in Engineering Education Research, Journal of Engineering Education, vol. 100, no. 1, pp. 186–210, 2011..