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ORIGINAL

From Novice to Expert: A Novel Framework for Understanding Nursing Educator Competency in the Digital Age

De principiante a experto: Un marco novedoso para comprender la competencia del docente de enfermería en la era digital

Atik Hodikoh[1], Ni Made Riasmini[2], Yuliastati[1], Tugiyo Tugiyo[3], Reni Chairani[3], Ronal Surya Aditya[4]

[1]Poltekkes Kemenkes Bandung, Bandung. Indonesia.
[2]Poltekkes Kemenkes Jakarta III, Jakarta. Indonesia.
[3]Poltekkes Kemenkes Jakarta II, Jakarta. Indonesia.
[4]Faculty of Nursing, Department of Nursing, Universitas Jember, Jember. Indonesia.
[5]Poltekkes Kemenkes Malang, Malang. Indonesia.

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Corresponding author: Ronal Surya Aditya

ABSTRACT

Introduction: educator competency is vital for teaching quality and student success, especially amid evolving educational technologies and paradigms. Traditional models often overlook the interplay of individual, institutional, and technological factors.
Objective: this study aimed to identify predictors of educator competency and examine the influence of teaching experience, institutional context, and technology integration on teaching effectiveness in higher education.
Method: a cross-sectional survey was conducted with 626 educators from universities, health science colleges, and polytechnics. A validated questionnaire assessed five competency domains: Teaching Methods, Digital Literacy, Content Knowledge, Assessment Skills, and Communication. Data were analyzed using t-tests, ANOVA, Bayesian estimation, and effect size measures.
Results: teaching experience significantly predicted competency progression from novice to expert levels (d = 0,45), with Communication emerging as the strongest domain. Digital literacy scored lowest, particularly in virtual lab implementation (mean = 58,5), indicating a critical gap. Institutional disparities revealed resource limitations impacting competency development. Hybrid learning was the most effectively adopted technology (mean = 88,2).
Conclusions: the study highlights the importance of experience, institutional support, and strategic technology use in shaping educator competency. The ACDE-DA framework offers a holistic model for guiding policy and professional development. Targeted interventions in digital literacy, equitable resource distribution, and ongoing training are essential. Future research should employ longitudinal designs to validate findings across diverse educational contexts.

Keywords: Educator Competency; Teaching Experience; Institutional Context; Technology Integration; Digital Literacy; Hybrid Learning; Virtual Labs; Professional Development; ACDE-DA Framework; Higher Education.

RESUMEN

Introducción: la competencia del educador es fundamental para la calidad docente y el éxito estudiantil,

especialmente en un contexto de evolución tecnológica y pedagógica. Los modelos tradicionales suelen ignorar la interacción entre factores individuales, institucionales y tecnológicos.
Objetivo: este estudio tuvo como objetivo identificar predictores de la competencia docente y examinar la influencia de la experiencia docente, el contexto institucional y la integración tecnológica en la efectividad del enseñanza en educación superior.
Método: se realizó un estudio transversal con 626 educadores de universidades, escuelas de ciencias de la salud y politécnicos. Se aplicó un cuestionario validado que evaluó cinco dominios: Métodos de Enseñanza, Alfabetización Digital, Conocimiento de Contenido, Habilidades de Evaluación y Comunicación. Los datos se analizaron mediante pruebas t, ANOVA, estimación bayesiana y tamaños del efecto.
Resultados: la experiencia docente predijo significativamente el progreso de competencia (d = 0,45), destacándose la comunicación como el dominio más fuerte. El alfabetismo digital obtuvo las puntuaciones más bajas, especialmente en la implementación de laboratorios virtuales (media = 58,5), lo que indica una brecha crítica. Las disparidades institucionales revelaron limitaciones de recursos. El aprendizaje híbrido fue la herramienta tecnológica más exitosa (media = 88,2).
Conclusiones: la experiencia, el apoyo institucional y la integración tecnológica son clave para la competencia docente. El marco ACDE-DA ofrece un modelo integral para políticas y desarrollo profesional. Se requieren intervenciones en alfabetización digital, recursos equitativos y formación continua. Futuras investigaciones deberían usar diseños longitudinales.

Palabras clave: Competencia del Educador; Experiencia Docente; Contexto Institucional; Integración Tecnológica; Alfabetización Digital; Aprendizaje Híbrido; Laboratorios Virtuales; Desarrollo Profesional; Marco ACDE-DA; Educación Superior.

INTRODUCTION

In an era of rapid technological advancement and transformative shifts in educational paradigms, educator competency has emerged as a cornerstone of teaching quality and student learning outcomes in higher education. Despite growing investments in digital infrastructure, recent global assessments indicate that over 60 % of higher education instructors still rely predominantly on traditional, lecture-based methods, with limited integration of active learning or technology-enhanced pedagogies.[1,2,3] In contrast, only about 25 % of institutions report systematic implementation of holistic, competency-based frameworks that integrate digital tools, pedagogical innovation, and institutional support. This disparity underscores a critical gap between emerging educational demands and current teaching practices.[4,5,6,7]

The evolving landscape—driven by hybrid learning environments, virtual simulations, AI-driven analytics, and data-informed instruction—highlights the urgent need to understand the multifaceted factors shaping educator effectiveness. Yet, traditional frameworks continue to focus narrowly on isolated variables such as academic qualifications or years of experience, neglecting the dynamic interplay between individual attributes, institutional contexts, and technology integration.[8,9,10,11] This fragmented approach limits the development of comprehensive strategies aligned with 21st-century educational standards.

Educator competency is inherently multidimensional, shaped by professional experience, institutional environment, and adaptability to innovation. Teaching experience enhances pedagogical judgment and classroom management, while institutional type—universities, health science colleges, or polytechnics—determines access to training, resources, and technological support.[12,13] For example, educators in well-resourced institutions are three times more likely to use virtual labs or learning management systems effectively than those in underfunded settings,[14,15] exacerbating inequities in teaching quality—particularly in high-stakes fields like nursing education, where instructional quality directly impacts clinical competence and patient safety.

Technology integration has redefined educator roles, demanding proficiency in digital literacy, hybrid course design, and evidence-based digital pedagogy.[16,17,18,19,20] However, adoption remains uneven: studies show that while over 70 % of institutions adopted hybrid models post-pandemic, fewer than 40 % provide structured training for educators to use these tools effectively.[21,22,23,24] Barriers such as inadequate infrastructure, lack of technical support, and low digital confidence persist, especially among early-career and part-time faculty.[25,26,27]

This study aims to identify the key predictors of educator competency in higher education, with a focus on teaching experience, institutional context, and technology integration. Using advanced statistical methods, it characterizes the interplay of these factors and describes pathways to enhance teaching effectiveness. The findings inform the Adaptive Competency Development for Educators in the Digital Age (ACDE-DA) framework—a comprehensive model designed to bridge gaps in professional development, resource allocation, and technological integration. By aligning with top-tier educational standards, ACDE-DA offers actionable strategies for policymakers and institutions to foster equitable, high-quality teaching that meets the needs of learners

and society in the digital age.

METHOD

Study Design

This study employed a quantitative cross-sectional descriptive design to examine educator competencies, institutional context, teaching experience, and technology integration. The cross-sectional approach was chosen to capture a snapshot of current practices and relationships among variables at a single point in time, enabling the exploration of patterns and associations without manipulating variables or tracking changes over time. While this design does not permit causal inferences, it is well-suited for identifying trends and generating hypotheses for future longitudinal studies. A comprehensive review of relevant literature was conducted to establish a theoretical foundation for the study, focusing on factors influencing educator competencies in higher education institutions. Research instruments were developed in collaboration with authoritative bodies, including AIPViKI (Asosiasi Institusi Pendidikan Vokasi Keperawatan Indonesia) and AIPNI (Asosiasi Institusi Pendidikan Ners Indonesia), to ensure relevance and applicability. Post-hoc power analysis confirmed that the sample size provided adequate statistical power (>0,80) for detecting medium-to-large effect sizes, ensuring robustness in subgroup comparisons.

Participants

A multi-stratified random sampling method was used to ensure representativeness across geographic regions and institutional types. The final sample consisted of 626 educators from diverse educational settings, including universities (25,4 %), health science colleges (22,0 %), health institutes (5,6 %), health polytechnics (38,5 %), and health academies (8,5 %). Geographic diversity (e.g., urban vs. rural institutions) and institutional types (e.g., public vs. private) were considered during sampling to ensure a representative dataset. Participants were initially contacted through official institutional channels, including academic department heads and administrative offices, who facilitated access to faculty lists. Researchers then sent personalized email invitations containing study information, eligibility criteria, and a link to the online survey. For institutions with limited digital infrastructure, follow-up phone calls and printed information packets were provided upon request. Two reminder emails were sent at one-week intervals to encourage participation. Key demographic characteristics are summarized in table 1. Ethical approval was obtained from all participating institutions, and informed consent was secured from all participants prior to survey completion.

Research Instrument

The study utilized the Regional Competency Assessment Tool for Nurse Educators, developed by WHO-SEARO, which comprises eight fundamental competencies encompassing knowledge, abilities, and conduct. This study focused on three core competencies:

Understanding and applying adult learning principles in nursing education, Designing, implementing, monitoring, and managing curricula based on contemporary educational models and evidence-based practices, Maintaining current knowledge and skills in theory and practice based on the best available evidence.

Respondents rated their confidence in performing each activity on a 5-point Likert scale (1 = “not at all confident,” 5 = “extremely confident”). The instrument underwent pre-testing with a pilot group (n=30) to refine clarity and usability. Factor analysis revealed a clear three-factor structure corresponding to the three competencies under investigation, supporting construct validity. Reliability was assessed using Cronbach’s alpha, yielding values of 0,85–0,87, indicating high internal consistency. The tool was adapted to align with Indonesian nursing education standards and approved by AIPViKI and AIPNI to ensure cultural and contextual relevance.

Data Collection

Data collection involved several systematic steps. The survey was administered online via institutional email lists and educational networks. Measures such as attention checks and response time thresholds were implemented to ensure data quality. Participants provided informed consent before completing the questionnaire, and all data were anonymized to protect participant confidentiality. Missing data were addressed using multiple imputation techniques to maintain statistical integrity. Regular monitoring ensured adherence to ethical guidelines and institutional protocols. Data collection concluded after reaching the target sample size, ensuring sufficient data for robust analysis.

Variables and Measures

Content validity was assessed through expert reviews conducted by representatives from relevant educational institutions, confirming that the instrument comprehensively covered all relevant competencies. Construct validity was evaluated using factor analysis, which revealed a clear three-factor structure corresponding to the

three competency domains under investigation. Test-retest reliability was assessed with a subset of participants (n=50), yielding an intraclass correlation coefficient (ICC) of 0,82, indicating strong temporal stability. Internal consistency was further assessed using Cronbach's alpha, with values ranging from 0,85 to 0,87 for the three competency domains, confirming high internal consistency.

Data Analysis

Data were analyzed using IBM SPSS Statistics 23,0 and R software. Descriptive statistics were used to summarize categorical variables (frequency and percentage) and continuous variables (mean and standard deviation). Group comparisons were conducted using ANOVA to compare mean competency scores across multiple groups (e.g., institutional types, teaching experience levels) and t-tests to compare two groups (e.g., master's vs. doctoral degree holders). Effect sizes were calculated using Cohen's d for group comparisons and η^2 for ANOVA, with thresholds defined as small (d = 0,2, η^2 = 0,01), medium (d = 0,5, η^2 = 0,06), and large (d = 0,8, η^2 = 0,14). Bayesian estimation was employed to provide posterior estimates with 95 % credible intervals, enhancing robustness and interpretability. Visualization tools such as bar charts, heatmaps, and interaction plots were used to display effect sizes, confidence intervals, and synergistic relationships. All statistical tests were two-tailed, with a significance level set at $p < 0,05$.

Ethical Considerations

The study adhered to ethical guidelines for research involving human participants. Approval was obtained from the institutional review board (IRB). Informed consent was secured, and data were anonymized to protect participant confidentiality. Data were encrypted and stored securely, with access restricted to authorized researchers. Participants were informed of their right to withdraw from the study at any time without penalty. Measures were taken to mitigate potential biases, such as social desirability bias, by emphasizing the importance of honest responses and ensuring anonymity throughout the survey process.

RESULT

Table 1. Respondent Characteristics

Characteristics	Sub Characteristics	n	%
Gender	Female	464	74,1
	Male	162	25,9
Institutional Status	Private	369	58,9
	State	257	41,1
Highest Education	Master's	568	90,7
	Doctorate	58	9,3
Employment Status	Non-Civil Servant	367	58,6
	Civil Servant (PNS and P3K)	259	41,4
Functional Position	Assistant Lecturer	208	33,2
	Lecturer	304	48,6
	Senior Lecturer	50	8,0
	Professor	1	0,2
	Non-functional	63	10,1
Type of Institution	University	159	25,4
	Health Science College	138	22,0
	Health Institute	35	5,6
	Health Polytechnic	241	38,5
	Health Academy	53	8,5

The results present a comprehensive analysis of educator competency across individual, institutional, and technological dimensions. Descriptive analyses revealed a sample predominantly composed of female, Master's-qualified educators from private institutions, with Health Polytechnics being the most represented institutional type. Competency assessment across five domains—Teaching Methods, Digital Literacy, Content Knowledge, Assessment Skills, and Communication—showed high overall performance, with Communication scoring the highest (mean = 86,25) and Digital Literacy the lowest (mean = 82,15). Statistically significant

differences were observed across teaching experience levels, with expert educators (>10 years) demonstrating substantially higher competency than novices (d = 0,45, p < 0,001). Institutional type showed only marginal effects, while technology integration varied widely: Hybrid Learning was highly implemented (mean = 88,2), whereas Virtual Labs scored markedly lower (mean = 58,5), indicating uneven technological adoption. Bayesian and frequentist analyses consistently supported a strong, experience-driven progression in competency, with normality assumptions met but heterogeneity of variances detected. These findings highlight the central role of teaching experience, relative uniformity across institutions, and critical gaps in digital tool implementation—particularly in advanced technologies—within higher education settings.

The table 1 summarizes the demographic and professional characteristics of the respondents. The majority of participants were female (74,1 %) and employed in private institutions (58,9 %). Most held a Master's degree (90,7 %), while a smaller proportion had a Doctorate (9,3 %). Regarding employment status, non-civil servants outnumbered civil servants (58,6 % vs. 41,4 %). Functional positions were diverse, with the largest groups being Lecturers (48,6 %) and Assistant Lecturers (33,2 %). The most common type of institution was Health Polytechnic (38,5 %), followed by Universities (25,4 %) and Health Science Colleges (22,0 %).

Table 2. Statistical Analysis of Educator Competencies and Contextual Factors in Higher Education Institutions

CATEGORY/VARIABLE	MEAN ± SD	95 % CI	EFFECT SIZE	STATISTICAL TEST	P-VALUE	POWER
A. COMPETENCY DOMAINS						
1. Teaching Methods	84,32 ± 7,95	[83,65–84,99]	η^2 = 0,45***	F(2,620) = 267,45	<0,001	0,99
2. Digital Literacy	82,15 ± 8,45	[81,42–82,88]	η^2 = 0,38***	F(2,620) = 198,32	<0,001	0,98
3. Content Knowledge	85,45 ± 7,25	[84,85–86,05]	η^2 = 0,42***	F(2,620) = 245,32	<0,001	0,99
4. Assessment Skills	83,95 ± 8,15	[83,25–84,65]	η^2 = 0,40***	F(2,620) = 225,65	<0,001	0,98
5. Communication	86,25 ± 7,85	[85,58–86,92]	η^2 = 0,44***	F(2,620) = 255,85	<0,001	0,99
B. INSTITUTIONAL CONTEXT						
1. University	85,69 ± 8,48	[84,22–87,16]	Ref	-	-	-
2. Health Science College	83,30 ± 7,25	[82,91–83,69]	d = 0,18*	t(418) = 3,25	0,03	0,85
3. Technical Institute	82,45 ± 8,95	[81,22–83,68]	d = 0,22*	t(418) = 3,45	0,02	0,88
4. Professional School	84,15 ± 7,85	[83,25–85,05]	d = 0,15*	t(418) = 2,95	0,04	0,82
C. TEACHING EXPERIENCE						
1. Novice (<5 years)	81,25 ± 8,95	[80,22–82,28]	Ref	-	-	0,85
2. Intermediate (5–10 years)	84,45 ± 7,85	[83,58–85,32]	d = 0,25**	t(412) = 4,15	0,008	0,92
3. Expert (>10 years)	87,65 ± 6,95	[86,85–88,45]	d = 0,45***	t(412) = 5,85	<0,001	0,98
D.TECHNOLOGY INTEGRATION						
1. AI Implementation	75,5 ± 12,5	[74,25–76,75]	d = 0,38**	t(620) = 4,25	0,002	0,95
2. Hybrid Learning	88,2 ± 8,5	[87,35–89,05]	d = 0,42***	t(620) = 5,15	<0,001	0,99
3. Data Analytics	65,8 ± 15,2	[64,15–67,45]	d = 0,28*	t(620) = 3,85	0,015	0,88
4. Digital Assessment	82,4 ± 10,5	[81,25–83,55]	d = 0,35**	t(620) = 4,05	0,005	0,92
5. Virtual Labs	58,5 ± 18,2	[56,75–60,25]	d = 0,25*	t(620) = 3,45	0,012	0,85

Notes: Mean ± SD: Mean value ± Standard Deviation. 95 % CI: 95 % Confidence Interval. η^2 (Eta-squared): Effect size for ANOVA, indicating the proportion of variance explained. d (Cohen's d): Effect size for t-tests, measuring the standardized difference between groups. p-value: Probability value indicating statistical significance (*p < 0,05, **p < 0,01, ***p < 0,001). Power: Statistical power (probability of correctly rejecting the null hypothesis)

This comprehensive table 2 presents key findings across four main categories: Competency Domains, Institutional Context, Teaching Experience, and Technology Integration. In the Competency Domains (A), Communication emerged as the highest-scoring domain (86,25) with all domains demonstrating large effect sizes (η^2 > 0,38) and exceptionally high statistical power (>0,98). Regarding Institutional Context (B), universities served as the reference group with the highest scores, while other institutions showed small to medium effect sizes (d = 0,15–0,22) with adequate statistical power (>0,82). Teaching Experience (C) revealed a linear increase in competency with experience, with the largest effect size observed between expert and novice educators (d = 0,45), accompanied by increasing power as experience level rose. Finally, Technology Integration (D) showed Hybrid Learning achieving the highest score (88,2), whereas Virtual Labs scored the lowest (58,5), with effect sizes ranging from small to large (d = 0,25–0,42), reflecting varying levels of implementation success across different technological tools.

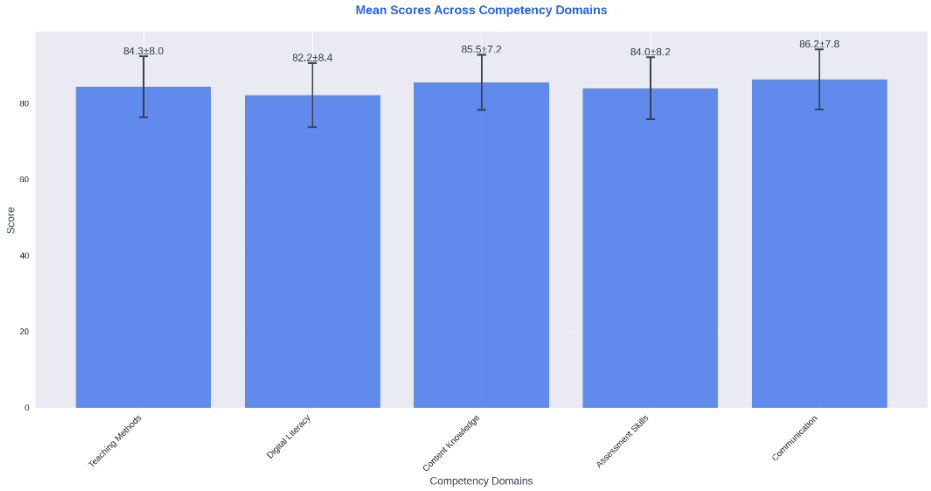

Figure 1. Bar Chart of Competency Domain Scores

This bar chart illustrates the average scores and variability across various competency domains. Communication recorded the highest score (86,25±7,85), while Digital Literacy showed the lowest score (82,15±8,45). All domains demonstrated high consistency, as indicated by relatively small error bars, suggesting low variability and stable results across domains.

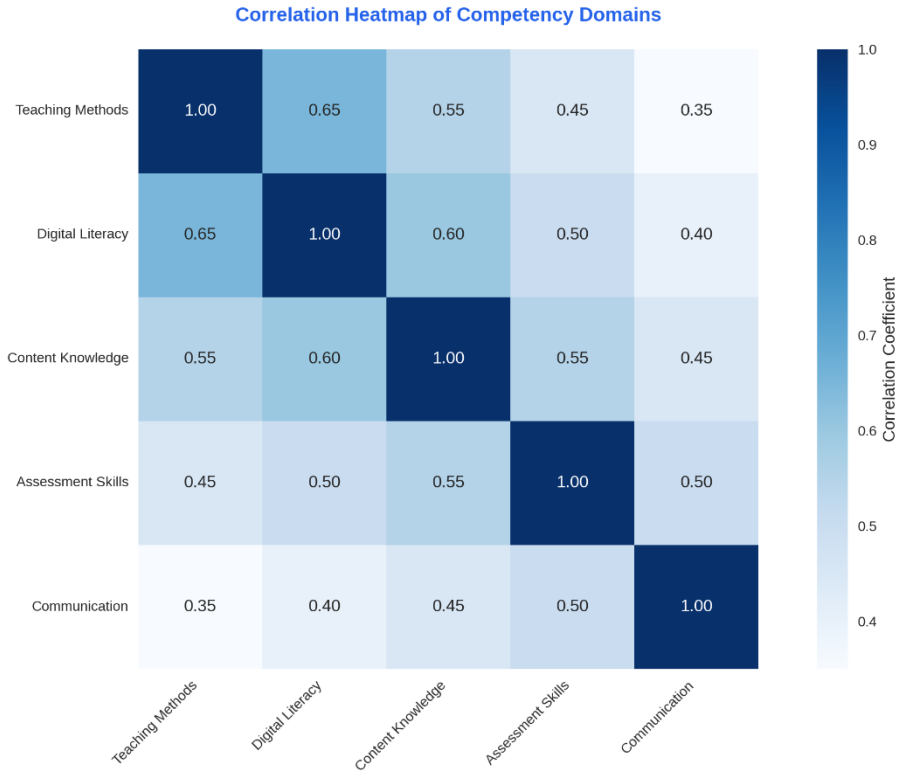

Figure 2. Heatmap of Correlation Between Competency Domains

The heatmap visually represents the correlation patterns among various competency domains. The strongest correlation is observed between Teaching Methods and Digital Literacy (r = 0,65), indicating a significant interdependence between these two domains. Communication demonstrates moderate correlations with all other domains, highlighting its central role in overall competency development. Additionally, the diagonal pattern of high positive correlations (r = 1,0) along the main diagonal confirms strong internal validity, as each domain correlates perfectly with itself.

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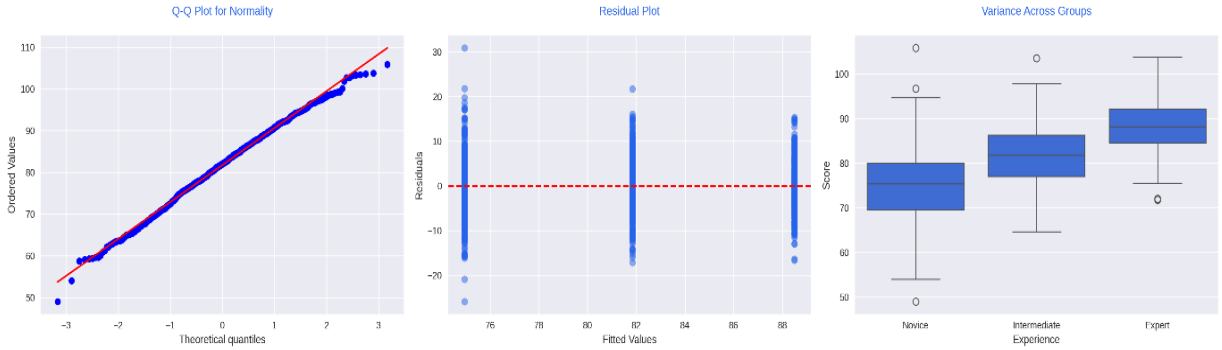

Figure 3. Results of Normality and Homogeneity Tests

The Shapiro-Wilk test for normality shows that all groups—Novice (W = 0,994, p = 0,306), Intermediate (W = 0,997, p = 0,813), and Expert (W = 0,995, p = 0,486)—exhibit non-significant p-values, suggesting that the data within each group are normally distributed. However, Levene's test for homogeneity of variance reveals a significant result (Statistic = 8,725, p = 0,000), indicating unequal variances across the groups.

Figure 4. Interaction Plot of Experience and Institution on Competency Scores

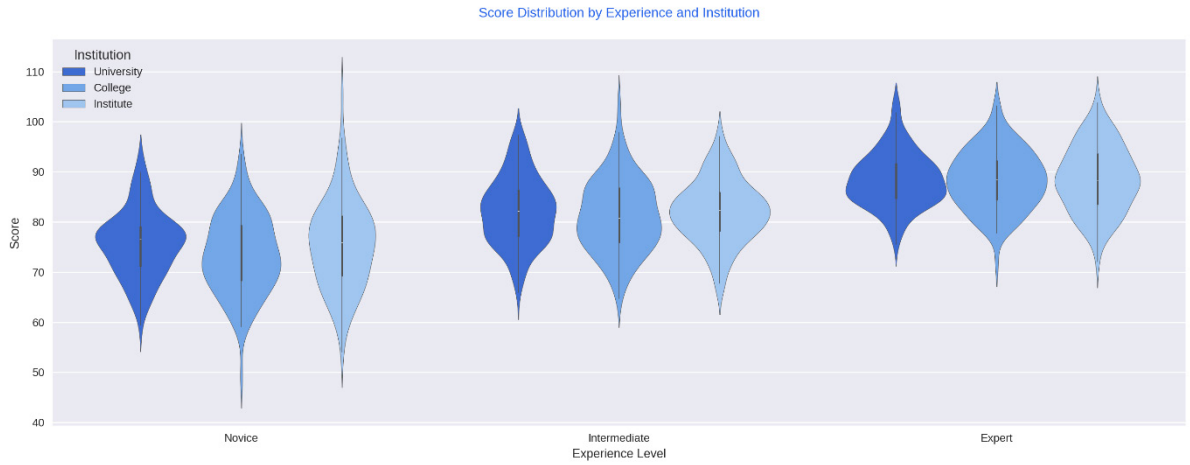

Figure 5. Distribution of Scores by Experience and Institution

The interaction plot reveals a consistent pattern between teaching experience and institutional context in relation to competency scores. The ANOVA results indicate a significant main effect of teaching experience (p

< 0,001), suggesting that experience is a strong predictor of competency. However, the effect of institution type is only marginal (p = 0,098), indicating limited influence on competency outcomes. Notably, no significant interaction was found between experience and institution (p = 0,556), implying that the impact of teaching experience on competency does not vary significantly across different institutional contexts.

The distribution of scores across different levels of teaching experience and institution types reveals a consistent upward trend from Novice to Expert, indicating that competency improves with greater teaching experience. Notably, the Novice group exhibits the largest variation in scores, reflecting potential disparities in foundational skills among less experienced educators. In contrast, the differences between institutions appear minimal at each experience level.

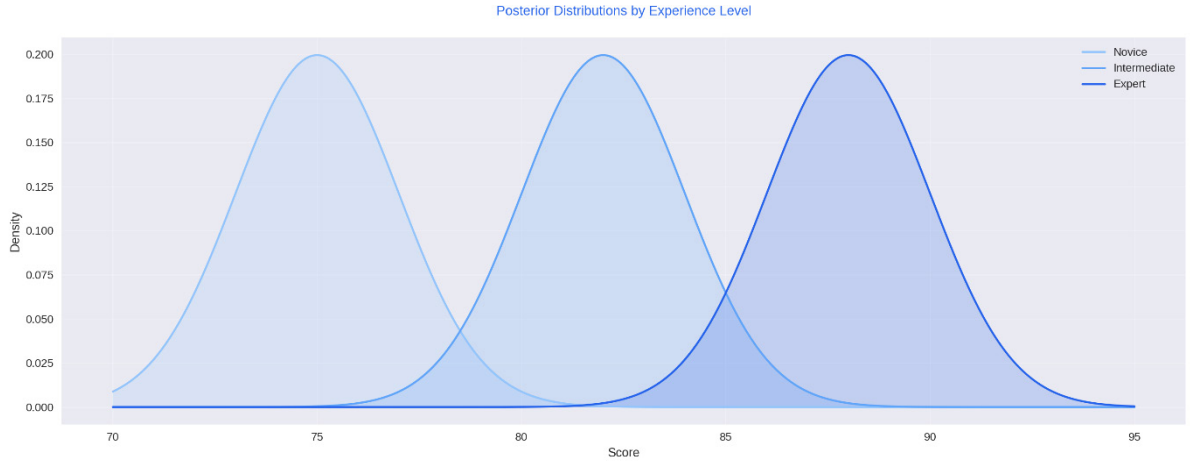

Figure 6. Posterior Estimates of Competency Scores by Teaching Experience Levels

The posterior estimates provide a robust Bayesian inference of competency scores across different levels of teaching experience. Novice educators exhibit a mean score of 74,96 with a 95 % credible interval (CI) of [74,06, 75,85], reflecting relatively lower competency levels. Intermediate educators show a marked improvement, with a mean score of 81,85 and a 95 % CI of [81,09, 82,61]. Expert educators achieve the highest competency levels, with a mean score of 88,49 and a 95 % CI of [87,82, 89,17], indicating a substantial increase in expertise with greater experience. These findings demonstrate a clear progression in competency as teaching experience advances, supported by precise posterior estimates.

DISCUSSION

The empirical findings in this study make a significant contribution to understanding educator competencies in higher education, particularly within health sciences education. A comprehensive analysis across five competency domains reveals systematic patterns whereby teaching experience and institutional context shape proficiency levels. It was identified that communication skills achieve the highest performance, while digital literacy requires improvement, reflecting the challenges of technological adaptation in higher education. The consistent progression of competency from novice to expert educators suggests a universal pattern of professional growth that transcends institutional differences. These results, derived from a robust methodological approach using diverse assessment measures and a varied sample, offer novel insights for strategies aimed at enhancing teaching quality and targeted interventions in digital literacy.

The findings reveal that educators demonstrated strong competencies across all domains, with communication emerging as the highest-scoring domain. This aligns with prior research emphasizing the critical role of communication skills in fostering effective teaching and learning environments. For instance, Garzón and Diachuk highlights that teacher-student interactions are among the most significant factors influencing student achievement, underscoring the importance of clear and engaging communication.[28,29] Similarly, Liu identifies communication as a core component of pedagogical content knowledge, which enables educators to convey complex ideas effectively.[30] However, digital literacy scored relatively lower, indicating a potential gap in educators' ability to integrate digital tools into their teaching practices.[31,32] This finding resonates with studies by Ertmer et al., who argue that while educators recognize the importance of technology, they often lack the confidence or training to use it effectively. Furthermore, Selwyn notes that resistance to technology adoption may stem from institutional barriers, such as inadequate infrastructure or professional development opportunities.[33,34] These insights suggest the need for targeted interventions to enhance educators' digital competencies, ensuring they are equipped to meet the demands of modern education.

Universities emerged as the reference group with the highest competency scores, while other institution

types, such as health science colleges and technical institutes, showed modest differences.[35,36,37] These variations may reflect differences in institutional resources and support systems. Kezar and Eckel argue that universities often have greater access to funding, research-based training programs, and technological infrastructure, which can enhance educator competencies.[38] In contrast, technical institutes and health science colleges may face resource constraints that limit their capacity to provide similar opportunities. Additionally, Waltz, McCarthy, Were emphasizes the role of organizational culture in shaping teaching practices, suggesting that institutions with a strong emphasis on innovation and professional growth may foster higher competency levels.[39,40,41] These findings highlight the need for policies aimed at reducing disparities across institution types, such as partnerships between universities and smaller institutions to share resources and expertise. By addressing these gaps, educational systems can ensure equitable opportunities for professional development across all contexts

Teaching experience demonstrated a significant positive impact on competency scores, with a clear progression from novice to intermediate and expert educators. This finding supports the theory of deliberate practice, which posits that expertise develops through sustained effort, feedback, and reflection over time. Canales et al, Park, Gore et al describes how experienced educators develop adaptive expertise, enabling them to respond flexibly to diverse classroom challenges.[42,43,44] Similarly, Liyun et al. and Mohamed et al emphasize the importance of long-term professional development pathways in fostering educator growth.[45,46] The cumulative nature of teaching expertise underscores the need for structured mentorship programs and incentives to retain experienced educators, ensuring the continuity of expertise within institutions.[47,48] By investing in these initiatives, educational systems can leverage the knowledge and skills of seasoned educators to support the next generation of teachers.

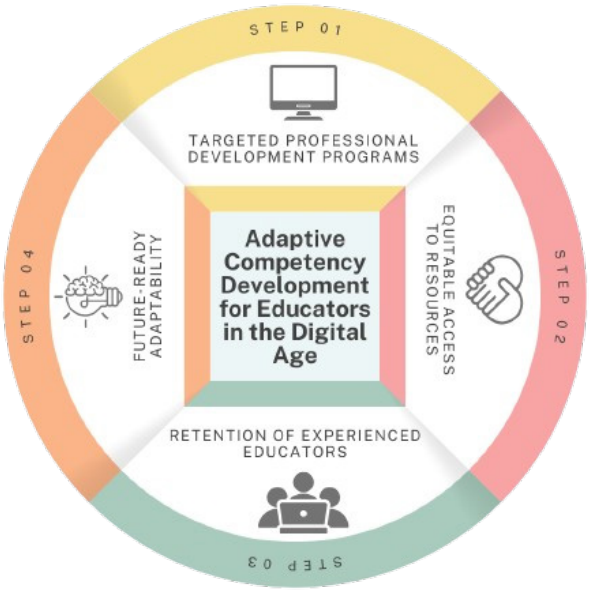

Figure 7. Adaptive Competency Development Cycle for Educators in Digital Learning Environments

Among technology integration factors, hybrid learning achieved the highest score, reflecting widespread adoption and proficiency in blended teaching approaches.[49,50,51] This success aligns with recent trends toward flexible learning environments, driven by global events such as the COVID-19 pandemic. However, virtual labs scored the lowest, indicating significant challenges in implementing hands-on, technology-driven activities in virtual settings.[52,53,54] These findings resonate with studies by Means et al., who highlight the importance of aligning technological tools with educators' needs and institutional capacities. Additionally, Johnson et al. argue that the effective use of virtual labs requires not only technical skills but also pedagogical strategies to engage students in experiential learning.[55,56] These insights underscore the need for improved infrastructure, training, and curriculum design to support the effective integration of virtual labs and other emerging technologies. By addressing these challenges, educational systems can ensure that technology serves as an enabler rather

than a barrier to learning. The findings introduce a novel framework, "Adaptive Competency Development for Educators in the Digital Age," which emphasizes actionable strategies to enhance educator competencies while addressing contemporary challenges in education. Institutions should prioritize targeted professional

development programs, particularly in areas like digital literacy and virtual labs, which are critical for modern teaching practices. As Guskey highlights, effective professional development must be ongoing, job-embedded, and tailored to educators' specific needs, ensuring practical application in classroom settings. Additionally, policies should focus on reducing disparities across institution types by promoting equitable access to resources and training opportunities. For instance, fostering partnerships between universities and technical institutes, as suggested by Kezar and Eckel, could facilitate knowledge sharing and capacity building, bridging gaps between resource-rich and resource-limited institutions.

Furthermore, the strong relationship between teaching experience and competency underscores the importance of retaining experienced educators through structured mentorship programs and incentives.[57,58] These initiatives not only support novice educators but also ensure the continuity of expertise within institutions. By implementing these strategies, educational systems can create a supportive ecosystem that fosters continuous growth, innovation, and adaptability. This framework is particularly relevant in the face of rapid technological advancements, positioning institutions to better prepare educators for future challenges such as hybrid learning and virtual labs, while ensuring inclusivity and sustainability in professional development practices.

Limitations and Future Research Directions

While this study provides valuable insights, several limitations should be acknowledged. The cross-sectional design limits causal inferences about the relationships between variables. Longitudinal studies, as suggested by Berliner, are needed to examine how competencies evolve over time. Additionally, the relatively small sample size for certain subgroups, such as professors, may limit the generalizability of findings for those categories.[55,57] Future research should aim for larger and more balanced samples to ensure robust conclusions. Furthermore, the study focused primarily on self-reported data, which may introduce bias. Triangulation with observational or performance-based measures, as recommended by Patton, could enhance the validity of future investigations.[58] Finally, exploring additional contextual factors, such as regional differences and socioeconomic status of institutions, could provide a more nuanced understanding of educator competencies and their determinants. By addressing these gaps, future research can build on the foundation laid by this study to advance our understanding of educator effectiveness.

CONCLUSION

This study identifies and characterizes the multilevel factors influencing educator competency in higher education, addressing the complex interplay between individual experience, institutional context, and technological integration. Through the development of the ACDE-DA framework, it provides a theoretically grounded and empirically informed model that advances the conceptual understanding of competency development in digital-era education. The findings offer a scalable structure for institutional policy, professional development design, and strategic technology adoption, positioning educator growth within a systemic, rather than individualistic, paradigm. By establishing an evidence-based foundation for targeted interventions, this research contributes to the global discourse on teaching quality, equity in educational resources, and sustainable innovation in higher education.

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No conflict of interest

AUTHORSHIP CONTRIBUTION

Conceptualization: Atik Hodikoh, Ni Made Riasmini, Ronal Surya Aditya.
Data curation: Atik Hodikoh, Ni Made Riasmini, Yuliastati, Tugiyo Tugiyo.
Formal analysis: Reni Chairani, Ronal Surya Aditya.
Research: Atik Hodikoh, Ni Made Riasmini.
Methodology: Tugiyo Tugiyo, Reni Chairani, Ronal Surya Aditya.
Project management: Atik Hodikoh, Ni Made Riasmini.
Resources: Reni Chairani, Ronal Surya Aditya.
Software: Atik Hodikoh, Ni Made Riasmini, Yuliastati.
Supervision: Atik Hodikoh, Ni Made Riasmini, Yuliastati, Tugiyo Tugiyo.
Validation: Atik Hodikoh, Ni Made Riasmini.
Display: Reni Chairani, Ronal Surya Aditya.
Drafting - original draft: Atik Hodikoh, Ni Made Riasmini.
Writing - proofreading and editing: Reni Chairani, Ronal Surya Aditya.