JOURNAL OF INTERDISCIPLINARY PERSPECTIVES

ISSN Print: 2984-8288, ISSN Online: 2984-8385
Vol. 3 No. 8, 436-444, August 2025

Exploring through Implications of Professional Development Activities in Implementing Students' 21st-Century Learning Skills

Jasper Kent A. Purisima*[1], Junan N. Romero[2], Jerome D. Meñale[3]
[1,3]Mobo National High School, Mobo, Masbate, Philippines
[2]Dimasalang National High School, Dimasalang, Masbate, Philippines

*Corresponding Author Email: jasperkent.purisima@deped.gov.ph

Date received: June 2, 2025
Date revised: June 18, 2025
Date accepted: July 11, 2025

Originality: 96%
Grammarly Score: 99%
Similarity: 4%

Recommended citation:
Purisima, J. K., Romero, J., & Meñale, J. (2025). Exploring through implications of professional development activities in implementing students' 21st-century learning skills. *Journal of Interdisciplinary Perspectives*, *3*(8), 436-444. https://doi.org/10.69569/jip.2025.477

Abstract. With the ever-changing educational landscape, professional development (PD) activities are crucial in addressing challenges and issues that arise from the stagnation or progress of every science classroom experience. More so, learners need to become globally competitive, equipped with 21st-century learning skills. However, research studies suggest a mismatch between the varying content of PD activities and the actual needs of teachers in the realities of the classroom setting. Therefore, this study aims to explore the experiences, critical needs, and challenges science teachers experience in effectively implementing 21st-century skills among learners. Through a sequential explanatory design, 27 science teachers were asked about their perceived applicability and relevance of their professional development activities, identified their critical needs, and discussed the challenges they experienced in implementing 21st-century learning skills. Findings revealed various insights in implementing the 21st-century learning skills: (1) acquired knowledge and skills from Seminar and Conferences were often utilized, while both Seminars and Conference and Coaching and Mentoring were more relevant, (2) science teachers emphasized the needs for technological, pedagogical, socio-emotional, and adaptability and innovative competence, and (3) science teachers also highlights various challenges involving the limitation to learning resources and infrastructures, existing institutional and systemic challenges, and pedagogical constraints. The findings suggest a more aligned, strengthened, and iterative process that addresses gaps and challenges, while empowering science teachers to become resilient and fully equipped to implement 21st-century learning skills effectively. Based on the study's results, future research directions were identified, focusing on professional development activities and the continuous improvement of the teaching and learning process.

Keywords: 21st-century skills; Challenges; Needs; Professional development; Science teachers.

1.0 Introduction

The advancement of technology and access to information have transformed the educational landscape into a distinct aspect of society in the 21st century, requiring the development of students with a range of skills and knowledge to ensure their success (Voogt et al., 2020). However, accompanied by these advancements are classroom challenges for adaptation and emphasis of these skills (Pellegrino & Hilton, 2012), such as teachers' pedagogy, competencies, and adequate training (Crawford, 2014; Heriman et al., 2024; Barot, 2019), lack of

necessary technology and resources (Hasibuan et al., 2024), and sufficient and relevant assessment (Safri & Jamaludin, 2022).

Classroom teachers are the most valuable instructional resource in each learning environment; empowering teachers is necessary and critical in meeting the demands of the ever-changing education landscape. The mismatch between the traditional training activities and the demands of the 21st-century competencies emphasizes the vitality of appropriate PD programs and opportunities. Teachers need PD programs that will equip them with the essential skills and promote their critical thinking and creativity (Naqvi et al., 2023). The PD activities aim to provide teachers with numerous opportunities to learn and acquire strategies, utilize innovative technologies, and share insights and ideas with colleagues and peers to broaden and widen the teaching prowess (Hammond et al., 2017). A study by Calacar (2020) found that public school teachers faced more challenges than their private school counterparts in terms of teaching practices. The study revealed a strong correlation between teachers' competence and the teaching of 21st-century skills among students. Meanwhile, a study by Gonzales (2020) revealed significant differences in the 21st-century skills of instructors across various dimensions, indicating that teachers require attending a series of training sessions and seminars, as well as receiving assistance and guidance from multiple curriculum experts. This was supported by Del Mundo (2022), who noted that the study revealed a lack of experience among teachers in effectively integrating 21st-century skills, particularly digital skills, into their instruction due to poor internet connections, inadequate support systems, and limited materials and equipment. Teachers should be trained and help demonstrate competencies with authentic tasks and assessments, such as performance-based and project-based assessments (Darling-Hammond et al., 2010).

While PD programs in the Philippines aim to enhance teacher competencies, studies indicate a persistent mismatch between PD content and the actual needs of science teachers in implementing 21st-century learning. Current PD initiatives often prioritize generic skills over context-specific demands, including pedagogical, socio-emotional, and technological competency. For instance, Padillo et al. (2021) said that PD programs in the Philippines are impractical and did not consider real situations in the Philippine educational system because their study revealed that the overall PD activities attended by teachers are less likely to be beneficial for teachers' performance. In Service Training for Teachers (INSET), for example, either school-based or division-wide training programs are often helpful but not quite significant for teachers' overall teaching skills (Ahme et al., 2021); teachers feel they need more to be equipped with teaching methods/strategies, teaching students with special learning needs (disabilities, giftedness and talents), strategies in giving remediation and enrichment activities, developing thinking skills of students, ICT skills for teaching, conducting action research, and personal development, like stress management, interpersonal, and communication skills (Ganal et al., 2019; Gepila, 2020; Redondo & Enciso, 2025).

This study is exploratory, which aims to gather initial insights into the experiences, needs, and challenges of science teachers regarding PD and 21st-century learning. Specifically, this study seeks to answer questions involving the types of PD activities teachers are most exposed to, how teachers perceive the implementation, in terms of applicability and relevance, of these activities to their teaching contexts, the specific needs as critical for effectively implementing 21st-century learning skills, and the experienced challenges that hinder science teachers from implementing 21st-century skills, despite participating in PD activities.

The findings are not intended to be generalizable but rather to inform future research and policy discussions. The findings will also provide valuable insights into current training initiatives, enabling the development of more targeted and effective training programs that suit science teachers in delivering 21st-century learning skills.

2.0 Methodology

2.1 Research Design

This study employed a mixed-methods research design, specifically a sequential explanatory design. This study utilized both the strengths of analyzing quantitative data and further explaining or expanding on it with qualitative data. According to Creswell (2009), the quantitative data in the study is followed by qualitative data to discuss results in more detail.

2.2 Participants and Sampling Technique

The respondents included in the study were determined using convenience sampling, and 27 individuals were recruited. The sampling method chosen was due to practical constraints and the ability to reach teachers in their

respective locations; therefore, anyone readily available and willing to participate was accepted. The respondents consisted of classroom teachers, with sufficient representation from the three congressional districts, covering the scope of the province's division. The participants were classroom teachers representing a range of years of experience in the profession and varying levels of professional proficiency across the different congressional districts in the province.

2.3 Research Instrument

A researcher-made questionnaire is the primary data collection tool used in this study, administered via Google Forms. The instrument was developed specifically to explore science teachers' experiences with PD activities, their perceived applicability to classroom contexts, and the challenges they face in implementing 21st-century learning skills.

The questionnaire was divided into three sections: (1) demographic profile, and both (2) quantitative (5-point Likert-scale) constructed based on the existing themes on PD activities (Education Advanced, 2023) assessed the frequency of exposure to various PD activities and (3) qualitative (open-ended) items aimed to elicit detailed responses on pedagogical, technological, and socio-emotional needs, as well as systemic barriers to implementing 21st-century learning strategies, and structured to address the four main research questions.

2.4 Data Gathering Procedure

The data for this study were gathered using a Google Forms-based questionnaire developed by the researchers. The survey link was shared via messaging mediums and other official communication platforms commonly used by teachers.

2.5 Data Analysis Procedure

Quantitative data from the Likert-scale items were encoded and analyzed using Microsoft Excel. Descriptive statistics, specifically frequency counts, percentages, means, and standard deviations, were used to determine the types of PD activities, which science teachers were most exposed to, and the perceived applicability of these sessions to their classroom contexts. Pearson's Correlation Coefficient (r) and p-value were determined to provide insight into the relationship between the perceived relevance and applicability of PD activities in the science classroom. Descriptive analysis, Pearson r for correlation, and significant p-value were analyzed using RStudio (version 2025.05.0+496).

Qualitative data from responses to the open-ended questions were analyzed using thematic analysis. The researchers reviewed the responses multiple times to identify recurring themes and concepts. Inductive coding was employed to identify existing themes within the responses. Due to time and resource constraints, the instrument was not subjected to formal expert validation or pilot testing. As such, the study assumes an exploratory nature, and the findings are intended to provide preliminary insights rather than generalizable conclusions. No formal reliability testing was conducted; however, item consistency and clarity were reviewed internally among the research team during development.

2.6 Ethical Considerations

A short message was embedded within the form, explaining the purpose of the study, ensuring confidentiality, and indicating that participation was voluntary. Furthermore, no personal details, such as names, school affiliations, addresses, or any other identifying information, were collected.

3.0 Results and Discussion

3.1 Science Teachers' Demographic Profile

Table 1 presents the demographics of 27 respondents, including years in service, current position, and location within the congressional district. Respondents consisted of 29.6% (≤5 years) in their early career, 59.2% (6–14 years) in their mid-career, and 11.1% (≥15 years) considered in their veteran career. The respondents occupying the current position are 85.2% as Teacher I-III (Proficient Teachers) and 14.8% as Master Teachers I-III (Highly Proficient Teachers). Proficient-level positions are capable of knowing the different scenarios inside a science classroom and reflecting on PD needs and experience; likewise, High Proficient-level positions could provide this study insights as classroom teachers at the same time instructional leaders, considered as mentor or coach in the practice, who could provide necessary feedback and the necessary improvement needed by proficient-level teachers. The respondents also come from the three congressional districts monitored by the division office. The

respondents could provide the study with and capture the varying needs, insights, and experiences relevant for exploring PD activities in implementing 21st-century learning skills.

Table 1. *Demographic Profile of Science Teachers*

Demographics	Frequency *N*	Percentage
Years in Service		
Less than 3 years	5	18.5
3 to 5 years	3	11.1
6 to 8 years	8	29.6
9 to 11 years	3	11.1
12 to 14 years	5	18.5
15 to 17 years	2	7.4
19 to 21 years	1	3.7
Total	27	100
Current Position		
Teacher I-III (Proficient Teachers)	23	85.2
Master Teacher I-III (Highly Proficient Teachers)	4	14.8
Total	27	100
Congressional District		
1st	4	14.8
2nd	18	66.7
3rd	5	18.5
Total	**27**	**100**

3.2 Science Teachers' Exposure to PD Activities

Perceived Applicability of PD Activities in Developing Students' 21st Century Learning Skills

Based on Table 2, among the PD activities, Seminars and Conferences (*M = 4.15)* were perceived as the most utilizable by science teachers in developing 21st-century learning skills. This indicates that these kinds of activities were the most often used in classroom instruction and increasing teachers' competencies, compared to other activities such as indulging oneself in the Qualification Programs such as any post-graduate degrees (*M* = 3.56), Peer Observation (*M* = 3.74), and Research (*M* = 3.74), which had lower mean scores. The higher mean for Seminars and Conferences suggests that structured, short-term PD formats may be more accessible and immediately actionable for teachers compared to long-term commitments like postgraduate degrees.

Table 2. *Descriptive Statistics of Perceived Applicability of PD Activities in Developing 21st-Century Learning*

	vars	*n*	*M*	*SD*	*Md*	*TM*	*MAD*	*min*	*max*	*R*	*Sk*	*K*	*SE*
Qualification Programs	1	27	3.56	1.01	4	3.61	1.48	1	5	4	-0.36	-0.27	0.19
Courses & Workshops	2	27	4.04	0.76	4	4.04	1.48	3	5	2	-0.06	-1.33	0.15
Coaching & Mentoring	3	27	4.04	0.98	4	4.13	1.48	2	5	3	-0.54	-0.96	0.19
Seminars & Conferences	4	27	4.15	0.77	4	4.17	1.48	3	5	2	-0.24	-1.34	0.15
Peer Observation	5	27	3.74	1.16	4	3.83	1.48	1	5	4	-0.50	-0.80	0.22
Research	6	27	3.74	1.23	4	3.83	1.48	1	5	4	-0.60	-0.95	0.24

The findings suggest that Seminars and conferences are more preferred PD activities for science teachers in terms of how often they apply them in the science classroom, especially in implementing 21st-century learning skills. For instance, Rimmer and Floyd (2020) found in their study that conferences enhance self-efficacy among teachers, thereby improving their confidence, knowledge, and skills. Neng and Cheo (2022) also concluded that seminars can educate teachers in cognitive, emotional, social, and technological competencies and skills, thereby fostering 21st-century learning skills among learners. This collective evidence underscores that while all PD activities contribute to teacher development, the immediacy and collaborative nature of seminars and conferences make them particularly effective for classroom application. This implies that PD Seminars and Conferences should always prioritize fostering 21st-century teaching competencies and skills to better equip teachers in delivering and implementing classroom instruction, thereby producing 21st-century skilled learners.

Perceived Relevance of PD Activities in Developing Students' 21st-century Learning Skills

As shown in Table 3, all PD activities were highly rated in terms of their relevance, with Coaching and Mentoring, and Seminars and Conferences receiving the same highest rating (*M* = 4.74). This shows that science teachers perceive PD activities and opportunities aligned with their professional goals, especially in integrating and

developing 21st-century skills. Although Qualification Programs (M = 4.41) got the lowest rating, it is still considered relevant. The near-identical high ratings for Coaching and Mentoring and Seminars and Conferences highlight that teachers value both peer-supported guidance and formal knowledge-sharing equally, possibly due to their complementary roles in skill development.

Table 3. *Descriptive Statistics of Perceived Relevance of PD Activities in Developing 21st-Century Learning*

	vars	*n*	*M*	*SD*	*Md*	*TM*	*MAD*	*min*	*max*	*R*	*Sk*	*K*	*SE*
Qualification Programs	1	27	4.41	1.05	5	4.61	0	1	5	4	-1.80	2.50	0.20
Courses & Workshops	2	27	4.70	0.54	5	4.78	0	3	5	2	-1.52	1.32	0.10
Coaching & Mentoring	3	27	4.74	0.45	5	4.78	0	4	5	1	-1.04	-0.95	0.09
Seminars & Conferences	4	27	4.74	0.59	5	4.87	0	3	5	2	-2.01	2.75	0.11
Peer Observation	5	27	4.52	0.64	5	4.61	0	3	5	2	-0.90	-0.36	0.12
Research	6	27	4.70	0.67	5	4.83	0	3	5	2	-1.85	1.80	0.13

The findings suggest that among PD activities, both effective Coaching and Mentoring, as well as seminars and Conferences, are sources of strength in better implementing 21st-century skills in the science classroom. This implies that a science teacher could rely on equipping themselves with appropriate competencies and skills and meeting their needs through these PD activities (Ke-Du, 2019; Dominado, 2020; Uzezi et al., 2025), highlighting a preference for more interactive, collaborative, and knowledge-sharing formats that likely provide practical strategies and peer support. Additionally, although Qualification Programs are still considered relevant, this specific activity could be designed for improvement and aligned with teachers' needs and growth. The slightly lower relevance score for Qualification Programs may reflect challenges such as time constraints or misalignment with immediate classroom needs, suggesting a need for more flexible or targeted advanced-degree offerings.

Moreover, the contrast in ratings between perceived applicability (Table 1) and perceived relevance (Table 2) emphasizes the gap between the acquisition of theory and its practical use. This disparity could stem from structural barriers, such as insufficient support or contextual factors, like curriculum constraints, which limit the translation of relevant PD content into classroom practice. A relevant study by Santos (2017) also revealed a disparate result between what students and teachers perceive as the transferred and acquired 21st-century skills. This could be supported by the study of Nwuba et al. (2024), where they also found that a gap exists between the teachers' awareness and utilization of different innovative pedagogical approaches, often attributed to and expected to be acquired from various PD activities. Further, these findings call for a systemic approach that aligns PD design with classroom realities and provides ongoing implementation support. This implies that PD activities are often not aligned with developing competencies and skills among teachers that are intended to support and foster the development of 21st-century learning skills among learners.

Correlation and Significance of Perceived Relevance and Applicability of PD Activities in Developing 21st-century Learning

Table 4 reveals significant positive correlations ($p < 0.05$) between perceived relevance and perceived applicability for most PD activities in implementing 21st-century learning skills in science classroom, such as the Qualification Programs ($r = 0.721$, $p < 0.001$) and Peer Observation ($r = 0.650$, $p < 0.001$) showed strong relationships. Courses & Workshops ($r = 0.589$, $p = 0.001$) and Seminars & Conferences ($r = 0.507$, $p = 0.007$) demonstrated moderate correlations. In contrast, Coaching & Mentoring ($r = 0.286$, $p = 0.147$) and Research ($r = 0.324$, $p = 0.099$) showed no statistically significant relationships, indicating their perceived relevance does not reliably predict practical applicability of PD activities in developing 21st-century learning skills in science classrooms.

Table 4. *Correlation and p-value Table of the PD Activities*

PD Activities	Pearson *r*	*p*-value
Qualification Programs	0.721	0.0000
Courses & Workshops	0.589	0.0012
Coaching & Mentoring	0.286	0.1474
Seminar & Conferences	0.507	0.0069
Peer Observation	0.650	0.0002
Research	0.324	0.0987

The positive correlation finding on Qualification Programs, Peer Observations, Courses and Workshops, and Seminars and Conferences implies a potential opportunity to craft high-impact PD activities designed to empower

teachers with the necessary and long-term competencies and skills, fostering and effectively implementing 21st-century learning skills among learners.

3.3 Science Teachers' Critical Needs in Effectively Implementing 21st-century Learning Skills

Based on the study participants' responses, four main themes emerged as critical needs that science teachers identified for effectively implementing 21st-century learning skills. Technological, pedagogical, socio-emotional, and adaptability and innovative aspects of competencies are still gray areas for science teachers despite various PD activities attended. This implies that there is still a need for improvement, incorporated with and pursued in developing PD activities to align with or strengthen these areas to fully maximize the potential of science teachers to implement 21st-century learning skills among learners effectively.

Technological Competence

Responses from the participants revealed that they still require competence or skills in technology, specifically in utilization, integration, access, and adaptation to progressive changes in educational settings. Participants expect to utilize and incorporate lessons with current and advanced technologies, such as virtual laboratories and simulations, to introduce real-world scenarios or environments and convey science concepts. A direct impact of technology in science classrooms is the change in behavior, attitude, and skills of the learners (Alneyadi, 2019; Walan, 2020; Arici et al., 2021). This implies that future PD activities initiated must adequately prioritize hands-on practice and continued support to empower teachers with the necessary skills and knowledge, leveraging the use and integration of advanced and appropriate technologies in science classrooms.

Pedagogical Competence

Responses from the participants revealed that they need upskilling in individual pedagogical competence as a critical need for effectively implementing 21st-century learning skills among learners. Participants were emphasized explicitly for Differentiated Instruction, Inquiry-Based Teaching, Designing Hands-on Activities, and action research and research-based practice. Research studies have consistently emphasized a persistent and similar gap between science teaching pedagogy and the implementation of 21st-century skills in various contexts (Wei & Othman, 2017; Djudin, 2020). This implies that future initiatives should focus on continuous, targeted, and practical PD activities prioritizing re-skilling and upskilling teachers' pedagogy, pursuing learner-centered and active learning methodologies, and reflective practice and evidence-based decision making.

Socio-emotional Competence

Responses from the participants revealed that possessing the skills and competencies in the socio-emotional aspects of teaching could help learners perform better and effectively implement 21st-century learning skills. According to the participants, this aspect encompasses catering to the socio-emotional well-being and needs of learners, supporting mental health, communicating with students on an emotional level, promoting self-awareness, and better managing the classroom. Gebre et al. (2025) and Doncillo (2025) emphasize the importance of socio-emotional competence among teachers, as it can foster resilient and healthy students, which is also correlated with increased engagement. This implies that effective teaching extends beyond cognitive and technological knowledge; therefore, it is also important to provide opportunities for science teachers to acquire socio-emotional competence, enabling them to cater to students who have needs beyond content or curriculum guidance. Additionally, this is an opportunity to integrate Socio-emotional Learning (SEL) into the curriculum, which helps students feel supported, understood, and become competent individuals.

Adaptability and Innovative Competence

The responses of the participants in this study also emphasized their need to become more creative and learn to adapt to the various circumstances of the educational setting. Being creative and adaptive teachers could support and alleviate challenges in learning, such as the lack of resources and necessary materials for instruction. Teachers are expected to contextualize and make materials available to foster a better relationship between students' learning and the content in their shared environment. For example, future PD activities could adopt Teachers' Creativity and Pedagogical Digital Competencies (TTS-IPCD) as a way of encouraging innovativeness, knowledge, and pedagogy digital competencies, which, in the study of Vesna Skrbinjek et al. (2024), has proven to foster innovative and creativity competency among teachers effectively. Andres et al. (2021) also highlight that teachers who perform better are likely to be adaptive, never giving up on change, innovation, and adjustments to the learning environment. These findings highlight the importance of PD activities that provide opportunities for

teachers to develop skills in improvisation, repurposing, and localizing content to enhance student learning, cultivate teachers of continuous improvement, and become resilient in transforming challenges into opportunities.

3.4 Science Teachers' Experienced Challenges in Effectively Implementing 21st-century Learning Skills

This section provides a discussion of the various challenges faced by science teachers in effectively implementing 21st-century skills. These challenges arise beyond teachers' competency and skills, other than as discussed in the previous section, which encompasses efforts that may be supported through PD activities.

Limitations on Learning Resources and Infrastructure

Responses from the participants highlighted their challenges related to tangible aspects beneficial in science classrooms, such as limited access to technology, outdated equipment, inconsistent internet access or power supply, the lack of and often limited learning resources available, and the scarcity of laboratory and other facilities. This situation is also similar to that of Lyimo et al. (2017), who emphasized that inadequacies in instructional materials and facilities could contribute to poor student performance, a point also highlighted by Jufrida et al. (2019) regarding the role of learning materials and environment in developing scientific literacy. Without reliable and accessible instructional materials and physical facilities to support learning, even with highly competent science teachers equipped with the necessary skills and knowledge, teachers will continue to struggle in effectively implementing 21st-century learning skills among learners. This implies an opportunity for PD activities to invest in bridging the gap in the inadequacies of resources and infrastructure through collaboration with teachers in assessing situations, development, and continued support.

Institutional and Systemic Challenges

Responses from the study participants highlighted the challenges posed by barriers within the organization and the education system. Others raised concerns about limitations on training, which may be illustrated by the lack of individualized opportunities for training, as noted by Yu and He (2024), at least those that are not relevant or applicable to the learning environment. Some said that they receive no support for teachers, such as not enough funding allocation (Şahin et al., 2024), or do not allow them to pursue PD activities. Purisima (2025) identified that educational leaders who support and encourage teachers' professional growth, rather than hinder training or learning, can promote confidence in their practice. Others also raised concerns about a congested curriculum, which therefore limits the time allotted for meaningful science instruction. Currently, Philippine Education has aimed to decongest the curriculum through the MATATAG curriculum (Diquito, 2024). The new efforts to address these challenges open new opportunities for PD activities. Workloads among teachers outside of classroom preparations are also a challenge for teachers, which is consistent with Jomuad et al. (2021), who say it is an eye-opener for the Department of Education (DepEd) in the Philippines. Lastly, some teachers remain misaligned with their specialization. This remains an ongoing issue, as 6 out of 10 teachers fail to match their specialization with their assigned teaching tasks (Penuliar & Natividad, 2025). The study implies that there is no one-size-fits-all PD models; PD activities should also cater to administrators, highlighting their roles in support for teachers, overworking could result in ineffective of the teacher despite having many PD activities attended, and lastly, designing PD activities that supports and empowers teacher who are mismatch in their specialization. This study also highlights that PD activities cannot stand alone or operate in isolation to address systemic and institutional challenges; a collaborative and holistic approach is needed.

Pedagogical Constraints

The participants' responses itemized the challenges of engaging pedagogy, including catering to diverse learners' needs, maintaining a conducive learning environment, utilizing various strategies, and addressing learning gaps. This scenario is related to the case of Malaysian science teachers (Mahmud et al., 2018), where support for continued PD efforts involves expansion of knowledge and practice, adapting to the demands of progressive education. This implies that PD should introduce teachers to a broader array of pedagogy, encompassing different methodologies, teaching strategies, practical applications, assessments, and theories, thereby moving teachers away from one-size-fits-all perspectives. PD activities must be ongoing, iterative, and responsive to the challenges and progressive educational landscape, ensuring learners acquire 21st-century skills regardless of their backgrounds and thrive in classrooms.

4.0 Conclusion

This paper explored the implications of PD activities attended by science teachers to effectively implement 21st-century learning skills, particularly in terms of its applicability and relevance inside the science classroom, critical

needs to address the demands of the educational landscape, and challenges experienced in the implementation and teaching practice. Key findings indicate, first, that Seminars and Conferences emerged as the preferred PD activity among science teachers, directly contributing to their acquisition of practical skills and knowledge. These gains were strongly linked to effective classroom implementation of 21st-century learning skills. Second, both Seminars and conferences, as well as coaching and Mentoring, demonstrated significant relevance in equipping teachers to integrate 21st-century skills into their instruction successfully. Third, a positive correlation between the perceived applicability and relevance of Qualification Programs, Peer Observations, Courses and Workshops, and Seminars and Conferences indicates that these activities are empowering for science teachers. Fourth, science teachers need to strengthen their competence in technology, pedagogy, socio-emotional aspects, and adaptability and innovation to better equip themselves for the effective implementation of 21st-century learning skills. Lastly, science teachers continually face challenges in effectively implementing 21st-century learning skills among learners, including limitations to learning resources and infrastructure, existing institutional and systemic challenges, and pedagogical constraints. The implication of these findings encompasses a long-standing effort, time, and dedication. The study underscores the need for continued support for teachers addressing limitations and the lack of basic but critical elements in instruction, chasing continuous improvement, and designing PD activities aligned with the critical needs in technology, content, and pedagogy of science teachers. For policymakers and PD designers, these findings offer a few recommendations: (1) prioritize short-term but emphasize collaborative PD formats; (2) conduct an in-depth assessment for teachers challenges, such as aligning funds and policy adjustments targetting to address systemic barriers; and (3) collaborate in designing PD programs with teachers to ensure alignment with classroom realities and 21st-century skill development. This study acknowledges any existing limitations in the methodology, including sampling, validity, and reliability of the instrument used, as well as social desirability and bias introduced during data collection. Future research directions could focus on the longitudinal impact of PD activities, evaluating models that directly address needs and challenges mentioned, investigating cultural and diversity-based PD designs, and lastly, varying research approaches similar to the focus of the study. In conclusion, while this study provides insights into varying needs and challenges, it is crucial to find collaboration, sustained, and responsive PD activities, working and pursuing continuous improvement to address such gaps between theory and practice. By aligning PD activities with the realities of diverse classrooms and leveraging teacher-driven innovations, important elements of the educational setting can transform these challenges into opportunities for better systemic change.

5.0 Contributions of Authors

The authors confirm their equal contributions to any part or initiative of this paper. All authors reviewed and approved the final revision of this paper.

6.0 Funding

This research received no specific grant funding from any agency or institution.

7.0 Conflict of Interests

All authors declared that they have no conflict of interest as far as this study is concerned.

8.0 Acknowledgment

The authors would like to extend their heartfelt thanks and appreciation to the respondents of this study for their support and voluntary participation, and to all the people behind them for their gentle push and guidance to make this possible.

9.0 References

Alneyadi, S. S. (2019). Virtual lab implementation in science literacy: Emirati science teachers' perspectives. Eurasia Journal of Mathematics, Science and Technology Education, 15(12). https://doi.org/10.29333/ejmste/109285

Andres, L., Dela Cruz, J., Gonzaga, M., Rodriguez, I., Sanchez, J., & Ortiz, A. (2021). Teachers' level of adaptability and performance: Their response to the rapidly transforming academic world. International Journal of English Literature and Social Sciences, 6(3). https://tinyurl.com/2esf55j3

Arici, F., Yilmaz, R. M., & Yilmaz, M. (2021). Affordances of augmented reality technology for science education: Views of secondary school students and science teachers. Human Behavior and Emerging Technologies, 3(5), 1153–1171. https://doi.org/10.1002/hbe2.310

Barrot, J. S. (2019). English curriculum reform in the Philippines: Issues and challenges from a 21st-century learning perspective. Journal of Language, Identity & Education, 18(3), 145–160. https://doi.org/10.1080/15348458.2018.1528547

Calacar, G. B. (2020). Teaching the 21st century skills: Teachers' competence, practices and challenges. Journal of World Englishes and Educational Practices, 2(2), 81–91. https://tinyurl.com/bdcjvsan

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In Handbook of Research on Science Education, Volume II (pp. 515–541). Routledge. https://doi.org/10.4324/9780203097267-36

Darling-Hammond, L., Adamson, F., & Abedi, J. (2010). Beyond basic skills: The role of performance assessment in achieving 21st century standards of learning (p. 52). Stanford Center for Opportunity Policy in Education. https://tinyurl.com/yc52ymwu

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute. Retrieved from https://tinyurl.com/m2sxhact

Del Mundo, H. J. C. (2022). 21st century digital skills, technology integration in instruction and challenges encountered by senior high school teachers in Muntinlupa National High School. International Journal of Multicultural Research and Analysis, 5, 1159–1172. https://doi.org/10.47191/ijmra/v5-i5-35

Diquito, T. J. (2024). Basic Education Curriculum under the newly implemented K to 10 (MATATAG) curriculum in the Philippines: The case of science education. American Journal of Education and Technology, 3(3), 123–132. https://doi.org/10.54536/ajet.v3i3.3396

Doncillo, J. (2025). Teachers' beliefs and practices of social and emotional learning implications on kindergartners' engagement in multi-grade classes in Indigenous Peoples' Education (IPed) schools. Ignatian International Journal for Multidisciplinary Research, 3. https://doi.org/10.5281/zenodo.15332584

Dominado, N. (2020). Teachers performance, technology, and 21st century skills: A basis for a faculty development program. International Journal of Innovation, Creativity and Change, 13(1), 1364–1375. https://tinyurl.com/yfe6rjrt
Djudin, T. (2020). Exploring the 21st century skills and science teaching pedagogy: Profiles, readiness, and barriers. Journal of Education, Teaching and Learning, 5(2), 346–355. https://tinyurl.com/5evdabct
Education Advanced. (2023). Professional development for teachers. Retrieved from https://tinyurl.com/4hpsjxts
Gebre, Z. A., Demissie, M. M., & Yimer, B. M. (2025). The impact of teacher socio-emotional competence on student engagement: A meta-analysis. Frontiers in Psychology, 16. https://doi.org/10.3389/fpsyg.2025.1526371
Gonzales, N. A. P. (2020). 21st century skills in higher education: Teaching and learning at Ifugao State University, Philippines. Asian Journal of Assessment in Teaching and Learning, 10(2), 72–81. https://doi.org/10.37134/ajatel.vol10.2.8.2020
Hasibuan, K., Ledy, A., & Az-Zahra, F. Z. (2024). Curriculum development for 21st century skills: Trends, challenges, and solutions. Modeling: Jurnal Program Studi PGMI, 11(4), 295–305. https://doi.org/10.69896/modeling.v11i4.2660
Heriman, M., Atung, D., Sutisna, E., Nurhayati, N., & Kartika, I. (2024). Pengembangan kurikulum berbasis keterampilan abad ke-21: Perspektif dan tantangan. Religion, Education, and Social Laa Roiba Journal (RESLAJ), 6(6). https://doi.org/10.47467/reslaj.v6i6.1709
Hilton, M. L., & Pellegrino, J. W. (Eds.). (2012). Education for life and work: Developing transferable knowledge and skills in the 21st century. National Academies Press. https://tinyurl.com/4j7m5crt
Jomuad, P., Leah, M., Cericos, E., Bacus, J., Vallejo, J., Dionio, B., Bazar, J., Cocolan, J., & Clarin, A. (2021). Teachers' workload about burnout and work performance. International Journal of Educational Policy Research and Review, 8(2), 48–53. https://doi.org/10.15739/IJEPRR.21.007
Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. International Journal of Evaluation and Research in Education (IJERE), 8(4), 630. https://doi.org/10.11591/ijere.v8i4.20312
Ke-Du, L. (2019). Effective teaching in the context of 21st century learning in a Malaysian secondary school. Asian Journal of University Education, 14(2), 1–12. https://tinyurl.com/bdd3enp9
Neng, S., & Cheo, N. (2022). The effect of teachers' participation in seminars on their teaching effectiveness in secondary schools in Tubah Sub Division. Procedia of Philosophical and Pedagogical Sciences, 178–191. https://tinyurl.com/mwu8vayp
Lyimo, N., Too, J., & Kipng'etich, K. (2017). Perception of teachers on availability of instructional materials and physical facilities in secondary schools of Arusha District, Tanzania. International Journal of Educational Policy Research and Review, 4(5), 103–112. https://doi.org/10.15739/IJEPRR.17.012
Mahmud, S. N. D., Nasri, N. M., Samsudin, M. A., & Halim, L. (2018). Science teacher education in Malaysia: Challenges and way forward. Asia-Pacific Science Education, 4(1). https://doi.org/10.1186/s41029-018-0026-3
Nwuba, I. S., Egwu, S. O., Okafor-Agbala, U. C., Christian-Ike, N. O., Okoye, T. N., & Ekoyo, D. O. (2024). Innovative pedagogical approaches for classroom delivery: The science teachers' perspective. International Research Journal of Science, Technology, Education, and Management, 4(3), 29–44. https://doi.org/10.5281/zenodo.13858789
Penuliar, A. J., & Natividad, L. (2025). Teacher specialization mismatch disrupts Philippine education system (Preprint). SSRN. https://doi.org/10.2139/ssrn.5086587
Purisima, J. K. A. (2025). Dynamism and ethos of educational leaders on teachers' motivation: A thematic literature review in the Philippine setting. International Journal of Research Studies in Education, 14(9). https://doi.org/10.5861/ijrse.2025.25107
Rimmer, W., & Floyd, A. (2020). The contribution of conferences to teachers' professionalism. Tesl-EJ, 24(1). https://files.eric.ed.gov/fulltext/EJ1257223.pdf
Şahin, A., Soylu, D., & Jafari, M. (2024). Professional development needs of teachers in rural schools. Iranian Journal of Educational Sociology, 7(1), 219–225. https://doi.org/10.61838/kman.ijes.7.1.22
Safri, U. S. A., & Jamaludin, K. A. (2022). PAK 21 skills and the challenges of its integration during teaching and facilitation sessions (PDPC). International Journal of Academic Research in Progressive Education and Development, 11(4). https://doi.org/10.6007/ijarped/v11-i4/15031
Santos, J. M. (2017). 21st century learning skills: A challenge in every classroom. International Journal of Emerging Multidisciplinary Research, 1(1), 31–35. https://doi.org/10.22662/IJEMR.2017.1.1.031
Uzezi, J. G., Garpiya, B. S., & Adah, I. S. (2025). Enhancing science teachers' continuous professional development through digital mentoring: Advancing teacher education for 21st-century classrooms. ATBU Journal of Science, Technology and Education. https://tinyurl.com/2mt3wkdc
Vesna Skrbinjek, M., Vičič Krabonja, M., Aberšek, B., & Flogie, A. (2024). Enhancing teachers' creativity with an innovative training model and knowledge management. Education Sciences, 14(12), Article 1381. https://doi.org/10.3390/educsci14121381
Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. Journal of Computer-Assisted Learning, 29(5), 403–413. https://doi.org/10.1111/jcal.12029
Walan, S. (2020). Embracing digital technology in science classrooms: Secondary school teachers' enacted teaching and reflections on practice. Journal of Science Education and Technology, 29(3), 431–441. https://doi.org/10.1007/s10956-020-09828-6
Wei, S., & Othman, N. (2017). Amalan pengajaran dan pembelajaran abad ke-21 dalam kalangan guru sekolah rendah [21st century teaching and learning practices among primary school teachers]. Prosiding Seminar Penyelidikan Pendidikan 2017 Mac 20–22 di IPBL, Kuching, Sarawak, 390–407. https://tinyurl.com/2rswj7sf
Yu, J., & He, Y. (2024). The current situation, difficulties, and optimization paths of county-level teacher training in border areas: Based on Y County in Yunnan Province. International Journal of New Developments in Education, 6(6). https://doi.org/10.25236/ijnde.2024.060604