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SHAPING FUTURE SCIENCE EDUCATION: POST PANDEMIC PERSPECTIVES OF PRESERVICE SCIENCE TEACHERS IN CENTRAL VISAYAS, PHILIPPINES

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Abstract

Tertiary education plays a pivotal role in shaping future-proof science education as it provides strong theoretical foundation to advance knowledge and foster innovation. In the context of post-pandemic education, exploring preservice science teachers' perspectives on how they envision science education can be relevant in an increasingly complex, uncertain, volatile, and ambiguous world, is a proactive measure. These preservice general science teachers (n=113) describe their point of views through drawing and narrative description. Qualitative data were analyzed using thematic analysis which resulted to four themes. Their perception of how Science education can be future-proofed centered on (1) highly advanced technology use, (2) personalized and adaptive learning (3) curated and open accessible learning resources, and (4) sustainability, social responsibility, and ethics-centered. These conceptions enable these future teachers who are also future leaders to prepare for the challenges and opportunities of a future world. These findings offer valuable insights into the need for teacher training institutions to recalibrate for the future skills in education that their graduates must possess and the curriculum to be designed to promote innovative and inclusive teaching practices.

Keywords – Future-proofing science, Philippines, Preservice science teachers, Future skills in education, Futures thinking.

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1. Introduction

1.1. Future Proofing Concept in Higher Education

The opinions of young people regarding technological progress are extremely relevant to educational aims because one's agency is linked to one's perceptions. The creation of science and technology education rarely takes into consideration the futuristic technological visions held by students (Rasa & Laherto, 2022). This article presents the findings from a qualitative study that examined the views of one hundred thirteen (113) prospective Science teachers, who were once recipient of instructional modality transitions brought about by the COVID-19 pandemic. Specifically, their perspectives focused on the attributes of future-proofed science teaching and learning. The research was conducted within a Center of Excellence in Teacher Education institution in Cebu City, Philippines. Future-proofing refers to the need to adopt innovative and creative approaches in response to challenges and risks (Fahnert, 2019). From the standpoint of educational technology, futureproofing implies that to reduce the possible consequences of obsolescence, it is important to continuously assess the state of technology and make the required modifications. One of the challenges of the present educational paradigm is that there's a chance that the push in higher education to prepare students for successful careers as workers could lessen their preparation as independent learners (Harmon & Dennison, 2016).

Education 4.0 is a concept derived from the rapid technological advancements and the integration of automation and technology that characterizes the Fourth Industrial Revolution (Marr, 2018). The present generation of learners has different preferences in their learning inclined toward the combination of soft skills (e.g. problem-based learning) and hard skills (i.e., technical IT knowledge) (Beke & Tick, 2024). This innovation has led to the creation and widespread adoption of emerging configurations such as artificial intelligence, which is now used across various sectors, including medicine, manufacturing, and industry. As a result, it is crucial to understand and address the importance of skills development and training to meet the evolving demands of the modern workforce (World Economic Forum, 2018). This implies that the business-as-usual ways of teaching and learning or the so-called traditional models of education are considerably insufficient to prepare students for the necessary skills that will be needed in the future where based on prediction, 65% of the children will be working on jobs that are yet to be defined or created (World Economic Forum, 2016; Ehlers & Eigbrecht, 2024). Hence, a call for a future-proofed education system that prepares not only for 21st-century skills but beyond (education 6.0) is necessary and it should be discussed among academic communities, on various platforms, across different countries.

Prospective teachers' conceptions regarding future-proofing are crucial within an educational context where graduates must be prepared for a rapidly evolving workforce, driven by unprecedented access to information and technology (Schleicher, 2023). In the context of the futures of education, educators are expected to be creative designers of innovative learning environments (Liesaputra, Ramirez-Prado, Barmada & Song, 2020). As regards curriculum, the future of education entails teachers and students co-creating the content and structure to meet the emerging needs and purpose of students. Additionally, as educational demands shift in response to Education 4.0 to 6.0, the role of teachers also undergoes significant changes. Teachers are no longer merely transmitters of content; they are expected to serve as facilitators and co-creators of the curriculum, guiding students through an increasingly complex landscape of knowledge and technology (Fisk, 2017). Thus, future-proofing in education encompasses not only preparing students for a world of continuous learning but also redefining the role of educators in this dynamic environment (Barrow, Perkins, Marini & Davidson, 2020) from sage on the stage to facilitator of learning and recently to being just an "accompanying teacher" in the emerging pedagogical renewal paradigm (Romero-García, Pericacho-Gómez, Buzón-García & Feu-Gelis, 2024).

Focusing on science education, there is an urgent need to redefine the objectives of Science, Technology, Engineering, and Mathematics (STEM, for brevity) education to equip students for this emerging "post-normal" world, with an emphasis on the sustainability mindset it demands (Cheadle, 2019; Khadri, 2022). The primary objective of STEM education is to address and resolve global grand challenges, a growing movement towards reforming STEM curricula has emerged, known as "Future-Oriented STEM Education" (Cerro-Velazquez & Lozano-Rivas, 2020). This approach to future-proofing Science teaching and learning involves professionals who are guided by a strategic understanding of the competencies and skills that industries will require in the future (Eguia, 2022). The significance of this study lies in its focus on the conceptions that prospective teachers hold regarding future-proofing science education – a field that in itself is continuously evolving. It is essential to understand the quality and direction of teacher preparation programs and subsequent classroom practices through the lens of future educational leaders. Future-proofing our students so that they will have the skills to negotiate and thrive in increasingly complex global workplaces is a challenge for all educators. These crucial skills are often referred to as 21st-century skills, general capabilities, graduate attributes, or transversal skills (Milligan, Luo, Hassim & Johnston, 2020).

1.2. Trends and Directions in Future-Proofing Education Across Discipline

Recent literature on future-proofing education explored various aspects of education. As to the field of science education, discussion around future-proofing is still at its developmental stage with high emphasis on the development of functional scientific literacy and less concern on whether the skills developed are sufficient enough to ensure their success in the unknown future (Cheadle, 2019) by transcending towards future skills in education (Ehlers, 2020). For instance, there is a demand for changing employment roles in this VUCAD world which requires graduates to have innovative, adaptable, and resilient attributes and to have an enterprising mindset (Barrow et al., 2020). Recently, future-oriented science education has been structured in terms of open schooling which is considered an innovative and inclusive approach to prepare students for the future by using real-life socio-scientific issues and a new pedagogical framework (CARE-KNOW-DO) that increases active engagement and supports problem-solving in the classroom (Okada, Sherborne, Kolionis, Koukovinis, Panselinas, Bizoi et al., 2023). Open schooling helps students obtain deep transferable learning (Gravett & Petersen, 2022). Similarly in other fields like computer science, they develop conceptual understanding and skills development of abstract computational thinking by situating it through a socially relevant context like cybersecurity, air pollution, and multiculturalism (Liesaputra et al., 2020). In music education, they future-proof their field by promoting creative pedagogies with technology (De Bruin & Merrick, 2023). Evidence suggests that integrating digital innovation and innovative pedagogy as a way of future-proofing instruction significantly enhances student achievement, engagement, and teacher satisfaction (Mawar, 2024).

In terms of curricula, higher education must continuously innovate their curricula as navigating the future world are uncertain (Huxley-Binns, Lawrence & Scott, 2023). They further added that in the context of teacher education preparation, possessing the skills, knowledge, and self-awareness needed to complete a task successfully is what it means to be competent. Applying discipline knowledge to professional practice, attending to real-world scenarios, or realistic teaching and evaluation that is pertinent to coursework, the workplace, and daily life, are all ways that students learn. Students as well as the surrounding community stand to gain from this as they develop their social, cultural, and educational capital. As Lawrence, Morrell and Scott (2024) described, competencies are taught in practice and assessed in application. As to assessment, Mastrogiacomi (2023) describes the shift in assessment methods from relying on computer-based quizzes and tests to portfolio-based, evidence-driven assessments that evaluate strategic thinking, collaboration, feedback, and participation. The latter fully reflected the creative, team-based, and inquiry-driven learning experience of students. This changes in his course assessment was due to some students using ChatGPT in final exams, raising ethical concerns and leading to the full adoption of portfolio assessments as the primary evaluation method. A recent futuristic study with closer methodologies to this article was reported by Rasa and Laherto (2022). Their study involved an examination of 58 secondary school students' essays about a normal day in 2035 or 2040, with an emphasis on the technology environment. Students' visions of the future, as revealed by qualitative content analysis, are characterized by technical advancements ranging from sophisticated personal electronics to extensive technological integration. Technology has been linked to many different effects, including those that are related to privacy, employment, the environment, convenience, and overall societal advancement.

Narrowing down to the Philippines as the context of this study, future-proofing started to attract attention among academic scholars such as the work of Amihan, Sanchez and Carvajal (2023) in the lens of quality assurance of teacher education institutions vis-à-vis ASEAN [Association of Southeast Asian Nations] education. Moreover, Berces (2023) identified the future-proofing priorities of private higher education institutions based on the variables of technology, curriculum, and partnerships. Eguia (2022) examined the skills of future-proofed graduate education which is composed of seven collective knowledge and skills demonstrated in planning and implementing the curriculum design and development. These knowledge and skills include innovation, design thinking, futures literacy, collaborative foresight, systems thinking, creative thinking, and reflective practice.

With all this aforementioned literature, an urgent need to identify new roles for STEM education that will prepare students for this post-normal world and the sustainability mindset it requires becomes more evident. STEM education helps future generations contribute to sustainable development, and adding Future Studies (FS) into STEM teaching is key to ensuring students become skilled problem-solvers for the 21st century. For this to happen, teachers need the right knowledge and skills for the future in their lessons (Khadri, 2022). Thus, looking into their perspectives is the first step.

1.3. Problem Statement

Significant disruptions to education were caused by the COVID-19 pandemic, which also accelerated the adoption of technology in the teaching and learning processes. This scenario underscored the need to prepare key players in education for a fast changing future. Preservice science teachers are leading the charge to create a future-proofed curriculum as education enters the post-pandemic era and industry 5.0. By exploring preservice science teachers' perceptions of how science education might adjust to the intricacies of an uncertain future while maintaining relevance, inclusivity, and sustainability in teaching and learning practices, addresses one of the gaps on this fertile research area. The objectives of the study are: (1) to explore preservice science teachers' perspectives on future-proofing science education in the next 50 years; and (2) to identify emerging themes in preservice teachers' conceptions of how technology, learning methodologies, and ethical considerations can shape future science education.

2. Methodology

Using a qualitative descriptive research approach, the goal of this study is to investigate preservice teachers' thoughts on future-proofing science instruction. The design aimed to provide comprehensive insights into the future of science education as envisioned by preservice science teachers, as well as the knowledge and tools required to stay relevant in a fast-changing educational environment.

The study was conducted within a teacher education institution focusing on the preservice science teachers (BSED – Science) at a university in Cebu City, Philippines. The study was conducted during the time that they were taking a course on educational research wherein they must conceptualize innovative ideas addressing pressing educational issues. Using total enumeration, the qualitative data were collected from three different classes in the same course. Interestingly, this batch of students had their Field Study 1 – Classroom Observation over a semester in an actual classroom set-up in both private and public schools. They were also the batch that experienced various flexible learning modalities (i.e., online classes, hybrid classes, and modular instruction) brought about by the COVID-19 pandemic. These experiences allowed them to have a glimpse of the scenarios in the teaching and learning environment.

Two types of data were collected: drawings and narratives. These were gathered during the first day of class in the initial week of a 15-week educational research course. Participants were asked to respond to the prompt, "Describe science education 50 years from now". After completing their drawings, they were instructed to write a narrative of five to ten sentences describing the content of their drawings. This data collection approach was implemented at the beginning of the course to minimize any potential influence of the course content on participants' responses (Subramaniam, 2013). Similar to the method used by Ormanci and Oren (2011) to explore both prospective and in-service teachers' K-12 and college experiences, providing insights into the foundations of their current and future instructional practices. Drawing can serve as a participatory research tool, allowing participants and researchers to collaboratively construct the meanings behind the drawings (Literat, 2013). Concurrently, narrative data were collected to complement the drawing artifacts, offering participants a chance to explain their drawings in their own words. This approach helped ensure an image or text balance and minimized the risk of researcher bias in interpreting the drawings (Canlas & Molino-Magtolis, 2024). By gathering narratives, the researcher could avoid solely relying on personal interpretation and better understand the participants' perspectives. In total, 113 drawings and 113 narratives were collected by the end of the study.

2.1. Drawings

All drawings were analyzed using three methods: holistic coding, emergent analytic coding, and trait coding. In holistic coding, (1) drawings were analyzed as a whole, and the themes were then identified

(Onwuegbuzie et al., 2016). Such as, if a drawing depicted different gadgets and images of advanced technology, it would be categorized, recorded, and coded accordingly. Also, with emergent analytic coding, the possibilities for discovering new patterns in the data (Miyaoka, 2023). Lastly, trait coding is used to document whether specific features are present in the drawing (Lindstrom, Jones & Price, 2021). These steps involved noting the distinctive elements within each drawing and using those elements to differentiate between them or to group similar drawings together based on shared features. Through these coding processes, the study aimed to systematically categorize the drawings, allowing for meaningful comparisons and further analysis based on the identified traits. Drawings are less likely misinterpreted when analysis incorporates both visual and written data (Theron, Mitchell & Smith, 2011).

2.2. Narratives

Kiger and Varpio (2020) identified thematic analysis that is used when analyzing narrative transcripts. This method is widely recognized for its effectiveness in identifying and interpreting patterns within qualitative data, particularly those that reveal participants' experiences and intentions as conveyed through spoken or written words. By applying thematic analysis, the narratives were meticulously examined and re-examined to uncover common themes that emerged across the dataset. The narratives, along with interview data (with six participants), were then used to cross-validate and provide additional context indicators that describe the future skills in education that need to be developed among learners that are implicitly mentioned in their narratives. This comprehensive approach allowed for a more robust and nuanced interpretation of the data.

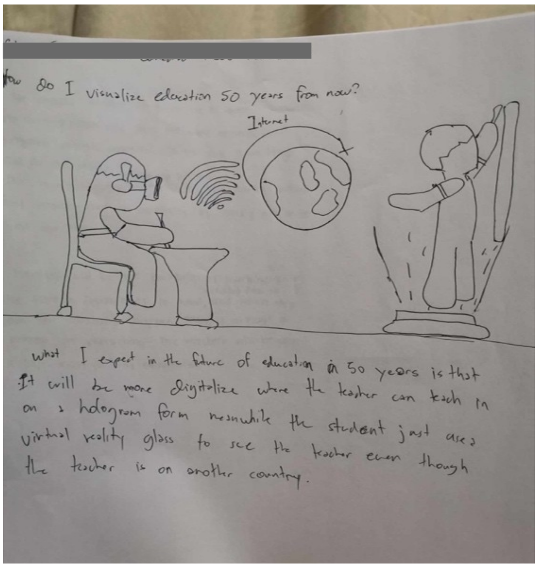
The information derived from the drawings and exhaustive narrative description of the drawing has been thematically analyzed by the researcher and further validated by two external validators who are professors in the same University handling Educational Research course. Thematic analysis followed the protocol of Braun and Clarke (2006) in the ATLAS.ti 22 software. The codes were generated through inductive coding following the strategies of Sandaña (2016) in its coding manual specifically, in Vivo coding, process coding, descriptive coding, and values coding. There were 660 codes from the first cycle of coding and subsequently 12 categories emerged in the second cycle of coding using the axial and pattern coding strategies. Thematic categorisation resulted in four themes as revealed in Table 1.

Theme	Categories	Number of codes
Highly advanced technology use	1.1. Holographic and 3D visualization of complex concepts	58
	1.2. Remote and virtual laboratories	45
	1.3. Blockchain for credentialing and learning records	12
Personalized and adaptive learning	2.1. AI-driven and assisted learning	90
	2.2. Individualized feedback systems	65
	2.3. Competency-based progression	34
Curated and open accessible learning resources	3.1. Open educational resource platforms	47
	3.2. Collaborative resource sharing	60
	3.3. Open and flexible learning modalities	92
sustainability, social responsibility, and ethics-centered	4.1. Project-based learning	78
	4.2. Community involvement	57
	4.3. Ethical considerations	22
Total		660

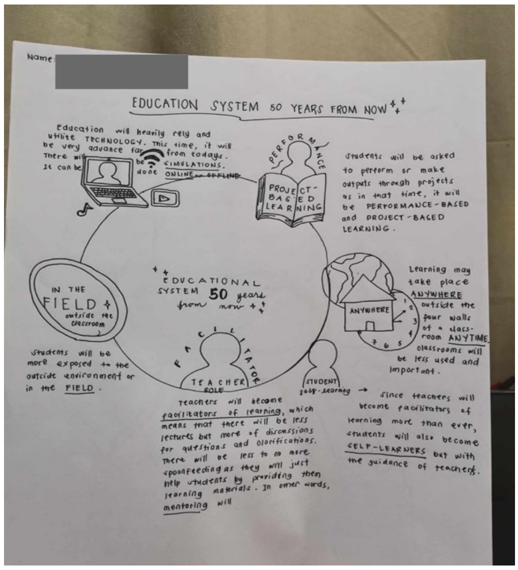
Table 1. Themes, codes, and number of remarks generated from the thematic analysis conducted

3. Results

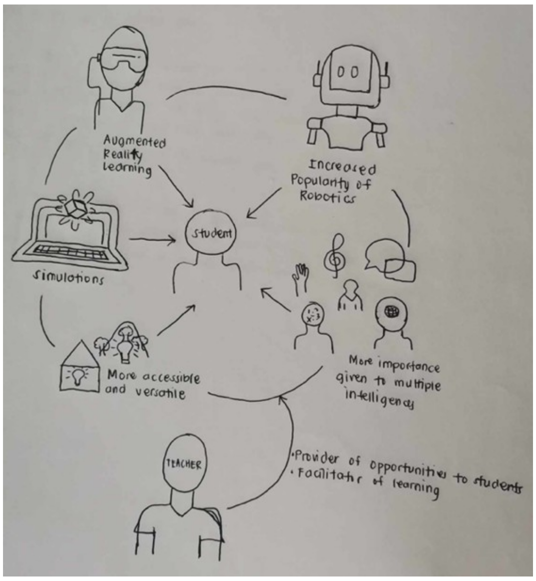
Below are the results of the thematic analysis conducted which revealed four (4) common perspectives in terms of how science education can be future-proofed (in the context of the future, 50 years from now) elucidated from the drawings and narrative accounts of the participants (Figure 1): (1) highly advanced technology use, (2) personalized and adaptive learning (3) curated and open accessible learning resources, and (4) sustainability, social responsibility, and ethics centered. It can be gleaned from these themes the increasing emphasis on future-proofed education that highlights the growing intersection between technology and education, signaling a broader transformation in how educational resources are developed, implemented, and governed.



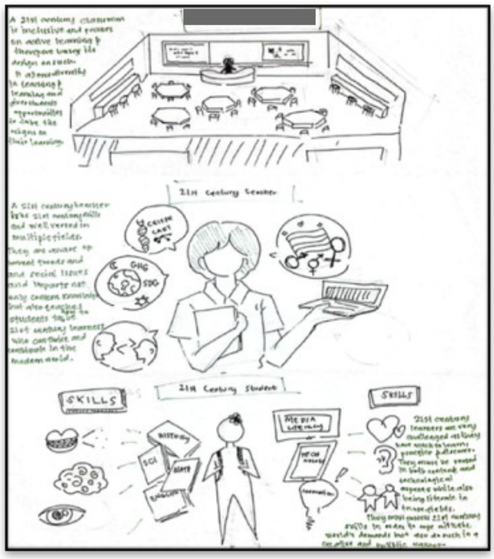
(1) highly advanced technology use



(2) personalized and adaptive learning



(3) curated and open accessible learning resources



(4) sustainability, social responsibility, and ethics centered

Figure 1. A glimpse of the imagined future-proofed science education as perceived by Preservice teachers

These future teachers hold a wide range of perspectives particularly on the emerging technologies significantly affecting education (e.g., an interactive teaching process that incorporates various technological tools such as smart TVs, artificial intelligence and machine learning, augmented reality and virtual reality; blockchain technology; data analytics and big data science, internet of things, robotics and automation, gamification and game-based learning, Open Educational Resources (OERs) and Massive Open Online Courses (MOOCs), among many others similar to what Rasa and Laherto (2022) found. Undeniably, the pandemic has introduced the world to these various technologies with massive acceptance particularly in the academic community as it allowed for seamless learning continuity. Learning in a supportive environment, coupled with guidance from a digitally literate and digitally savvy educator, has a deep understanding of the subject matter, is adaptable, and upholds strong values, fostering the development of lifelong learners. However, Rowan (2011) emphasizes factors that could influence the success or failure of an educational system, one of which is socioeconomic status. The Philippines, being a country in a situation of inequality, experiences this wide gap when it comes to equipment and materials used. Also, he added how this gap impacts the educational system in the long run. In the Philippines, a recent study by Olvido, Dayagbil, Alda, Uytico and Rodriguez (2024) on the quality of graduates from teacher education institutions revealed the significant role socioeconomic status plays in the effectiveness of teachers.

3.1. Theme 1. Highly Advanced Technology Use

Technology was widely cited by preservice teachers as the key to the success of science education in the future. They envisioned advanced data analytics, virtual and augmented reality (VR/AR), and artificial intelligence (AI) transforming classrooms. Using technology to provide immersive experiences, interactive simulations, and real-time feedback will not only increase student engagement but also increase learning efficiency (Arici, Yildirim, Caliklar & Yilmaz, 2019).

Many preservice teachers imagined futuristic classrooms where learners will engage with virtual laboratories for experimentation and AI-driven tutoring systems that provide individualized support in their stories and drawings. This is consistent with more general developments in educational technology, wherein administrative activities can be automated and learning experiences may be tailored with the help of AI. AI tutors may, for instance, help students comprehend difficult subjects or offer one-on-one support during exams. Although they would still play a crucial role, teachers would now more closely resemble mentors and facilitators who help students navigate learning experiences that are improved by technology. The teacher's areas of competence would be in deciding which technical tools to employ and how to use them, assisting students in developing their critical thinking abilities and making sure that technology is used ethically in the classroom.

> *"The classroom will be more on technology-based materials. The teacher will have a censor-generated presentation that can be accessed by using voice-activated commands. Students can be in a 3D virtual world when exploring lessons like Solar system."* (P32)

> *"There would be a 3D virtual presentation in the classroom, and everything is automatic. The students can use hoverboards as a method of transportation from one building to another since the establishments are floating in the air virtually."* (P57)

Although these participants recognize the need to fully embrace technology in the instructional processes, a recent report by Alda, Boholano and Dayagbil (2020) on the readiness of Teacher Education Institutions in the country regarding Education 4.0 says otherwise especially the lack of training and expertise on the use of advance technology (i.e., augmented reality, robotics, and digital enablers like 3D printing, as well as other online learning modalities like the learning management system). They further claimed that the problem is exacerbated by the lack of digital infrastructure and virtual laboratories that could develop 21^{st}-century skills.

3.2. Theme 2. Personalized and Adaptive Learning

The necessity of tailored and flexible instruction to meet the needs of each student was the focus of the second main theme. Preservice teachers were upbeat about the potential of technology to customize instruction to each student's individual interests, pace, and learning style. As Slater & Sanchez-Vives (2016) put it, the true power of virtual reality lies not so much in creating an accurate replica of "reality" as it does in providing the ability to transcend the conventional boundaries of reality and achieve objectives in a completely creative and unexpected way.

They imagined that instead of using a one-size-fits-all strategy, schools of the future would have access to adaptive learning technologies that would allow teachers to modify their curriculum, assessment, evaluations, and content in response to the changing needs and purpose of learners and the degree program itself. Similar to the concept of open schooling that uses real-life SSI [socio-scientific issues] to promote problem-solving skills among learners (Okada et al., 2023), this theme is situated to adaptive learning through virtual simulations and practical experiences relevant to the needs of the industry. SSI has been extensively proven as an innovative science education future-oriented pedagogy (Sanchez, Picardal, Fernandez & Caturza, 2024).

To ensure that no student is left behind, participants envision learning environments as AI-driven platforms adaptive in real time to each student's development. Additionally, the concept of modular learning paths surfaced, allowing students to advance through the course at their own speed and based on content mastery rather than adherence. Van Staden and Nadoo (2022) emphasized how the blended approach was increasingly introduced and promoted. Benefits were even highlighted such as accessibility, engagement, flexibility and efficiency, and optimal use of digital equipment. These changes train both key players in education to the inevitable virtual transition.

> *"The education system would improve, and learning would not only be limited inside the classroom but it could also be experienced from any part of the world or universe. The students would learn based on what they want and need. The teachers will still be present and act as the facilitator of learning. Perhaps, robot instructors would be invented, but the teachers would still be available and highly skilled, knowledgeable even in another field."* (P10)

> *"50 to 100 years from now, the school will all be virtual. The classroom will have a menu that students can choose from, language software, and hardware devices. This paradigm works like a one-talk app, an auto-receptionist that if ever a learner wants to be lectured by a Spanish teacher, they just need to press 1 or press for English."* (P8)

3.3. Theme 3: Curated and Open Accessible Learning Resources

The preservice teachers' views on the significance of free and open access to educational resources and materials emerged as a major theme in the data. In their idealized future, high-quality learning materials would be accessible to students from all socioeconomic levels, democratizing education through the use of open educational resources (OERs). Preservice teachers depicted how students and teachers may readily access, create, and contribute educational information on large, networked digital libraries and resource-sharing platforms through their drawings. The most recent scientific knowledge would be imparted to pupils thanks to the constant updating of these materials. Efficient and effective knowledge creation and sharing are underpinning future core competencies through strengthened industry-academe collaboration (Kettunen, Järvinen, Mikkonen & Mannisto, 2022).

> *"Education would be technologically dependent, and it explored limitless possibilities of how to learn. The word 'heutagogy' or self-directed learning will be the central focus of the curriculum. Students have the freedom to learn as they are exposed to a little bit of everything all the time."* (P65)

> *"The future education system will value more on flexibility and lifelong learning, with greater emphasis on micro-credentialing. Although few are starting it now, it will become globally practiced few years from now with specific skills and competencies that a student can stack up to suit to his career goals, and they don't rely solely on traditional degrees anymore."* (P111)

Participants strongly advocated for technologies that filter and arrange massive volumes of data into relevant, context-specific learning pathways, highlighting the concept of curated material. They highlighted the significance of being able to distinguish between trustworthy and untrustworthy sources, which is in line with the increasing demand for digital literacy in an information-rich society.

3.4. Theme 4: Sustainability, Social Responsibility, and Ethics-Centered

The significance of incorporating principles of sustainability, social responsibility, and moral decision-making into science education going forward was the concluding theme. The necessity for scientific curricula to address global issues including social injustice, environmental degradation, and climate change was emphasized by preservice teachers. Kinnula, Iivari and Fails (2021) and Paño, Jumao-as and Picardal (2022) stressed the importance of starting the collaborative, transdisciplinary value-creation at a very young age. They called for a change in scientific education that would prioritize creating a greater feeling of responsibility for the environment and future generations over merely imparting information and skills. Their predictions of scientific classrooms of the future, which stress project-based learning centered on real-world challenges and community involvement in tackling regional environmental and social issues, mirrored this.

> *"Education will not only focus on the development of knowledge but would highly focus on values. Every student could also master the skill needed for the world or profession that he wants in the future, as early as in grade school. The students could solve various problems in the world because research will be taught in earlier years."* (P45)

> *"Students will be very active in making products or something very useful in the community. Research of the students focuses more on how to preserve the environment and are very applicable in sustainable development of the country."* (P72)

The necessity of ethical frameworks to direct the application of developing technologies in science and society was also brought up by preservice teachers. For example, they envisaged science classes in the future that address the ethical implications of AI and genetic engineering tools in addition to teaching students how to utilize them. This futuristic view is synonymous with the narratives shared in the study of Rasa and Laherto (2022) that technoscience (and the growing integration of technology into human existence) has also been linked to issues that seem to be technomoral in nature. Put another way, technology was perceived as a problem that arose from values and ideas, leading to societal and cultural difficulties and polarization, rather than as something that benefited diverse stakeholders or communities. Interestingly, another future oriented role is emerging among teachers recently brought about by the rise of misinformation, fake news, and the overwhelming amount of information available online. Science teachers are increasingly taking on the role of science communicators and even diplomatic communicators in various ways. Their responsibilities now extend to critical thinking, media literacy, and community engagement to ensure that students and the broader community can navigate scientific information effectively. This technical and development communication competencies should be embedded in the teacher education preparation program.

4. Conclusion

Education 4.0 guarantees that educational activities will leverage the boundless opportunities these fast-paced technological developments offer (Olvido et al., 2024). But there is a unanimous question echoing the halls of academe "How can preservice teachers be prepared for the kind of education 30, 40, 50 years and beyond if the same kind of preservice training is afforded to them (i.e., in terms of preparation of instructional materials, assessment, or the whole lesson design). Futures scholars are clamoring for the "future skills turn" at a global scale by rethinking the educational praxis, systems, and mindset before the human workforce is completely replaced by automation and emerging configurations due to the mismatch of skills needed (Eigbrecht & Ehlers, 2024). In the context of teacher education plagued by massive attrition, demographic shifts, and career changes; workplace flexibility and support alone do not guarantee effective teachers but a more novel approach such as building a community of practice is imperative (White, Bourke, Mills, Mills, van Leent, Wood et al., 2024). Doing this image-mapping of the future allows students' futures thinking and sociotechnical thinking. The present work emphasizes how critical it is to get ready for a future in which education is thoroughly infused with cutting-edge technologies, tailored to the needs of specific students, and based on ethical responsibility and open access. The future education for the next generation of learners requires recalibration because what may be considered effective teaching and learning strategies for Gen Zs may no longer be applicable to the alpha and beta generations. These younger generations have manifested a different kind of thought-processing abilities brought about by the advanced technologies. Therefore, teacher preparation programs should adapt to meet these new demands by emphasizing technology integration, individualized learning approaches, digital resource curation, and the advancement of the common good.

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