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Self-Efficacy as a Predictor of Inquiry-Based Pedagogy and Digital Competence among STEM Faculty in a Philippine Regional University

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Abstract

This study investigated the predictive relationships between teacher self-efficacy, inquiry-based pedagogy (IBP) implementation, and digital competence among STEM faculty at North Eastern Mindanao State University (NEMSU). Utilizing a quantitative descriptive-comparative and predictive research design, data were collected from 100 STEM educators across seven constituent campuses. Analysis involved Exploratory Factor Analysis (EFA) to purify research constructs and Partial Least Squares Structural Equation Modeling (PLS-SEM) to determine the extent of influence between variables. The results revealed that while faculty report a high baseline of instructional self-efficacy (M=3.486), a measurable "theory-practice gap" exists, characterized by significantly lower confidence in facilitating complex hands-on engineering prototypes and open-ended scientific investigations. Furthermore, a significant "innovation dip" was observed among faculty in the 7–9-year experience bracket, suggesting that instructional routines become fixed without targeted mid-career intervention. The structural model confirmed that self-efficacy is a potent engine for pedagogical change, explaining a substantial 30.4%of the variance in inquiry-oriented facilitation ($\beta=0.552$, $p<0.001$). Conversely, its predictive power over digital mastery was notably constrained (10.2%), identifying a "pedagogical-digital dissonance" where high internal confidence is bottlenecked by external infrastructural barriers. The study concludes with the Integrated STEM Teacher Competency Framework, advocating for a synchronized dual-pathway strategy. This approach recommends pairing psychological empowerment through career-stage-specific coaching and reverse-mentoring with urgent structural digital upgrades to ensure pedagogical willingness is matched by technological opportunity. These findings provide institutional leaders with an empirical roadmap to sustain instructional excellence and bridge the divide between theoretical confidence and practical mastery in regional state universities.

Keywords: STEM Education, Teacher Self-Efficacy, Inquiry-Based Pedagogy, Digital Competence, PLS-SEM, Tertiary Education, Philippines.

1. Introduction

Science instructional quality has been widely recognized as a central factor shaping student learning and institutional effectiveness in higher education. Research has shown that effective teaching practices contribute significantly to improved learner outcomes, particularly in scientific disciplines that require critical thinking, literacy, and complex problem-solving (Townley, 2018). In response, many higher education systems have prioritized innovative pedagogy and advanced digital skills to align with Sustainable Development Goal 4 (Quality Education) and Goal 9 (Industry, Innovation, and Infrastructure), which clarify expectations for 21st-century instruction and support continuous professional growth (United Nations, 2015). In the tertiary sector, science educators are expected to bridge the gap between theoretical knowledge and professional application. However, while university instructors often possess high conceptual confidence, a significant disconnect remains between their theoretical expertise and the actual execution of complex, hands-on scientific investigations in the classroom.

The rationale for this study was grounded in continuing concerns about the "theory-practice gap" in STEM education despite the modernization of university curricula. In the North Eastern Mindanao State University (NEMSU) system, while faculty demonstrate high academic qualifications, the transition from traditional lecture-based methods to open-ended inquiry frameworks remains inconsistent. This situation raised questions about how teacher self-efficacy—the internal belief in one's capacity to execute effective instruction—influences the implementation of inquiry-based pedagogy and digital tools. International evidence has emphasized that the existence of modern curricula alone does not guarantee improved learning unless they are meaningfully enacted through a teacher's psychological readiness and technological mastery (Morris, 2025; Nagel, 2021). Examining the interplay between these competencies at the university level therefore became necessary to understand how institutional policy is translated into actual classroom innovation.

The significance of this study lies in its focus on the predictive relationships between psychological beliefs and pedagogical practices among STEM faculty in a regional state university. While existing studies have examined teacher competencies in isolation, limited empirical evidence has been available on how self-efficacy, digital competence, and inquiry-based pedagogy (IBP) jointly shape the instructional landscape. Research has shown that differences in career stages, academic backgrounds, and access to infrastructure can shape how innovative methods are enacted in the laboratory and lecture hall (Guerrero & Bautista, 2023). This study addressed these gaps by assessing the levels of these core competencies and utilizing structural equation modeling to determine their predictive influence. The findings were intended to inform targeted faculty development, strengthen instructional quality, and support the development of a localized competency framework aimed at enhancing STEM education in the North Eastern Mindanao region.

Aim of the Study

This study aimed to investigate the levels of teacher self-efficacy, digital competence, and the extent of inquiry-based pedagogy implementation among the STEM faculty of North Eastern Mindanao State University (NEMSU), as reflected in survey and profile data.

Research Questions

This study was guided by the following research questions:

a. What is the profile of the STEM teachers in terms of age, sex, highest educational attainment, and years of teaching experience?
b. What are the levels of teacher self-efficacy, digital competence, and the extent of inquiry- based pedagogy implementation among the STEM faculty?
c. Are there statistically significant differences in the core variables when teachers are grouped according to their profile?
d. What are the significant relationships between teacher self-efficacy and the implementation of pedagogical and digital practices?
e. To what extent does teacher self-efficacy influence inquiry-based pedagogy and digital competence?
f. Based on the findings, what structural framework can be developed to characterize the core competencies of STEM teachers at NEMSU?

Hypotheses

The following null hypotheses were tested in the study at the 0.05 level of significance, using the quantitative data obtained from the respondent profiles and the competency measures:

H_{01}: There is no significant difference in the levels of teacher self-efficacy, the extent of inquiry-based pedagogy implementation, and the level of digital competence of the STEM teachers when they are grouped according to their profile (age, sex, highest educational attainment, and years of teaching experience).

H_{02}: There is no significant relationship between the STEM teachers' level of self-efficacy and their extent of inquiry-based pedagogy implementation.

H_{03}: There is no significant relationship between the STEM teachers' level of self-efficacy and their level of digital competence.

H_{04}: Teacher self-efficacy does not significantly influence inquiry-based pedagogy and digital competence.

Theoretical Framework

This study was anchored on Bandura's Social Cognitive Theory, Constructivist Learning Theory, and the Technological Pedagogical Content Knowledge (TPACK) framework to explain how instructional competencies are understood, enacted, and sustained in university STEM contexts. Social Cognitive Theory emphasizes the role of self-efficacy in shaping professional behavior. Teachers who believe in their capacity to execute innovative instruction are more likely to apply student-centered and technology-rich practices consistently in classroom practice (Bandura, 1997). Within the context of the Advanced STEM Teacher Capability Framework, self-efficacy influences how faculty members interpret complex instructional tasks, engage in pedagogical risk-taking, and commit to continuous professional growth. Empirical studies have shown that higher teacher self-efficacy is associated with stronger inquiry-based practices and greater resilience in the face of technological challenges (Boz & Çetin-Dindar, 2021; Perera et al., 2022).

Constructivist Learning Theory provides a complementary lens by framing inquiry-based pedagogy as a continuous and active knowledge-construction process rather than a passive transmission of facts. According to this theory, meaningful science instruction occurs when teachers and students share a clear focus on evidence-based reasoning and receive sustained support through discovery-oriented environments (Arega & Hunde, 2025). The implementation of inquiry-based pedagogy requires not only individual teacher effort but also pedagogical conditions that promote higher-order thinking, collaborative experimentation, and scientific investigation. Research has shown that the professor's role as a facilitator plays a critical role in shaping how scientific concepts are translated into daily laboratory practice, particularly in tertiary contexts where theoretical rigor and professional application are essential (Morris, 2025; Park et al., 2021).

The TPACK Framework further strengthens the framework by emphasizing the integrated nature of digital competence. The theory highlights that effective technology integration and development occur through the interaction of a teacher's knowledge of technology, pedagogy, and specialized scientific content (Mishra & Koehler, 2006). Applied to university STEM teachers, this perspective suggests that digital mastery is reinforced through the purposeful application of discipline-specific tools, such as virtual simulations and data-modeling software, within a professional learning community. Recent studies have supported the role of TPACK in improving instructional consistency and enhancing the quality of inquiry-based science education (Singh & Malik, 2024; López et al., 2025). Together, these theories explain how individual psychological beliefs, pedagogical facilitation, and technological opportunity interact to shape the overall instructional effectiveness of STEM faculty.

Conceptual Framework

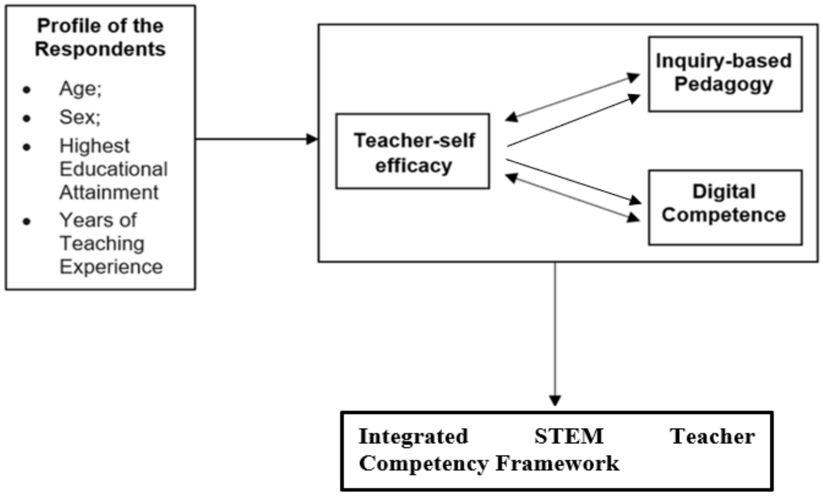

Figure 1. Conceptual Framework of the Study

The conceptual framework illustrates how teacher self-efficacy, inquiry-based pedagogy, and digital competence were examined among STEM faculty at North Eastern Mindanao State University (NEMSU). The framework was derived directly from the study title, research questions, and hypotheses, and it reflects the actual variables and data sources used in the investigation. The model identifies respondent characteristics and core instructional variables as the primary explanatory components (Figure 1).

Respondent characteristics include age, sex, highest educational attainment, and years of teaching experience. These demographic and professional factors are positioned as the contextual foundation of the study. These characteristics were examined to determine whether differences in professional background are associated with variations in perceived instructional capabilities and the execution of modern teaching strategies in a university setting.

The core variables represent the dimensions of professional practice assessed in the study: teacher self-efficacy, inquiry-based pedagogy, and digital competence. In this model, teacher self-efficacy acts as the central psychological hub, signifying a reciprocal and inter-relational link between a teacher's internal belief in their capacity and their actual classroom practices. The framework shows that respondent characteristics and core variables were examined through a quantitative assessment process involving the administration of a validated survey instrument and the application of descriptive, correlational, and predictive statistical analyses. Specifically, the use of Partial Least Squares Structural Equation Modeling (PLS-SEM) enabled the determination of the extent of influence between the psychological and pedagogical domains.

The outcome of the framework is the developed *Integrated STEM Teacher Competency Framework*, which characterizes the essential professional qualities of science faculty in the region. These outcomes provide evidence-based inputs for institutional policy, targeted faculty development programs, and instructional leadership strategies aimed at improving teaching quality and ensuring that STEM instruction remains responsive to the demands of 21st-century education. This conceptual framework presents a clear, linear, and methodologically sound representation of the study, ensuring alignment with its quantitative design and suitability for academic publication.

2. Review of Related Literature

Teacher instructional competencies have been widely recognized as a central mechanism for improving student learning and strengthening scientific literacy. International literature has emphasized that well-defined pedagogical and digital standards provide a shared language for instruction and serve as benchmarks for performance evaluation and professional growth (OECD, 2019). Empirical evidence from large-scale studies has shown that science faculty working within inquiry-based frameworks report clearer instructional expectations and stronger student engagement (OECD, 2020). Recent research consistently demonstrates that while university faculty recognize the theoretical value of Inquiry-Based Pedagogy (IBP), they often encounter significant hurdles in its practical implementation. Many tertiary educators continue to favor teacher-directed or "cookbook" laboratory methods, citing limited instructional confidence and the persistence of traditional didactic habits as primary barriers to adopting student-centered investigations (Park et al., 2021; Talavera-Mendoza et al., 2024).

Within the Philippine context, recent studies have examined the implementation of innovative pedagogies and their influence on STEM education. Research has indicated that while university teachers generally report moderate to high levels of digital competence, the focus remains on administrative communication rather than transformative integration (Abulencia, 2022). Studies conducted in state universities have also shown that technical skill alone is insufficient; a positive disposition toward technological innovation and a robust sense of instructional self-efficacy are the strongest predictors of a faculty member's willingness to adopt new digital tools in the laboratory (Chu et al., 2023; Ogegbo et al., 2024). These findings highlight the importance of examining teacher self-efficacy as the "psychological engine" that determines whether an instructor will attempt innovative methods or retreat into traditional, lecture-heavy habits (Boz & Çetin-Dindar, 2021).
Recent international research has further emphasized that instructional innovation is shaped by professional profiles and career stages. School leaders and institutional policies play a critical role in providing the infrastructure and mentoring necessary to sustain teacher confidence (Harris & Jones, 2019). Studies focusing on regional and resource-constrained institutions have noted that limited access to sustained digital support may lead to a "pedagogical-digital dissonance," where a teacher's high internal willingness is bottlenecked by external environmental barriers (Basilotta-Gómez-Pablos et al., 2022). Furthermore, evidence suggests an "innovation dip" among mid-career educators, whose instructional routines may become fixed over time (Guerrero & Bautista, 2023). These studies point to a continuing research gap in understanding the predictive relationships between self-efficacy and practice in regional Philippine state universities. Addressing this gap is essential for informing targeted faculty development and institutional policies that support a standardized level of STEM excellence.

3. Methodology

This study employed a quantitative research approach to examine the levels of teacher self-efficacy, digital competence, and the extent of inquiry-based pedagogy implementation among STEM faculty at North Eastern Mindanao State University (NEMSU). A quantitative approach was appropriate because the study focused on measuring instructional competencies, identifying relationships between variables, and testing predictive influences using numerical data derived from a structured instrument. Quantitative methods have been widely used in educational psychology and pedagogical research to provide objective descriptions of teacher behavior and to support complex path analysis across respondent characteristics (Creswell & Creswell, 2018; Sileyew, 2020).

A descriptive–comparative, correlational, and predictive research design was adopted. The descriptive component enabled the determination of respondents' demographic profiles and the measured levels of self-efficacy, digital competence, and inquiry-based pedagogy. The comparative and correlational components allowed for the examination of differences across profile variables and the exploration of associations between instructional beliefs and practices. Finally, the predictive component utilized advanced structural modeling to determine the extent of influence between the identified teacher qualities. This design was appropriate because the study did not seek to manipulate variables but rather to describe existing conditions and analyze predictive relationships, a design commonly used in teacher competency and capability studies (Gay et al., 2012; Curtis & Curtis, 2011).

The population of the study consisted of all Science, Technology, Engineering, and Mathematics (STEM) faculty members across the seven campuses of the NEMSU system during School Year 2024–2025. Given the specialized nature of the respondent group, total population sampling (universal sampling) was employed, specifically targeting 100 faculty members with a teaching tenure of ten years or less. This sampling strategy ensured that all eligible educators were included, thereby minimizing sampling error and enhancing the representativeness of the findings. Total enumeration is considered appropriate in institutional-level studies where population size allows comprehensive participation and complete data capture (Etikan et al., 2016).

Data collection was carried out using a validated four-part structured survey instrument. The instrument consisted of sections gathering demographic profiles (Part I), measuring Teacher Self-Efficacy (Part II), gauging Inquiry-Based Teaching Practices (Part III), and assessing Digital Practices (Part IV) using a 4-point Likert-type scale. To ensure the psychometric soundness of the questionnaire, a rigorous validation process was undertaken, including content validation by a panel of experts and a pilot test to determine internal consistency through Cronbach's Alpha. Questionnaires were administered through a hybrid approach involving printed and secured online platforms to ensure clarity of instructions and completeness of responses. This approach supported higher response rates and improved data reliability as recommended in survey-based instructional research (Dillman et al., 2014).

Data analysis involved descriptive, inferential, and advanced predictive statistical techniques. Frequency counts and percentage distributions were used to describe respondent profiles, while weighted means and standard deviations were computed to determine the measured levels of teacher competencies. To test differences in perceptions when respondents were grouped according to profile variables, analysis of variance (ANOVA) and independent samples t-tests were utilized. Relationships between variables were explored using the Pearson Product-Moment Correlation Coefficient. Furthermore, Exploratory Factor Analysis (EFA) was performed to purify constructs, followed by Partial Least Squares Structural Equation Modeling (PLS-SEM) to determine path coefficients (β) and the coefficient of determination ($R2$). These statistical procedures are appropriate for testing complex structural hypotheses and building teacher capability frameworks in quantitative education studies (Field, 2018; Hair et al., 2019).

Ethical considerations were strictly observed throughout the research process. The study was cleared by the NEMSU Institutional Ethics Review Committee (IERC), and informed consent was formally obtained from all participants. Participation was voluntary, and respondents were assured of confidentiality and anonymity under the Philippine Data Privacy Act of 2012, with no identifying information included in the data set. Collected data were used solely for academic purposes and were stored securely on encrypted devices. The study adhered to institutional research protocols and ethical guidelines for educational research, ensuring respect for participants' rights, dignity, and professional standing (BERA, 2018).

4. Results and Discussion

Table 1. The Profile of the Respondents

Age	**Frequency**	**Percentage**
24 – 26	36	36%
27 – 28	9	9%
29 – 30	8	8%
31 and above	47	47%
Total	100	100%
Sex	**Frequency**	**Percentage**
Male	67	67%
Female	33	33%
Total	100	100%
Highest Educational Attainment	**Frequency**	**Percentage**
With Masters Degree units	42	42%
Masters Degree holder	22	22%
With doctoral degree units	23	23%
Doctoral degree holder	13	13%
Total	100	100%
Years in Teaching	**Frequency**	**Percentage**
1 – 3 years	44	44%
4 – 6 years	18	18%
7 – 9 years	38	38%
Total	100	100%

Table 1 presents the demographic profile of the STEM faculty, revealing a polarized distribution in age and experience. Nearly half of the respondents are 31 or older (47%), while 36% belong to the 24–26 age group; this split is mirrored in teaching tenure, where 44% are novices (1–3 years) and 38% are mid-career educators (7–9 years). This division reflects the observations of Agormedah (2022) and Zhao et al. (2021), suggesting a landscape split between "digital natives" who may lack pedagogical mastery and veteran educators who possess content expertise but struggle with digital integration. Consequently, faculty development must be differentiated to provide classroom mentoring for novices and technological upskilling for veteran educators.

Regarding academic attainment, 42% of faculty hold only Master's units, with a mere 13% possessing doctoral degrees. This profile aligns with the assertions of Park et al. (2021) and Sultan (2020), who argue that advanced research training directly influences an educator's confidence in executing complex inquiry-based instruction. Without the rigorous background provided by terminal degrees, educators may default to structured "cookbook" laboratory methods rather than facilitating open discovery. This highlights the need for institutional scholarship incentives to elevate the theoretical foundation and instructional quality of the STEM departments.
Finally, the faculty is predominantly male (67%), with female teachers comprising only 33% of the population. This gender imbalance may inadvertently shape the university's instructional culture, potentially prioritizing technical laboratory execution over collaborative inquiry-based dialogue (Sellami, 2024; Vieira et al., 2023). Such a dynamic underscores the importance of policy-driven recruitment strategies that promote gender diversity to ensure a broader range of pedagogical perspectives and technological innovations in the STEM classroom.

Table 2. The level of Teacher Self-Efficacy of the STEM teachers of NEMSU

Teacher Self-Efficacy	**WM**	**SD**	**VD**
I am confident that I can guide students to understand the interconnected nature of science, technology, engineering, and mathematics	3.63	0.525	Very Confident
I am confident that I can help students formulate investigable questions and testable hypotheses.	3.51	0.502	Very Confident
I am confident that I can guide students in designing controlled investigations or engineering prototypes.	3.27	0.679	Very Confident
I am confident that I can teach students to collect data systematically using appropriate technologies.	3.46	0.593	Very Confident
I am confident that I can help students use scientific and mathematical thinking to accurately analyze and interpret data.	3.52	0.643	Very Confident
I am confident that I can teach students to use models to represent and understand complex systems.	3.48	0.643	Very Confident
I am confident that I can create a learning environment where students engage in collaborative, evidence-based arguments.	3.52	0.522	Very Confident
I am confident that I can teach students to effectively communicate their findings and solutions using multiple formats.	3.47	0.658	Very Confident
I am confident that I can help students develop the resilience to tackle complex, open-ended problems.	3.44	0.608	Very Confident
I am confident that I can guide students to connect STEM concepts to real-world problems and their societal impact.	3.56	0.538	Very Confident
Average Weighted Mean	**3.486**	**0.411**	Very Confident

Legend: 1.00 – 1.75 Not Confident 1.76 – 2.50 Somewhat Confident 2.51 – 3.25 Confident 3.26 – 4.00 Very Confident

Table 2 presents the level of teacher self-efficacy among NEMSU STEM faculty, which achieved an overall mean of 3.486, interpreted as "Very Confident." This finding supports the framework of Bandura's (1997) Social Cognitive Theory and aligns with Boz and Çetin-Dindar (2021), who argue that high instructional confidence serves as a primary driver for the adoption of student-centered practices. This high baseline indicates that the faculty possesses the psychological readiness required for university administrators to introduce advanced pedagogical training with minimal resistance.

The highest rating was observed in guiding students to understand the interconnected nature of STEM disciplines (M=3.63). This specific strength reflects the observations of Sultan (2020) and Stylos et al. (2022), who noted that university instructors typically display peak confidence when teaching foundational concepts closely aligned with their primary academic specialization. Because theoretical explanation requires less spontaneous technical troubleshooting than live experiments, it provides a "safer" instructional zone for faculty. Such confidence ensures that students receive clear instruction on core scientific principles, fulfilling a fundamental requirement of higher education science programs.

Conversely, faculty reported a measurable hesitation in facilitating complex hands-on design activities, with the lowest mean recorded at 3.27. This slight decline mirrors the findings of Park et al. (2021) and Nhlengethwa et al. (2020), identifying the transition from structured lectures to open-ended investigations as a significant professional hurdle. Since managing investigations requires spontaneous problem-solving and the ability to handle experimental failures, it demands significantly more pedagogical content knowledge than lecturing. This gap underscores the need for institutional policies to prioritize hands-on laboratory simulation training to ensure that theoretical confidence translates into physical instructional competence.

Table 3. The extent of implementation of Inquiry-Based Pedagogy among the STEM, teachers of NEMSU

Inquiry-Based Pedagogy	WM	SD	VD
I provide opportunities for students to formulate their own investigable scientific questions.	3.44	0.656	Highly Implemented
I guide students to develop testable hypotheses based on prior knowledge and observations.	3.30	0.628	Highly Implemented
I allow students to design and conduct their own investigations to answer their questions	3.56	0.625	Highly Implemented
I teach students specific methods for collecting, organizing, and recording data accurately.	3.56	0.656	Highly Implemented
I structure classroom activities where students must use evidence to support and defend their claims.	3.62	0.528	Highly Implemented
I encourage students to question their results and consider alternative explanations for their findings.	3.56	0.608	Highly Implemented
I explicitly connect the scientific inquiry process in our classroom to how science is practiced in the real world.	3.52	0.611	Highly Implemented
I prompt students to reflect on the investigation process and suggest improvements for future experiments.	3.49	0.611	Highly Implemented
I facilitate activities where students collaborate to investigate a shared scientific problem.	3.57	0.498	Highly Implemented
I guide students to analyze their data and draw conclusions that are supported by evidence.	3.56	0.625	Highly Implemented
Average Weighted Mean	**3.518**	**0.452**	Highly Implemented

Legend: 1.00 – 1.75 Not Implemented 1.76 – 2.50 Partially Implemented 2.51 – 3.25 Moderately Implemented 3.26 – 4.00 Highly Implemented

Table 3 presents the extent of Inquiry-Based Pedagogy (IBP) implementation among the faculty, which yielded an overall mean of 3.518, signifying that these methods are "Highly Implemented." This finding aligns with the constructivist principles described by Wang (2020) and Arega and Hunde (2025), which emphasize active discovery as essential for developing higher-order thinking skills. Such high implementation suggests a strong institutional alignment toward modernizing the science curriculum, providing a fertile environment for transitioning beyond structured laboratory exercises.

The most frequent practice involved structuring activities where students utilize evidence to support and defend scientific claims (M=3.62). This result validates the observations of García-Ruíz et al. (2022) regarding the critical role of evidence-based reasoning in contemporary science education. By prioritizing argumentation, instructors transform passive lecture halls into hubs of critical discourse, shifting students away from rote memorization toward the analytical rigor required in professional scientific fields. Such a focus strengthens the ability of learners to connect theoretical concepts to empirical data, serving as a core indicator of effective science instruction.

However, the data reveals a potential reliance on guided rather than open-ended inquiry, as guiding students to develop testable hypotheses received the lowest rating (M=3.30). This slight dip reflects the challenges documented by Park et al. (2021) and Talavera-Mendoza et al. (2024), who noted that university instructors often default to teacher-directed frameworks due to the unpredictable nature of open discovery. Facilitating evidence-based arguments within controlled structures is often perceived as more manageable than navigating the complex variables of open experiments. Consequently, future faculty development should shift from merely promoting inquiry as a concept toward providing practical training in managing the risks and variables of open, student-led investigations.

Table 4. The level of Digital Competence of the STEM teachers of NEMSU

Digital Competence	WM	SD	VD
I use digital tools to find and evaluate credible online information for my lessons.	3.56	0.519	Highly Proficient
I use digital communication tools (e.g., email, messaging apps) to interact with students, parents, and colleagues.	3.67	0.514	Highly Proficient
I create my own digital learning materials, such as presentations, videos, or interactive worksheets.	3.56	0.556	Highly Proficient
I purposefully integrate digital tools and apps to enhance my instructional methods.	3.67	0.514	Highly Proficient
I facilitate online collaborative activities for students using tools like shared documents or digital whiteboards.	3.52	0.627	Highly Proficient
I use digital tools, such as online quizzes or digital portfolios, to assess student learning.	3.54	0.558	Highly Proficient
I provide timely and constructive feedback to students using digital methods.	3.53	0.611	Highly Proficient
I design learning activities that allow students to use technology to express their understanding creatively.	3.57	0.517	Highly Proficient
I teach my students how to be safe and responsible when they are online.	3.67	0.533	Highly Proficient
I participate in online professional learning networks to improve my teaching practice.	3.52	0.611	Highly Proficient
Average Weighted Mean	**3.581**	**0.404**	Highly Proficient

Legend: 1.00 – 1.75 Limited Proficiency 1.76 – 2.50 Basic Proficiency 2.51 – 3.25 Proficient 3.26 – 4.00 Highly Proficient

Table 4 presents the level of digital competence among the STEM faculty, which achieved an overall mean of 3.581, interpreted as "Highly Proficient." This finding supports the research of Basilotta-Gómez-Pablos et al. (2022), indicating that NEMSU teachers have successfully navigated the transition toward flexible learning modes through the adoption of fundamental digital tools. Such a high baseline suggests that the faculty possesses the technical fluency required to move from basic digital usage toward more advanced, transformative pedagogical integration.

Peak proficiency was observed in the use of digital tools for communication and the maintenance of online safety (M=3.67). This result aligns with the observations of Çebi and Reisoglu (2020), who noted that university educators are often most comfortable with tools that facilitate administrative and routine pedagogical tasks. While these skills are essential for efficient course management, they remain distinct from the specialized technological integration defined by the TPACK framework. A prioritization of connectivity over complex scientific modeling suggests that faculty may still feel underprepared for the specialized digital demands of advanced tertiary-level laboratories and research-driven instruction.

Conversely, the lowest scores related to online collaboration and participation in professional learning networks (M=3.52). This minor divergence mirrors the findings of Mcgarr and McDonagh (2020), highlighting a persistent disconnection from the complex pedagogical integration required for high-level scientific simulations and global research engagement. Because managing safety and communication requires significantly less specialized knowledge than facilitating real-time digital experiments, a clear gap remains in discipline-specific mastery. Consequently, future faculty development must shift away from basic technical literacy toward targeted training in molecular modeling, virtual laboratory platforms, and global professional networking to ensure technology becomes a transformative element of STEM instruction.

Table 5. Difference in the levels of teacher self-efficacy, the extent of inquiry-based pedagogy implementation, and the level of digital competence of the STEM teachers when they are grouped according to their profile (age, sex, educational attainment, teaching experience)

Age with TSE	Mean	SD	F-value	p-value	Decision	Interpretation
24 – 26	3.5	0.471	0.459	0.712	Failed to reject H_{01}	No significant difference
27 – 28	3.57	0.32				
29 – 30	3.59	0.318				
31 and above	3.44	0.396				
Age with IBP	Mean	SD	F-value	p-value	Decision	Interpretation
24 – 26	3.69	0.471	4.04	0.009	Reject H_{01}	There is significant difference
27 – 28	3.61	0.348				
29 – 30	3.58	0.362				
31 and above	3.36	0.426				
Age with TDC	Mean	SD	F-value	p-value	Decision	Interpretation
24 – 26	3.78	0.364	10.399	0	Reject H_{01}	There is significant difference
27 – 28	3.87	0.141				
29 – 30	3.53	0.423				
31 and above	3.39	0.365				
Sex with TSE	Mean	SD	t-value	p-value	Decision	Interpretation
Male	3.47	0.439	0.703	0.484	Failed to reject H_{01}	No significant difference
Female	3.53	0.35				
Sex with IBP	Mean	SD	t-value	p-value	Decision	Interpretation
Male	3.55	0.482	1.032	0.305	Failed to reject H_{01}	No significant difference
Female	3.45	0.384				
Sex with TDC	Mean	SD	t-value	p-value	Decision	Interpretation
Male	3.63	0.4	1.852	0.067	Failed to reject H_{01}	No significant difference
Female	3.48	0.395				
HEA with TSE	Mean	SD	F-value	p-value	Decision	Interpretation
With Masters Degree units	3.44	0.416	0.447	0.72	Failed to reject H_{01}	No significant difference
Masters Degree holder	3.57	0.507				
With doctoral degree units	3.48	0.337				
Doctoral degree holder	3.5	0.358				
HEA with IBP	**Mean**	**SD**	**F-value**	**p-value**	**Decision**	**Interpretation**
With Masters Degree units	3.58	0.472	1.839	0.145	Failed to reject H_{01}	No significant difference
Masters Degree holder	3.57	0.401				
With doctoral degree units	3.33	0.499				
Doctoral degree holder	3.58	0.314				
HEA with TDC	**Mean**	**SD**	**F-value**	**p-value**	**Decision**	**Interpretation**
With Masters Degree units	3.68	0.366	3.566	0.017	Reject H_{01}	There is significant difference
Masters Degree holder	3.46	0.439				
With doctoral degree units	3.42	0.431				
Doctoral degree holder	3.73	0.275				
Years Teaching with TSE	Mean	SD	F-value	p-value	Decision	Interpretation
1 – 3 years	3.48	0.438	0.289	0.75	Failed to reject H_{01}	No significant difference
4 – 6 years	3.55	0.371				
7 – 9 years	3.46	0.404				
Years Teaching with IBP	Mean	SD	F-value	p-value	Decision	Interpretation
1 – 3 years	3.63	0.477	6.76	0.002	Reject H_{01}	There is significant difference
4 – 6 years	3.68	0.339				
7 – 9 years	3.32	0.403				
Years Teaching with TDC	Mean	SD	F-value	p-value	Decision	Interpretation
1 – 3 years	3.69	0.359	11.208	0	Reject H_{01}	There is significant difference
4 – 6 years	3.78	0.359				
7 – 9 years	3.36	0.381				

Table 5 illustrates the significant differences in teacher self-efficacy, IBP implementation, and digital competence across profile variables. Inferential analysis revealed that age is a decisive factor in the implementation of inquiry-based pedagogy (p=0.009) and digital competence (p=0.000), requiring the rejection of H_{01} for these domains. Younger faculty (24–26 years) reported higher adoption rates, supporting observations by García-Ruíz et al. (2022) and Zhao et al. (2021) that "digital natives" are more comfortable with contemporary, student-centered frameworks. Conversely, no significant gender-based disparities were observed across any variables (p>0.05), aligning with Aljuzayri and Pleasant (2022) and suggesting that instructional competencies are comparable across sex lines in higher education. This gender neutrality implies that professional development initiatives can be implemented inclusively rather than through segregated interventions.

Highest educational attainment significantly influenced digital competence (p=0.017), though it did not affect self-efficacy (p=0.720) or IBP implementation (p=0.145). Faculty with doctoral degrees reported higher digital proficiency, supporting López et al. (2025), who noted that advanced research activities often necessitate the use of sophisticated digital tools. This suggests that instructional approaches are shaped more by professional practice than by degree status alone (Sultan, 2020), although advanced academic progression serves as a catalyst for technological mastery.

Finally, years of teaching experience emerged as a powerful predictor of instructional behavior. While self-efficacy remained stable across career stages (p=0.750), a significant decline in IBP (p=0.002) and digital implementation (*p*=0.000) was observed among mid-career faculty. This "innovation dip" supports the findings of Park et al. (2021) and Nagel (2021), indicating that as instructional routines become fixed, experienced educators may retreat into traditional didactic habits. To sustain innovation, the university must prioritize career-stage-specific training and reverse-mentoring programs to bridge the gap between novice adopters and veteran content experts.

Table 6. The relationship between STEM teachers' level of self-efficacy in inquiry-based pedagogy and their digital competence

TSE and;	r – value	p-value	Decision	Interpretation
IBP	0.723	0.000	Reject H_{02}	There is significant relationship
TDC	0.635	0.000	Reject H_{02}	There is significant relationship

Table 6 presents the correlation matrix between teacher self-efficacy and instructional practices. The analysis revealed a strong and highly significant positive relationship between self-efficacy and the implementation of inquiry-based pedagogy (r=0.723, p=0.000), leading to the rejection of *H*02. This high correlation confirms the framework of Bandura's (1997) Social Cognitive Theory, identifying self-efficacy as the primary driver of instructional persistence and pedagogical risk-taking (Perera et al., 2022). Faculty with a robust internal belief in their capacity are significantly more willing to navigate the unpredictable dynamics of the scientific discovery process, suggesting that self-efficacy is the foundational trait required for effective constructivist facilitation.

A similarly significant positive relationship was found between teacher self-efficacy and digital competence (r=0.635, p=0.000), requiring the rejection of *H*03. This result aligns with the reciprocal relationship described by Shi et al. (2025), where digital mastery and instructional confidence reinforce one another. When faculty members feel empowered to handle technological challenges, they move beyond routine administrative tasks toward the purposeful integration of technology in science instruction. This suggests that digital competence at NEMSU is not merely a technical skill but is deeply rooted in the psychological readiness to utilize tools for complex instructional goals.

These correlations provide a clear directive for institutional policy. Since self-efficacy acts as the primary psychological catalyst for both inquiry-based practices and digital integration, faculty development should prioritize mentorship and "efficacy-building" interventions over mere technical training. The data suggests that providing tools or curricula alone will not guarantee improved science education if the faculty lacks the internal belief necessary for execution. By fostering a culture of professional resilience and peer support, the university can establish the psychological foundation required for teachers to confidently embrace the complexities of 21st-century STEM instruction.

Table 7. The Extent of Influence of Advanced STEM Instructional Competence (ASIC) on Pedagogical and Digital Practices

Path Relationship	Beta (β)	p-value	R-squared (R^2)	Decision
ASIC to Inquiry-Oriented Facilitation	0.552	0.000	0.304	Significant
ASIC to Digital Pedagogical Mastery	0.320	0.001	0.102	Significant

Table 7 shows that Advanced STEM Instructional Competence (ASIC) significantly influences both pedagogical and digital teaching practices. The stronger effect is observed in **Inquiry-Oriented Facilitation** (β = 0.552, p = 0.000), indicating that higher ASIC is associated with a greater ability to facilitate inquiry-based STEM learning. The R^2 value of 0.304 means that ASIC explains **30.4%** of the variation in inquiry-oriented facilitation. ASIC also has a significant positive influence on **Digital Pedagogical Mastery** (β = 0.320, p = 0.001). Although the effect is weaker than its influence on inquiry-oriented facilitation, the result still indicates that teachers with stronger advanced STEM instructional competence tend to demonstrate better digital pedagogical practices. The R^2 value of 0.102 shows that ASIC explains **10.2%** of the variation in digital pedagogical mastery. Overall, the findings suggest that ASIC is a significant predictor of both outcomes, with a stronger contribution to inquiry-based instructional practices than to digital pedagogy.

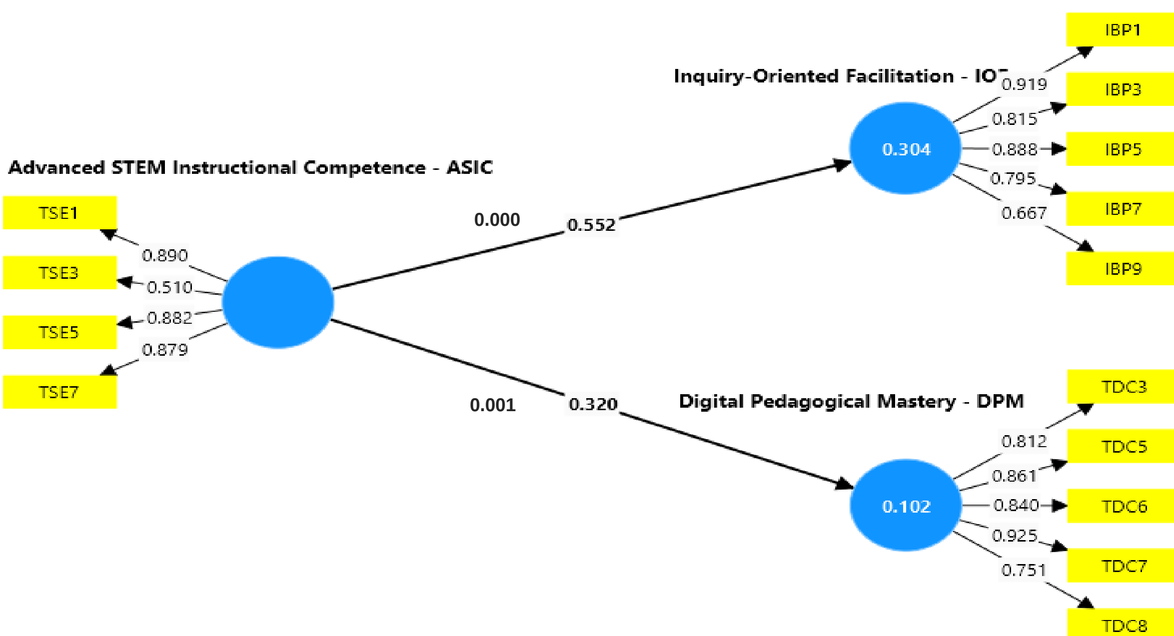

Figure 2. The Structural Equation Model for Advanced STEM Instructional Competence

Figure 2 presents the Integrated STEM Teacher Competency Framework derived from the exploratory factor analysis and structural modeling results. The analysis reduced 30 competency indicators into seven factors, with digital mastery, instructional confidence, and inquiry-oriented facilitation emerging as the most coherent dimensions. The framework shows that Advanced STEM Instructional Competence (ASIC) significantly influences both inquiry-oriented facilitation and digital pedagogical mastery, although its effect is stronger on inquiry-based teaching than on digital integration. This suggests a dual pathway of professional growth: teachers' internal competence and self-efficacy strengthen their capacity for inquiry-driven instruction, while digital mastery also depends on institutional conditions such as infrastructure, technical support, and access to resources. Thus, the framework emphasizes that sustaining STEM teaching excellence at NEMSU requires both professional mentoring and systemic support for digital teaching practice.

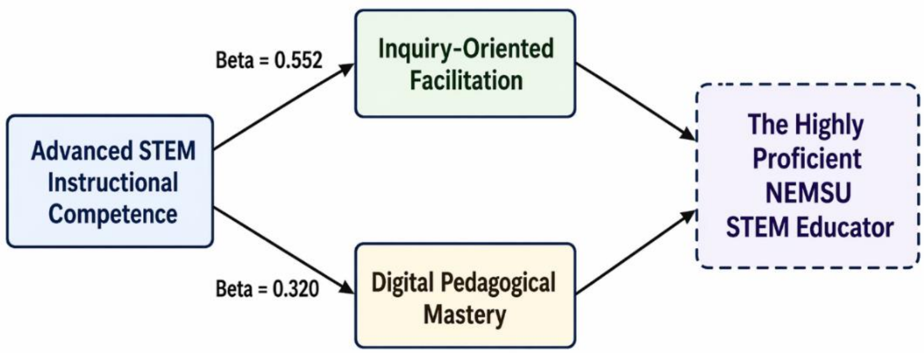

Figure 3. Integrated STEM Teacher Competency Framework for NEMSU

The synthesis of exploratory factor analysis (EFA) and structural equation modeling (SEM) culminated in the Integrated STEM Teacher Competency Framework, providing a context-specific derivation of professional traits essential for science instruction at NEMSU. At the model's core lies Advanced STEM Instructional Competence (ASIC), representing the educator's psychological core. The structural model identifies ASIC as the primary catalyst for Inquiry-Oriented Facilitation, demonstrating that robust self-efficacy is the most potent predictor of a teacher's ability to translate theoretical knowledge into student-led, evidence-based discovery. Conversely, the framework reveals a "technological decoupling," where a weaker predictive link exists between ASIC and Digital Pedagogical Mastery. This suggests that digital integration at NEMSU is not merely a product of teacher confidence but is heavily mediated by external environmental variables. Institutional infrastructure and resource accessibility act as structural gatekeepers that can constrain instructional potential regardless of internal efficacy levels. Ultimately, the framework posits that producing a Highly Proficient STEM Educator requires a synchronized Dual-Pathway Strategy. To achieve standardized excellence across all campuses, the university must pair psychological empowerment through targeted mentoring with systemic structural digital upgrades. This integrated approach ensures that pedagogical willingness is matched by technological opportunity, meeting the rigorous demands of the modern scientific landscape.

Implications of the Findings

The strong predictive relationship between teacher self-efficacy and inquiry-based implementation implies that the psychological "core" of the educator has been successfully established as the primary engine of pedagogical change at NEMSU. This alignment strengthens instructional coherence and supports sustained university-wide improvement, particularly in regional settings where the transition from traditional lecturing to student-centered discovery is critical for 21st-century science instruction.

The limited but significant effects of age, experience, and educational attainment highlight the need for targeted professional development rather than broad, uniform training programs. Advanced practical skills—specifically in engineering prototyping and open-ended scientific investigation—should be prioritized in career-stage-specific coaching, especially for mid-career educators who exhibit an "innovation dip" as their instructional routines become fixed over time.

The consistently high ratings in theoretical self-efficacy and evidence-based argumentation indicate that the faculty's conceptual foundation is well-established. These strengths can serve as anchors for future reforms, allowing the university to focus improvement efforts on more technically demanding and resource-dependent domains, such as specialized scientific modeling, virtual laboratory orchestration, and global professional research networking.

The findings affirm that strengthening differentiated professional learning, resolving the "pedagogical-digital dissonance" through infrastructure upgrades, and investing in advanced research competencies will further enhance the quality and equity of STEM instruction across all university campuses.

5. Conclusion and Recommendations

Conclusion

This study examined teacher self-efficacy, inquiry-based pedagogy, and digital competence among STEM faculty in a regional state university. The findings revealed a consistently high level of instructional confidence and implementation across all domains. Both the descriptive and inferential results indicate that the faculty possesses a robust psychological readiness for modern science instruction, particularly in theoretical delivery and evidence-based argumentation. However, the study identifies a measurable "theory-practice gap," where instructors are notably more hesitant when facilitating complex hands-on engineering prototypes and open-ended scientific discovery. Inferential analysis showed that demographic and professional variables significantly influence instructional behavior. Age and teaching experience emerged as primary predictors of practice, with younger, early-career faculty outperforming their mid-career peers. A critical "innovation dip" was observed among faculty with 7–9 years of experience, suggesting that instructional routines may become fixed over time without targeted intervention. While sex does not influence these competencies, advanced academic credentials specifically improve digital mastery. Furthermore, the absence of perceptual gaps between instructional leadership and classroom practice indicates a coherent professional culture within the university. Ultimately, the study concludes that while teacher self-efficacy is a potent engine for pedagogical shifts, it is an insufficient driver for digital transformation when constrained by external barriers. The structural model proves that internal confidence explains a significant 30.4% of the variance in inquiry-oriented facilitation but only 10.2% in digital mastery. This "technological decoupling" proves that while teacher confidence drives pedagogical behavior, it cannot overcome the external infrastructure hurdles that limit technological execution. Therefore, achieving standardized excellence requires a dual-pathway approach that pairs psychological empowerment with systemic structural upgrades.

Recommendations

University administrators should sustain existing strengths in theoretical conceptualization and evidence-based argumentation, as these competencies currently anchor the instructional quality of the STEM departments. Structured professional development should be intensified in hands-on engineering prototypes, open-ended scientific investigations, and transformative digital integration, as these domains demand advanced practical and pedagogical mastery to bridge the identified theory-practice gap. Targeted capacity-building programs are recommended rather than uniform training. Faculty members reaching the mid-career stage (7–9 years) should be prioritized for specialized coaching to mitigate the identified "innovation dip" and prevent a retreat into traditional didactic habits. Institutional leaders should also consider the implementation of a Reverse Mentoring Initiative, formally pairing digitally fluent junior faculty with content-expert senior faculty to facilitate a transgenerational exchange of technological and pedagogical skills. Graduate studies and terminal doctoral certification should be actively encouraged through scholarship grants and thesis completion incentives, as advanced academic attainment was shown to significantly enhance digital competence and research-oriented instructional mastery. Furthermore, STEM-focused Learning Action Cells and professional learning communities should be strengthened across all campuses to promote reflective practice, shared expertise, and the collaborative development of virtual laboratory protocols. Future studies may expand the research scope to other regional state universities to validate the *Integrated STEM Teacher Competency Framework* across broader institutional contexts. Research should also incorporate classroom observations and objective student learning outcomes to triangulate the self-reported data provided by faculty. Finally, longitudinal research may be conducted to examine how sustained institutional support and infrastructure upgrades influence instructional innovation and student achievement over an educator's entire career trajectory.

Declarations

Ethics approval and consent to participate.
This study observed the ethical protocols required for educational research. Ethical clearance was secured from the North Eastern Mindanao State University Institutional Ethics Review Committee. Prior to data collection, informed consent was obtained from the STEM faculty respondents. Participation was voluntary, and respondents were informed of the purpose of the study, their right to decline or withdraw, and the confidentiality of their responses. No personally identifying information was included in the dataset, and the data were used solely for academic and research publication purposes. The study also complied with the principles of confidentiality, anonymity, and responsible data handling under the Philippine Data Privacy Act of 2012, as stated in the methodology section of the manuscript.

Consent for publication.
The authors give consent for the publication of this manuscript in the *International Journal of Education and Contemporary Explorations* by Virtual Realia Organization, subject to the journal's editorial and publication policies. No individual participant data, images, or personally identifiable information are disclosed in the manuscript.

Availability of data and materials.
The datasets generated and analyzed during the study are not publicly available to protect the confidentiality of the respondents but may be made available from the corresponding author upon reasonable request and subject to institutional approval.

Competing interests.
The authors declare that they have no competing interests, financial or non-financial, that could have influenced the conduct, analysis, interpretation, or reporting of this study.

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Authors' contributions.
Jasmine D. Cubillan served as the primary author and was responsible for the conceptualization of the study, data gathering, analysis, and manuscript preparation. Florabel P. Mutia contributed to the refinement of the research framework, literature integration, data interpretation, and manuscript review. Both authors read and approved the final manuscript for publication.

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. Their institutional affiliations, email addresses, and ORCID details are indicated in the manuscript.

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