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Multiliteracy Enhancement Amid Pandemic: A Comprehensive Study on Pre-Service Science Teachers' Integration of Computer-Based Technologies

Multiliteracy Enhancement Amid Pandemic: A Comprehensive Study on Pre-Service Science Teachers' Integration of Computer-Based Technologies

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ABSTRACT

The ongoing pandemic has significantly transformed the educational landscape, necessitating the design of curricula that seamlessly integrate innovative technologies and pedagogies to support students in a multimodal world. As a result, teacher-training programs must prioritize the development of pedagogical and technological skills for new educators. This investigation explored the utilization of computer-based technology (CBT) by pre-service teachers during classroom instruction and its integration for promoting multiliteracy in science education. The study connected CBT applications to Gardner's multiple intelligences theory and employed the Multiliteracy Pedagogy framework to analyze the technology used, adhering to the 7Es instructional model. Employing case study research and observation methodologies, the study assessed pre-service science teachers' demonstrations. The findings revealed that pre-service science teachers incorporated CBTs into their instruction, addressing various intelligences. Examples of CBTs included digital interactive whiteboards, virtual laboratories, video sharing websites, presentation software, and online quiz platforms. Although these tools accommodated diverse learners, the integration of CBTs into contextualized and localized approaches remained limited. Consequently, the results highlight the necessity for systematic strategies that enable pre-service teachers to effectively incorporate CBTs into various learning experiences. Such approaches facilitate a smooth transition from training to professional practice and promote the consistent use of technology at all levels of education.

RESUMO

A pandemia em curso transformou significativamente o cenário educacional, exigindo o design de currículos que integram tecnologias e pedagogias inovadoras para apoiar os alunos em um mundo multimodal. Assim, os programas de formação de professores devem priorizar o desenvolvimento de competências pedagógicas e tecnológicas para os novos educadores. Esta investigação explorou a utilização de tecnologia baseada em computador (CBT) por professores de formação inicial durante o ensino em sala de aula e sua integração para promover o multiletramento na educação científica. O estudo conectou as aplicações da TCC à teoria das inteligências múltiplas de Gardner e empregou a estrutura da Pedagogia do Multiletramento para analisar a tecnologia utilizada, aderindo ao modelo instrucional 7Es. Empregando pesquisa de estudo de caso e metodologias de observação, o estudo avaliou as demonstrações dos professores de ciências em formação. Os resultados revelaram que os professores de ciências em formação incorporaram CBTs em sua instrução, abordando várias inteligências. Exemplos de CBTs incluem quadros brancos interativos digitais, laboratórios virtuais, sites de compartilhamento de vídeo, software de apresentação e plataformas de quiz online. Embora essas ferramentas acomodassem diversos alunos, a integração de CBTs em abordagens contextualizadas e localizadas permaneceu limitada. Consequentemente, os resultados destacam a necessidade de estratégias sistemáticas que permitam aos professores em formação incorporar efetivamente as TCCs em várias experiências de aprendizagem. Essas abordagens facilitam uma transição suave do treinamento para a prática profissional e promovem o uso consistente da tecnologia em todos os níveis de ensino.

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Introduction

The COVID-19 pandemic has drastically transformed the educational landscape, accelerating the transition from traditional classrooms to digital learning environments. This shift has not only redefined teaching and learning methods, but has also underscored the need for multiliteracy skills among educators and learners alike. In this context, pre-service science teachers' ability to effectively integrate computer-based technologies (CBTs) in teaching is of paramount importance.

Multiliteracy, a concept introduced by the New London Group (1996), goes beyond the ability to read and write, incorporating the capacity to communicate across cultural and linguistic boundaries, and to use diverse media forms, especially digital technologies (Kim & Xing, 2019). Given the increasingly diverse and technology-driven social environment, the development of multiliteracy skills is now essential for pre-service science teachers.

Research indicates that the use of CBTs in teaching can enhance the learning experience and cater to diverse learners' needs (Ally, 2004; König et al., 2020). However, incorporating CBTs into teaching requires more than mere technological understanding. Teachers must also possess digital literacy, an ability that extends to information, computer, media, communication, visual, and technology literacy, all of which are crucial for societal progress (Mesko et al., 2015). The integration of CBTs in teaching also necessitates innovative content creation to maintain student engagement and comprehension (Purnama et al., 2021).

Despite the obvious benefits, integrating technology into teaching can be challenging, especially for pre-service teachers. Prior studies have indicated that teachers' reluctance to utilize technology often stems from its absence in their initial training (Buabeng-Andoh, 2012). Furthermore, teacher cognitions, which take years to form, are resistant to change, making it difficult to adopt new methods later (Bagheri & East, 2021). Therefore, teacher education programs must incorporate technology training to prepare pre-service teachers to integrate technology into their teaching practices (Santos & Castro, 2021).

In light of the above, this study aims to examine pre-service science teachers' use of CBTs within a multiliteracy pedagogical framework during their teaching practice. As the use of technology becomes increasingly integral to teaching, it is crucial to understand how these teachers apply their newly acquired skills and knowledge in real-world teaching scenarios (Asan, 2002; Davis & Witt, 2022; Yildiz Durak, 2021).

The need for such research is underscored by the significant role that teachers play in achieving educational goals, the rapidly evolving educational landscape, and the transformations in social and professional spheres brought about by technological advancements (Dayagbil et al., 2021; Blazar & Kraft, 2017; Ra et al., 2019; Wong et al., 2017). By focusing on the use of CBTs by pre-service science teachers, this study will contribute to the ongoing discourse on the integration of technology in teaching and the development of multiliteracy skills among teachers.

The study seeks to accomplish several goals. First, it aims to uncover the types of computer-based technologies (CBTs) that pre-service teachers use during their science teaching demonstrations. Next, it endeavors to understand how these teachers align their use of CBTs with the principles of the 7Es instructional model. Furthermore, the study intends to identify which of the employed CBTs are aimed at targeting multiple intelligences. Finally, the research aspires to elucidate how pre-service science teachers leverage CBTs to scaffold learners' scientific understanding and multiliteracy learning.

Methodology

To address qualitative research questions focusing on contemporary phenomena within real-world contexts, where investigators have limited control over events, an increasing number of researchers in social sciences, including education, are adopting case study research (CSR). The qualitative research approach best suited for observing and documenting teacher processes in teaching is the case study method (Crowe et al., 2011). The case study method allows researchers to conduct an in-depth investigation of a particular phenomenon, in this case, the teaching process, within its real-life context. It is valuable for understanding complex situations and relationships, as well as the reasons behind observed practices and behaviors.
Data collection was conducted through observational methods, involving direct witness and documentation of participants' behaviors and interactions within their physical and social environments. Observation offers insight into group dynamics, context, and the influence of physical surroundings (Holmes, 2013). Observation approaches can vary from non-participant to participant, with recording techniques ranging from systematic templates to unstructured field notes. Video-recording has recently been demonstrated as an effective means of capturing observations (Crowe, 2011; Holmes, 2013; Mey, 2022).

The study examined pre-service science teachers in the Bachelor of Science in Education (BSED) Science program at the Polytechnic University of the Philippines. The main objectives were to (1) investigate pre-service science teachers' use of CBTs in virtual classrooms, and (2) identify effective scaffolding techniques for teaching and learning science within a multiliteracies framework. BSED Science pre-service teachers participated in a Teaching of Science course, learning about science teaching concepts and the 7Es model for classroom instruction. Data were collected through observations of teaching demonstrations and analysis of lesson plans for virtual classrooms. Video recordings, lesson plans, and slide presentations were stored on a shared cloud drive. Data analysis involved narrative presentation and interpretation, guided by the 7Es model of instruction, multiple intelligences theory, and multiliteracy pedagogy framework.

Table 1 outlines each of the parts and includes examples of classroom activities in which CBTs are used (New London Group, 1996; Hilton et al., 2010). The examples are based on scientific teaching experience, but they might be applied to a wide range of subjects. The examples and tactics supported by the multiliteracies framework inform the creation of a unit of work used in research to assess pre-service science teachers' practices in science teaching.

Table 1.

Examples of scaffolding strategies that may be implemented under multiliteracies pedagog.

Pedagogy	Characterized by	Examples from Classroom practice
Situated Practice	▪ Immersion in experiences allowing learners to apply existing knowledge within a community of learners and experts. ▪ Explicit connections between school and learner's personal experiences.	▪ Participation in investigations, explaining and discussing results with peers ▪ Exploration of real-world settings, linking learning experiences to practical applications ▪ Utilization of CBTs for developing representations or investigating ideas
Overt Instruction	▪ Active teacher interventions for scaffolding learning, drawing on learners' prior knowledge ▪ Systematic, analytic comprehension and management of information and texts ▪ Explicit metalanguages for describing and interpreting various forms of meaning	▪ Use of digital representations to present and explain experimental data, concepts, or inquiry outcomes ▪ Understanding, interpreting, and translating meanings in diverse forms and texts
Critical Framing	▪ Analyzing digital representations to present and explain	▪ Identifying additional information needed for supporting statements or connecting facts and claims.

	▪ experimental data, concepts, or inquiry outcomes, ▪ Understanding and interpreting meanings in diverse forms and texts, ▪ Selecting optimal methods for conveying information for specific purposes.	▪ Contextualizing information to assess audience awareness and appropriateness of wording or depiction.
Transformed Practice	▪ Transfer and modification of meanings in new or different settings. ▪ Reflective application of knowledge. ▪ Redesign or reformat of existing texts.	▪ Application of inquiry learning outcomes to new settings, problem-solving, or modification of experimental techniques or research methodologies ▪ Representing knowledge to new audiences or converting it into new genres (e.g., creating a webpage, poster, PowerPoint presentation, or video from a research report)

Source: (New London Group, 1996; Hilton et al., 2010).

Results and Discussions

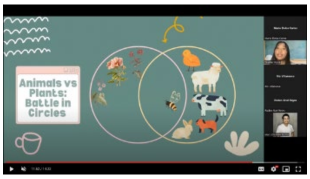
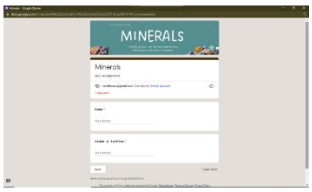
CBT used by Pre-service Science Teachers.

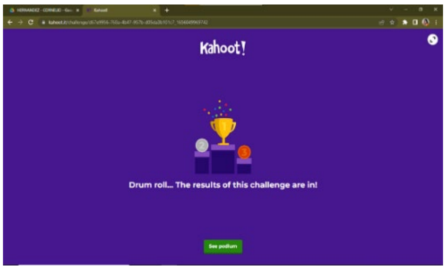
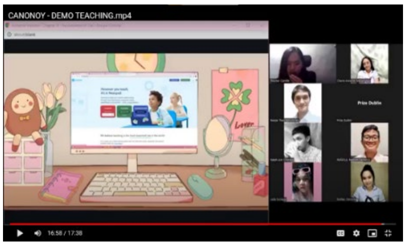
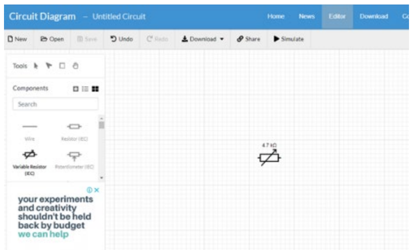
The BSED Science pre-service teachers employed a diverse array of CBTs in their classrooms, as shown in Table 2. The 7Es model of education, comprising Elicit, Engage, Explore, Explain, Elaborate, Extend, and Evaluate, was used to categorize the various ways pre-service teachers utilized CBTs. During the motivation-focused section, pre-service science teachers leveraged digital technologies to create gamified activities, enhancing student engagement and participation. CBT activities allowed pre-service teachers to elicit learning, enabling students to write, dance, sketch, and connect science concepts with their environment.

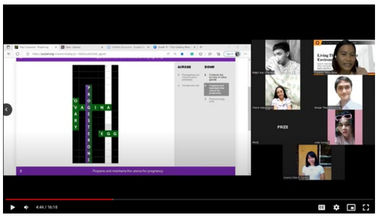
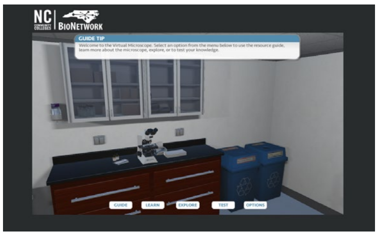
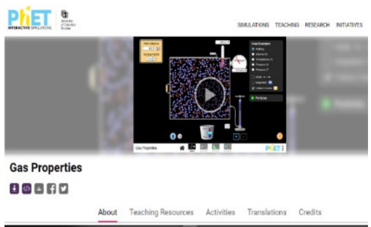
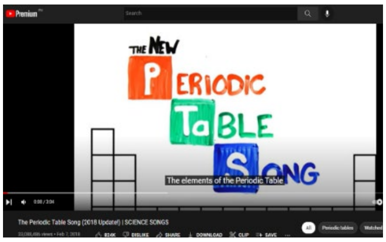
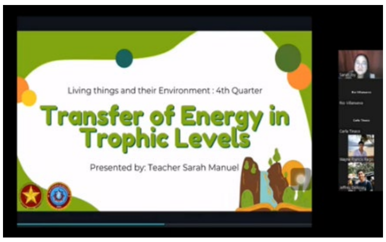
Key insights were obtained through CBT application, supported by observations related to the multiple intelligence theory. Pre-service teachers employed various digital technologies, such as software, online simulations, laboratories, presentation tools, video sharing platforms, and online quiz systems. Observations demonstrated that pre-service teachers incorporated CBTs into their classroom instruction following the 7Es model. The CBTs utilized by pre-service science teachers included virtual labs, simulations, presentation software, video sharing platforms, and online quiz systems, as outlined in Table 2.

Table 2.

CBT used by Pre-service Science Teachers during the online teaching demonstration.

CBT used	Description	Classroom Instruction and CBT used Screenshot
Microsoft PowerPoint	Presentation software.	
Canva	Online presentation software.	 
Google Form	Online Assessment software.	

Kahoot	Online Interactive Assessment software	
Nearpod	Online Assessment software.	
Circuit-diagram	Online circuit-diagram generator (for Physics Lessons)	
Google Jamboard	Digital interactive whiteboard	
Sketchful.io	Free online drawing and guessing game	

		
Puzzel.org	Free online crossword puzzle generator.	
Bioman Biology	Online Biology Games and Virtual Laboratory	
NC Bionetwork Educational Resources	Online Educational Resources and Virtual Laboratory	
PhET Interactive Simulations	Online Educational Resources and Virtual Laboratory	
Youtube	Online Free video sharing and streaming	
Zoom	Video conferencing platform	

Source: Own authorship.

The findings of this study, along with those from previous research (Asan, 2002; Ertmer & Ottenbreit-Leftwich, 2010; Rackley & Viruru, 2015; Yildiz Durak, 2021; Santos &

Castro, 2021; Davis & Witt, 2022), indicate significant utilization of computer-based technology (CBTs) by pre-service teachers. The adoption of CBTs in science education may be driven by pre-service teachers perceiving them as requirements from significant individuals (their mentors) for successful teaching practice (Batane & Ngwako, 2017). The UTAUT model posits that social influence plays a crucial role in determining the adoption of new systems (Abbad, 2021). In the context of this study, pre-service teachers may misconceive that mentors and evaluators expect technology usage in their classes, leading to increased implementation. The results are suggestive that future science educators employ CBTs in their classroom instruction at various levels, frequently utilizing prevalent applications and software, including presentation and publishing software, as well as educational computer programs. CBTs are gaining prominence as a teaching approach in the 21st century (Haleem et al., 2022).

CBTs and the 7Es model of instruction as practiced by the Pre-Service Science Teachers

The usage of CBTs with classroom instruction and strategies seen among pre-service science teachers is summarized in Table 3.

Table 3.

CBT used by the Pre-service Science Teachers in 7Es Model of Instruction.

7Es Model of Instruction	Description	Classroom Instruction/Strategies
Elicit	During the elicit phase, educators employ various strategies to activate learners' existing knowledge, identify misconceptions, and generate interest in the subject matter. This phase involves the implementation of concept cartoons, video films, animations, and simple scientific demonstrations as motivational tools to assess learners' prior understanding.	Pre-service teachers utilized digital platforms such as Microsoft PowerPoint presentations or CANVA.com, enhanced with animations and online images, to engage learners through guess-the-word mini-games. These activities served as a starting point for introducing new lessons.
Engage	In the engagement phase, educators utilize small-scale experiments or unusual events to captivate learners' attention,	In the engage phase, pre-service teachers employed PPT/Canva presentations with captivating images and figures to present thought-provoking questions to the class.

	stimulate curiosity, and foster active involvement. This phase encourages learners to pose inquiries and actively participate in the learning process.	This approach aimed to sustain learners' interest and active participation.
Explore	The explore phase adopts a questioning approach to facilitate learners' discovery and revision of content. Within the framework of subject-specific activities, learners generate assumptions and hypotheses through brainstorming. The utilization of worksheets can guide learners and facilitate data collection during this phase.	During the explore phase, pre-service teachers guided learners through the experimental process by providing digital worksheets and pre-recorded videos. Accompanying PowerPoint slides contained instructions, facilitating learners' engagement with the subject matter.
Explain	During the explain phase, learners engage in the interpretation and comprehension of their findings obtained during the explore phase. Educators employ instructional strategies such as videos, concept maps, slideshows, and direct lecturing to convey ideas, concepts, rules, and factual information. This phase aims to guide learners towards developing coherent generalizations, facilitate the acquisition of scientific vocabulary, and encourage the use of vocabulary to explain the outcomes of their explorations.	In the explain phase, pre-service teachers integrated activities from the engage and explore phases, delving deeper into theories, laws, and concepts relevant to the topic. PowerPoint presentations, videos, and simulation software were utilized to facilitate learners' understanding.

Elaborate	The elaborate phase promotes the application of acquired knowledge to novel scenarios, encouraging learners to generate new questions and hypotheses. Additionally, learners may engage in mathematical tasks that are relevant to the subject matter.	To promote the application of knowledge, pre-service teachers prompted learners to engage in activities such as designing electric circuits and calculating electric usage. This phase was supported by virtual laboratory simulations, multimedia presentations, and simulation software.
Extend	In the extend phase, learners are challenged to apply their knowledge in new and diverse real-world contexts, fostering a broader understanding of the subject matter.	During the extend phase, pre-service teachers created opportunities for learners to connect their knowledge to real-life situations. Presentation software tools were utilized to facilitate activities such as creating environmental awareness slogans.
Evaluate	The evaluation phase encompasses both formative assessment and summative evaluation to gauge learners' progress. Various assessment methods, including multiple-choice questions, quizzes, puzzles, structured grids, and true-false questions, are employed to measure learners' learning outcomes.	To assess learning outcomes, pre-service teachers administered quizzes primarily consisting of multiple-choice questions. These quizzes were accessible online through platforms like Google Forms or Kahoot, providing immediate feedback and evaluation for learners.

Source: Own authorship.

The pre-service science teachers in the study demonstrated a clear implementation of Computer-Based Technologies (CBTs) following the 7Es model of teaching, as observed. Many of these teachers employed gamification strategies, utilizing web applications, music, and videos, to engage learners during the elicit phase of instruction. Prior research in the field of science education has consistently shown that the 7E learning cycle has a positive impact on learners' achievements and abilities, as evidenced by studies conducted by Khashan et al. (2011), Khadjooi et al. (2011), Vick (2018), and Villacrusis et al. (2021). By allowing learners to explore, the utilization of the 7E learning cycle in scientific classes enhances learners' academic and conceptual progress. Furthermore, due to the distinct stages of the model, effective learning is facilitated (Khadjooi et al., 2011).

CBTs utilization by Pre-service Science Teachers in relation to Multiple Intelligences Theory

The pre-service science teachers' selection and implementation of CBTs was found to address and cater to a varied learner in the classroom. Table 4 summarizes the CBT used in relation to the multiple intelligences of learners.

Table 4.

CBTs utilization by Pre-service Science Teachers in relation to Multiple Intelligences Theory

Multiple Intelligences	Description	Pre-service Teachers' Strategies
Verbal-Linguistic	Verbal-Linguistic Intelligence allows individuals to communicate and make sense of the world through language.	During the elicit phase of the lessons, the observed pre-service teachers utilized word games such as guess the gibberish, crossword puzzles, and fill in the blanks. To facilitate this, they employed presentation tools like PowerPoint (PPT) and Canva, as well as crossword problem generators.
Logical-Mathematical	Logical-Mathematical Intelligence enables individuals to use and appreciate abstract relations.	Pre-service teachers created mathematical puzzles and shared them using online presentation applications. For instance, learners were presented with an image of a popular chocolate bar and tasked with calculating the total calories per serving.
Musical	Musical Intelligence allows people to create, communicate, and understand meanings made out of sound	To engage learners during the elicit phase of classroom instruction, pre-service teachers incorporated songs and encouraged learners to sing along or follow the lyrics. This method was consistently employed and accompanied by videos sourced from video streaming websites.
Visual-Spatial	Spatial Intelligence makes it possible for people to perceive visual or spatial information, to transform this information, and to recreate visual images from memory.	Throughout the elicit and engage phases of classroom teaching, pre-service teachers made use of various visual aids, including photographs, graphics, pictographs, simulations, virtual laboratories, and online videos. For example, in introducing the Macromolecules course, learners

		were prompted to guess words based on provided photographs. During the complex phase, one pre-service teacher conducted an exercise where learners characterized matter by analyzing the presented photographs.
Bodily-Kinesthetic	Bodily-Kinesthetic Intelligence allows individuals to use all or part of the body to create products or solve problems	Pre-service teachers designed exercises that involved learners' physical movement and the utilization of measurement equipment. Learners navigated virtual laboratories, calibrated instruments, and were guided through instructions displayed on online presentation tools. Additionally, learners were encouraged to create 3D models of cells using modeling clay, with clear directions provided in slide presentations.
Naturalist	Naturalist Intelligence allows people to distinguish among, classify, and use features of the environment.	A noticeable trend among pre-service teachers, particularly when delivering biological science subjects, was the incorporation of natural elements and flora images into slide presentations. The educational materials designed by pre-service teachers had a natural-feeling aesthetic.
Intrapersonal	Intrapersonal Intelligence helps individuals to distinguish among their own feelings, to build accurate mental models of themselves, and to draw on these models to make decisions about their lives.	Pre-service teachers implemented exercises that targeted learners' personal viewpoints and perspectives on various topics. Self-reflection exercises were presented through online presentation slides, and learners were instructed to enter their responses into word processing software and upload them to the learning management system (LMS).

Interpersonal	Interpersonal Intelligence enables individuals to recognize and make distinctions about others' feelings and intentions. T	To foster collaboration and interaction among learners, pre-service teachers organized group activities that involved planning, discussions, interactions, and brainstorming among peers. Instructions for these activities were presented using online presentation tools, and rubrics and worksheets were distributed through the LMS.

Source: Own authorship.

The utilization of computer-based technologies (CBTs) by pre-service science teachers demonstrated their ability to effectively cater to the diverse needs of learners in the classroom. Recognizing the significance of multiple intelligences and various teaching approaches can enhance learning motivation, memory retention, and expedite the learning process, as evidenced by studies conducted by Charlier et al. (2015) and Schneider et al. (2021). The proposal of alternative pathways to achieve educational objectives, such as utilizing spatial connections for learning science or linguistic skills for musical education, enables more efficient problem-solving in teaching and comprehending scientific and mathematical concepts. It is imperative for educators to acknowledge that no single teaching method universally surpasses others, as emphasized by Burroughs et al. (2019). By embracing multiple intelligences, teachers can gain a deeper understanding of learners' cognitive profiles, learning styles, and instructional preferences. Consequently, reassessing the role of educators, implementing effective teaching and learning strategies, and acquiring essential information, skills, and methods become necessary for fostering successful learning outcomes, as highlighted by Schaffer et al. (2022). The interplay between intelligences and the teaching-learning process should be a central consideration when developing strategies to enhance academic achievement, learner success, and lifelong learning, as underscored by Gouws (2007).

CBTs used to Scaffold the Development of Multiliteracy Science Skills

CBTs were utilized by pre-service teachers to accommodate the varied M.I.s of their students and to promote multiliteracy learning. The observed classroom methods and practices, as well as the CBTs utilized by the pre-service science teachers, are summarized in Table 5.

Table 5.

CBTs used by the Pre-service Science teachers to Scaffold the Development of Multiliteracy Science Skills.

<table>
<tr><th>Pedagogy</th><th>Pre-service Teachers' observed Classroom Practice</th><th>CBT Used</th></tr>
<tr><td>Situated Practice</td><td>

- The pre-service educators facilitated the integration of historical and contemporary knowledge within a relatable learning environment, as evidenced by the volcanic eruption activity and hair straightening treatments.
- Digital resources such as online tools, presentation software, and movies were employed to augment classroom instruction.

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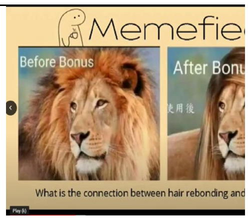

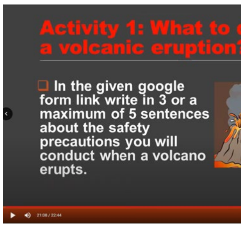

</td></tr>
<tr><td>Overt Instruction</td><td>

- The pre-service teachers provided learners with opportunities to establish connections between past and current information in relevant contexts, as exemplified by the volcanic eruption activity and the functioning of hair straightening treatments.
- Online materials, presentation software, and movies were utilized to support and enhance classroom activities

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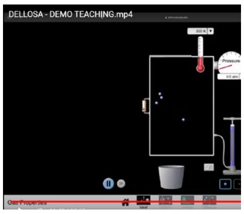

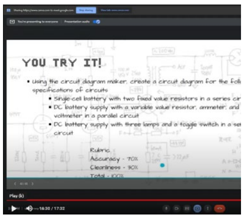

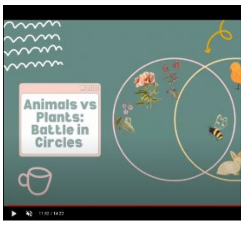

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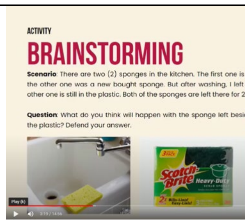
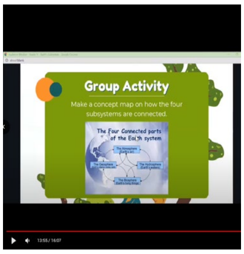
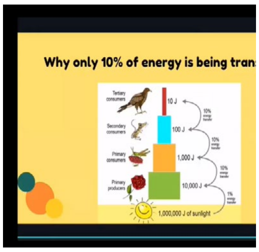
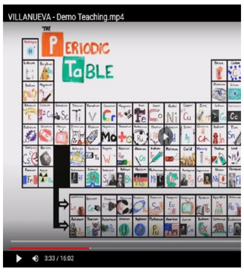
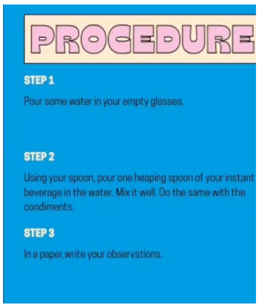
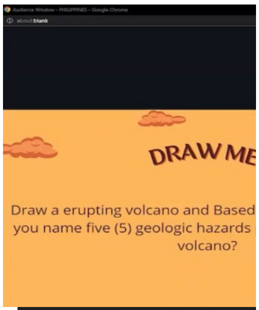
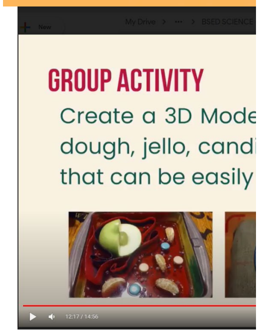
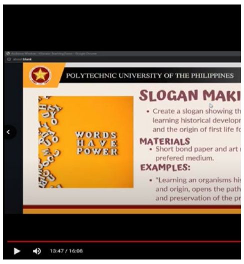




Critical Framing	▪ The pre-service teachers implemented computer-based trainings (CBTs) that enabled learners to create, access, and exchange educational content. ▪ The incorporation of digital tools facilitated the learning process, and the utilization of online whiteboard applications/software allowed for the utilization of mind mapping and concept mapping techniques.





Transformed Practice	▪ Pre-service teachers afforded learners the opportunity to apply acquired knowledge in both simulated and real-world scenarios, as exemplified prominently during the instruction's expansion phase. ▪ Learners were empowered to articulate and demonstrate their understanding of scientific concepts through the utilization of online presentation tools and simulation programs. Notably, applications such as the circuit generator app, sketching app, and virtual laboratory provided platforms for learners to recontextualize and present their knowledge to diverse audiences.	   

Source: Own authorship.

Pre-service science teachers strategically harnessed Computer-Based Technologies (CBTs) to respond to learners' diverse Multiple Intelligences (M.I.s) and bolster multiliteracy development. They constructed learning scenarios that facilitated learners' ability to synthesize and correlate historical and contemporary data within pertinent contexts, such as volcanic activity and hair straightening procedures. An assortment of online tools, presentation software, and films served as supportive pillars for classroom activities. Pre-service teachers designed exercises that allowed learners to articulate their viewpoints in multiple mediums. Furthermore, digital technologies provided a platform for the visualization of experimental concepts, with pre-service teachers incorporating the use of virtual laboratories and simulation software in their lesson plans. This approach afforded learners the opportunity to investigate, adjust variables, take measurements, adapt conditions, and conduct critical analysis of their observations.

CBTs facilitated an environment conducive to active learning, where learners could generate, view, and share content, with digital tools playing a pivotal role in driving the learning process. Cognitive structuring methods such as mind mapping and concept mapping were deployed using web-based whiteboard applications. Pre-service teachers facilitated learners' application of their acquired knowledge in real-life scenarios, notably during the extend phase of learning. Online presentation tools and simulation programs were used to support the creation of outputs that mirrored learners' understanding of scientific principles. However, a noticeable gap was the application of CBTs in context-specific and localized pedagogical strategies, potentially attributed to limitations inherent in virtual learning and logistical challenges (Baker et al., 2022).

The cultivation of scientific literacy necessitates an understanding of the interplay between global and local societies (Zen, 1990). The present study suggests that elements of scientific literacy may indeed encapsulate facets of multiliteracy. The instruction and assimilation of scientific knowledge, paired with the practice of scientific literacy, significantly contribute to the evolution of broader multiliteracies. Learners engaged in various tangible and emotive interactions, thereby constructing meaning and communication through a multimodal design that encompassed gestural, spatial, visual, auditory, and linguistic components (New London Group, 1996). Through this approach, learners became active participants in the establishment of scientific multiliteracy. The enhancement of scientific literacy requires proficiency in describing, explaining, and predicting natural phenomena. Therefore, the inclusion of scientific method-based activities in the classroom is crucial to facilitate the acquisition of multiple literacy skills (Dani, 2009; Snow et al., 2016; Zhang et al., 2018; Manning-Lewis & Sanford, 2022).

Conclusions

The integration of Computer-Based Technologies (CBTs) by pre-service science teachers presents a potent approach to scaffold multiliteracy development in secondary science classrooms. By providing diverse learning resources, encouraging collaboration, and facilitating efficient formative assessment, these technologies significantly augment students' multiliteracy skills, thus preparing them for the demands of contemporary society. These pre-service educators, in catering to students' diverse Multiple Intelligences (M.I.s), have orchestrated learning scenarios that span historical and contemporary contexts, enriching the pedagogical environment with a multitude of digital resources. CBTs have successfully fostered a learner-centric environment, enabling students to generate, consume, and disseminate knowledge. However, the application of CBTs in context-specific and local scenarios was noticeably limited, possibly due to inherent constraints in remote learning environments and logistical challenges.

Scientific literacy, with its imperative for appreciating global and local interconnections, is posited to encompass aspects of multiliteracy. Thus, the teaching and learning of science, along with associated literacy practices, contribute significantly to the development of comprehensive multiliteracies. Through these methods, learners actively participate in creating scientific multiliteracy, further enhancing their ability to describe, elucidate, and predict natural phenomena. This underscores the importance of integrating scientific method-based activities in classroom environments for effective cultivation of multiliteracy skills.

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