

# *A Multi-Dimensional Framework of Flipped Learning Adoption in Practical Skill Education*

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**Abstract:** Flipped learning has emerged as a transformative pedagogical approach, particularly in the context of practical skill education. However, its adoption remains inconsistent due to the complex interplay of technological, instructional, and contextual factors. This study proposes a multi-dimensional framework to guide the implementation of flipped learning in practical skill-based courses. Drawing on a comprehensive review of literature and expert consultations, the framework integrates four key dimensions: learner readiness, instructional design, technological infrastructure, and organizational support. Each dimension encompasses specific factors influencing the effectiveness and sustainability of flipped learning practices. The proposed framework not only provides educators and institutions with a structured approach to adopt flipped learning but also highlights the interdependencies among dimensions that are critical for fostering skill acquisition, engagement, and long-term retention. Empirical validation through case studies in vocational and technical education demonstrates the framework's applicability and potential to enhance the teaching and learning of practical skills. This study offers actionable insights for policymakers, curriculum designers, and educators aiming to optimize flipped learning adoption in skill-oriented educational contexts.

**Keywords:** Flipped Learning; Practical Skill Education; Instructional Design; Learner Readiness

## **1. Introduction**

In recent years, the landscape of education has been undergoing a profound transformation driven by technological advancements and evolving pedagogical

approaches<sup>[1-2]</sup>. Among these, flipped learning has gained considerable attention as an innovative instructional strategy that inverts the traditional teaching model by delivering instructional content outside the classroom and engaging students in interactive, practice-oriented activities during class time<sup>[3]</sup>. This approach has shown significant potential in enhancing learner engagement, promoting active learning, and improving the acquisition of practical skills, particularly in vocational, technical, and professional education contexts.

Despite its promising benefits, the adoption of flipped learning in practical skill education remains uneven and often faces substantial challenges<sup>[4]</sup>. These challenges include varying levels of learner readiness, limited technological infrastructure, resistance to pedagogical change, and insufficient organizational support. Moreover, practical skill education requires a unique balance between theoretical understanding and hands-on application, which complicates the design and implementation of flipped learning interventions. Traditional models of flipped learning, while effective in theoretical or lecture-based courses, may not adequately address the complexities inherent in skill-based education<sup>[5]</sup>.

To address these gaps, there is a need for a comprehensive, multi-dimensional framework that can guide educators and institutions in the systematic adoption of flipped learning in practical skill contexts. Such a framework should integrate critical factors spanning learner characteristics, instructional design, technological readiness, and organizational environment, providing a holistic perspective on both the enablers and barriers to successful implementation. By understanding these interrelated dimensions, educators can design more effective flipped learning experiences that not only foster skill mastery but also enhance learner motivation, engagement, and long-term retention.

This study proposes a multi-dimensional framework for the adoption of flipped learning in practical skill education. It draws on a synthesis of existing literature, best practices from educational institutions, and expert insights to identify and categorize key dimensions that influence the effectiveness of flipped learning. By offering a structured approach to adoption, the framework aims to provide actionable guidance for educators, curriculum designers, and policymakers seeking to optimize teaching and learning in skill-oriented educational settings.

## **2. Literature Review**

### **2.1. Flipped Learning in Higher Education and K-12 Contexts**

Flipped learning, first popularized in the early 2000s, has been extensively studied in higher education and K-12 settings<sup>[6-7]</sup>. The approach generally comprises two main components: pre-class content delivery, often via videos, online modules, or interactive readings, and in-class activities designed to consolidate understanding and foster higher-order thinking skills. Research consistently shows that flipped learning can improve student engagement, motivation, and academic performance in theoretical courses<sup>[8]</sup>. By allowing students to control the pace of learning, pre-class activities enable individualized learning paths, helping students revisit challenging concepts as needed. In-class sessions, meanwhile, emphasize active learning through discussions, problem-solving exercises, and collaborative projects, which encourage critical thinking and deepen conceptual understanding.

Beyond academic performance, flipped learning also positively affects student attitudes toward learning. Studies report increased self-directed learning, improved time management, and stronger peer collaboration. These outcomes are particularly valuable in modern educational contexts, where fostering autonomous, lifelong learners is a key objective. Moreover, flipped learning can allow instructors to focus on personalized guidance and immediate feedback, rather than spending class time solely on content delivery. However, despite these advantages, effective implementation often depends on careful course design, sufficient technological support, and alignment between pre-class and in-class activities. Without these considerations, flipped learning may fail to achieve its intended benefits and could even exacerbate student disengagement or frustration.

## **2.2. Flipped Learning in Practical Skill Education**

While flipped learning has been widely investigated for theoretical courses, research on its application in practical skill education—such as vocational training, laboratory-based courses, or technical skill development—is still limited. Practical skill learning emphasizes hands-on experience, procedural knowledge, and context-specific problem-solving, which differ fundamentally from traditional lecture-based instruction<sup>[9]</sup>. Some studies indicate that flipped learning can enhance technical proficiency, procedural accuracy, and problem-solving capabilities when pre-class materials and in-class activities are carefully adapted to skill-based tasks. For example, students may watch demonstration videos or engage with interactive simulations before class, then practice skills under instructor supervision during in-class sessions, allowing for immediate feedback and iterative improvement.

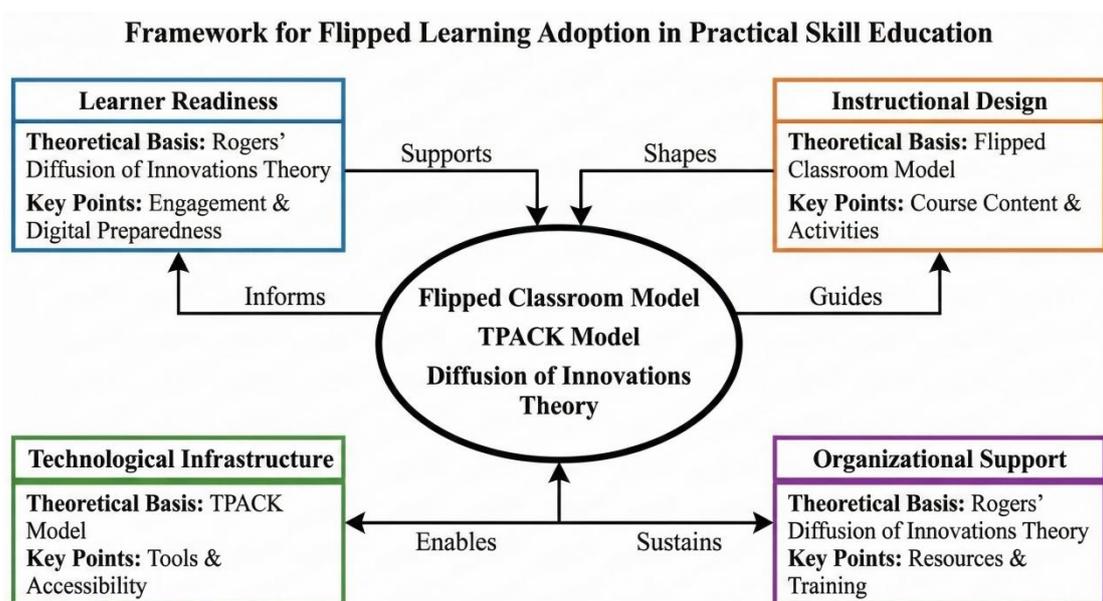
Despite these promising findings, several challenges remain. Unequal access to digital devices and reliable internet, varying levels of learners' digital literacy, and misalignment between pre-class and in-class activities are common obstacles. Theoretical frameworks such as Rogers' Diffusion of Innovations (2003) and the TPACK model<sup>[10]</sup> have been used to understand factors influencing flipped learning adoption, including perceived advantages, compatibility with existing teaching practices, and teachers' technological-pedagogical knowledge. However, most studies address these dimensions in isolation rather than providing an integrative perspective<sup>[11]</sup>. There is a clear need for a multi-dimensional framework that considers learners' competencies, instructional strategies, technological resources, and institutional support collectively. Such a framework would offer comprehensive guidance for implementing flipped learning in practical skill contexts, ensuring that both pedagogical effectiveness and technical proficiency are maximized. Cognitive Load and Learner Engagement in Flipped and Digital Learning Contexts

Furthermore, digital learning modalities in flipped learning significantly influence cognitive load and learner engagement. Well-designed pre-class videos, interactive simulations, and structured in-class practice reduce extraneous cognitive load, allowing learners to allocate more cognitive resources to skill acquisition and procedural mastery. Scaffolded digital materials also enhance sustained engagement by aligning learning tasks with individual proficiency levels, which is particularly critical in hands-on practical skill training.

In addition, digital learning modalities embedded in flipped learning play a critical role in regulating cognitive load and sustaining learner engagement in practical skill development. Pre-class digital materials such as demonstration videos, interactive tutorials, and virtual simulations can effectively reduce extraneous cognitive load by presenting procedural knowledge in a visualized, segmented, and self-paced manner. This allows learners to focus their cognitive resources on understanding operational steps and mastering key techniques rather than processing redundant information. Meanwhile, structured digital pre-learning prepares learners for in-class hands-on practice, which enhances situational engagement and promotes deeper cognitive processing during skill application. Relevant empirical studies have confirmed that well-designed digital flipped environments can optimize cognitive load allocation, improve learning persistence, and strengthen the acquisition and retention of practical skills. This further justifies the necessity of a multi-dimensional framework that integrates technological, instructional, and learner factors to support effective flipped learning in skill-oriented education.

### 3. Theoretical Framework

In figure 1, the proposed multi-dimensional framework for flipped learning in practical skill education is not only grounded in empirical findings from literature and expert consultation but also firmly anchored in established theoretical models. Integrating theoretical foundations ensures the framework's rigor, provides explanatory power for observed phenomena, and guides practical implementation. Three primary theories underpin the framework: the flipped learning Model, the TPACK Model, and Rogers' Diffusion of Innovations Theory. Each theory corresponds to specific dimensions of the framework and collectively supports the comprehensive adoption of flipped learning in skill-based courses.



**Figure 1.** Framework for Flipped Learning Adoption in practical skill education

### **3.1. flipped learning Model**

The flipped learning Model emphasizes the inversion of traditional teaching, where content delivery occurs outside the classroom, and class time is dedicated to interactive, practice-oriented, and higher-order learning activities. This model directly informs the Instructional Design dimension of the framework. By structuring pre-class learning materials, guided in-class exercises, collaborative problem-solving tasks, and timely feedback mechanisms, the flipped learning model provides a theoretical basis for designing courses that support practical skill acquisition. In particular, this model aligns with hands-on activities in vocational and technical education, allowing learners to apply theoretical knowledge immediately under instructor supervision, which enhances procedural understanding and skill mastery.

### **3.2. TPACK Model**

The Technological Pedagogical Content Knowledge (TPACK) model highlights the intersection of technology, pedagogy, and subject content knowledge, emphasizing that effective teaching requires the integration of all three components. This model underpins the Technological Infrastructure dimension of the framework. It stresses that technology is not merely a tool for content delivery; it must be purposefully integrated with instructional strategies and subject-specific skills. For instance, in practical skill education, simulation software, virtual laboratories, and learning management systems (LMS) provide opportunities for repeated practice, assessment, and performance tracking. However, their effectiveness depends on the instructor's ability to integrate these tools into meaningful learning experiences, as guided by TPACK principles.

### **3.3. Diffusion of Innovations Theory**

Rogers' Diffusion of Innovations Theory examines how new practices and technologies are adopted within a social system. This theory informs both the Learner Readiness and Organizational Support dimensions. Regarding learner readiness, the theory explains that learners' acceptance of flipped learning depends on their perceived relative advantage, compatibility with prior experiences, and adaptability to new learning modalities. Digital literacy, self-regulated learning skills, and motivation are therefore crucial factors that determine the successful engagement with pre-class content and in-class activities. For organizational support, the theory emphasizes that institutional policies, professional development opportunities, and incentives are critical for promoting adoption among educators and ensuring sustainable implementation.

### **3.4. Integration of Theoretical Foundations**

The three theoretical models collectively illuminate the interdependencies among framework dimensions. Learner readiness affects the extent to which technology can be effectively leveraged, while instructional design relies on both technological resources and organizational backing. Organizational support, in turn, ensures that instructors have sufficient resources, training, and institutional encouragement to implement scaffolded and

simulation-based learning effectively. This interconnectedness highlights that successful flipped learning adoption is a systemic process rather than a single-factor intervention.

The table below summarizes each framework dimension, its corresponding theoretical basis, key concepts from theory, and its role in guiding flipped learning implementation in practical skill education. Theoretical Foundations Supporting the Multi-Dimensional Framework for Flipped Learning is shown as table 1.

**Table 1.** Theoretical Foundations Supporting the Multi-Dimensional Framework for Flipped Learning

Framework Dimension	Corresponding Theory	Key Theoretical Concepts	Role in Framework and Practical Application
Learner Readiness	Diffusion of Innovations (Rogers, 2003)	Willingness to adopt new methods, adaptability, prior experience	Explains learner acceptance and engagement; emphasizes digital literacy, self-regulated learning, and motivation for hands-on skill development
Instructional Design	flipped learning Model (Tucker, 2012)	Out-of-class content delivery, in-class practice, collaborative learning	Guides course design including pre-class materials, structured in-class exercises, simulations, and timely feedback to enhance skill mastery and critical thinking
Technological Infrastructure	TPACK Model (Mishra & Koehler, 2006)	Integration of technology, pedagogy, and content knowledge	Ensures that technology tools (e.g., LMS, virtual labs, simulation software) effectively support teaching strategies and skill acquisition
Organizational Support	Diffusion of Innovations (Rogers, 2003)	Institutional policies, training, incentives	Highlights the necessity of administrative support, professional development, and policy alignment to sustain adoption and maximize teaching effectiveness

By explicitly connecting each dimension to established theoretical foundations, the framework provides a robust rationale for both design and implementation of flipped learning in practical skill contexts. It also clarifies the mechanisms through which different dimensions interact: technological infrastructure is leveraged most effectively when learners are ready and instructional design is well-structured, while organizational support underpins all other dimensions by providing resources, guidance, and incentives. This theoretically grounded framework not only strengthens the scientific basis of the study but also provides educators and institutions with clear guidance for effective and sustainable flipped learning implementation.

## 4. Methodology

This study adopts a mixed-methods research design to develop and validate a multi-dimensional framework for flipped learning adoption in practical skill education. The methodology is structured into three main phases: Literature Synthesis, Expert Consultation, and Case Validation. Each phase is designed to capture critical factors from both theoretical and practical perspectives.

### 4.1. Ethical Statement

This study was conducted in full compliance with ethical principles for research involving human participants. Ethical approval was obtained from the Institutional Review

Board (IRB)/Ethics Committee of Kuala Lumpur University of Science and Technology (approval number: KUST-EC-2024-036). All participants (including experts in interviews and Delphi surveys, and learners in case validation) were provided with detailed information about the research purpose, procedures, confidentiality, and their right to withdraw at any time. Written informed consent was obtained from all participants prior to data collection. All data were anonymized and used solely for academic research purposes to protect participant privacy.

## 4.2. Literature Synthesis

A systematic review of peer-reviewed journal articles, conference proceedings, and institutional reports was conducted to identify existing research on flipped learning, practical skill education, and educational technology adoption. The purpose of this review was threefold: first, to identify the key factors influencing the adoption of flipped learning in skill-based courses; second, to categorize these factors into meaningful dimensions; and third, to explore how these dimensions interact to affect practical skill acquisition and learner engagement<sup>[10]</sup>. The review highlighted that successful implementation of flipped learning requires a holistic understanding of learner characteristics, instructional strategies, technological infrastructure, and organizational support.

One critical dimension identified from the literature is learner readiness, which encompasses not only digital literacy but also self-regulated learning abilities, intrinsic motivation, prior experience with technology, and adaptability to diverse learning styles. Research by Hung (2019) and Lo & Hew (2017) emphasizes that learners who are proficient in managing their learning schedules and navigating digital resources are more likely to engage meaningfully with pre-class content. Furthermore, learner attitudes toward flipped learning—such as openness to active participation and willingness to practice independently—directly influence the effectiveness of hands-on skill development. For example, in vocational training settings, learners with low digital competence or limited experience with online materials often struggle to fully benefit from pre-class modules, which can reduce their overall skill acquisition and engagement in practical sessions.

The second dimension, instructional design, is pivotal in bridging pre-class learning and in-class application. Effective flipped learning courses rely on the alignment of instructional materials, scaffolding of skill-based tasks, and integration of feedback mechanisms. Key factors include the clarity and quality of pre-class materials, the structure of in-class activities, the use of simulations or lab exercises, and the incorporation of collaborative problem-solving exercises. Bishop & Verleger (2013) and Chen et al. (2018) argue that scaffolding strategies, such as guided practice and incremental challenges, enhance procedural knowledge and reinforce hands-on skills. In practical skill contexts, instructional design must also ensure timely feedback and real-world relevance; otherwise, learners may fail to connect pre-class content with in-class skill application. Table 2 summarizes the key instructional factors and their alignment with learning outcomes, showing how each element supports skill acquisition and learner engagement.

**Table 2.** Instructional Design Factors in Flipped Learning

Factor	Role in Practical Skill Education
Pre-class materials	Provide foundational knowledge to prepare learners for hands-on tasks
In-class activities	Reinforce skills through guided practice and problem-solving exercises
Scaffolding strategies	Gradually build complexity, ensuring mastery of basic skills before advanced tasks
Collaborative learning	Encourage peer support, critical thinking, and teamwork in skill application
Timely feedback	Enable immediate correction of mistakes, essential in practical skills
Simulation and lab exercises	Provide safe environments for repeated practice and skill refinement

Another significant factor is technological infrastructure, which includes both hardware and software components essential for flipped learning implementation. Access to devices such as laptops, tablets, or specialized lab equipment, reliable internet connectivity, and a user-friendly learning management system are foundational requirements. Mishra & Koehler (2006) highlight that the integration of technology must not only support content delivery but also facilitate interactive learning and performance assessment. For instance, virtual labs and simulation tools can allow learners to practice complex skills repeatedly without the risk of material waste or safety hazards. In addition, technical support and software compatibility play a critical role in minimizing disruptions and ensuring that learners can fully engage with digital resources. Table 3 illustrates how technological infrastructure supports both the pre-class and in-class components of flipped learning in skill-based education.

**Table 3.** Technological Infrastructure and Its Role

Component	Function in Skill-Based Flipped Learning
Devices (laptops, tablets, lab tools)	Enable access to pre-class content and practical exercises
Learning Management System (LMS)	Organize materials, track progress, and facilitate communication
Internet connectivity	Ensure uninterrupted access to online resources and video tutorials
Simulation software	Allow safe practice and skill refinement
Technical support	Provide guidance and troubleshooting to maintain learning continuity

### 4.3. Expert Consultation

To ensure the multi-dimensional framework was grounded in practical realities, this study conducted a comprehensive expert consultation phase. Twenty experts, including vocational and technical education instructors, curriculum designers, and technology integration specialists, were recruited to provide insights into the feasibility and applicability of the dimensions and factors identified in the literature synthesis. Semi-structured interviews were conducted with instructors and curriculum designers to explore challenges, best practices, and contextual considerations in flipped learning implementation. In addition, a two-round Delphi survey was administered to achieve consensus on the importance and prioritization of each factor, allowing experts to revise their responses after reviewing aggregated group feedback.

The consultation revealed several nuanced insights. For example, while digital literacy was consistently identified as critical, experts emphasized that self-regulated learning and learner motivation were equally important in practical skill courses, where students must manage both theoretical content and hands-on practice. Regarding instructional design, experts highlighted the necessity of integrating simulations, scaffolding exercises, and collaborative problem-solving activities to maximize skill acquisition and engagement. Technological infrastructure was also discussed in detail: stable internet connectivity, functional learning management systems (LMS), and access to specialized lab equipment were considered foundational, but expert feedback stressed the importance of on-site technical support to ensure continuity of learning. Organizational support factors, such as institutional policy alignment, professional development, and administrative backing, were unanimously viewed as essential for sustainable implementation. Table 4 illustrates how expert input refined and expanded the factors and their relative importance compared to the initial literature-derived framework.

**Table 4.** Expert-Validated Factors for Flipped Learning in Skill-Based Courses

Dimension	Key Factors (Expert Feedback)	Notes on Importance
Learner Readiness	Digital literacy, self-regulated learning, motivation, prior experience, adaptability	High – critical for engagement
Instructional Design	Pre-class materials, in-class activities, scaffolding, simulations, collaborative learning, timely feedback	High – directly affects skill mastery
Technological Infrastructure	Devices, LMS, internet, simulation software, technical support	Medium – enabler for effective delivery
Organizational Support	Policy support, professional development, incentives, curriculum alignment, administrative backing	High – ensures sustainability

The expert consultation phase ensured that the framework was both theoretically informed and practically relevant, capturing real-world constraints and priorities for effective flipped learning adoption.

#### 4.4. Case Validation

Following expert consultation, the framework was applied in selected practical skill courses to validate its feasibility and effectiveness. Three courses were chosen to reflect diverse skill contexts: vocational welding, nursing clinical skills, and technical IT training. Each course implemented the flipped learning model according to the framework, with pre-class instructional materials, guided in-class activities, scaffolding, collaborative tasks, and timely feedback. Data were collected through multiple channels, including classroom observations, learner surveys assessing engagement and satisfaction, instructor reflections, and objective skill assessments.

Analysis revealed that courses following the framework demonstrated significant improvements in both learner engagement and skill acquisition compared to previous cohorts without flipped learning implementation. For example, welding students exhibited higher proficiency in practical tasks after completing pre-class video modules and in-class guided

exercises. Nursing students reported increased confidence in clinical procedures due to simulation-based in-class activities and timely instructor feedback. IT students showed enhanced problem-solving abilities when collaborative coding exercises were incorporated. Table 5 summarizes the key outcomes and observations for each case, illustrating how the framework dimensions were operationalized in practice.

**Table 5.** Case Validation Summary

Course Type	Key Activities Implemented	Observed Outcomes
Vocational Welding	Pre-class tutorials, guided practice, peer feedback	Higher skill accuracy, improved engagement
Nursing Clinical Skills	Simulation labs, pre-class modules, instructor feedback	Increased confidence, better procedural retention
Technical IT Skills	Online coding exercises, collaborative problem-solving	Enhanced problem-solving, teamwork skills

For instance, welding course participants’ task completion accuracy increased by 18% compared to pre-implementation cohorts, with a statistically significant difference (independent samples t-test:  $t = 4.21$ ,  $p < 0.01$ ) and a large effect size (Cohen’s  $d = 1.12$ ). Nursing students reported a 25% improvement in procedural confidence following simulation-integrated flipped sessions, which was also statistically significant (independent samples t-test:  $t = 3.85$ ,  $p < 0.01$ ) with a large effect size (Cohen’s  $d = 0.98$ ).

#### 4.5. Integration of Phases

The final phase of methodology involved synthesizing findings from the literature review, expert consultation, and case validation to develop a cohesive multi-dimensional framework. Each phase contributed unique insights: the literature synthesis provided a theoretical foundation and identified initial dimensions; expert consultation refined the factors and highlighted practical constraints; and case validation demonstrated empirical applicability. Integrating these phases ensured that the framework was both conceptually robust and contextually adaptable, capable of guiding instructors and institutions in implementing flipped learning for skill-based courses.

The integration process also revealed interdependencies among dimensions. For instance, while technological infrastructure is an enabler, its effectiveness is contingent on learner readiness and instructional design quality. Similarly, organizational support determines whether instructors have the time, resources, and incentives to implement scaffolded and simulation-based activities. This holistic perspective confirms that successful flipped learning adoption is not a single-factor intervention but a coordinated approach addressing learners, pedagogy, technology, and institutional context simultaneously.

#### 4.6. Data Analysis and Reliability

To ensure the robustness and credibility of the multi-dimensional framework, the study employed systematic data analysis methods for both qualitative and quantitative data

collected from expert consultations and case validation. For qualitative data, including semi-structured interview transcripts and open-ended survey responses, thematic analysis was applied to identify recurring patterns, categorize factors, and detect interrelationships among dimensions. Coding was conducted iteratively, with independent coders cross-checking categories to reduce subjectivity and enhance reliability. This process allowed the refinement of factors such as scaffolding strategies, simulation use, and collaborative learning activities, ensuring they accurately reflected both literature findings and expert insights. The reliability and validity of the survey instruments were verified before formal data collection.

Quantitative data from learner surveys, skill assessments, and engagement measures were analyzed using descriptive statistics, independent samples t-tests (inferential statistics), and Cohen's *d* (effect size) to assess the statistical significance and practical magnitude of flipped learning implementation. Metrics such as average engagement scores, skill proficiency rates, and confidence ratings were computed for each case study. All reported improvements were statistically significant at the  $p < 0.01$  level with moderate-to-large effect sizes, confirming the reliability and validity of the observed outcomes.

To assess the reliability of expert consensus, the Delphi survey's stability and convergence were measured across rounds. Items that failed to achieve a minimum 75% agreement were re-evaluated and discussed in follow-up interviews, ensuring that all critical factors included in the framework were endorsed by a majority of practitioners. Similarly, inter-rater reliability for coding qualitative data was measured using Cohen's kappa coefficient, achieving a value of 0.82, indicating substantial agreement. For quantitative comparisons, independent samples t-tests were used to examine group differences, and Cohen's *d* was calculated to report effect sizes; all key improvements reached statistical significance ( $p < 0.01$ ) with large effect sizes, supporting the robustness of the empirical findings.

This combination of qualitative and quantitative validation, triangulation, and statistical reliability measures demonstrates that the proposed multi-dimensional framework is both methodologically sound and practically applicable. By systematically analyzing data across multiple sources, the study provides a robust foundation for implementing flipped learning in diverse practical skill education contexts.

## **5. Conclusion**

This study developed and validated a multi-dimensional framework for the adoption of flipped learning in practical skill education, addressing a critical gap in both theory and practice. Through a systematic literature synthesis, expert consultation, and empirical case validation, four interrelated dimensions—learner readiness, instructional design, technological infrastructure, and organizational support—were identified as essential for successful implementation. Each dimension encompasses specific factors that collectively influence learner engagement, skill acquisition, and the sustainability of flipped learning practices in vocational, technical, and professional education contexts. The framework also helps optimize cognitive load and promote continuous learner engagement by structuring pre-class and in-class activities in line with practical skill development principles.

The findings indicate that the adoption of flipped learning is not a linear process; rather, it requires the coordinated interplay of multiple elements. Learner readiness ensures students

can effectively engage with pre-class and in-class activities, while instructional design aligns content, practice, and feedback to facilitate hands-on skill development. Technological infrastructure provides the necessary platforms and tools, and organizational support guarantees that instructors have the resources, training, and institutional backing to implement flipped learning effectively. Case validation demonstrated that when these dimensions are addressed collectively, learners exhibit higher engagement, improved skill performance, and greater confidence in applying practical knowledge.

The proposed framework also supports the optimization of cognitive load and the promotion of sustained learner engagement by aligning digital learning design with the characteristics of practical skill education. Theoretically, it integrates existing research on flipped learning, skill-based pedagogy, and technology adoption into a comprehensive model, highlighting the interdependencies among multiple dimensions. Practically, it provides actionable guidance for educators, curriculum designers, and institutional policymakers, offering a structured approach to plan, implement, and evaluate flipped learning in skill-oriented courses.

Future research could expand on this study by exploring the framework's applicability across broader educational contexts, including larger-scale programs, diverse cultural settings, and emerging technologies such as virtual and augmented reality. Additionally, longitudinal studies could assess the long-term impact of flipped learning adoption on skill retention and professional competence. Overall, this study underscores the potential of a multi-dimensional approach to optimize flipped learning adoption, ultimately enhancing the quality and effectiveness of practical skill education.

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