

# From Classroom to Online Learning during the COVID-19 Transition in Thailand: A Mixed-Methods Study of Pedagogical Transformation and Digital Resilience in Science-Based Faculties

Piyachat JITTAM<sup>a</sup>, Namkang SRIWATTANAROTHAI<sup>a</sup>,  
Watcharee KETPICHAINARONG<sup>a</sup>, Pirom CHENPRAKHON<sup>a</sup>,  
Chailerd PICHITPORNCHAI<sup>a\*</sup>

<sup>a</sup>*Institute for Innovative Learning, Mahidol University, Nakhonpathom Province, Thailand*

\*Corresponding author: [chailerd.pit@mahidol.ac.th](mailto:chailerd.pit@mahidol.ac.th)

Received: November 6, 2025; Revised: December 12, 2025; Accepted: December 19, 2025

**Abstract:** The transition from classroom to online learning has reshaped higher education, offering greater flexibility while presenting new challenges for teaching and learning. This study examines how a Thai university adapted its pedagogical practices across four science-based faculties—Medicine, Science, Engineering, and Information and Communication Technology—using a large-scale mixed-methods approach. This study employed a convergent parallel mixed-methods design, in which quantitative and qualitative data were collected simultaneously, analyzed separately, and integrated during interpretation. The study analyzed 320,856 student grading records alongside surveys and interview data from 324 students and 18 instructors. Although statistically significant differences were observed ( $p < 0.001$ ), the effect sizes were extremely small ( $d \approx 0.04$ ), indicating no practically meaningful differences in academic performance between classroom and online modes. In contrast, qualitative evidence highlighted notable contrasts in student motivation, interaction, and engagement. Students appreciated the flexibility and accessibility of online learning but also reported reduced social connection and limited hands-on experience. Three factors—learning motivation, social interaction, and learning environment readiness—were identified as predictors of academic performance ( $R^2 = 0.28$ ) and were also associated with perceived learning experiences. Using the Community of Inquiry (CoI) and Technological Pedagogical Content Knowledge (TPACK) frameworks, the study interprets the transition by linking student learning experiences with instructors' pedagogical design, positioning the shift as both a pedagogical transformation and a process of institutional learning toward digital resilience. This study offers an integrated perspective on how pedagogical adaptation and institutional learning contribute to digital resilience.

**Keywords:** Community of inquiry, TPACK, digital resilience, higher education, mixed methods, online learning

## Introduction

Higher education around the world is experiencing a major shift in how learning is designed, delivered, and supported. The growing integration of digital technologies has blurred the lines between classroom and online instruction, creating new opportunities for flexibility, accessibility, and learner autonomy. At the same time, this transformation exposes the limits of traditional teaching models that rely heavily on physical presence and synchronous interaction. Understanding how institutions and learners adjust to these changes is crucial for building sustainable and innovative learning environments.

The COVID-19 pandemic accelerated this shift by pushing institutions at all levels to adopt online or hybrid learning models almost overnight. This rapid transition changed the ways students learn, develop digital skills, and manage their own learning. Instructors were required to redesign lessons that could sustain engagement and ensure continuity of learning in unfamiliar formats (Bao, 2020; Dhawan, 2020). These changes highlighted two important challenges: preparing learners to navigate digital learning environments and supporting instructors in integrating technology effectively into their teaching.

In Thailand, the transition mirrored global trends as universities expanded digital infrastructure and learning management systems (LMS) during and after the pandemic. However, the level of pedagogical adaptation varied significantly across disciplines. Science-based faculties—such as Medicine, Science, Engineering, and Information and Communication Technology (ICT)—face unique challenges in translating laboratory work, simulations, and hands-on activities into online formats.

While earlier studies have primarily focused on students' satisfaction, engagement, and digital readiness in online learning environments, these studies tend to examine outcomes primarily at the level of individual learners or single courses. As a result, they provide limited insight into how pedagogical adaptations are sustained, coordinated, and scaled at the institutional level over time. In particular, there remains a lack of empirical research that connects changes in instructional practices with broader processes of institutional learning and long-term organizational transformation. Without this perspective, online learning is often framed as a temporary or situational response rather than as part of a deeper and more sustained process of educational change. This gap limits our understanding of how universities develop the capacity to adapt, respond, and evolve under conditions of disruption. In this study, this capacity is conceptualized as digital resilience, defined as an institution's ability to sustain and adapt teaching and learning practices through technological, pedagogical, and organizational adjustments (Gao, Kong, & Cheng, 2023).

Two conceptual frameworks help address this gap: Technological Pedagogical Content Knowledge (TPACK) and the Community of Inquiry (CoI). The TPACK framework (Mishra & Koehler, 2006) explains how effective teaching arises from the integration of content knowledge, pedagogical strategies, and technological tools. Instructors with strong TPACK competencies are more likely to design technology-enabled learning experiences that support participation and adaptability (Chai et al., 2013). However, many educators still struggle with using technology in ways that are pedagogically meaningful rather than tool-driven, highlighting the continued need for professional learning.

The CoI framework (Garrison, Anderson, & Archer, 2000) complements TPACK by describing meaningful online learning as the interaction of cognitive, social, and teaching presence. Research shows that a balanced integration of these presences supports collaboration, satisfaction, and higher-order thinking (Arbaugh, 2008; Shea & Bidjerano, 2010). Weak interaction or unclear instructional design, in contrast, can quickly reduce

engagement and lead to fragmented learning experiences. Together, TPACK and CoI offer a clear lens for understanding both the instructional and experiential aspects of digital transformation. In this study, the CoI framework is operationalized through students' reported experiences of engagement, interaction, and communication, which reflect cognitive, social, and teaching presence. In parallel, the TPACK framework is used to interpret how instructors design and implement technology-integrated learning activities, as evidenced in course documents, instructional practices, and interview data. These frameworks are integrated by examining how TPACK-informed instructional design supports the development of teaching presence within the CoI framework, thereby linking pedagogical decisions with students' learning experiences. This integration provides a coherent analytical basis for understanding how technology, pedagogy, and interaction co-evolve during the transition to online learning.

The shift to online learning also reshaped academic roles. Students increasingly took on the role of self-directed learners, navigating digital resources and peer networks to make sense of new content (Song & Bonk, 2016). Instructors evolved into facilitators and motivators—roles that require not only technical skills but also empathy, adaptability, and the ability to design intentional learning experiences (Hodges et al., 2020). These changes show that successful technology integration depends as much on human connection and sound pedagogy as it does on digital infrastructure.

In summary, digital transformation in higher education has improved access and flexibility but also heightened disparities in readiness, digital fluency, and social connectedness. Insights from TPACK and CoI provide a strong foundation for exploring how technology, pedagogy, and presence interact in real learning environments. Guided by these frameworks, this study examines how a Thai university transformed its teaching and learning practices across four science-based faculties during the transition from classroom to online education.

Building on this gap and conceptual framing, this study contributes to the literature in three important ways. First, while prior studies have often examined online learning in terms of student satisfaction, engagement, or perceived readiness, this study provides large-scale empirical evidence ( $N = 320,856$  records) demonstrating that academic performance remained stable across classroom and online modes. These findings challenge assumptions that changes in learning modality necessarily result in measurable differences in academic outcomes. Second, rather than treating the Community of Inquiry (CoI) and Technological Pedagogical Content Knowledge (TPACK) frameworks as separate analytical lenses, this study integrates them to explain the relationship between instructional design and learning experience. Specifically, it demonstrates how TPACK-enabled pedagogical redesign supports teaching presence within the CoI framework. Third, this study extends the analysis beyond the level of individual courses and instructors by providing empirical evidence of institutional learning. By systematically examining policy development, faculty collaboration, and instructional redesign, the study shows how pedagogical adaptation evolves into organizational learning and contributes to digital resilience over time.

To support this contribution, CoI is used to interpret students' learning experiences, while TPACK is used to examine how instructors design technology-integrated pedagogy, thereby linking instructional design with learning experience within a coherent analytical framework.

The study addressed three research questions:

1. To what extent did students' academic performance differ between classroom and online learning modes?
2. How did students and instructors perceive changes in motivation, engagement, and interaction during the transition?

3. In what ways did the transition contribute to institutional learning and digital resilience?

In this study, institutional learning is conceptualized through evidence from policy development, faculty collaboration, and changes in course design practices. This conceptualization is operationalized through a cross-source analysis of document data, instructor interviews, and observation logs to identify consistent patterns of institutional adaptation.

## **Methodology**

This study adopted a convergent parallel mixed-methods design, with equal priority given to quantitative and qualitative data to investigate how higher education reconfigured its pedagogical systems during the transition from classroom to online learning. Data were collected concurrently, analyzed separately, and integrated through a weaving approach during interpretation. In cases where inconsistencies emerged between quantitative and qualitative findings, the data were re-examined across sources to identify contextual explanations. Rather than treating discrepancies as errors, they were interpreted as complementary insights that provided a more nuanced understanding of pedagogical adaptation. Integration was achieved by comparing and interpreting findings across data strands to identify converging and complementary patterns.

The design was guided by the Community of Inquiry (CoI) and Technological Pedagogical Content Knowledge (TPACK) frameworks, which together provided a comprehensive lens for examining both instructional innovation and institutional learning. The CoI framework informed the analysis of how teaching, social, and cognitive presence shaped students' learning experiences across different modes of delivery. The TPACK framework offered insight into how instructors integrated technology with pedagogy and disciplinary content to redesign learning activities, assessments, and interactions during the transition. This mixed-methods approach enabled triangulation between large-scale quantitative records and rich qualitative evidence, allowing the study to capture not only measurable changes in learning outcomes but also the dynamic processes through which pedagogical adaptation unfolded within the university's evolving learning environment.

### ***Participants and Data Sources***

The research was conducted at a large public university in Thailand and involved four science-based faculties: Medicine, Science, Engineering, and Information and Communication Technology (ICT). These faculties were intentionally selected to represent a wide range of pedagogical contexts, from clinical and laboratory-intensive courses to digitally supported lecture-based teaching.

Three complementary datasets were used to explore pedagogical adaptation from multiple perspectives:

#### ***1) Institutional Academic Records***

A total of 320,856 student grading records from academic years 2019–2021 were extracted from the university's centralized database. These records represent course-level enrollments rather than unique students. Because a single student may enroll in multiple courses across different course types, the counts reported for theoretical, practical, and combined courses may overlap and therefore should not be summed to produce a single total. Because a single student may enroll in multiple courses across different course types, the count reported for theoretical, practical, and combined courses may overlap and therefore should not be summed to produce a single total. Accordingly, the unit of analysis was defined at the course-level records rather than the individual student.

- Theoretical courses: 134,911 online and 85,499 on-site records;
- Practical courses: 62,548 online and 39,292 on-site records;
- Combined courses: 55,520 online and 42,586 on-site records.

Consequently, the number of records reported within each category may exceed the number of unique student enrollments. These data provided a robust foundation for comparing academic outcomes across delivery modes and course types.

Student performance was measured using a 4.0 GPA scale. Grades were converted from letter grades to a standardized 4.0 scale using the institutional grading system (A = 4.0, B+ = 3.5, B = 3.0, C+ = 2.5, C = 2.0, D+ = 1.5, D = 1.0, F = 0). This standardized conversion ensured consistency in comparing academic performance across courses and delivery modes.

It should be noted that on-site data were primarily derived from pre-pandemic periods (2019), while online data were largely from pandemic years (2020–2021). Therefore, delivery mode may be partially confounded with temporal and contextual factors.

### *2) Student and Instructor Perceptions*

Perception data were collected from 324 undergraduate students (approximately 65% female, 35% male) and 18 instructors through structured surveys and semi-structured interviews. The student survey examined motivation, engagement, interaction, and perceptions of learning across modes. Instructor interviews explored evolving teaching strategies, assessment practices, and approaches to technology integration. Observation logs from synchronous and asynchronous online sessions were also examined to triangulate students' and instructors' accounts.

Participants were recruited using convenience sampling across the four faculties. However, efforts were made to include students and instructors from different year levels and course types to ensure representation across key academic contexts. Participants represented all four faculties and a range of year levels and course types.

Instructor interviews explored evolving teaching strategies, assessment practices, and approaches to technology integration. Instructor participants were purposively selected based on teaching experience, course type, and involvement in online teaching. Participants were recruited through faculty coordination to ensure representation across the four faculties and a range of instructional contexts. This approach enabled the study to capture diverse perspectives on pedagogical adaptation during the transition.

### *3) Document Analysis*

Document analysis included both course-level materials (e.g., course specifications, CLOs, instructional activities, and assessment strategies) and institutional-level documents (e.g., policy announcements, faculty-level guidelines, and administrative directives issued during the transition period). These documents were analyzed to identify how pedagogical practices and institutional responses evolved in relation to the shift to online learning.

All study procedures were reviewed and approved by the university's Institutional Review Board (COE No. MU-MOU 2023/001.0601). Participation was voluntary, and all data were anonymized and securely stored.

### ***Instruments and Procedures***

Multiple instruments were used to ensure that the evidence collected from diverse sources was both valid and comprehensive:

- *Institutional Grading Records*—Quantitative data extracted from the academic database to compare student performance across course types and delivery modes.
- *Student Surveys*—A 15-item Likert-scale instrument measuring engagement, flexibility, communication, and motivation. Items corresponded to the three CoI presences, and the instrument demonstrated strong reliability (Cronbach's  $\alpha = 0.82$ ).
- *Instructor Interviews*—Semi-structured interviews examining how instructors balanced technological, pedagogical, and disciplinary considerations while redesigning their courses.
- *Observation Logs*—Observation logs were used as a supplementary data source to support triangulation of findings from quantitative records and qualitative interviews. Observations from synchronous and asynchronous class sessions were used to verify patterns of interaction, instructional strategies, and student engagement identified from other data sources. While a fixed number of sessions was not predefined, observations were conducted across different faculties and course contexts to ensure alignment and consistency of emerging findings. A structured observation protocol was used to maintain consistency in data recording. This triangulation approach strengthened the credibility of findings by cross-validating evidence across multiple data sources.
- *Document Analysis*—Structured coding of pre-pandemic (classroom) and pandemic (online) course specifications to identify changes in pedagogical design.

All instruments were administered following standardized ethical procedures and were administered concurrently to allow for integration and triangulation during analysis.

### **Data Analysis**

A convergent mixed-methods analytical strategy was used, with quantitative and qualitative data analyzed separately and then integrated to build a comprehensive interpretation of pedagogical adaptation.

*Quantitative Analysis*—Descriptive statistics, independent sample *t*-tests, and ANOVA were used to compare mean grades between classroom and online modes across course types. Effect sizes (Cohen's *d*) were interpreted according to standard thresholds (small = 0.2, medium = 0.5, large = 0.8). Although statistically significant differences were detected ( $p < 0.001$ ), effect sizes were minimal ( $d \approx 0.04$ ), indicating stable performance across delivery modes. Regression and correlation analyses examined relationships among motivation, social interaction, and learning environment readiness—variables conceptually linked to CoI presences and TPACK constructs.

*Qualitative Analysis*—Qualitative data, including open-ended survey responses, interview transcripts, and observation logs, were analyzed using Braun and Clarke's (2006) six-step thematic analysis. Two independent coders identified themes related to CoI and TPACK dimensions, achieving strong inter-rater reliability (Cohen's  $\kappa > 0.85$ ). Three meta-themes emerged:

- 1) Redesign of instructional activities and assessments (teaching presence)
- 2) Variation in social and cognitive engagement across modes
- 3) Emergent institutional learning loops through faculty collaboration and reflection.

Document analysis supported these findings by tracing the evolution of CLOs, instructional strategies, and assessment approaches, offering additional evidence of institutional learning and adaptive capacity during the transition.

Institutional learning was examined through a cross-source qualitative analysis of

document data, instructor interviews, and observation logs. Evidence was identified when consistent patterns of adaptation emerged across these sources, particularly in relation to (1) changes in instructional design and assessment practices, (2) collaborative knowledge-sharing among faculty, and (3) institutional-level responses such as policy development and infrastructure support. This analytic approach enabled triangulation of evidence and provided a systematic basis for interpreting institutional learning and digital resilience.

## Results

### *Academic Outcomes across Learning Modes*

Analysis of 320,856 student records showed that overall academic performance remained stable across classroom and online learning modes. Although independent t-tests revealed statistically significant differences ( $p < .001$ ) for all course types, the effect sizes were extremely small ( $d \approx 0.04$ ), indicating that the transition from classroom to online teaching did not meaningfully affect students' achievement.

**Table 1.** Comparison of Student Grading Scores in On-site and Online Learning

Course Type	Online (M±SD)	On-site (M±SD)	<i>t</i> (df)	<i>p</i>	Cohen's <i>d</i>
Theoretical	3.05 ± 0.97	3.01 ± 0.97	9.43 (181,904)	< .001	0.04
Practical	3.46 ± 0.70	3.43 ± 0.68	6.78 (85,275)	< .001	0.04
Combined	3.17 ± 0.83	3.14 ± 0.78	5.81 (94,185)	< .001	0.04

*Note: Data derived from institutional academic records (2019-2021)*

Across faculties, practical courses showed slightly higher mean scores than both theoretical and combined courses. This pattern may reflect differences in assessment design and grading structures across course types. In many practice-oriented subjects, student performance is often evaluated through continuous assessment, project work, or structured practical activities, which provide multiple opportunities for students to demonstrate competence. In contrast, theoretical subjects tend to rely more heavily on summative examinations, which may result in slightly lower average scores. Importantly, despite these variations in mean scores, the effect sizes remained extremely small ( $d \approx 0.04$ ), indicating that the mode of delivery had minimal influence on overall academic performance. Overall, the findings indicate that consistent course design and aligned assessment practices helped maintain learning continuity during the transition.

### *Student Perceptions and Learning Experiences*

Survey data from 324 undergraduate students revealed distinct differences in how learners experienced classroom and online learning environments. Four dimensions were examined: overall satisfaction, engagement, communication with instructors, and perceived flexibility.

**Table 2.** Student Perceptions of Learning Across Delivery Modes

Dimension	Online (M±SD)	On-site (M±SD)	Notable pattern
Overall satisfaction	3.87 ± 0.71	4.32 ± 0.56	Higher in classroom
Engagement	3.62 ± 0.68	4.28 ± 0.60	Higher in classroom
Communication with instructor	3.74 ± 0.65	4.41 ± 0.54	Higher in classroom
Flexibility	4.25 ± 0.59	3.12 ± 0.64	Higher in online

*Note: Data derived from student perception survey (N = 324).*

Students reported higher satisfaction, stronger engagement, and better communication in classroom settings. Many described face-to-face learning as more interactive, immediate, and socially connected. In contrast, online learning was valued for its flexibility and allowance for self-paced study. However, learners also expressed concerns about reduced interaction, feelings of isolation, and limited hands-on practice—issues most prominent in laboratory-based and clinical courses.

Representative student comments included:

*“It’s easier to ask questions and learn from peers face-to-face.”*

*“I could watch recorded lectures anytime and balance study with work.”*

*“Without laboratory practice, I felt I only learned theory, not real skills.”*

These responses illustrate that while online learning improved access and convenience, it also diminished opportunities for collaborative learning, social presence, and experiential engagement.

### ***Predictors of Learning Outcomes***

Integrated analysis of quantitative academic data and student survey responses identified three variables that consistently predicted learning success across both classroom and online modes: learning motivation, social interaction, and readiness of the learning environment.

**Table 3.** Predictors of Learning Outcomes Across Learning Modes

<b>Predictor variable</b>	<b>Statistical range</b>	<b>Key observations</b>	<b>Implication for performance</b>
Learning motivation	$r \approx 0.30\text{--}0.45$	Higher intrinsic motivation associated with stronger academic performance, persistence, and satisfaction.	Most influential predictor; motivated learners managed independent study effectively.
Social interaction	$r \approx 0.20\text{--}0.30$	Interaction with peers and instructors linked to higher engagement and participation.	Supported consistent attendance, collaboration, and feedback-seeking.
Learning environment readiness	$r \approx 0.15\text{--}0.25$	Reliable devices, connectivity, and digital literacy critical for learning continuity.	Helped students adapt effectively to online or blended settings.

Multiple regression analysis showed that these variables collectively explained a moderate portion of variance in academic performance ( $R^2 = 0.28$ ). Learning motivation emerged as the strongest predictor, followed by social interaction and environmental readiness. These results suggest that student success depended more on internal and contextual readiness than on the mode of instruction itself.

### ***Discipline-Specific Insights***

Adaptation to online learning varied across disciplines, reflecting differences in pedagogical practices, technological readiness, and the nature of disciplinary content.

**Table 4.** Discipline-Specific Insights on Learning Mode Transition

Faculty/ Discipline	Observed changes and adaptations	Student and instructor feedback	Notable outcomes
Medicine / Nursing	Clinical and lab activities shifted to simulations and video demonstrations; limited real-time hands-on practice.	Concern about reduced authentic clinical experience and skill development.	Stable achievement but lower engagement and confidence
Science / Engineering	Adoption of virtual labs, remote data analysis, and digital collaboration.	Appreciation for flexibility; some difficulty maintaining focus without supervision.	Stable performance; improved collaboration but inconsistent practical engagement
ICT	Extensive use of digital platforms, cloud tools, and online assessments.	Smooth adaptation; relatively high satisfaction.	Highest achievement and engagement; strong acceptance of digital learning.

Disciplines emphasizing theoretical or computational learning (such as ICT) adapted most smoothly, while practice-based disciplines (e.g., Medicine and Nursing) faced greater barriers in replicating hands-on experiences online.

***Emergent Institutional Learning and Innovation***

Qualitative analyses of interviews, observation logs, and course documents highlighted how the transition encouraged institutional learning across multiple levels.

Evidence presented in this section was derived from document analysis of institutional and faculty-level policies, instructor interviews, and observation data.

**Table 5.** Emergent Institutional Adaptations during the Transition

Organizational level	Emergent learning themes / Adaptations	Examples of implementation or evidence	Observed outcomes
Course (Level 1)	Redesign of learning activities and assessments.	Use of synchronous–asynchronous mix; online quizzes; reflective tasks.	Stable performance; improved access to materials.
Faculty (Level 2)	Peer mentoring and professional sharing.	Cross-faculty workshops; informal “teaching circles.”	Increased instructor confidence; more consistent digital pedagogy.
Institution (Level 3)	Policy development and infrastructure investment.	Online delivery guidelines; expanded LMS features; stronger e-learning support.	Institutional readiness for sustained blended learning.

What began as emergency adaptation evolved into structured institutional learning supported by policy development, faculty collaboration, and strategic investment in digital infrastructure. Administrative units also began using survey and document-analysis findings to inform long-term academic policy. Collectively, these adaptations helped

position the university to sustain pedagogical and organizational innovation beyond the pandemic.

## Discussion

This study examined how a Thai university navigated the large-scale transition from classroom to online learning across four science-based faculties. Although the shift occurred rapidly and under challenging circumstances, students' academic performance remained largely stable across delivery modes. This consistency suggests that institutional systems—course design, assessment practices, and instructional support—were able to maintain learning continuity despite the abrupt modality change. However, qualitative findings revealed that while performance outcomes were stable, the learning experience itself changed considerably. These findings suggest that stable grades do not necessarily indicate unchanged learning processes or experiences. Therefore, academic performance should be interpreted with caution, as it may reflect assessment structures rather than deeper learning processes or skill development.

Students frequently reported reduced motivation, weaker social interaction, and fewer opportunities for hands-on engagement during online learning. Instructors also described challenges in sustaining student participation and creating authentic learning experiences in virtual environments. These findings underscore an important distinction: digital tools can deliver content effectively, but meaningful learning requires intentional design that supports interaction, engagement, and presence.

Interpreting these patterns through the CoI framework highlights the interconnected roles of teaching, social, and cognitive presence. Stable academic outcomes indicate that cognitive presence—the structure and quality of content and assessment—remained largely intact. However, declines in motivation and interaction suggest weakened teaching and social presence. This aligns with research showing that online environments can reduce immediacy, relational connection, and opportunities for spontaneous exchange (Gamage et al., 2020; Aldosari et al., 2022). These findings emphasize that robust digital infrastructure must be paired with strategies that actively promote community and interaction.

The TPACK framework (Mishra & Koehler, 2006) further explains how instructional quality was maintained despite the logistical challenges of the transition. Instructors who successfully integrated technological tools with pedagogical strategies and disciplinary content were able to preserve coherence in their courses. Many adopted innovations such as flipped learning, asynchronous lecture recordings, and authentic online assessments. These adaptations demonstrate that meaningful digital transformation occurs when technology serves pedagogical goals rather than functioning as an add-on (Chai et al., 2013).

In this study, digital resilience can be understood through sustained instructional continuity, adaptive course redesign, and institutional support mechanisms such as policy development and faculty collaboration. These policy developments reflect not only administrative responses but also deeper organizational learning, as institutions adapted their strategies based on emerging challenges and feedback. Together, these elements demonstrate digital resilience as an adaptive capacity built through the alignment of instructional practices, faculty collaboration, and institutional support mechanisms, enabling the institution to sustain learning continuity while refining pedagogical and organizational strategies over time.

A further observation concerns the slightly higher mean scores for practical courses delivered online ( $M = 3.46$ ) compared with on-site formats ( $M = 3.43$ ). Although the difference is minimal, this pattern may reflect changes in assessment practices during

the transition to online learning. When access to physical laboratories or clinical settings was limited, many practical courses adopted alternative forms of evaluation, such as project-based assignments, recorded demonstrations, reflective reports, or simulated activities. These approaches were widely used to maintain learning continuity during the pandemic (Gamage et al., 2020; Hodges et al., 2020). Such assessment formats may provide students with multiple opportunities to demonstrate competence and receive feedback, which could contribute to slightly higher average scores compared with traditional in-person practical evaluations. Importantly, the very small effect size observed in this study suggests that these differences should be interpreted cautiously.

Together, the CoI and TPACK frameworks provided integrated explanation of how continuity and innovation coexisted during the transition. While CoI illustrates changes in learning presence, TPACK accounts for how instructional redesign learning activities and assessment. This pedagogical redesign directly supported teaching presence within the CoI framework by maintaining instructional structure, clarity, and facilitation, thereby sustaining student engagement despite the shift in learning modality.

Beyond the level of individual courses, the findings indicate that the transition acted as a catalyst for institutional learning. Faculty members initially adapted their courses independently, but over time these individual experiments evolved into collaborative practices, such as peer mentoring, teaching circles, and cross-faculty workshops. These developments reflect the principles of double-loop learning (Argyris & Schön, 1978), where educators revisited their underlying assumptions about teaching rather than simply adjusting techniques. Evidence from course documents and administrative actions also suggests elements of triple-loop learning, in which the institution itself revisited its identity and strategic direction regarding digital pedagogy and resilience.

In short, the university's experience demonstrates that effective digital transformation in higher education requires alignment across instructional, professional, and institutional levels. When technological, pedagogical, and organizational learning reinforce one another, temporary adjustments can evolve into lasting innovation.

This study has several limitations. First, it was conducted within a single institution, which may limit generalizability. Second, survey data relied on self-reported perceptions. Third, the study did not include direct measures of practical or clinical competencies, particularly in laboratory- and practice-based disciplines. In addition, the comparison between on-site and online learning may be influenced by temporal factors, as the data were drawn from pre-pandemic and pandemic periods. Future research should incorporate direct measures of learning processes and practical competencies, particularly in laboratory and clinical contexts, to better understand how instructional modality influences skill development.

## **Implications for Educators and Institutions**

The findings from this study highlight several implications for educators and institutions seeking to strengthen teaching and learning in online, blended, and hybrid environments.

For educators, the findings suggest that if the goal is to maintain student's engagement and learning continuity in online environments, then design must intentionally support cognitive, social, and teaching presence. In this study, reduced interaction and motivation were key challenges reported by students; therefore, instructional strategies such as structured discussion, collaborative tasks, formative feedback, and guided interaction should be explicitly imbedded in course design. These practices directly

support the development of teaching and social presences as described in the CoI framework.

In addition, if instructors are expected to design effective online or blended learning experiences, then professional development should move beyond technical training to focus on the integration of technology, pedagogy, and disciplinary content. The findings show that instructional coherence was mainlined when instructors applied TPACK-informed strategies such as flipped learning, asynchronous materials, and authentic assessments. Therefore, training programs should emphasize how to align digital tools with pedagogical goals rather than focusing solely on tool usage.

At the institutional level, the findings indicate that if faculties or university aim to sustained digital transformation beyond emergency response, then governance structures must support continuous organizational learning. Evidence from this study shows that policy development, faculty collaboration, and institutional support systems such as feedback loops, cross-faculty collaboration platforms, and data-informed policy development to support iterative improvement. These mechanisms reflect organizational learning processes and contribute to building long-term digital resilience.

More broadly, if institutions seek to strengthen digital resilience, then technological infrastructure must be aligned with pedagogical innovation and organizational strategy. This study demonstrates that resilience is not solely dependent on technology, but emerges from the alignment between instructional practices, faculty capabilities, and institutional support systems.

## **Conclusion**

This study investigated how a Thai university navigated the transition from classroom to online learning across four science-based faculties during the COVID-19 pandemic. Despite major disruptions, academic performance remained stable; while teaching and learning practices underwent significant qualitative changes. Using the CoI and TPACK frameworks, the study showed that sustainable digital transformation depends not only on technological readiness but also on pedagogical coherence, human connection, and institutional reflection.

The transition fostered multiple layers of learning. Students adapted their strategies for engagement and self-directed learning; instructors redesigned their courses and refined their understanding of digital pedagogy; and the institution learned from collective experiences to build a more resilient and flexible learning environment. Temporary adjustments ultimately evolved into long-term strategies that strengthened digital resilience and supported future blended-learning opportunities.

This study highlights three key takeaways. First, stable academic performance does not necessarily indicate unchanged learning experiences, as qualitative findings revealed significant shifts in student motivation, interaction, and engagement. Second, effective online learning depends on the alignment between instructional design and learning experience, where TPACK-informed pedagogical redesign supports teaching presence within the CoI framework. Third, sustainable digital transformation requires institutional-level adaptation, where policy development, faculty collaboration, and instructional innovation collectively contribute to organizational learning and digital resilience.

By integrating pedagogical innovation with institutional learning, the university demonstrated how higher education can transform in ways that are both evidence-based and human-centered. The lessons from this case provide valuable insights for institutions

seeking to design sustainable and adaptive learning ecosystems in a rapidly changing educational landscape.

Future research should examine how digital resilience evolves in post-pandemic learning environments through longitudinal studies, and should extend this analysis across multiple institutions to enhance generalizability and comparative understanding.

## Acknowledgements

The authors gratefully acknowledge the support and collaboration of the participating faculties, administrators, and staff members at Mahidol University who contributed to this research. Special appreciation is extended to the deans, instructors, and students from the four science-based faculties for their assistance and cooperation throughout the data collection process. The authors also thank the Office of Academic Affairs and the Division of Information Technology for facilitating access to institutional data used in this study. Finally, the authors acknowledge the Knowledge Network Institute of Thailand (KNIT) for providing research funding that made this study possible.

## References

- Aldosari, A. M., Alramthi, S. M., & Eid, H. F. (2022). Improving social presence in online higher education: Using live virtual classroom to confront learning challenges during COVID-19 pandemic. *Frontiers in Psychology, 13*, 994403. <https://doi.org/10.3389/fpsyg.2022.994403>
- Arbaugh, J. B. (2008). Does the community of inquiry framework predict outcomes in online MBA courses? *The International Review of Research in Open and Distributed Learning, 9*(2), 1–21. <https://doi.org/10.19173/irrodl.v9i2.490>
- Argyris, C., & Schön, D. A. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison-Wesley.
- Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies, 2*(2), 113–115. <https://doi.org/10.1002/hbe2.191>
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society, 16*(2), 31–51.
- Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems, 49*(1), 5–22. <https://doi.org/10.1177/0047239520934018>
- Gamage, K. A., Wijesuriya, D. I., Ekanayake, S. Y., Rennie, A. E., Lambert, C. G., & Gunawardhana, N. (2020). Online delivery of teaching and laboratory practices: Continuity of university programmes during COVID-19 pandemic. *Education Sciences, 10*( 10) , 291. <https://doi.org/10.3390/educsci10100291>
- Gao, X., Kong, Y., & Cheng, L. (2023). Strategies and mechanism for building digital resilience of container shipping platform in crisis situation: A network orchestration perspective. *Ocean & Coastal Management, 246*, 106887. <https://doi.org/10.1016/j.ocecoaman.2023.106887>
- Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2–3), 87–105. [https://doi.org/10.1016/S1096-7516\(00\)00016-6](https://doi.org/10.1016/S1096-7516(00)00016-6)
- Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *EDUCAUSE Review*. <https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning>
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Shea, P., & Bidjerano, T. (2010). Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of communities of inquiry in online and blended learning environments. *Computers & Education, 55*(4), 1721–1731. <https://doi.org/10.1016/j.compedu.2010.07.017>
- Song, D., & Bonk, C. J. (2016). Motivational factors in self-directed informal learning from online learning resources. *Cogent Education, 3*(1). <https://doi.org/10.1080/2331186X.2016.1205838>