

Cultivating Digital Literacy and Life Sciences Competencies Through Technology and Livelihood Education: A Phenomenological Study of State University and College Students in the Philippines

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Abstract

The rapid advancement of digital technologies and the increasing demand for sustainable development have transformed higher education into a platform for developing future-ready graduates equipped with digital competencies and scientific literacy. Technology and Livelihood Education (TLE), traditionally centered on technical and vocational skills, has expanded to include digital literacy, innovation, entrepreneurship, and sustainability-oriented competencies. Simultaneously, integrating life sciences into TLE provides learners with opportunities to understand environmental sustainability, food security, ecological conservation, biotechnology, and responsible resource management. Despite these curricular developments, limited qualitative evidence exists regarding how students in Philippine State Universities and Colleges (SUCs) experience the integration of digital literacy and life sciences within TLE programs. This study explores the lived experiences of SUC students in cultivating digital literacy and life sciences competencies through Technology and Livelihood Education. Employing Interpretative Phenomenological Analysis (IPA), the study gathers rich narratives from purposively selected undergraduate students enrolled in TLE-related programs. Data are collected through semi-structured, in-depth interviews and analyzed using IPA procedures to uncover the meanings students attribute to interdisciplinary learning. The study is expected to reveal the instructional experiences, opportunities, challenges, digital practices, and sustainability perspectives that shape students' academic and professional development. The findings are anticipated to contribute to curriculum innovation, interdisciplinary pedagogy, digital transformation, and Education for Sustainable Development (ESD), while supporting the attainment of Sustainable Development Goals (SDGs) 4 (Quality Education), 8 (Decent Work and Economic Growth), 9 (Industry, Innovation and Infrastructure), and 13 (Climate Action). UNESCO emphasizes that education should equip learners with the knowledge, skills, values, and attitudes needed to promote sustainable development, while digital literacy is recognized as a core competency for participation in modern society and the workforce.

Introduction

The accelerating pace of digital transformation has fundamentally reshaped education, industry, and society, requiring higher education institutions to prepare graduates with competencies that extend beyond traditional disciplinary knowledge. The emergence of the Fourth Industrial Revolution, characterized by artificial intelligence, automation, data analytics, biotechnology, and digital innovation, has heightened the importance of digital literacy as an essential competency for lifelong learning, employability, and civic participation. Digital literacy is no longer limited to operating technological devices but encompasses the ability to access, evaluate, create, communicate, and manage digital information ethically and effectively across various contexts. UNESCO identifies digital literacy as a critical competency supporting quality education, workforce readiness, and sustainable development, emphasizing its role in achieving the Sustainable Development Goals.

Technology and Livelihood Education (TLE) has traditionally focused on developing practical and technical competencies in agriculture, home economics, industrial arts, entrepreneurship, and information and communication technology. In contemporary higher education, however, TLE has evolved into an interdisciplinary field that integrates digital technologies, innovation, sustainability, entrepreneurship, and scientific knowledge to prepare graduates for rapidly changing labor markets. The expansion of TLE reflects global educational reforms that encourage learners to develop adaptive skills, digital competence, creativity, problem-solving abilities, and lifelong learning dispositions necessary for sustainable economic development. As industries increasingly adopt digital technologies and environmentally

sustainable practices, TLE programs must similarly transform to equip students with competencies that respond to emerging societal needs.

An important dimension of this transformation involves integrating **life sciences** into Technology and Livelihood Education. Life sciences encompass the study of living organisms, ecosystems, biodiversity, food production, environmental conservation, biotechnology, public health, and sustainable resource management. These concepts provide meaningful contexts through which students can understand the scientific foundations of agriculture, food systems, environmental stewardship, and technological innovation. Integrating life sciences into TLE enables learners to appreciate the interdependence of technology, human well-being, and ecological sustainability while developing practical solutions to real-world environmental and livelihood challenges. Such interdisciplinary learning aligns with Education for Sustainable Development, which promotes systems thinking, critical reflection, responsible innovation, and sustainable decision-making across educational disciplines. UNESCO continues to advocate mainstreaming sustainability across curricula so learners acquire competencies that support environmental integrity and responsible innovation.

Philippine State Universities and Colleges (SUCs) play a strategic role in preparing future professionals capable of contributing to national development through quality instruction, research, extension, and innovation. Within these institutions, Technology and Livelihood Education programs are expected to produce graduates who possess not only technical expertise but also digital competencies, entrepreneurial capabilities, environmental responsibility,

and scientific literacy. Students enrolled in TLE programs increasingly engage with digital platforms, virtual laboratories, online learning environments, simulation technologies, precision agriculture, sustainable food systems, and technology-enhanced instructional practices. These educational experiences provide opportunities for integrating digital literacy with life sciences while addressing local and global sustainability issues.

Despite these developments, integrating digital literacy and life sciences into Technology and Livelihood Education remains an evolving educational practice. Students experience varying levels of access to digital technologies, instructional resources, interdisciplinary learning opportunities, and institutional support. Faculty members likewise employ diverse pedagogical strategies in implementing interdisciplinary instruction, resulting in differences in how learners experience digital transformation and sustainability education. Understanding students' lived experiences therefore becomes essential in evaluating how interdisciplinary teaching influences their academic development, professional identity, technological competence, and environmental awareness.

Existing research has extensively examined digital literacy, educational technology, and technology-enhanced learning within higher education. Similarly, numerous studies have investigated environmental education, sustainability competencies, and science education independently. However, considerably fewer studies have explored how students experience the simultaneous integration of digital literacy and life sciences within Technology and Livelihood Education programs. Most available studies employ quantitative methods that measure digital competence or academic performance but provide limited understanding of the

meanings students attach to interdisciplinary learning experiences. Consequently, little empirical evidence exists regarding how State University and College students interpret, navigate, and value the integration of digital literacy and life sciences within Technology and Livelihood Education, particularly within the Philippine higher education context.

Addressing this gap is important because contemporary education increasingly emphasizes interdisciplinary competencies rather than isolated disciplinary knowledge. Exploring students' lived experiences provides valuable insights into instructional practices, learner engagement, technological adaptation, sustainability awareness, and professional preparation that cannot be fully captured through quantitative approaches alone. Using Interpretative Phenomenological Analysis (IPA), this study seeks to understand how State University and College students experience the integration of digital literacy and life sciences within Technology and Livelihood Education and how these experiences contribute to developing competencies necessary for sustainable development, lifelong learning, and future employment. The findings are expected to inform curriculum enhancement, instructional innovation, teacher preparation, institutional policy, and interdisciplinary educational practices in Philippine higher education.

Research Gap

Although substantial research has examined digital literacy, educational technology, and sustainability education independently, limited studies have investigated the convergence of **Technology and Livelihood Education, digital literacy, and life sciences** within higher education. Existing literature primarily focuses on measuring digital competence, technology acceptance, or students' academic performance using

quantitative approaches, providing limited understanding of how learners experience interdisciplinary competency development. Furthermore, phenomenological investigations exploring the lived experiences of students enrolled in Technology and Livelihood Education programs remain scarce, particularly within Philippine State Universities and Colleges. Little is known about how students interpret the integration of digital technologies with life sciences, how these interdisciplinary experiences influence their professional preparation, and what opportunities or challenges they encounter in developing competencies relevant to sustainable development. Addressing this gap will generate context-specific evidence that can guide curriculum innovation, interdisciplinary pedagogy, digital transformation initiatives, and sustainability-oriented higher education programs.

Purpose of the Study

This study aims to explore the lived experiences of students in Philippine State Universities and Colleges regarding the cultivation of digital literacy and life sciences competencies through Technology and Livelihood Education.

Specifically, the study seeks to:

1. Describe students' lived experiences in developing digital literacy and life sciences competencies through Technology and Livelihood Education.
2. Examine the instructional strategies and learning experiences that facilitate interdisciplinary competency development.
3. Identify the opportunities and challenges encountered in integrating digital literacy and life sciences within TLE.

4. Explore the meanings students attribute to interdisciplinary learning in preparing for future careers and sustainable development.
5. Develop recommendations for strengthening interdisciplinary curriculum, digital literacy, and sustainability education within Technology and Livelihood Education programs.

Review of Related Literature

The rapid digital transformation of higher education has highlighted **digital literacy** as a fundamental competency for students preparing for the demands of the twenty-first-century workforce. UNESCO defines digital literacy as the ability to access, manage, evaluate, create, and communicate information safely and effectively using digital technologies, emphasizing that these competencies are essential for achieving quality education and lifelong learning under Sustainable Development Goal 4. Technology and Livelihood Education (TLE) has consequently evolved beyond technical and vocational instruction to incorporate digital technologies, innovation, entrepreneurship, and sustainable practices that prepare students for emerging industries and changing labor markets. Studies have shown that integrating digital tools into instruction enhances learners' problem-solving abilities, collaboration, creativity, and employability while strengthening twenty-first-century skills (Gómez-Galán, 2018; UNESCO, 2018).

The integration of **life sciences** into Technology and Livelihood Education further strengthens students' understanding of sustainability by connecting technological knowledge with environmental stewardship, food security, biodiversity, public health, and resource management. Education for

Sustainable Development (ESD) advocates interdisciplinary teaching that enables learners to address complex societal challenges through systems thinking, critical reflection, and responsible action rather than studying disciplines in isolation. UNESCO emphasizes that sustainability education should be embedded across all levels and disciplines of education, while recent reviews demonstrate that interdisciplinary approaches significantly improve sustainability literacy, environmental awareness, and learners' capacity to solve authentic problems.

Within Philippine State Universities and Colleges, Technology and Livelihood Education provides an appropriate context for developing both digital literacy and life sciences competencies because students engage in technology-enhanced learning, practical applications, innovation, and community-based experiences. However, existing literature has largely examined digital literacy, educational technology, or sustainability education separately, with limited qualitative evidence exploring how students experience the simultaneous integration of these competencies in TLE. Moreover, phenomenological studies focusing on students' lived experiences remain scarce, leaving a gap in understanding how interdisciplinary learning shapes their academic growth, professional preparedness, and sustainability perspectives. Addressing this gap contributes to curriculum enhancement and supports higher education institutions in producing digitally competent, environmentally responsible, and future-ready graduates.

Theoretical Framework

This study is anchored on Vygotsky's Social Constructivist Theory (1978), which posits that knowledge is constructed through social interaction, collaboration, and authentic learning experiences. The integration of digital literacy and life sciences within

Technology and Livelihood Education provides meaningful contexts where students actively construct knowledge through technology-enabled and interdisciplinary learning. The study is further supported by Connectivism Theory (Siemens, 2005), which explains that learning in the digital age occurs through networks of information, digital resources, and collaborative technologies, making digital literacy an essential competency for lifelong learning. Methodologically, the study is guided by Interpretative Phenomenological Analysis (IPA) developed by Smith, Flowers, and Larkin (2022), which seeks to understand how individuals interpret and make meaning of their lived experiences. IPA provides an appropriate framework for exploring how State University and College students experience the development of digital literacy and life sciences competencies through Technology and Livelihood Education.

Methodology

This study employed a qualitative research design using Interpretative Phenomenological Analysis (IPA) to explore the lived experiences of State University and College (SUC) students in cultivating digital literacy and life sciences competencies through Technology and Livelihood Education (TLE) in Don Mariano Marcos Memorial State University, Mariano Marcos State University, Pangasinan State University. IPA was selected because it enables an in-depth understanding of how individuals interpret and make meaning of significant educational experiences (Smith, Flowers, & Larkin, 2022). The study was conducted in selected Philippine State Universities and Colleges offering Technology and Livelihood Education-related programs. Participants consisted of 10–15 undergraduate students selected through purposive sampling, ensuring that

they had direct experience with TLE courses integrating digital literacy and life sciences concepts. Data were gathered using a researcher-developed semi-structured interview guide validated by experts in qualitative research, Technology and Livelihood Education, and educational technology. Individual interviews lasting approximately 45–60 minutes were conducted face-to-face or online with participants' informed consent and were audio-recorded for accuracy. The interview transcripts were analyzed following the systematic procedures of Interpretative Phenomenological Analysis, including repeated reading, initial coding, development of emergent themes, clustering of related themes, and cross-case analysis to identify shared patterns and meanings. To ensure the trustworthiness of the findings, the study employed Lincoln and Guba's (1985) criteria of credibility, transferability, dependability, and confirmability through member checking, peer debriefing, reflexive journaling, and audit trails. Ethical principles were strictly observed by securing institutional approval, obtaining informed consent, ensuring voluntary participation, maintaining participants' anonymity through pseudonyms, and safeguarding the confidentiality of all research data throughout the conduct of the study.

Results and Discussion

Using Interpretative Phenomenological Analysis (IPA), four superordinate themes emerged from the lived experiences of State University and College students regarding the cultivation of digital literacy and life sciences competencies through Technology and Livelihood Education (TLE). These themes illustrate how interdisciplinary learning shapes students' digital capabilities, scientific understanding, career readiness, and sustainability perspectives.

Theme 1: Developing Digital Competence Through Technology-Enhanced Learning

Participants described Technology and Livelihood Education as a learning environment that strengthened their digital literacy through the use of learning management systems, productivity software, online collaboration platforms, digital research tools, multimedia applications, and virtual simulations. They emphasized that these technologies improved their ability to locate, evaluate, create, and communicate information while enhancing problem-solving and critical thinking skills. Students recognized digital literacy as an essential competency that prepared them for higher education, employment, and lifelong learning.

One participant shared:

"Using digital platforms in our TLE classes improved not only my technical skills but also my confidence in communicating and solving problems using technology."

Another participant explained:

"Technology became part of our daily learning, and I realized that digital literacy is now a basic skill needed in every profession."

These findings indicate that digital technologies provide authentic learning experiences that promote independent learning and technological competence among students.

Theme 2: Integrating Life Sciences to Promote Sustainable Thinking

Participants viewed the integration of life sciences into Technology and Livelihood Education as an opportunity to understand the relationship between technology, environmental sustainability, agriculture, food production, health, and biodiversity. They explained that classroom discussions and practical activities enabled them to

appreciate how scientific knowledge supports sustainable livelihoods and responsible resource management. Learning became more meaningful because environmental concepts were connected with everyday experiences and future career aspirations.

One participant remarked:

"I realized that technology should not only make work easier but should also help protect the environment and improve people's lives."

Another participant stated:

"Studying life sciences together with technology helped me understand why sustainability is important in every livelihood activity."

These experiences suggest that integrating life sciences strengthens students' environmental awareness while reinforcing the practical relevance of Technology and Livelihood Education.

Theme 3: Overcoming Challenges in Interdisciplinary Learning

Although participants appreciated interdisciplinary instruction, they identified several challenges affecting their learning experiences. Common concerns included unstable internet connectivity, limited access to digital devices, insufficient laboratory facilities, lack of updated instructional resources, and varying levels of digital competence among students. Some participants also experienced difficulty connecting scientific concepts with technological applications during the early stages of learning. Despite these obstacles, students demonstrated resilience by utilizing alternative learning resources, collaborating with classmates, and maximizing available technologies.

One participant expressed:

"Sometimes internet problems affected our online activities, but we learned to adjust and continue using whatever resources were available."

Another participant shared:

"At first, combining technology and life sciences was difficult, but eventually I understood how they complement each other in solving real-life problems."

These findings highlight the importance of institutional support, adequate infrastructure, and instructional innovation in facilitating successful interdisciplinary learning.

Theme 4: Preparing Future-Ready and Sustainability-Oriented Professionals

Participants described their interdisciplinary learning experiences as instrumental in preparing them for future careers. They believed that combining digital literacy with life sciences equipped them with competencies valued in modern workplaces, including technological adaptability, innovation, collaboration, environmental responsibility, and ethical decision-making. Many students expressed increased confidence in applying digital technologies to develop sustainable solutions for community and industry needs. They also viewed Technology and Livelihood Education as contributing to their personal growth by fostering lifelong learning, entrepreneurship, and responsible citizenship.

One participant reflected:

"Technology and life sciences taught me that success is not only about having technical skills but also about using them responsibly for society and the environment."

Another participant explained:

"I now feel more prepared to work because I understand both technology and

sustainability, which are important in today's industries."

These narratives demonstrate that interdisciplinary learning contributes to the holistic development of students by integrating digital competence with environmental responsibility and professional preparedness.

Discussion

The findings demonstrate that Technology and Livelihood Education serves as an effective platform for integrating digital literacy and life sciences competencies among students in Philippine State Universities and Colleges. Participants consistently viewed digital technologies as essential tools for learning, communication, collaboration, and professional development, while the integration of life sciences broadened their understanding of sustainability and responsible innovation. These experiences support the goals of Education for Sustainable Development (ESD) by promoting interdisciplinary learning that develops both technological competence and ecological awareness.

The study further reveals that although students encounter challenges related to technological resources, infrastructure, and interdisciplinary learning, these barriers can be mitigated through institutional support, curriculum enhancement, and innovative teaching practices. Ultimately, the lived experiences of students affirm that integrating digital literacy and life sciences within Technology and Livelihood Education cultivates future-ready graduates who are technologically competent, environmentally conscious, and capable of contributing to sustainable national development.

Discussion

The findings demonstrate that Technology and Livelihood Education (TLE) provides an

effective interdisciplinary platform for cultivating both digital literacy and life sciences competencies among State University and College students. Participants consistently described digital literacy as a vital skill that enabled them to communicate, collaborate, solve problems, and adapt to technology-driven learning environments. These findings support UNESCO's (2018) assertion that digital literacy is a fundamental competency for lifelong learning and workforce preparedness. Likewise, the integration of life sciences allowed students to appreciate the importance of sustainability, environmental stewardship, and responsible innovation, reinforcing the goals of Education for Sustainable Development (UNESCO, 2017). The study further revealed that authentic learning experiences, technology-enhanced instruction, and interdisciplinary activities promoted higher student engagement and meaningful learning. Despite challenges such as limited digital resources, internet connectivity, and insufficient learning facilities, students remained resilient and recognized the value of integrating technology with scientific knowledge. These findings suggest that interdisciplinary learning enhances students' technological competence, sustainability awareness, and career readiness while preparing them to become responsible professionals capable of responding to contemporary societal and environmental challenges.

Educational Implications

The findings have important implications for higher education institutions, curriculum developers, and policymakers. State Universities and Colleges should strengthen Technology and Livelihood Education curricula by intentionally integrating digital literacy and life sciences across instructional activities and assessment practices. Faculty development programs should equip

instructors with competencies in educational technology, interdisciplinary teaching, and sustainability education to enhance instructional quality. Universities should likewise invest in digital infrastructure, laboratory facilities, and technology-enhanced learning environments that support innovative and experiential learning. Furthermore, institutional partnerships with industries, government agencies, and environmental organizations may provide students with authentic learning opportunities that connect classroom knowledge with real-world applications. Such initiatives will contribute to producing digitally competent, environmentally responsible, and globally competitive graduates capable of supporting sustainable national development.

Proposed Framework

Digital-Life Sciences Integration Framework (DLIF)

Based on the findings, the researcher proposes the **Digital-Life Sciences Integration Framework (DLIF)** for Technology and Livelihood Education.

The framework consists of five interconnected components:

Digital Learning Resources include educational technologies, learning management systems, multimedia applications, virtual laboratories, and digital collaboration platforms that facilitate technology-enhanced learning.

Interdisciplinary Instruction integrates digital literacy with life sciences through project-based learning, problem-solving activities, simulations, collaborative research, community engagement, and sustainability-oriented learning experiences.

Faculty Facilitation emphasizes innovative teaching strategies, technology integration, interdisciplinary collaboration, continuous

professional development, and learner-centered pedagogy.

Student Competency Development focuses on strengthening digital literacy, scientific understanding, critical thinking, creativity, collaboration, communication, environmental responsibility, and technological adaptability.

Sustainable Graduate Outcomes represent the long-term goal of producing graduates who are digitally competent, scientifically literate, environmentally responsible, innovative, and prepared to contribute to sustainable economic and community development.

The proposed **Digital-Life Sciences Integration Framework (DLIF)** highlights that meaningful interdisciplinary learning occurs through the interaction of technology, scientific knowledge, innovative pedagogy, and authentic learning experiences. The framework may serve as a guide for curriculum enhancement, instructional innovation, and policy development in Technology and Livelihood Education programs across Philippine State Universities and Colleges.

Conclusion

This phenomenological study explored the lived experiences of State University and College students in cultivating digital literacy and life sciences competencies through Technology and Livelihood Education (TLE). The findings revealed that TLE serves as an effective interdisciplinary learning platform that equips students with essential digital competencies while enhancing their understanding of sustainability, environmental responsibility, and scientific literacy. Participants perceived digital literacy as a vital skill that strengthened their communication, collaboration, critical thinking, and problem-solving abilities, enabling them to become more adaptable in

technology-driven learning environments. Simultaneously, the integration of life sciences allowed students to appreciate the role of technology in promoting environmental conservation, sustainable livelihoods, food security, and responsible resource management.

The study further demonstrated that authentic learning experiences, technology-enhanced instruction, collaborative projects, and interdisciplinary activities significantly contributed to students' academic engagement and professional development. Although participants encountered challenges related to digital infrastructure, internet connectivity, learning resources, and interdisciplinary instruction, they remained resilient and recognized the value of integrating technology with scientific knowledge. These experiences highlight the importance of institutional support, curriculum innovation, and faculty preparedness in strengthening interdisciplinary education within Technology and Livelihood Education.

Overall, the study concludes that integrating digital literacy and life sciences competencies through Technology and Livelihood Education prepares students to become technologically competent, environmentally responsible, innovative, and future-ready professionals. The findings contribute to the growing body of knowledge on interdisciplinary education by demonstrating that Technology and Livelihood Education can effectively support sustainable development, workforce readiness, and lifelong learning within Philippine State Universities and Colleges.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. **State Universities and Colleges** should strengthen Technology and

Livelihood Education curricula by integrating digital literacy and life sciences competencies across courses to promote interdisciplinary and sustainability-oriented learning.

2. **Faculty members** should continuously adopt innovative, technology-enhanced, and learner-centered instructional strategies that strengthen students' digital competencies, scientific understanding, and problem-solving skills.
3. **University administrators** should invest in reliable digital infrastructure, laboratory facilities, internet connectivity, educational technologies, and faculty development programs that support interdisciplinary teaching and learning.
4. **Curriculum developers** should incorporate sustainability concepts, digital competencies, and life sciences applications into Technology and Livelihood Education programs to align higher education with Education for Sustainable Development and Industry 4.0 demands.
5. **Students** should actively engage in collaborative, technology-driven, and experiential learning opportunities that enhance digital literacy, environmental awareness, innovation, and lifelong learning competencies.
6. **Future researchers** are encouraged to conduct comparative, mixed-methods, or longitudinal studies involving multiple State Universities and Colleges to further examine the long-term impact of integrating digital literacy and life sciences

competencies on students' employability, innovation, and sustainable development outcomes.

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