ISSN 3082-5326
Research Article

A Comprehensive Analysis of Mathematics Teachers' Initiatives in Implementing Education 4.0: Blueprint For Strategic Foresight

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International Journal of Interdisciplinary Viewpoints
Vol. 2, No. 4, pp. 10-20, 2026

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Abstract

This study examined the Education 4.0 initiatives implemented by mathematics teachers and students and their influence on classroom climate in the Prosperidad District, Schools Division of Agusan del Sur, Philippines, during Academic Year 2025–2026. Using a mixed-method explanatory sequential design (QUAN–qual), the quantitative phase employed a descriptive-correlational approach involving 101 mathematics teachers selected through complete enumeration and 388 students identified using Slovin's Formula and stratified random sampling. Descriptive statistics, one-way analysis of variance (ANOVA), and Pearson product–moment correlation were utilized to analyze the quantitative data. The qualitative phase involved focus group discussions with purposively selected master teachers and students, and thematic analysis was employed to interpret the responses. Results indicated that mathematics teachers demonstrated a high level of Education 4.0 initiatives, particularly in personal and professional development, digital literacy, and collaborative learning practices, whereas moderate levels were observed in emerging technology integration and community linkages. Students exhibited a moderate level of Education 4.0 initiatives, with strengths in collaboration and utilization of learning resources. Classroom climate was perceived by both teachers and students as positive and learner-centered. Significant differences in Education 4.0 initiatives and classroom climate were identified according to age, teaching experience, technological proficiency, and exposure to emerging technologies. Correlation analysis further revealed significant positive relationships between Education 4.0 initiatives and classroom climate among both teacher and student respondents. Qualitative findings underscored the transformative role of Education 4.0 in enhancing instructional practices, learner engagement, and educational experiences, while also highlighting persistent challenges related to technological infrastructure and digital accessibility. Based on the findings, a strategic framework was developed to strengthen the implementation of Education 4.0 practices in mathematics education.

Keywords

Education 4.0; Classroom climate; Mathematics education; Digital literacy; Teaching and learning initiatives

Citation

Cinchez, L. (2026). A Comprehensive Analysis of Mathematics Teachers' Initiatives in Implementing Education 4.0: Blueprint For Strategic Foresight . *International Journal of Interdisciplinary Viewpoints* , *2*(4), 10–20.
https://doi.org/10.64612/ijiv.v2i4.112

Received: 27 February 2026
Accepted: 23 April 2026
Published: 30 April 2026

Peer Review Statement
This article underwent a double-anonymous peer review process in accordance with the editorial policies of the International Journal of Interdisciplinary Viewpoints. Both author and reviewers remained anonymous throughout the review process.
Open Access Statement
The International Journal of Interdisciplinary Viewpoints is a fully open-access, peer-reviewed journal. All articles are freely available online immediately upon publication without subscription or access fees.
Funding Statement
The author received no financial support for the research, authorship, and/or publication of this article.
Conflict of Interest
The author declared no conflicts of interest.
Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request.
Author Contributions
The author contributed to conceptualization, methodology, investigation, writing—original draft preparation, writing—review and editing, and supervision. The author approved the final manuscript.
Ethics Statement
This study was conducted in accordance with ethical standards.

INTRODUCTION

The emergence of Education 4.0 has transformed the way teaching and learning are experienced across the world, especially in the field of mathematics education. In many classrooms, learning is no longer confined to traditional lectures and printed materials, as digital technologies, artificial intelligence (AI), cloud computing, interactive learning platforms, and data-driven systems increasingly shape the educational experience. This transformation reflects the growing demand for learners to develop critical thinking, collaboration, adaptability, and digital literacy in preparation for the Fourth Industrial Revolution. Education 4.0 promotes learner-centered instruction and flexible learning environments where students actively construct knowledge and engage meaningfully in the learning process. Studies revealed that digital resources and AI-assisted platforms significantly improve student engagement, conceptual understanding, and academic performance while encouraging innovation in teaching practices (Adams & Kauffman, 2022; Tai et al., 2022; Van Pham, 2025). Likewise, Education 4.0 fosters transformative digital pedagogy, open innovation, and complex thinking that empower both teachers and learners to adapt to rapidly changing educational demands (Miller, 2021; Ramírez-Montoya et al., 2022; Kumar, 2025). Furthermore, the integration of Industry 4.0 skills into mathematics education highlights the growing importance of technology-enhanced instruction in preparing future-ready learners (Akgunduz & Mesutoglu, 2021; Ayanwale, 2023; Pasi & Dhamak, 2025).

In the Philippine context, the transition toward Education 4.0 remains both promising and challenging. Teacher education institutions and schools continue to adopt digital transformation initiatives to align instruction with global educational trends, yet disparities in technological infrastructure, internet accessibility, and teacher preparedness continue to shape the realities of many learning communities (Alda et al., 2020). Mathematics teachers often navigate the tension between innovative teaching approaches and limited institutional resources while striving to maintain meaningful student engagement. Research emphasized that teachers' attitudes toward technology and their professional competence greatly influence the success of digital instruction in mathematics classrooms (Zulkipli & Musa, 2022; Sison & Simpal, 2025). Similarly, interactive learning modules, culture-based instructional practices, and innovative teaching strategies positively contribute to student motivation, engagement, and self-efficacy (Baring & Berame, 2022; Saro & Chua, 2025; Saro et al., 2026). However, studies also revealed that teachers continue to encounter challenges related to instructional adaptation, professional development, classroom conditions, and institutional support (Augusto et al., 2026; Bustamante, 2025; Baynosa & Simpal, 2025; Rosario, 2026). In many local settings, particularly in public schools, educators are expected to embrace technology-driven instruction despite infrastructural and pedagogical constraints. These realities become even more significant in mathematics education, where learners often require interactive, engaging, and context-sensitive learning experiences to strengthen conceptual understanding and academic participation (Ondap & Simpal, 2025; Valencia & Bulay, 2025).

Although numerous studies explored the benefits of technology integration and Education 4.0 in teaching and learning, there remains limited understanding of how mathematics teachers specifically implement Education 4.0 initiatives within localized educational contexts. Existing literature primarily focused on digital pedagogy, student engagement, teacher attitudes, and technology-enhanced learning environments (Bond et al., 2021; Caballero & Morre, 2026; Göker & Göker, 2020; Ramírez-Montoya et al., 2021), yet few studies deeply examined the lived experiences, instructional initiatives, and adaptive strategies of mathematics teachers and students in public secondary schools. Moreover, while previous research emphasized the importance of professional development, leadership readiness, and instructional innovation in fostering Education 4.0 practices (Awodiji & Naicker, 2024; Bustamante, 2025; Elragal & Habibipour, 2025), limited investigations focused on how these elements intersect in geographically and economically challenged communities. There is also a scarcity of localized frameworks that guide mathematics instruction toward meaningful Education 4.0 integration. Existing studies on student engagement, parental involvement, and pre-service teacher challenges further suggest that educational transformation involves not only technology adoption but also human relationships, emotional support, and contextual realities within schools (Cariaga & Gerodias, 2025; Cariaga et al., 2025; Oliveres et al., 2026; Taja-on et al., 2025). These gaps underscore the need to explore how mathematics teachers and students navigate digital learning environments amid institutional limitations and evolving educational expectations.

This study aimed to investigate the initiatives and approaches adopted by mathematics teachers and students in integrating Education 4.0 and to develop a framework that could strengthen digital learning in mathematics instruction. By examining the experiences, strategies, challenges, and adaptive practices present in technology-based teaching and learning, the study sought to provide meaningful insights for educators, school administrators, and policymakers. The research also hoped to contribute to the growing body of knowledge on Education 4.0 by emphasizing the importance of digital literacy, professional development, innovative pedagogy, supportive learning environments, and collaborative educational practices in fostering effective mathematics instruction (Tai et al., 2022; Kumar, 2025; Zhong et al., 2025). Furthermore, the study intended to support educational reforms that recognize both technological advancement and the human dimension of learning, where teachers remain facilitators of meaning, connection, and empowerment within increasingly digital classrooms. Through this, mathematics education may become more engaging, inclusive, adaptive, and responsive to the demands of contemporary society.

METHODOLOGY

Design

This study employed a mixed-method research approach using an explanatory sequential design (quan→QUAL), where quantitative data were collected first and followed by qualitative data for deeper interpretation. The quantitative phase utilized a descriptive-correlational design to determine the level of Education 4.0 initiatives, classroom climate

manifestations, and their relationships. Comparative analyses using ANOVA and t-test were also conducted based on respondents' profiles. The qualitative phase used Focus Group Discussions (FGDs) to explore participants' experiences and perceptions regarding Education 4.0 implementation. Thematic analysis was applied to identify recurring themes and patterns. The integration of quantitative and qualitative findings provided a comprehensive understanding of how Education 4.0 initiatives influence classroom climate and learning experiences in mathematics education.

Locale

The study was conducted in the Prosperidad District under the Schools Division of Agusan del Sur during the Academic Year 2025–2026. The locale included twelve public secondary schools selected due to their ongoing efforts to integrate digital learning strategies and Education 4.0 initiatives in mathematics instruction despite challenges in infrastructure and technological access. These schools provided an appropriate setting for examining the implementation of Education 4.0 in public secondary education.

Participants

The respondents of the study included mathematics teachers and secondary students from selected schools in the Prosperidad District. For the quantitative phase, all 101 mathematics teachers were selected through complete enumeration, while 388 students were chosen using Slovin's Formula with stratified random sampling. For the qualitative phase, purposive sampling was used to select five master teachers and five students for the Focus Group Discussions (FGDs) based on their experiences and involvement in Education 4.0 initiatives and digital learning practices.

Instrument

The study utilized a researcher-adapted survey questionnaire derived from related studies and DepEd provisions. The instrument covered respondents' demographic profile, Education 4.0 initiatives, and classroom climate manifestation using a five-point Likert scale. Expert validation and reliability testing were conducted to ensure the instrument's validity and consistency. For the qualitative component, a researcher-made interview guide with open-ended questions was used during the Focus Group Discussions (FGDs) to gather participants' experiences, perceptions, challenges, and insights regarding Education 4.0 implementation.

Procedure

Prior to the conduct of the study, the researcher secured formal approval from the Graduate School and obtained permission from the Schools Division Superintendent, Public Schools District Supervisor, and school principals of the participating schools. After approval was granted, the researcher personally administered the survey questionnaires to the respondents. The purpose of the study was explained clearly to all participants, and informed consent was obtained prior to participation. Respondents were given sufficient time to answer the questionnaires honestly and independently. The collected questionnaires were retrieved, checked, and organized for statistical analysis. For the qualitative phase, Focus Group Discussions were conducted with the selected participants in a conducive and confidential environment. The discussions were audio-recorded with participants' permission and later transcribed for thematic analysis. All gathered data were treated with utmost confidentiality and used solely for research purposes.

Statistical Treatment and Data Analysis

The quantitative data gathered were analyzed using appropriate statistical tools. Frequency counts and percentages were used to describe the demographic profiles of the respondents, while weighted mean determined the level of Education 4.0 initiatives and classroom climate manifestations among teachers and students. Pearson Product-Moment Correlation Coefficient was utilized to examine the relationships between Education 4.0 initiatives and classroom climate. One-way Analysis of Variance (ANOVA) and independent samples t-test were employed to determine significant differences based on profile variables and between teacher and student initiatives. For the qualitative data, thematic analysis was used to identify recurring themes and patterns from the Focus Group Discussions (FGDs). The integration of quantitative and qualitative findings provided a comprehensive understanding of Education 4.0 implementation in mathematics education.

Ethical Considerations

The study strictly adhered to ethical standards in research involving human participants. Participation was voluntary, and respondents were informed of their right to withdraw from the study at any stage without penalty. Informed consent was secured prior to data collection. Confidentiality and anonymity were maintained by ensuring that participants' identities were not disclosed in any part of the study. Codes and pseudonyms were utilized in presenting qualitative responses. All electronic data were stored in password-protected devices, while printed documents were securely kept and properly disposed of after the completion of the study. The researcher ensured honesty, transparency, and objectivity throughout the conduct of the study, including data collection, analysis, interpretation, and presentation of findings.

RESULTS AND DISCUSSION

Table 1 presents the demographic profile of the 101 mathematics teachers. Findings revealed that most respondents were aged 31–40, indicating a workforce that combines adaptability to innovation with instructional maturity (Ayanwale, 2023; Kumar, 2025). Female teachers slightly outnumbered males, reflecting diversity that supports inclusive and collaborative learning environments (Saro & Chua, 2025). In terms of educational attainment, the majority had pursued graduate studies, demonstrating commitment to professional growth and Education 4.0 competencies (Alda et al., 2020; Bustamante, 2025). Most teachers also had 6–15 years of teaching experience, suggesting a balance between experience and openness to modern instructional practices (Ramírez-Montoya et al., 2021). However, results showed limited institutional support for digital resources, with many teachers relying on personal resources and possessing only intermediate technology proficiency, highlighting the continuing need for professional development and stronger technological support systems in mathematics education (Awodiji & Naicker, 2024; Elragal & Habibipour, 2025; Van Pham, 2025).

Table 1
Profile Data of Mathematics Teachers

Profile Variable	Category	Frequency	Percentage
Age	21–30 years old	22	22%
	31–40 years old	52	51%
	41–50 years old	16	16%
	51–60 years old	11	11%
Sex	Male	47	47%
	Female	52	51%
	LGBTQIA+	2	2%
Educational Background	Bachelor's Degree	12	12%
	With MA Units	28	28%
	With MA CAR	47	47%
	Master's Degree	11	11%
	Doctoral/Doctoral Units	3	3%
Length of Service	5 years and below	22	22%
	6–10 years	26	26%
	11–15 years	27	27%
	16–20 years	14	14%
	21–25 years	10	10%
	26–29 years	2	2%
Access to Digital Tools	Fully provided by school	17	17%
	Partially provided	53	52%
	Mostly personal resources	31	31%
Technology Proficiency	Beginner	22	22%
	Intermediate	59	58%
	Advanced	20	20%
Use of Emerging Tech	Frequently	30	30%
	Occasionally	53	52%
	Rarely	18	18%

Note. N = 101.

Table 2 presents the professional development profile of mathematics teachers in Education 4.0. Findings revealed that most teachers attend professional development activities only 1–2 times annually, with training sessions commonly lasting 1–3 days. Webinars and workshops were the most attended programs, primarily focusing on digital literacy and ICT integration. DepEd emerged as the primary provider of these trainings. Although the majority of teachers perceived these professional development activities as highly relevant to Education 4.0, the findings suggest the need for more sustained and intensive training programs to strengthen digital competencies and effective technology integration in mathematics instruction (Akgunduz & Mesutoglu, 2021; Bustamante, 2025; Van Pham, 2025).

Table 2
Mathematics Teachers' Professional Development in Education 4.0

Profile Variable	Category	Frequency	Percentage
Frequency of Attendance	None	3	3%
	1–2 times per year	82	81%
	3–5 times per year	11	11%
	More than 5 times per year	5	5%
Duration of Training	Less than 1 day	20	20%
	1–3 days	70	69%
	4–7 days	11	11%
Type of Training Attended	Webinars	77	76%
	Workshops	72	71%
	Certification Courses	35	35%
	Conferences	22	22%
Focus Area of Training	Digital Literacy	66	65%
	ICT Tools Acquisition	57	56%
	Emerging Technologies	50	50%
	Pedagogical Innovations	27	27%
	Personalized Learning	21	21%
Source of Training	DepEd	83	82%
	Online Platforms	36	36%

	Private Institutions	8	8%
	Local/Regional	3	3%
Relevance to Education 4.0	Highly Relevant	82	81%
	Somewhat Relevant	19	19%

Note. Multiple responses were allowed for selected variables.

Table 3 presents the demographic profile of the 388 student respondents. Most respondents were aged 16–17, indicating a learner group that is generally more adaptable to technology and digital learning environments (Pasi & Dhamak, 2025; Kumar, 2025). Female students comprised the majority, reflecting inclusive student representation. In terms of educational level, most respondents were enrolled in Junior High School, followed by Senior High School students. Findings also revealed a digital access gap, as many students relied primarily on personal resources while only a few received full technological support from schools. Technology proficiency was mostly at the intermediate and beginner levels, and the majority of students only occasionally used emerging technologies. These findings highlight the continuing need for improved digital access, technological support, and enhanced digital literacy among learners in Education 4.0 environments (Van Pham, 2025; Adams & Kauffman, 2022).

Table 3
Profile Data of Students

Profile Variable	Category	Frequency	Percentage
Age	12–13 years old	99	26%
	14–15 years old	84	22%
	16–17 years old	153	39%
	18 years and above	52	13%
Sex	Male	151	39%
	Female	204	53%
	LGBTQIA+	33	9%
Educational Level	Junior High School (JHS)	193	50%
	Senior High School (SHS)	96	25%
	SHS Graduating	99	26%
Access to Digital Tools	Fully provided by school	38	10%
	Partially provided	144	37%
	Mostly personal resources	157	40%
	No access	49	13%
Technological Proficiency	Beginner	138	36%
	Intermediate	188	48%
	Advanced	55	14%
	Expert	7	2%
Use of Emerging Technologies	Frequently	107	28%
	Occasionally	197	51%
	Rarely	69	18%
	Never	15	4%

Note. N = 388.

Table 4 presents the mathematics teachers' initiatives across seven domains. The overall mean of 3.442 indicates a high level of engagement in professional development, technology integration, and innovative teaching practices essential in Education 4.0 (Tai et al., 2022; Kumar, 2025). Personal Growth and Development obtained the highest mean, showing teachers' strong commitment to improving their professional competencies and adapting to technological changes in education (Bustamante, 2025). Digital Literacy and Competency also ranked high, reflecting teachers' ability to utilize digital tools and online resources effectively. However, Community Linkages registered the lowest mean, indicating limited collaboration with external stakeholders and community-based initiatives. This suggests the need to strengthen partnerships that support real-world learning experiences and resource sharing in mathematics education (Göker & Göker, 2020).

Table 4
Mathematics Teachers' Initiatives in Education 4.0

Parameters	Mean	Adjectival Description
Digital Literacy and Competency	3.752	High
Integration of Emerging Technologies	2.893	Moderate
ICT Skills Acquisition and Enhancement	3.681	High
Collaborative Learning Practices and Readiness	3.657	High
Personal Growth and Development	3.784	High
Community Linkages	2.578	Moderate
Learning Resources	3.750	High

Overall Mean	3.442	High

Note. Scale interpretation: 4.20–5.00 = Very High; 3.40–4.19 = High; 2.60–3.39 = Moderate; 1.80–2.59 = Low; 1.00–1.79 = Very Low.

Table 5 presents students' Education 4.0 initiatives. The overall mean of 3.345 indicates a moderate level of engagement in collaborative learning, digital resource utilization, and technology-based activities. Collaborative Learning Practices and Readiness obtained the highest mean, showing that students are actively engaged in teamwork, peer interaction, and collaborative problem-solving, which are essential components of Education 4.0 learning environments (Tai et al., 2022; Zhong et al., 2025). Learning Resources and Digital Literacy and Competency also received high ratings, reflecting students' growing ability to access and utilize digital tools for learning (Adams & Kauffman, 2022; Van Pham, 2025). However, Community Linkages registered the lowest mean, suggesting limited student involvement in community-based and external collaborative activities. This highlights the need to strengthen partnerships and experiential learning opportunities that connect students with real-world educational experiences (Göker & Göker, 2020; Pasi & Dhamak, 2025).

Table 5
Students' Initiatives in Education 4.0

Parameters	Mean	Adjectival Description
Digital Literacy and Competency	3.581	High
Integration of Emerging Technologies	3.092	Moderate
ICT Skills Acquisition and Enhancement	3.282	Moderate
Collaborative Learning Practices and Readiness	3.685	High
Personal Growth and Development	3.360	Moderate
Community Linkages	2.832	Moderate
Learning Resources	3.582	High
Overall Mean	3.345	Moderate

Table 6 presents the classroom climate as perceived by teachers. The overall mean of 4.02 indicates that positive, dynamic, and learner-centered classroom practices frequently occur in mathematics instruction under Education 4.0 settings. The highest ratings were observed in dynamic learner-centered instruction and the use of assessment to support student growth, reflecting teachers' efforts to encourage active participation, self-directed learning, and meaningful feedback mechanisms (Alda et al., 2020; Tai et al., 2022). Equal participation and recognition of diverse learning styles also received high ratings, suggesting sensitivity to learners' individual needs and inclusive classroom practices (Saro & Chua, 2025). However, valuing the efforts and contributions of one another obtained the lowest mean, although still interpreted as frequently occurring, indicating the need to further strengthen peer appreciation, collaboration, and supportive classroom relationships among learners (Zhong et al., 2025; Göker & Göker, 2020).

Table 6
Teachers' Classroom Climate Manifestation in Response to Initiatives

Indicator	Mean	Adjectival Description
1. Cooperative and effective teamwork under teacher guidance	3.93	Frequently Occurs
2. Valuing effort, contributions, and achievements of one another	3.73	Frequently Occurs
3. Students feel welcomed, comfortable, and confident with teacher	4.06	Frequently Occurs
4. Meaningful, relevant curriculum promoting growth of all learners	4.05	Frequently Occurs
5. Teacher goes beyond standard duties to provide individual assistance	4.06	Frequently Occurs
6. Strong sense of belonging and competence among learners	3.93	Frequently Occurs
7. Equal participation by recognizing diverse learning styles	4.11	Frequently Occurs
8. Dynamic, engaging, learner-centered, and challenging instruction	4.12	Frequently Occurs
9. Structured opportunities for reflection and self-assessment	4.07	Frequently Occurs
10. Assessments as tools for learning, growth, and self-awareness	4.12	Frequently Occurs
Overall Mean	4.02	Frequently Occurs

Table 7 presents student perceptions of classroom climate. The overall mean of 3.91 indicates that students generally experience a supportive, inclusive, and learner-centered classroom environment in mathematics education. The highest ratings were observed in feeling welcomed and confident, the use of assessments as learning tools, and opportunities for reflection and self-assessment, suggesting that teachers foster active participation, student empowerment, and meaningful learning experiences (Tai et al., 2022; Adams & Kauffman, 2022). These findings also reflect the growing emphasis of Education 4.0 on collaborative and student-centered learning environments (Kumar, 2025). However, dynamic and engaging instruction obtained the lowest mean, indicating that students still seek more interactive, technology-enhanced, and stimulating classroom experiences. This highlights the importance of strengthening innovative instructional strategies and digital learning practices to sustain learner engagement and participation (Van Pham, 2025; Zhong et al., 2025).

Table 7
Students' Classroom Climate Manifestation in Response to Initiatives

Indicator	Mean	Adjectival Description
1. Cooperative teamwork under teacher guidance	3.97	Frequently Occurs

2. Valuing effort, contributions, and achievements	3.89	Frequently Occurs
3. Students feel welcomed, comfortable, and confident	4.04	Frequently Occurs
4. Meaningful, relevant curriculum promoting student growth	3.84	Frequently Occurs
5. Teacher provides individual assistance beyond standard duties	3.88	Frequently Occurs
6. Strong sense of belonging and competence	3.84	Frequently Occurs
7. Equal participation recognizing diverse learning styles	3.91	Frequently Occurs
8. Dynamic, engaging, learner-centered instruction	3.75	Frequently Occurs
9. Structured opportunities for reflection and self-assessment	3.98	Frequently Occurs
10. Assessments as tools for learning and self-awareness	4.00	Frequently Occurs
Overall Mean	3.91	Frequently Occurs

Table 8 presents the ANOVA results for significant differences in Education 4.0 initiatives across profile variables. Findings revealed that technological proficiency and exposure to emerging technologies were the most consistent and significant predictors across various Education 4.0 domains, suggesting that practical experience and continuous engagement with innovation play a greater role than formal credentials alone (Van Pham, 2025; Elragal & Habibipour, 2025). Personal Growth and Development showed the highest significant difference in relation to age, followed by Collaborative Learning Practices and Integration of Emerging Technologies, indicating that teachers' adaptability and engagement with digital practices vary across age groups. Length of service also showed significant differences in ICT skills, collaborative learning, personal growth, and emerging technology integration, highlighting the influence of teaching experience on technology adoption and instructional practices (Ayanwale, 2023; Ramírez-Montoya et al., 2021). Meanwhile, sex was only significant in Collaborative Learning Practices, suggesting that collaborative engagement may differ across gender-related interactions within learning environments (Saro & Chua, 2025).

Table 8
Significant Differences in Education 4.0 Initiatives

Domain	Source of Variation	Computed F	p-value	Decision
Digital Literacy	Technological Proficiency	5.410	.006	Significant
	Use of Emerging Tech	5.880	.004	Significant
Emerging Technologies	Age	14.090	.000	Significant
	Length of Service	7.590	.000	Significant
	Technological Proficiency	3.310	.041	Significant
	Use of Emerging Tech	9.730	.000	Significant
ICT Skills	Age	5.580	.001	Significant
	Length of Service	3.880	.006	Significant
	Use of Emerging Tech	7.620	.001	Significant
Collaborative Learning	Age	17.400	.000	Significant
	Sex	3.660	.029	Significant
	Length of Service	4.340	.003	Significant
	Technological Proficiency	4.650	.012	Significant
	Use of Emerging Tech	10.380	.000	Significant
Personal Growth	Age	28.900	.000	Significant
	Length of Service	6.100	.000	Significant
	Use of Emerging Tech	7.320	.001	Significant
Community Linkages	Age	3.210	.026	Significant
	Technological Proficiency	5.930	.004	Significant
	Use of Emerging Tech	5.460	.006	Significant
Learning Resources	Age	9.670	.000	Significant
	Use of Emerging Tech	3.320	.040	Significant

Table 9 presents the ANOVA results for classroom climate differences across profile variables. Findings revealed that age, length of service, technological proficiency, and exposure to emerging technologies significantly influenced classroom climate, indicating that experience, maturity, and familiarity with digital tools contribute to creating more positive and engaging learning environments (Ayanwale, 2023; Van Pham, 2025). In contrast, sex, educational attainment, access to digital tools, and professional development showed no significant differences, suggesting that the presence of resources or credentials alone does not automatically improve classroom climate. These findings emphasize that effective Education 4.0 implementation depends more on teachers' practical technological competence, adaptability, and sustained engagement with innovative teaching practices (Kumar, 2025; Elragal & Habibipour, 2025).

Table 9
Classroom Climate When Grouped According to Profile

Source of Variation	Computed F	p-value	Decision	Conclusion
Age	14.360	.000	Reject Ho	Significant

Sex	0.540	.586	Failed to Reject Ho	Not Significant
Educational Background	0.870	.459	Failed to Reject Ho	Not Significant
Length of Service	5.820	.001	Reject Ho	Significant
Access to Digital Tools	0.480	.622	Failed to Reject Ho	Not Significant
Technological Proficiency	3.090	.050	Reject Ho	Significant
Use of Emerging Technologies	6.190	.003	Reject Ho	Significant
Professional Development	1.780	.155	Failed to Reject Ho	Not Significant

Table 10 presents the Pearson correlation results between teachers' Education 4.0 initiatives and classroom climate. Findings revealed that all seven initiative domains had statistically significant positive relationships with classroom climate, indicating that stronger Education 4.0 practices contribute to more positive, engaging, and learner-centered classroom environments. Personal Growth and Development showed the strongest correlation, suggesting that teachers who promote confidence, independence, and continuous learning greatly enhance classroom climate (Bustamante, 2025; Kumar, 2025). Integration of Emerging Technologies also demonstrated a strong relationship, highlighting the role of technology-enhanced instruction in encouraging active participation and engagement among learners (Van Pham, 2025; Adams & Kauffman, 2022). Likewise, Learning Resources, Community Linkages, ICT Skills, Collaborative Learning, and Digital Literacy all showed significant moderate correlations, confirming that effective utilization of Education 4.0 initiatives positively influences classroom interaction, participation, and overall learning experiences (Tai et al., 2022; Zhong et al., 2025).

Table 10
Significant Relationship Between Teachers' Initiatives in Education 4.0 and Classroom Climate

Variable	Computed r	p-value	Decision	Conclusion
Digital Literacy	0.331	.001	Reject Ho	Significant
Emerging Technologies	0.461	.000	Reject Ho	Significant
ICT Skills	0.428	.000	Reject Ho	Significant
Collaborative Learning	0.364	.000	Reject Ho	Significant
Personal Growth	0.558	.000	Reject Ho	Significant
Community Linkage	0.396	.000	Reject Ho	Significant
Learning Resources	0.404	.000	Reject Ho	Significant

Table 11 presents the Pearson correlation results between students' Education 4.0 initiatives and classroom climate. Findings revealed that all variables had highly significant positive relationships, indicating that students' active participation in Education 4.0 practices contributes to a more positive and engaging classroom environment. Collaborative Learning showed the strongest correlation, highlighting the importance of teamwork, peer interaction, and shared learning experiences in shaping classroom climate (Tai et al., 2022; Zhong et al., 2025). Digital Literacy and Personal Growth also demonstrated strong positive relationships, suggesting that students who are technologically competent and self-directed are more likely to engage meaningfully in learning activities (Adams & Kauffman, 2022; Kumar, 2025). Moreover, Learning Resources, ICT Skills, and Integration of Emerging Technologies showed moderate positive correlations, emphasizing the value of digital tools and technology-supported instruction in enhancing classroom interaction and participation (Van Pham, 2025; Elragal & Habibipour, 2025). Although Community Linkage obtained the lowest correlation, it remained significant, indicating that real-world connections and external learning experiences still contribute to a supportive classroom climate (Göker & Göker, 2020).

Table 11
Significant Relationship Between Students' Initiatives in Education 4.0 and Classroom Climate

Variable	Computed r	p Value	Decision	Conclusion
Digital Literacy	0.589	.000	Reject Ho	Significant
Emerging Technologies	0.417	.000	Reject Ho	Significant
ICT Skills	0.431	.000	Reject Ho	Significant
Collaborative Learning	0.628	.000	Reject Ho	Significant

Table 12 presents the t-test results comparing teachers' and students' Education 4.0 initiatives. Findings revealed significant differences in six of the seven domains, particularly in Personal Growth and Development and ICT Skills Acquisition, indicating noticeable gaps between teachers' and students' competencies in these areas (Bustamante, 2025; Van Pham, 2025). Significant differences were also observed in Digital Literacy, Integration of Emerging Technologies, Community Linkages, and Learning Resources, suggesting that while teachers continue to enhance their professional and technological capacities, these developments are not yet fully reflected in students' learning experiences and competencies (Elragal & Habibipour, 2025; Kumar, 2025). However, Collaborative Learning Practices showed no significant difference, indicating that both teachers and students share relatively balanced experiences in collaboration and teamwork, which serve as a strong foundation for Education 4.0 implementation (Tai et al., 2022; Zhong et al., 2025).

Table 12
Significant Difference Between Mathematics Teachers' and Students' Initiatives in Education 4.0

Domain	Computed t	p-value	Decision	Conclusion
Digital Literacy	2.700	0.007	Reject Ho	Significant
Emerging Technology	2.990	0.003	Reject Ho	Significant
ICT Skills Acquisition	6.000	0.000	Reject Ho	Significant
Collaborative Learning Practices	0.360	0.717	Failed to Reject Ho	Not Significant
Personal Growth and Development	6.180	0.000	Reject Ho	Significant
Community Linkages	3.190	0.002	Reject Ho	Significant
Learning Resources	2.590	0.010	Reject Ho	Significant

Table 13 summarizes the perceived impact of Education 4.0 initiatives as described by Master Teachers, while Table 15 presents the students' perspectives. Three major themes emerged: Transformation of Teaching Practices, Use of Digital Tools and Technologies, and Impact on Student Engagement and Learning. Teachers described a shift toward more interactive, learner-centered, and real-life-based mathematics instruction, where digital platforms, multimedia resources, and AI-assisted tools enhanced lesson delivery and student participation (Bond et al., 2021; Tai et al., 2022; Kumar, 2025). Interactive tools such as online quizzes, video platforms, and digital learning applications supported flexible and self-paced learning while encouraging greater classroom engagement, particularly among less active learners (Adams & Kauffman, 2022; Van Pham, 2025). Both teachers and students also perceived that Education 4.0 initiatives increased motivation, collaboration, and understanding of mathematical concepts through gamified and technology-supported learning experiences (Zhong et al., 2025; Elragal & Habibipour, 2025).

Table 13
Thematic Summary: Perceived Impact of Education 4.0 Initiatives by Master Teachers

Category	Theme	Subtheme
Transformation of Teaching Practices	Shift toward Interactive and Learner-Centered Instruction	Use of digital tools and real-life contexts to make mathematics engaging
	Enrichment of Instructional Delivery	Integration of multimedia resources and AI-assisted lesson planning
	Flexibility in Teaching and Learning	Anytime access and self-paced learning through online platforms
Use of Digital Tools and Technologies	Adoption of Interactive Assessment Recall	Kahoot, Quizizz, Google Forms, Wayground for instant feedback
	Integration of Learning Platforms	Khan Academy and YouTube for guided practice and concept mastery
	Technology-Supported Lesson Planning	AI tools to enhance instructional preparation
Impact on Student Engagement and Learning	Increased Student Participation	Active involvement of quiet/passive students in online activities
	Enhanced Motivation and Interest in Math	Learning through games, videos, and interactive quizzes
	Improved Understanding with Guided Support	Opportunities for review, practice, and differentiated support

Students reported meaningful changes in their learning experiences through increased engagement in interactive digital platforms, personalized self-paced learning, and easier access to learning materials anytime and anywhere (Zhong et al., 2025; Adams & Kauffman, 2022). Many students also expressed higher motivation and enjoyment in learning mathematics, particularly through gamified and technology-supported activities that enhanced curiosity, participation, and confidence in solving problems independently (Van Pham, 2025; Tai et al., 2022). Despite these positive experiences, students also identified persistent challenges such as unstable internet connection, limited access to devices, online distractions, and difficulties understanding lessons without immediate teacher guidance. To cope, students adopted strategies such as minimizing distractions, taking notes during online lessons, and responsibly utilizing AI-assisted tools. These findings suggest that effective Education 4.0 implementation requires not only access to technology but also strong teacher support, digital literacy development, and well-designed instructional strategies that sustain meaningful learning experiences (Elragal & Habibipour, 2025; Kumar, 2025).

Table 14
Thematic Summary: Perceived Impact of Education 4.0 Initiatives by Students

Category	Theme	Subtheme
Changes in Learning Experience	Increased Engagement and Participation	Enjoyment through interactive tools
	Personalized and Self-Paced Learning	Control over learning progress
	Convenience and Accessibility	Anytime learning availability
Motivation and Interest	Intrinsic Motivation	Increased curiosity and attentiveness
	Enjoyment and Fun in Learning	Interactive lesson enjoyment
	Confidence and Initiative	Increased self-confidence

Category	Theme	Subtheme
Challenges and Focus	Technical Difficulties	Poor internet connection and device availability
	Distractions and Self-Management	Focus maintenance strategies
	Comprehension Issues	Difficulty following steps without teacher

Conclusion and Recommendations

Mathematics teachers in the Prosperidad District are generally young to middle-aged professionals who demonstrate strong commitment to professional growth and adaptability to educational innovations. Despite balanced gender representation and moderate to high levels of technological proficiency, many teachers still rely on personal resources to access digital tools, indicating insufficient institutional support. Similarly, students exhibit moderate access to technology, with noticeable disparities in digital resources that continue to affect equitable participation in Education 4.0 initiatives. Teachers displayed high commitment in areas such as digital literacy, collaborative learning, and personal development, while students demonstrated moderate engagement, particularly in collaborative practices and resource utilization. However, both groups encountered challenges in emerging technology integration, community linkages, and sustained digital engagement. Significant differences between teachers' and students' initiatives across most domains further suggest gaps in implementation, although collaborative learning emerged as a shared strength. Moreover, the frequent manifestation of positive classroom climates and the strong relationships between Education 4.0 initiatives and classroom climate confirm that these practices contribute to more engaging, learner-centered, and supportive learning environments. The proposed strategic framework, grounded in educational theories, constitutional mandates, and Philippine educational policies, therefore provides a comprehensive roadmap for strengthening Education 4.0 implementation in Prosperidad District by 2030.

In light of these findings, mathematics teachers are encouraged to continuously improve their pedagogical practices by integrating technology with clear instructional purpose, fostering digital literacy, and promoting independent and collaborative learning among students. Students should likewise strengthen their ICT competencies, actively participate in digital and collaborative learning environments, and assume greater responsibility for their academic growth. School administrators must prioritize the enhancement of digital infrastructure, provide mentoring and technical support for teachers, and cultivate a culture of innovation within schools. The Department of Education should ensure sustained professional development programs, equitable distribution of technological resources, and continuous monitoring of Education 4.0 implementation to address existing gaps and challenges. Furthermore, future researchers are encouraged to conduct longitudinal and comparative investigations to further assess the long-term effectiveness, sustainability, and broader educational impact of Education 4.0 initiatives across different learning contexts.

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