



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.935

Volume 15, Issue 8, August 2026

Technostress, Digital Competence, and Pedagogical Resilience among 21st Century Teachers: An Input to E-Learning Innovation

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ABSTRACT: The rapid integration of digital technologies in education has transformed teaching practices and created new opportunities and challenges for educators. As teachers adapt to evolving technological demands, factors such as technostress, digital competence, and pedagogical resilience have become essential in sustaining effective instruction. This mixed-method study examined the relationship among technostress, digital competence, and pedagogical resilience of 21st-century teachers during AY 2025–2026 as a basis for e-learning innovation initiatives. Participants were 230 higher education teachers selected through stratified random sampling from a population of 547. Data were collected using adapted questionnaires on technostress, digital competence, and pedagogical resilience, along with a researcher-made focus group discussion guide. Statistical tools included frequency, percentage, mean, standard deviation, ANOVA, and Pearson r at 0.05 alpha. Findings showed low technostress, high digital competence, and high pedagogical resilience. Teachers demonstrated strong skills in digital safety, content creation, communication, and problem-solving, while optimism emerged as the strongest resilience dimension. Significant differences in resilience were found across levels of technostress and digital competence. Higher digital competence was associated with lower technostress and stronger resilience, while higher technostress was related to lower resilience. The proposed E-Learning Innovation Model emphasizes structured strategies, institutional support, and skill development to enhance competence, reduce technostress, and strengthen resilience.

KEYWORDS: Technostress, Digital Competence, Pedagogical Resilience, 21st-Century Teachers, e-Learning Innovation

I. INTRODUCTION

The 21st century has transformed the educational landscape, requiring teachers to integrate digital technologies into teaching and learning. Online platforms, multimedia tools, artificial intelligence (AI), and virtual communication systems now create both opportunities and challenges for educators. These changes have highlighted the importance of technostress, digital competence, and pedagogical resilience among teachers.

Technostress refers to the negative feelings experienced when individuals struggle to adapt to new technologies [1]. It includes techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty [2]. In the Philippine context, many teachers experienced technostress during the shift to remote and hybrid learning because of limited access to technology, unstable internet, and inadequate support [3]. [4] and [5] further found that teachers in rural areas and older educators were more vulnerable to anxiety, overload, and reduced teaching effectiveness.

Digital competence refers to the knowledge, skills, attitudes, and critical use of digital technologies in education [6]. According to [7], it includes information literacy, communication and collaboration, content creation, safety, and problem-solving. Teachers with stronger digital competence are better able to integrate technology, adapt to change, and reduce technology-related stress [8]. However, [9], [10], and [11] noted that many Filipino teachers still need more training and institutional support to strengthen these skills.

Pedagogical resilience refers to teachers' ability to adapt, recover, and sustain effective teaching despite challenges [12]. It includes adaptability, persistence, optimism, and self-efficacy. Resilient teachers are better able to cope with stress, remain motivated, and continue quality instruction [13]; [14]. In the Philippines, [15] and [16] found that resilience was strengthened by faith, community support, collaboration, and professional identity.

Studies show that digital competence can lessen technostress, while pedagogical resilience helps teachers manage pressures and remain effective [17]; [18]; [19]. Thus, this study explored the relationships among technostress, digital competence, and pedagogical resilience of 21st-century teachers to guide programs that enhance teachers' digital readiness, adaptability, and instructional resilience.

The main aim of this study was to examine the relationship among technostress, digital competence, and pedagogical resilience of 21st-century teachers, providing input to support e-learning innovation for the academic year 2025–2026. Specifically, it sought to answer the following questions:

1. What is the level of technostress experienced by 21st-century teachers overall in terms of techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty?
2. What is the level of digital competence of 21st-century teachers collectively and in terms of information literacy, communication and collaboration, content creation, digital safety, and problem-solving?
3. What is the level of pedagogical resilience of 21st-century teachers as a whole and in terms of adaptability, persistence, optimism, and self-efficacy?
4. Is there a significant difference in pedagogical resilience of 21st-century teachers across varying levels of technostress and digital competence?
5. Is there a significant relationship between: a. Technostress and digital competence, b. Technostress and pedagogical resilience, and c. Digital competence and pedagogical resilience?
6. Based on the findings, what input to e-learning innovation may be proposed?

II. RELATED LITERATURE

Technostress

Technology has transformed communication, work, and education, but it has also created challenges such as smartphone dependence, cyberbullying, and data breaches [20]; [21]; [22]. One major challenge is technostress, the psychological strain caused by difficulty coping with technological demands, which can reduce well-being, motivation, and job satisfaction [2]. Although first studied in business settings [23]; [24], technostress is now recognized in education, where teachers are pressured to integrate technology into instruction, assessment, and communication [17]; [25]. Technostress is commonly explained through five dimensions: techno-invasion, techno-overload, techno-complexity, techno-insecurity, and techno-uncertainty [2]. Without sufficient training and institutional support, prolonged technostress can harm teacher well-being, instructional quality, and student outcomes.

Digital Competence

The increasing role of technology in society has made digital competence essential for teachers [26]. Teachers are expected not only to use technology effectively in teaching but also to model responsible digital practices for students [27]; [28]. Digital competence includes skills, knowledge, and attitudes for the confident, critical, and creative use of technology in learning, work, and daily life [26]. The widely used DigComp Framework identifies five key areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving [29]. Studies show that teachers' digital competence is influenced by age, gender, experience, and training opportunities [30]; [31]. Importantly, structured training programs significantly improve teachers' digital skills and readiness for technology integration [32].

Pedagogical Resilience

In today's changing educational environment, teachers must also develop pedagogical resilience—the ability to remain effective, motivated, and emotionally balanced despite challenges [12]. It involves recovering from setbacks, adapting to change, and sustaining quality teaching under pressure. [33] noted that resilience is strengthened through self-efficacy, optimism, and social support. Research shows that resilient teachers maintain commitment, creativity, and instructional effectiveness even under stress [34]. Studies further highlight that resilience is supported by personal strengths, collegial support, institutional backing, and even religiosity [35]; [36]. Strengthening teacher resilience is therefore vital for sustaining well-being, motivation, and effective teaching in the 21st century.

III. METHODOLOGY

The study investigated the relationship among technostress, digital competence, and pedagogical resilience of 21st-century teachers using a mixed-methods approach with an explanatory sequential design, where quantitative data were collected first, followed by qualitative data to explain the initial results [37]. Mixed-methods research combines qualitative and quantitative approaches to provide a more comprehensive analysis [38]. The quantitative phase employed a descriptive-correlational design to examine relationships among variables without manipulation [39], while the qualitative phase used focus group discussions (FGDs) to gather deeper insights into teachers' experiences and coping strategies related to digital technologies and pedagogical challenges [40]. Data were gathered using standardized instruments adapted from [41], [7], and [42]. Technostress and digital competence were the independent variables, while pedagogical resilience was the dependent variable. Participants were 230 teachers selected from 547 faculty members in public and private higher education institutions using Taro Yamane's formula and stratified random sampling. Descriptive statistics included mean, and standard deviation, while inferential statistics included ANOVA and Pearson's r at a 0.05 level of significance. Qualitative data were analyzed thematically to enrich the interpretation of the quantitative findings.

IV. RESULTS AND DISCUSSION

A. Level of Technostress

Table 1 shows that the overall level of technostress among 21st-century teachers was low ($M = 2.58$, $SD = 0.64$), indicating that participants generally experienced minimal technology-related stress. Among the five dimensions, techno-invasion obtained the highest mean ($M = 2.91$, $SD = 0.88$), categorized as moderate, suggesting that work-related technology moderately intruded into teachers' personal time. This was followed by techno-overload ($M = 2.69$, $SD = 0.78$), also moderate, reflecting pressure from excessive technology-related tasks. Meanwhile, techno-complexity ($M = 2.57$, $SD = 0.86$), techno-uncertainty ($M = 2.52$, $SD = 0.84$), and techno-insecurity ($M = 2.23$, $SD = 0.93$) were all rated low, indicating that teachers generally felt confident in using technology, experienced limited uncertainty, and did not perceive technology as a threat to job security.

Table 1: Mean and Standard Deviation of Technostress

Category	Mean	Description	SD
Technostress	2.58	Low	0.64
Techno-invasion	2.91	Moderate	0.88
Techno-overload	2.69	Moderate	0.78
Techno-complexity	2.57	Low	0.86
Techno-uncertainty	2.52	Low	0.84
Techno-insecurity	2.23	Low	0.93

Note Interval. Very High - 4.21 - 5.00: High - 3.41 - 4.20: Moderate - 2.61 - 3.40:
Low -1.81 - 2.60: Very Low - 1.00 - 1.80

The overall level of technostress among 21st-century teachers was low, indicating that teachers were generally able to manage the demands of digital teaching without significant stress. This implies that they have developed the skills, adaptability, and confidence needed to use technology effectively, supported by professional development programs, technical assistance, and institutional policies. As a result, teachers can focus on student learning, innovative instruction, and continuous professional growth. Focus group discussants also expressed positive experiences, describing technology as helpful in improving efficiency, flexibility, and work-life balance. This finding supports studies showing that adequate digital competence and institutional support help keep technostress manageable [43]; [44].

Among the dimensions, techno-invasion and techno-overload were rated moderate, indicating that technology sometimes intruded into personal time and occasionally increased workload. Teachers noted blurred work-life boundaries, constant connectivity, and multiple digital tasks, but many managed these pressures through time

management, setting limits, self-learning, and peer support. These findings align with studies showing that after-hours connectivity and multiple platform demands are common stressors, but can be reduced through digital competence and institutional support [45]; [23].

Meanwhile, techno-complexity, techno-uncertainty, and techno-insecurity were rated low, suggesting that teachers generally found digital tools manageable, were confident in adapting to technological changes, and did not fear being replaced by technology. Factors such as prior experience, user-friendly platforms, professional development, clear institutional guidelines, and supportive leadership likely contributed to these results. Teachers viewed technology not as a threat, but as a tool that enhances instruction and expands pedagogical possibilities. These findings are consistent with studies emphasizing the role of digital competence, self-efficacy, and institutional support in reducing technology-related stress [46]; [47]; [48].

The focus group discussants supported this finding, as they generally described manageable levels of technostress, although experiences varied. Some teachers reported stress related to connectivity issues, workload from multiple digital platforms, and the need to continuously learn new technologies. However, many also emphasized that these challenges are often mitigated through coping strategies such as self-learning, peer support, setting boundaries, and adapting their use of technology. Several discussants also highlighted that technology has become a helpful tool that improves efficiency, flexibility, and work-life balance, indicating that technostress remains under control and does not hinder their teaching effectiveness overall.

B. Level of Digital Competence

Table 2 shows that 21st-century teachers have a high overall level of digital competence ($M = 4.06$, $SD = 0.72$), indicating that they are generally confident and capable in using digital tools and technologies. Among the five domains, Digital Safety received the highest rating and was classified as very high ($M = 4.33$, $SD = 0.82$), suggesting strong skills in protecting personal information, practicing safe online behavior, and managing digital security. The other domains were also rated high: Content Creation ($M = 4.07$, $SD = 0.81$), showing competence in producing and managing digital materials; Information Literacy ($M = 4.00$, $SD = 0.81$), reflecting the ability to locate and evaluate information; Problem Solving ($M = 3.97$, $SD = 0.81$), indicating capability in addressing technical issues; and Communication and Collaboration ($M = 3.96$, $SD = 0.78$), demonstrating proficiency in working and interacting through digital platforms.

Table 2: Mean and Standard Deviation of Digital Competence

Category	Mean	Description	SD
Digital Competence	4.06	High	0.72
Digital Safety	4.33	Very High	0.82
Content Creation	4.07	Moderate	0.81
Information Literacy	4.00	High	0.81
Problem Solving	3.97	High	0.81
Communication and Collaboration	3.96	High	0.78

Note Interval. Very High - 4.21 - 5.00: High - 3.41 - 4.20: Moderate - 2.61 - 3.40: Low - 1.81 - 2.60: Very Low - 1.00 - 1.80

The 21st-century teachers demonstrate a high level of digital competence, indicating their ability to effectively use and integrate technology in educational settings. This competence extends beyond basic familiarity with digital tools, as teachers are capable of incorporating technology into teaching practices, lesson planning, classroom management, and professional development. This high level of competence is attributed to ICT training, professional development programs, and the necessity of adapting to technology-enhanced and blended learning environments.

The discussants affirmed that teachers use digital tools creatively and effectively in delivering instruction, designing learning materials, communicating, and addressing instructional challenges. They are flexible and resourceful in responding to students' technological needs and classroom constraints, using platforms and tools such as Canva, LMS,

and multimedia applications to enhance learning and ensure continuity of instruction. Their experiences show that teachers are not only skilled users of technology but also adaptive practitioners who meaningfully integrate it into pedagogy.

Overall, teachers demonstrate high competence across key domains of digital literacy. In digital safety, they show strong awareness of online privacy, data protection, and responsible technology use. In content creation, they are capable of producing and managing engaging instructional materials. In information literacy, they effectively locate, evaluate, and organize digital resources. In problem-solving, they are able to address technical and instructional challenges using adaptive strategies. In communication and collaboration, they effectively use digital platforms to interact with students and colleagues and support collaborative learning.

These findings emphasize that teachers possess well-developed digital skills that enable them to enhance instruction, manage challenges in technology-rich environments, and support student learning effectively in the 21st century.

C. Level of Pedagogical Resilience

As shown in Table 3, the 21st-century teachers demonstrate an overall high level of pedagogical resilience, indicating a strong capacity to manage and overcome teaching challenges effectively. Among its dimensions, optimism obtained the highest rating ($M = 4.27$, $SD = 0.73$), described as very high, reflecting a highly positive outlook toward teaching. The other dimensions were also rated high, including self-efficacy ($M = 4.16$, $SD = 0.78$), persistence ($M = 4.12$, $SD = 0.81$), and adaptability ($M = 4.04$, $SD = 0.76$), indicating strong confidence, determination, and flexibility in responding to educational demands. Overall, the results suggest that teachers possess well-developed pedagogical resilience across all dimensions.

Table 3: Mean and Standard Deviation of Pedagogical Resilience

Category	Mean	Description	SD
Pedagogical Resilience	4.15	High	0.71
Optimism	4.27	Very High	0.73
Self-Efficacy	4.16	High	0.78
Persistence	4.12	High	0.81
Adaptability	4.04	High	0.76

Note Interval. Very High - 4.21 - 5.00: High - 3.41 - 4.20: Moderate - 2.61 - 3.40: Low - 1.81 - 2.60: Very Low - 1.00 - 1.80

The 21st-century teachers demonstrate a high level of pedagogical resilience, reflecting their strong ability to cope with the complex and evolving demands of modern education. This suggests that resilient teachers are better able to sustain instructional quality, respond constructively to challenges, and maintain stability in their professional practice. High pedagogical resilience also supports teacher well-being, strengthens commitment to the profession, and contributes to improved student learning outcomes. This resilience is likely influenced by continuous professional development, institutional support, collaborative environments, and accumulated teaching experience, which together enhance teachers' adaptability, confidence, and persistence in the face of change.

The discussants emphasized that they exhibit strong pedagogical resilience through their ability to adapt to challenges, sustain motivation, and continuously improve their teaching practices. They combine personal qualities such as perseverance, passion, and a growth mindset with practical strategies like time management, work-life balance, continuous learning, and reliance on support systems. These enable them to remain effective despite technological disruptions, workload pressures, and changing educational demands.

Across dimensions, teachers demonstrate very high optimism, showing a consistently positive outlook and viewing challenges as opportunities for growth. They also exhibit high self-efficacy, reflecting strong confidence in their ability to plan, deliver instruction, and manage classroom challenges effectively. In terms of persistence, teachers show sustained effort and commitment to achieving educational goals despite difficulties. Meanwhile, adaptability is also

high, indicating their ability to adjust instructional strategies, classroom practices, and professional behaviors in response to changing conditions.

Overall, the findings show that teachers possess strong resilience traits that enable them to remain effective, motivated, and responsive in dynamic and technology-driven educational environments.

D. Differences in Pedagogical Resilience Across Varying Levels of Technostress and Digital Competence

As shown in Table 4, the one-way ANOVA results revealed significant differences in the pedagogical resilience of 21st-century teachers across varying levels of technostress and digital competence. In terms of technostress, there was a statistically significant difference in pedagogical resilience, $F(4, 225) = 10.803$, $p < .05$. Teachers experiencing low technostress demonstrated higher pedagogical resilience compared to those with higher levels of technostress, indicating that lower stress associated with technology use is linked to stronger resilience in teaching. Similarly, significant differences were found across levels of digital competence, $F(4, 225) = 156.242$, $p < .05$. Teachers with very high digital competence exhibited the highest pedagogical resilience, suggesting that greater proficiency in using digital tools is strongly associated with higher resilience in pedagogical practices.

Table 4: ANOVA Results on the Differences in Pedagogical Resilience Across Varying Levels of Technostress and Digital Competence

Category	Sum of Squares	df	Mean Square	F	Sig.
Technostress					
Between Groups	18.797	4	4.699	10.853*	.000
Within Groups	97.869	225	.435		
Total	116.666	229			
Digital Competence					
Between Groups	85.782	4	21.446	156.242*	.000
Within Groups	30.883	225	.137		
Total	116.666	229			

* $p < .05$ – significant at 5% level

The significant differences in pedagogical resilience across varying levels of technostress suggest that teachers' capacity to adapt, persist, and maintain effective instruction is influenced by the level of stress they experience in using technology. Teachers with low technostress demonstrated higher pedagogical resilience, indicating that when digital demands are manageable, they are better able to sustain instructional quality, emotional stability, and professional confidence. This implies that excessive technological demands—such as frequent system changes, heavy digital workload, and limited technical support—may reduce teachers' cognitive and emotional resources needed for reflection, innovation, and problem-solving. Conversely, lower technostress allows teachers to perceive technology as a supportive tool, enabling them to focus more on student engagement and instructional improvement.

The discussants reflect this pattern by acknowledging technology-related challenges such as weak connectivity, lack of formal training, and limitations in instructional platforms. However, they consistently emphasize coping strategies like preparation, backup materials, continuous learning, and peer support. These responses highlight that while technostress exists, teachers actively manage it through adaptive and resilience-building practices rather than allowing it to hinder their teaching effectiveness.

Similarly, the significant variation in pedagogical resilience across levels of digital competence highlights the role of technological proficiency in strengthening teachers' adaptive capacity. Teachers with very high digital competence exhibited the highest pedagogical resilience, suggesting that confidence and skill in using digital tools enhance their ability to manage disruptions and evolving educational demands. Digital competence enables teachers to integrate technology more effectively, explore innovative strategies, and respond calmly to technical difficulties. Thus, it functions not only as a technical ability but also as a psychological resource that supports self-efficacy and professional

autonomy. In contrast, lower digital competence may lead to uncertainty and reliance on external support, which can weaken resilience in technology-driven instructional contexts.

The discussants strongly support this finding, as those with higher digital competence demonstrate greater resilience by adapting instructional strategies during disruptions, maintaining motivation despite challenges, and confidently navigating online and blended learning environments. Their experiences show that continuous practice, preparation, and familiarity with digital tools contribute to smoother teaching delivery, even in the presence of technical issues.

This aligns with studies showing that higher digital competence is associated with improved well-being, reduced technostress, and stronger coping capacity among educators [49]; [50]; [51].

E. Relationships Among Technostress, Digital Competence, and Pedagogical Resilience

Table 5 presents the relationships among technostress, digital competence, and pedagogical resilience. The results show a significant moderate negative relationship between technostress and digital competence ($r = -.379$, $p < .05$), indicating that higher digital competence is associated with lower technostress. This means that as teachers become more skilled in using digital tools, they tend to experience less stress related to technology use. Likewise, technostress has a significant negative relationship with pedagogical resilience ($r = -.299$, $p < .05$), suggesting that higher levels of technostress are associated with lower pedagogical resilience among teachers. In contrast, digital competence shows a very strong positive relationship with pedagogical resilience ($r = .857$, $p < .05$), indicating that teachers with higher digital competence are more likely to demonstrate stronger pedagogical resilience in handling instructional challenges.

Table 5: Pearson r Among the Technostress, Digital Competence, and Pedagogical Resilience of the 21st Century Teachers

Variables	r	Sig
Technostress and Digital Competence	-.379*	.000
Technostress and Pedagogical Resilience	-.299*	.000
Digital Competence and Pedagogical Resilience	.857*	.000

* $p < .05$ – significant at 5% level

There is a significant moderate negative relationship between technostress and digital competence, indicating that as teachers' digital competence increases, their technostress decreases. This relationship suggests that digital skills enhance teachers' confidence, efficiency, and control in using technology. Teachers with higher digital competence are more capable of navigating learning platforms, troubleshooting technical issues, and integrating digital tools into instruction, which reduces feelings of overload, uncertainty, and anxiety. In contrast, limited digital competence may increase difficulty in managing technological demands, leading to higher technostress. This highlights the protective role of digital competence in buffering teachers from stress in technology-rich teaching environments.

The discussants' experiences support this finding, as they consistently report that confidence and familiarity with digital tools reduce stress in teaching. Teachers with stronger digital skills describe smoother teaching delivery and greater ease in handling technology, while those with less experience acknowledge higher effort when managing digital demands. Overall, their testimonies reflect that increased competence leads to lower perceived technostress, as practice, preparation, and prior exposure help teachers manage challenges more effectively.

Similarly, technostress shows a significant negative relationship with pedagogical resilience, indicating that higher technostress is associated with lower resilience. When teachers experience excessive technological demands, their ability to adapt, persist, and maintain effective instruction may be reduced. Technostress consumes cognitive and emotional resources, limiting teachers' flexibility, motivation, and problem-solving capacity. Thus, minimizing technostress is essential for sustaining instructional quality and teacher well-being.

The discussants reflect this pattern by describing how technical difficulties and system failures require additional effort, adjustments, or alternative strategies. While they demonstrate coping mechanisms such as preparation and backup

planning, high levels of stress from technology still affect teaching efficiency and delivery. This suggests that technostress can hinder pedagogical resilience when not properly managed.

On the other hand, digital competence shows a very strong positive relationship with pedagogical resilience, indicating that higher digital competence is strongly associated with greater resilience. This suggests that digital competence functions as a key enabling factor in modern teaching, allowing teachers to adapt to disruptions, integrate technology effectively, and maintain student engagement despite challenges. It enhances teachers' confidence and professional self-efficacy, which strengthens their ability to sustain effective instruction.

The discussants affirm this finding by emphasizing that digitally competent teachers feel more confident, prepared, and adaptable in handling instructional demands. Their experiences show that digital competence supports creativity, flexibility, and persistence in teaching. As a result, teachers are better able to manage challenges and maintain instructional effectiveness, reinforcing their pedagogical resilience.

F. Input to E-Learning Innovation

Based on the findings, the study proposes the E-Learning Innovation Model, which positions e-learning innovation as a strategic institutional approach to strengthen teachers' capabilities and ensure instructional sustainability in digitally intensive environments. The model is anchored on the results showing that digital competence has a strong positive effect on pedagogical resilience, while technostress negatively affects both digital competence and pedagogical resilience. Thus, e-learning innovation is viewed not only as technology adoption but as a structured system that enhances digital competence, reduces technostress, and builds pedagogical resilience.

Input Dimension: E-Learning Innovation Strategies

The input dimension consists of institutional strategies such as adaptive Learning Management Systems (LMS), AI-assisted tools, AR/VR technologies, microlearning modules, modular course design, and continuous professional development focused on digital skills. These initiatives represent institutional investments that support digital transformation in education. By providing accessible platforms, structured tools, and training, institutions reduce technological complexity and uncertainty—key contributors to technostress—while equipping teachers with the resources needed for effective digital instruction.

Mediating Dimension: Digital Competence

Digital competence serves as the core mediating factor in the model. It refers to teachers' ability to use e-learning platforms, integrate digital tools into instruction, engage students through technology, and evaluate digital resources effectively. The study findings support its mediating role, showing a negative relationship with technostress and a very strong positive relationship with pedagogical resilience.

Thus, digital competence: reduces technostress by increasing confidence and control in technology use, and strengthens pedagogical resilience by enhancing flexibility, self-efficacy, and instructional adaptability.

Output Dimension 1: Technostress Reduction

Technostress reduction is the first outcome of the model. Technostress refers to stress caused by technological overload, complexity, or rapid change. The model conceptualizes technostress as a manageable condition that can be reduced through institutional support and improved digital competence. As teachers become more competent, they perceive technology as less threatening, allowing them to focus more on teaching quality and student engagement.

Output Dimension 2: Pedagogical Resilience

The outcome is pedagogical resilience, or teachers' ability to sustain effective instruction despite challenges. It includes adaptability, persistence, and instructional continuity. Findings show that higher digital competence strengthens resilience, while technostress weakens it. Therefore, pedagogical resilience is developed through two pathways: increased digital competence and reduced technostress. Overall, the model shifts e-learning innovation from simple technology integration to a holistic framework for sustaining effective, resilient teaching in digital environments.

Proposed E-Learning Innovation Model

The proposed model posits that structured e-learning innovation strategies—such as adaptive Learning Management Systems (LMS), AI-assisted instructional tools, immersive technologies, microlearning modules, and targeted

professional development—serve as institutional inputs that strengthen teachers' digital competence. These strategies equip educators with the necessary tools, skills, and confidence for effective technology integration in teaching.

Digital competence functions as the central mediating factor in the model. As teachers become more digitally competent, they experience lower levels of technostress due to increased confidence and control in using technology. At the same time, stronger digital competence enhances pedagogical resilience by improving teachers' adaptability, confidence, and instructional flexibility. Overall, the model shows that e-learning innovation reduces technostress and strengthens pedagogical resilience through the development of teachers' digital competence, enabling them to sustain effective instruction in technology-driven educational environments.

V. CONCLUSION

21st-century teachers tend to perform more effectively and demonstrate stronger pedagogical resilience when they possess sufficient digital competence and receive adequate institutional support. In today's technology-driven educational environment, teachers are expected to integrate digital tools into instruction, manage online platforms, and adapt to continuous technological changes. When teachers are digitally competent, they are able to navigate these demands with confidence and efficiency. They can design more engaging learning experiences, manage classroom tasks more smoothly, and respond more effectively to technical challenges. This competence reduces uncertainty and allows teachers to focus more on meaningful instruction and student learning rather than being hindered by technological difficulties.

Institutional support further strengthens this capacity by providing essential resources such as professional development, technical assistance, accessible training programs, updated digital infrastructure, and supportive policies. These forms of support create an enabling environment that guides teachers in their use of technology rather than leaving them to navigate complex systems alone. As a result, teachers become more open to innovation, more willing to experiment with new instructional strategies, and more capable of continuously improving their teaching practices. The combination of strong digital competence and institutional support ultimately fosters greater adaptability, confidence, and resilience among teachers.

However, the findings also indicate that technostress can weaken teachers' effectiveness when it is not properly managed. High levels of technostress—caused by workload overload, constant connectivity demands, system complexity, or rapid technological change—can strain teachers' cognitive and emotional resources. This may result in fatigue, reduced motivation, and diminished instructional quality. Over time, unmanaged technostress can limit teachers' ability to adapt, reduce their capacity for innovation, and weaken their overall pedagogical resilience.

Overall, the results highlight a clear and interconnected pattern: teachers are most effective and resilient when they are digitally competent and supported by their institutions, as these factors enhance confidence and instructional capability. Conversely, when technostress becomes excessive and unmanaged, it can undermine performance and reduce teachers' capacity to sustain quality teaching in technology-rich educational environments.

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