Environment and Social Psychology (2025) Volume 10 Issue 4 ISSN: 2424-8975 (O)
doi: 10.59429/esp.v10i4.3266 2424-7979 (P)

RESEARCH ARTICLE

Using technology in instruction to increase innovative mindset and behavior: Lens from higher education learners in science and ICT

Richard N. Verdeflor[1,*], Rhea V. Dellosa[2], Rodel R. Ventures[3], Abegail G. Bordios[4], Andres Iii B. Sequito[4], Princess Claubette R. Mujeres[2]

[1] *College of Education, Northwest Samar State University (Main Campus), Calbayog City, Samar, 6710, Philippines*

[2] *Teacher Education, Art and Sciences, Northwest Samar State University (San Jorge Campus), San Jorge, Samar, 6707, Philippines*

[3] *College of Computing and Information Sciences, Northwest Samar State University (Main Campus), Calbayog City, Samar, 6710, Philippines*

[4] *College of Education, Samar State University, Catbalogan City, 6700, Philippines*

*** Corresponding author:** Ricahrd N. Verdeflor, richard.verdeflor@nwssu.edu.ph

ABSTRACT

This research explores how integrating technology influences the development of an innovative mindset and behavior in higher education students studying science and information and communication technology (ICT). Utilizing qualitative exploratory research, the study relies on narrative accounts from 25 students participating in various science and ICT programs. The results indicate that technology greatly improves collaboration, analytical abilities, and autonomous learning. Important technological tools recognized encompass online collaboration platforms like Google Docs and Trello, project management applications such as Asana and Monday.com, and data visualization resources like Tableau. The study emphasizes the importance of having access to top-tier coding platforms, extensive research databases, and interactive e-learning modules. It highlights efficient teaching methods that encourage creativity via project-based learning, virtual labs, and simulations, all of which facilitate both collaborative learning and personal exploration. The results indicate that a thoughtful incorporation of technology in higher education can cultivate a student-focused environment that prepares learners with the competencies required for the workforce of the 21st century. The research encourages additional exploration of joint efforts among educational organizations, industry executives, and tech firms to improve the incorporation of technology and innovation in higher education.

Keywords: technology integration; innovative mindset; higher education; collaborative learning; project-based learning

1. Introduction

The incorporation of technology into teaching methods is greatly transforming higher education, especially in the fields of science and ICT. This educational transformation is mainly motivated by the necessity to adapt to a swiftly digitizing world, where conventional teaching methods frequently fail to captivate students or equip them for tech-heavy professions[1].

ARTICLE INFO
Received: 25 November 2024 | Accepted: 26 March 2025 | Available online: 8 April 2025

CITATION
Verdeflor RN, Dellosa RV, Ventures RR, et al. Using technology in instruction to increase innovative mindset and behavior: Lens from higher education learners in science and ICT. *Environment and Social Psychology* 2025; 10(4): 3266. doi:10.59429/esp.v10i4.3266

In this changing landscape, cultivating an innovative mindset and behavior in students has become essential in education. This is particularly relevant in science and ICT fields, where adaptability, problem-solving abilities, and creative thinking are essential skills for future career success. The learning environment influenced by the interaction between technological resources and social learning patterns is vital in shaping student behavior. The psychological effects of engaging and immersive technologies like virtual reality (VR), artificial intelligence (AI), and online learning systems go beyond just delivering content. These tools significantly affect students' motivation, involvement, and ability to utilize theoretical knowledge in practical situations[2,3].

The COVID-19 pandemic significantly expedited the use of digital teaching tools, demonstrating their ability to ensure ongoing education and to boost student autonomy and creativity via remote, collaborative learning settings[4]. Research shows that technology-based learning settings promote vital cognitive abilities like problem-solving and divergent thinking, which are crucial for developing creativity and innovation[5]. Simulations, online labs, and cooperative digital platforms enable learners to experiment with hypotheses, illustrate scientific processes, and obtain prompt feedback, thus enhancing a deeper understanding[6,7]. Within a wider context, these teaching innovations can be viewed as drivers of behavioral transformation. They transform the educational environment and social interactions, fostering a culture of innovation. This study examines how the integration of technology in teaching affects the cultivation of innovative attitudes and behaviors in higher education students within science and ICT, emphasizing the convergence of educational settings, technological ecosystems, and psychological adjustment in learning during the 21st century.

Instruction enhanced by technology is revolutionizing the educational environment by offering adaptive, student-focused experiences that encourage creativity and independent thinking. This type of teaching accommodates various learning styles and speeds, enabling students, especially in science and ICT, to participate in individualized learning journeys that foster creativity, critical thinking, and problem-solving skills[8]. By utilizing adaptive learning systems, learners engage with tailored material that encourages self-directed study and independent exploration, in line with modern educational aims of nurturing lifelong learning and innovative practices. This adaptability is especially essential in ICT education, where acquiring proficiency in intricate software tools and programming languages thrives in self-directed and exploratory learning settings. Studies indicate that when students have control over their learning experiences, they are more likely to utilize creative thinking and connect more profoundly with the material[9]. Analytics powered by AI improve teaching by allowing educators to customize educational strategies for each learner's needs, thereby fostering a setting that promotes innovation[10].

Despite the advantages, successful technology integration in higher education necessitates tackling significant structural and psychological obstacles. The digital literacy of both students and faculty is inconsistent, potentially obstructing the effective use of educational technologies[11]. Furthermore, differences in access to devices and fast internet perpetuate an ongoing digital divide, exacerbating current inequalities in educational opportunities. Organizations need to actively invest in digital infrastructure, training, and support systems to guarantee fair involvement in technology-enhanced learning settings. Collaborative tools like virtual workspaces, discussion forums, and project management platforms provide students with chances to co-create knowledge, nurturing a community of inquiry that is vital for fostering teamwork and communication skills[12]. These social-cognitive exchanges are particularly significant in ICT, where collaboration frequently leads to innovative problem-solving.

The strategic use of teaching technologies like flipped classrooms, blended learning, and immersive media can greatly enhance the learning experiences of students in science and ICT[13]. These models not only

improve engagement but also connect theoretical understanding with practical application, thus preparing students with the abilities required for future jobs in fast-changing digital sectors.

As the needs of the 21st-century workforce evolve, it is essential for educational leaders to advocate for the incorporation of technology that fosters academic success and psychosocial growth. In conclusion, by nurturing settings that encourage digital innovation and mental empowerment, higher education institutions can develop the upcoming generation of inventive, flexible, and socially conscious professionals. By carefully integrating technology, fostering innovative mindsets and behaviors in learners within science and ICT becomes not only possible but crucial for sustainable educational advancement.

2. Literature review

The incorporation of technology into higher education, especially in science and ICT fields, persistently transforms teaching methods and student involvement. Recent research highlights the crucial impact of digital technologies in promoting creative thinking and actions among students. These resources enable students to investigate and understand abstract scientific concepts, simplifying intricate phenomena by utilizing interactive platforms like virtual labs and simulation settings[15]. Technological tools in instructional design not only improve cognitive involvement but also foster a mindset that values innovation. Chavez and Lamorinas[16] highlight that integrating digital tools into teaching promotes enhanced learning and equips students for the growing digital and complex requirements of today's job market. Emerging technologies—like VR, AI, and cloud-focused collaborative resources—allow higher education institutions to rethink conventional teaching methods, promoting experiential and participatory learning.

An essential aspect of innovation in education is the improvement of collaboration and communication—fundamental skills associated with creative problem-solving. AI-powered platforms, for example, offer tailored learning experiences and allow educators to track student progress via analytics-driven interventions[17]. These platforms also facilitate interactive learning environments—discussion boards, collaborative workspaces, and online portfolios—where students can share ideas and obtain ongoing feedback. These settings play a key role in encouraging iterative thinking and cultivating an innovative mindset[18,19].

The Incorporation of technology in higher education signifies a significant change in teaching methods, especially in the fields of science and ICT. Recent studies highlight the considerable promise of digital technologies in improving students' creative skills, enabling them to formulate and explore concepts that could otherwise stay abstract or unreachable. For example, simulation software and virtual labs enable students to investigate and interact with intricate scientific phenomena outside the limits of conventional classrooms[15] Chavez and Lamorinas[16] highlight that integrating technology in educational environments promotes more profound learning while also providing students with the essential skills to succeed in an ever-evolving digital and complex job market.

A major benefit of incorporating technology into science and ICT education is its capacity to improve collaboration and communication—factors essential for promoting creative thinking. AI-powered tools have demonstrated potential in customizing learning experiences, addressing the varied needs of students, and allowing educators to efficiently track student progress[17]. Resources like cloud-driven project software, internet discussion boards, and teamwork platforms foster a setting that promotes idea exchange and varied viewpoints[18]. By offering data-informed insights, these technologies enable focused interventions that enhance students' creativity and problem-solving abilities. Additionally, the real-time feedback systems provided by these platforms motivate students to continuously improve their work, fostering a creative

mindset[19]. In addition to skill enhancement, this cooperative method equips students for workplaces where digital competency and collaboration are crucial. The integration of VR and augmented reality (AR) technologies enhances the educational experience by developing immersive learning environments, enabling students to visualize intricate scientific ideas and participate in practical learning that strengthens their theoretical comprehension. This diverse application of technology fosters an inventive mindset while also improving the overall educational experience for students in science and ICT fields.

The COVID-19 pandemic has accelerated a major transition to online learning platforms, increasing interactivity and collaboration among higher education students, especially in Science and ICT. These platforms have been demonstrated to enhance student engagement and enthusiasm, ultimately promoting an innovative mindset[20]. Massive Open Online Courses (MOOCs) have been crucial in broadening access to top-notch educational materials. Nonetheless, various obstacles hinder successful execution, including lack of technical support, insufficient training for teachers, and the widespread digital gap, which results in underserved students lacking essential resources[21]. Tackling these inequalities is crucial for guaranteeing fair educational chances and fostering innovation in STEM areas. Approaches to address these issues involve investing in the professional growth of faculty and improving students' digital skills.

Moreover, the incorporation of gamification in science and ICT education has been associated with heightened motivation and engagement, resulting in enhanced creative skills[22]. Gamified learning tasks offer an engaging educational experience that differs from conventional teaching approaches, introducing problem-solving challenges that encourage critical and creative thinking[23]. Platforms that utilize game-based learning, for example, can replicate real-life situations, compelling students to use their theoretical understanding to tackle intricate problems[24]. As learners advance in these simulated settings, they develop the capacity to tackle issues from various viewpoints—a talent that is becoming more appreciated in creative sectors. By means of these initiatives, technology in teaching can greatly improve both the creative mindset and the behavioral skills of students in higher education.

The incorporation of technology into educational teaching has become a crucial element in promoting innovative thinking and behaviors among university students, especially in the areas of science and ICT. Studies show that using adaptive learning technologies can support individualized learning routes, crucial for fostering independent study and creativity[25]. AI-powered tools enable students to interact with content that suits their proficiency levels by customizing materials to fit each learner's progress, thus encouraging more in-depth investigation and understanding of concepts[26]. This method enables science and ICT students to manage their learning at their own speed, resulting in improved experiences and greater abilities for creativity and independent problem-solving[27].

Additionally, technology acts as a means for executing interdisciplinary learning frameworks, which are essential for nurturing creativity in the fields of ICT and modern science[28]. By incorporating technology, these models allow students to link scientific concepts with practical applications, thus enhancing their capacity to tackle challenges from a creative and comprehensive viewpoint[29]. Interdisciplinary projects present students with real-life challenges demanding knowledge from various fields, promoting the synthesis of skills vital for creative thinking[30]. By integrating technology into scientific and ICT programs, higher education institutions can foster interactive learning settings that prepare students with the skills needed to succeed in a constantly changing, technology-based job market.

3. Methodology

3.1. Research design

This study looks at how integrating technology into science and ICT courses in higher education can help students develop a creative mentality and behavior. It explores student narratives through qualitative exploratory research, shedding light on complex relationships, interactions, and experiences that are frequently hard to measure or distill to quantifiable characteristics[31]. The research shows how the use of particular technology tools and procedures might improve students' capacity for creative thought via the prism of these tales. This investigation highlights how technology has the power to revolutionize science and ICT education, thereby enhancing students' capacity for innovation.

3.2. Population and sampling

The research included 25 students from various higher education institutions, such as universities, community colleges, and technical schools, all participating in science and ICT programs. These organizations differ in their educational emphasis, available resources, and student populations, greatly affecting the experiences students have with technology-assisted learning. University students frequently gain from comprehensive research resources and knowledgeable instructors, promoting thorough involvement with technology. Conversely, community college students often focus on practical skills and the direct use of technology, influencing their views on real-world situations. Students at technical institutes emphasize vocational education, acquiring knowledge about the practical elements of technology. These contextual differences impact experiences by affecting resource availability and shaping educational results. The purposive sampling method guarantees a thorough insight into how various educational settings affect the experiences of students in the science and ICT domains[32].

3.3. Instrument

To conduct one-on-one interviews, the participants will use a question guide that was developed. George[33] states that the interview questions were designed to be unstructured in order to provide a flexible approach that "offers a flexible approach that allows for detailed insights on the topic." The interview guide's design was also based on the recommendations of Sikov[34], which highlights the significance of asking both follow-up and probing questions. These inquiries were designed to delve into the goals of the study using both direct and indirect methods. **Table 1** presents a list of all the guide questions that were utilized in this study.

Table 1. Interview guide questions.

Objectives	Interview question
1. Identify common technology tools that increase student innovative mindset in science and ICT	1. What are your favorite frequent ways technology is used in your classes? (Focus on specific examples and the impact on their learning) 2. How does technology help you think creatively or solve problems differently? (Explore their experiences with specific tools or approaches) 3. What are some ways technology could be used more effectively to help you learn and be innovative? (Identify potential areas for improvement and student-driven suggestions)
2. Determine technology-based strategies that can enhance the innovative behaviors of science and ICT learners	4. What instructional materials do you believe the school can provide to promote innovative behabiors? 5. What teaching strategies of your teachers encourage you to be innovative? Explain and provide example 6. What values or traits does your teachers espouse in learning which help you become innovative? Explain further.

3.4. Data gathering procedure

Prior to engaging in the study, each participant was given a consent letter that explicitly detailed the research's aims and extent. The interviews were carried out in person, utilizing a semi-structured interview format. At the start of every session, participants received comprehensive guidance about the procedure and were invited to pose questions to resolve any ambiguities. If necessary, additional clarifications were provided to make sure all participants were at ease and comprehended the procedures clearly.

Taherdoost[35] outlines various methods for collecting interview data, each presenting distinct benefits and difficulties. These techniques involve utilizing audio recorders (with participants' permission), jotting down notes during the interview, or transcribing answers later on. In this research, the investigator employed both note-taking and audio recording methods to guarantee a thorough and precise documentation of the participants' replies.

In narrative interviews, recognizing the collaborative aspect of the process is crucial. According to Mendoza[36], narratives arise from the interactive and dynamic exchange between the interviewer and the participants. This exchange is an essential component of the methodology, as the narrative is collaboratively created through the conversation between both parties[37].

3.5. Data analysis

The research examines how the incorporation of technology influences the development of an innovative mindset in higher education students in science and ICT. Employing qualitative exploratory research, it examines stories from 25 students from universities, community colleges, and technical institutes. These varied educational environments influence how students engage with technology, as university students utilize abundant resources, community college students emphasize practical uses, and technical institute students obtain vocational knowledge. The purposive sampling technique guarantees a thorough comprehension of these diverse experiences. Flexible question-guided unstructured interviews enabled participants to provide in-depth insights regarding the impact of technology on their creative thinking and innovative actions. The comfort of participants was prioritized during data collection, employing note-taking and audio recording to effectively document responses. The interviews' collaborative aspect highlights the joint creation of stories, showcasing technology's ability to transform education. In the end, the research emphasizes technology as a driving force for boosting creativity and innovation in students within Science and ICT.

4. Results

Research Objectives 1. Identify common technology tools that increase student innovative mindsets in science and ICT.

Question No. 1. What are your favorite frequent ways technology is used in your classes? (Focus on specific examples and the impact on their learning)

1.1 Online Collaboration Tools

Ten (10) respondents mentioned for their group projects in environmental science, they use platforms like Google Docs. These tools facilitate easy communication, particularly when organizing research projects from a distance. It has kept everyone interested and improved their collaborative abilities. They added that they can collaborate on reports at the same time by using Google Docs. They adore being able to view one other's contributions instantly, which facilitates discussion of modifications and keeps the project going without requiring email responses. These resources highlight how collaboration technologies help

environmental science students communicate, take responsibility for their actions, and operate as a team in addition to making project management easier.

> "For our group projects in environmental science, we use platforms like Google Docs and Trello. These tools make collaboration seamless, especially when coordinating research efforts remotely. It has enhanced our teamwork skills and kept everyone engaged."

> "Using Google Docs allows us to work simultaneously on reports. I love that we can see each other's edits in real-time, which makes it easier to discuss changes and keep the project moving forward without waiting for email replies."

1.2 Project Management Software

Ten (10) responders, ten said they use Asana and Monday.com for group projects. Their efficiency and organization have increased as a result of their assistance in assigning duties and breaking down work. They believe they are better equipped to handle project management situations in the real world. They also remarked how Asana has made their tasks much clearer. There is less uncertainty because everyone is aware of their responsibilities. They value how it holds everyone accountable, and this clarity has made it easier for them to routinely fulfill deadlines. These observations show how project management tools help ICT students become more organized, communicate, and work together, preparing them for professional settings where these abilities are crucial.

> "We utilize tools like Asana and Monday.com for our group projects. They help us break down tasks and assign responsibilities, which has improved our organization and efficiency. I feel more prepared for real-world project management scenarios."

> "Using Asana has really clarified our tasks. Each member knows what they're responsible for, and it reduces confusion. This clarity has helped us meet deadlines more consistently, and I appreciate how it keeps everyone accountable."

1.3 Data Visualization Tools

Five (5) respondents said they use Tableau and other similar applications to produce visual representations of data in their data science classes. This has enhanced their capacity to effectively explain findings as well as their analytical abilities. It's crucial for effectively and clearly presenting data. They added that their attitude to data analysis has changed as a result of utilizing Tableau in the classroom. The practical experience of working with data and producing visualizations aids in the consolidation of acquired concepts. It greatly brings theoretical subjects to life. These answers demonstrate how students are better prepared for practical data science applications, develop their analytical abilities, and communicate more effectively when they use data visualization tools like Tableau.

> "In our data science classes, we use tools like Tableau to create visual representations of data. This has not only improved my analytical skills but also my ability to communicate findings effectively. It's essential for presenting data in a clear and impactful way."

> "Using Tableau in class has transformed how I approach data analysis. The hands-on experience of manipulating data and creating visuals helps solidify concepts I've learned. It makes theoretical topics much more tangible."

Question No. 2. How does technology help you think creatively or solve problems differently? (Explore their experiences with specific tools or approaches)

2.1 Mind Mapping Software

Ten (10) respondents, brainstorming using MindMeister has significantly altered the way they arrange their ideas. They can find connections they might not have thought of when concepts are visualized in a mind map, which leads to fresh, original solutions to coding challenges. They added that before beginning a project, mind mapping aids in their ability to organize their thoughts. They can quickly spot knowledge gaps or areas that require further study by visualizing their concepts. Their work is well-founded on this clarity. These observations show how programs like MindMeister improve students' brainstorming sessions, promote teamwork, and stimulate original thought in a range of assignments and topics.

> "Using tools like MindMeister for brainstorming has really changed how I organize my thoughts. Visualizing ideas in a mind map helps me see connections I might not have considered, which sparks new creative solutions to coding problems."

> "Mind mapping helps me clarify my thoughts before starting a project. By visualizing my ideas, I can easily identify gaps in my understanding or areas that need more research. This clarity sets a solid foundation for my work."

2.2 Virtual Labs

Fifteen (15) respondents, they use virtual lab simulations in chemistry to safely experiment with reactions. Without the limitations of a physical lab, this ability to experiment with many factors encourages them to think imaginatively about the design of experiments and their results. They added that they can immediately see the outcomes of their tests when they use virtual simulations. Their understanding of the cause-and-effect link in chemical reactions is strengthened by this instant feedback, which also enables them to swiftly modify their strategy. These observations demonstrate how virtual lab simulations improve chemistry education by encouraging safety, participation, teamwork, and a more thorough comprehension of experimental design and results.

> "In chemistry, we use virtual lab simulations that allow us to experiment with reactions safely. This freedom to explore different variables helps me think creatively about experimental design and outcomes without the constraints of a physical lab."

> "When using virtual simulations, I can see the results of my experiments instantly. This immediate feedback helps me understand the cause-and-effect relationship in chemical reactions, reinforcing my learning and allowing me to adjust my approach quickly."

Question No. 3. What are some ways technology could be used more effectively to help you learn and be innovative? (Identify potential areas for improvement and student-driven suggestions)

3.1 More Real-World Case Studies

Ten (10) respondents, it would be advantageous to use interactive technology to integrate real-world case studies into their training. They may be better able to comprehend real-world applications of what they study in class if they examine real projects and their results. They added that contextualizing theoretical notions will be possible through the analysis of real-world case studies. It would make the subject more

relevant and understandable by enabling them to see how the concepts they learn in class relate to real-world circumstances. Students' need for more hands-on, interactive learning experiences that link theory to practical applications and eventually improve their educational journeys is reflected in these observations.

> "Incorporating real-world case studies into our coursework using interactive technology would be beneficial. Analyzing actual projects and their outcomes could help us understand practical applications of what we learn in class."

> "Analyzing real-world case studies would provide context to theoretical concepts. It would help me see how the principles we learn in class apply to actual situations, making the material more relevant and easier to grasp."

3.2 Collaborative Research Platforms

Ten (10) participants expressed that a centralized platform for collaborative research where they can share findings, resources, and data sets would be useful. This would encourage interdisciplinary projects and help them learn from one another. Additionally, they mentioned that a centralized platform would make it much easier to share resources like research papers, articles, and datasets. It would save time searching for materials and ensure that everyone has access to the same information, promoting equality in research opportunities. These responses emphasize the advantages of a centralized platform for collaborative research, highlighting how it could enhance communication, resource sharing, and interdisciplinary collaboration among students.

> "A centralized platform for collaborative research where we can share findings, resources, and data sets would be useful. This would encourage interdisciplinary projects and help us learn from one another."

> "A centralized platform would make it much easier to share resources like research papers, articles, and datasets. It would save time searching for materials and ensure that everyone has access to the same information, promoting equality in research opportunities."

3.3 Gamified Learning Environments

Five (5) participants expressed that creating more gamified learning experiences, such as coding competitions or science challenges, could make learning more engaging and motivate them to push their limits in a fun way. Additionally, they mentioned that gamification adds an element of fun that keeps them motivated to learn. Competing for points or badges makes them want to engage more deeply with the material and strive to improve their skills. These insights highlight how gamified learning experiences can enhance engagement, motivation, and collaboration among students, ultimately enriching their educational journey.

> "Creating more gamified learning experiences, such as coding competitions or science challenges, could make learning more engaging and motivate us to push our limits in a fun way."

> "Gamification adds an element of fun that keeps me motivated to learn. Competing for points or badges makes me want to engage more deeply with the material and strive to improve my skills."

Research Objectives 2. Determine technology-based strategies that can enhance the innovative behaviors of science and ICT learners.

Question No. 4. What instructional materials do you believe the school can provide to promote innovative behaviors?

4.1 Online Coding Resources

Ten (10) respondents indicated that access to premium coding platforms like Codecademy or Pluralsight would allow them to learn new programming languages and technologies at their own pace. Interactive tutorials can foster self-directed learning and skill development. Additionally, they mentioned that interactive coding exercises are invaluable. They let them apply what they've learned immediately, which reinforces their understanding. The ability to practice in real-time helps solidify their skills more effectively than traditional lectures. These responses emphasize how access to premium coding platforms can significantly enhance students' learning experiences by providing flexibility, hands-on practice, and a wealth of resources tailored to current industry needs.

> "Access to premium coding platforms like Codecademy or Pluralsight would allow us to learn new programming languages and technologies at our own pace. Interactive tutorials can foster self-directed learning and skill development."

> "Interactive coding exercises are invaluable. They let me apply what I've learned immediately, which reinforces my understanding. The ability to practice in real-time helps solidify my skills more effectively than traditional lectures."

4.2 Access to Research Databases

Ten (10) respondents expressed that providing access to extensive research databases and journals would help them stay updated on the latest developments in their fields. This exposure is essential for fostering innovative ideas and understanding current trends. Additionally, they mentioned that access to research databases allows them to keep up with the latest studies and breakthroughs in their field. Being informed about current trends helps them incorporate new ideas into their projects and discussions. These insights highlight the critical role that access to research databases and journals plays in enhancing students' learning, fostering innovation, and preparing them for future academic and professional endeavors.

> "Providing access to extensive research databases and journals would help us stay updated on the latest developments in our fields. This exposure is essential for fostering innovative ideas and understanding current trends."

> "Access to research databases allows me to keep up with the latest studies and breakthroughs in my field. Being informed about current trends helps me incorporate new ideas into my projects and discussions."

4.3 Interactive E-Learning Modules

Five (5) participants expressed that they developing interactive e-learning modules that incorporate quizzes, videos, and gamified elements would make learning more engaging. This format encourages them to actively participate rather than passively consume information. Additionally, they mentioned that interactive modules force them to engage with the material rather than just read or watch. When they are quizzed or asked to solve problems along the way, they retain information much better. These insights reflect students' appreciation for interactive e-learning modules, emphasizing their potential to enhance engagement, motivation, and retention of information through active participation.

> *"Developing interactive e-learning modules that incorporate quizzes, videos, and gamified elements would make learning more engaging. This format encourages us to actively participate rather than passively consume information."*

> *"Interactive modules force me to engage with the material rather than just read or watch. When I'm quizzed or asked to solve problems along the way, I retain information much better."*

Question No. 5. What teaching strategies of your teachers encourage you to be innovative? Explain and provide example

5.1 Project-Based Learning

Ten (10) participants expressed that their professor assigns real-world projects that require creative problem-solving. For instance, they had to develop a mobile app that addresses a specific community need. This challenge pushed them to think outside the box and collaborate with their peers for innovative solutions. Additionally, they mentioned that when they created a mobile app for a local charity, it felt great to know their work had a real-world impact. This sense of purpose motivated them to think innovatively about how to best serve the charity's mission and the community. These responses emphasize how real-world projects in ICT education stimulate creative problem-solving, enhance collaboration, and provide valuable learning experiences that prepare students for their future careers.

> *"My professor assigns real-world projects that require creative problem-solving. For instance, we had to develop a mobile app that addresses a specific community need. This challenge pushed me to think outside the box and collaborate with my peers for innovative solutions."*

> *"When we created a mobile app for a local charity, it felt great to know our work had a real-world impact. This sense of purpose motivated us to think innovatively about how to best serve the charity's mission and the community."*

5.2 Integration of Technology

Fifteen (15) participants mentioned that their chemistry professor integrates technology by using virtual labs and simulations. When they had to analyze chemical reactions, using a virtual lab allowed them to explore different variables creatively. They experimented with conditions they couldn't test in a traditional lab, leading to unique insights. Additionally, they expressed that using virtual labs allows them to conduct experiments that would be dangerous or impossible in a physical lab. For example, simulating chemical reactions involving hazardous materials helps them understand safety protocols without the risk. These insights highlight how virtual labs and simulations significantly enhance the learning experience for science-oriented students, promoting safety, engagement, and a deeper understanding of complex concepts.

> "My chemistry professor integrates technology by using virtual labs and simulations. When we had to analyze chemical reactions, using a virtual lab allowed me to explore different variables creatively. I experimented with conditions I couldn't test in a traditional lab, leading to unique insights."

> "Using virtual labs allows me to conduct experiments that would be dangerous or impossible in a physical lab. For example, simulating chemical reactions

> involving hazardous materials helps me understand safety protocols without the risk."

Question No. 6. What values or traits does your teachers espouse in learning which help you become innovative? Explain further.

6.1 Emphasis on Collaboration

Ten (10) participants mentioned that collaboration is highly valued in their classes. Teachers encourage group work and discussions, which helps them share different perspectives and come up with more innovative ideas. Working with others opens up avenues of creativity they wouldn't explore on their own. Additionally, they indicated that in group projects, each of them brings different skills to the table. For instance, one teammate might excel in coding while another has a knack for design. This diversity allows them to create more well-rounded and innovative solutions than any of them could achieve alone. These insights illustrate how collaboration in ICT classes enhances creativity, learning, and preparedness for real-world challenges, ultimately fostering a more innovative mindset among students.

> "Collaboration is highly valued in my classes. Teachers encourage group work and discussions, which helps us share different perspectives and come up with more innovative ideas. Working with others opens up avenues of creativity I wouldn't explore on my own."

> "In group projects, we each bring different skills to the table. For instance, one teammate might excel in coding while another has a knack for design. This diversity allows us to create more well-rounded and innovative solutions than any of us could achieve alone."

6.2 Support for Individual Interests

Fifteen (15) participants shared that their professors support individual exploration by allowing them to pursue topics of personal interest in their projects. This flexibility encourages them to innovate based on what they are passionate about rather than just sticking to the syllabus. Additionally, they mentioned that when they are allowed to choose their project topics, they feel more invested in their work. For instance, they focused on renewable energy solutions, and the enthusiasm they have for the subject drove them to explore innovative ideas and solutions beyond what was taught in class. These responses highlight how the opportunity for individual exploration in projects enhances student engagement, fosters innovation, and allows for a deeper connection to the material in science-oriented education.

> "My professors support individual exploration by allowing us to pursue topics of personal interest in our projects. This flexibility encourages me to innovate based on what I'm passionate about rather than just sticking to the syllabus."

> "When I'm allowed to choose my project topics, I feel more invested in my work. For instance, I focused on renewable energy solutions, and the enthusiasm I had for the subject drove me to explore innovative ideas and solutions beyond what was taught in class."

5. Discussion

Research Objectives 1. Identify common technology tools that increase student innovative mindsets in science and ICT.

Incorporating technology into teaching offers a valuable opportunity to cultivate innovative thinking and behaviors in higher education students studying science and ICT. This study explores different technological resources that improve creativity and collaboration, especially in virtual learning settings. Participants have emphasized the effectiveness of tools like Google Docs and Trello, which enhance teamwork marked by considerable engagement and resolution of issues. These results align with previous research[5,6] claiming that collaborative learning enhances crucial abilities in both educational and professional environments, such as communication, accountability, and teamwork.

Additionally, the research highlights the essential function of project management tools such as Asana and Monday.com in ICT coursework. These platforms are vital for helping students manage tasks, enhancing communication, and working together efficiently on intricate projects. The significance of project management abilities is being more widely acknowledged, as these skills enable students to break down projects into attainable tasks, assign roles, and adhere to deadlines—abilities that are directly relevant in the workplace[10]. Richardson[12] emphasizes the importance of these tools in the ICT sector, where effective communication and collaboration are crucial for achieving favorable results. Nonetheless, although the advantages of these technologies are evident, it is important to tackle considerable limitations that come with their application. A significant issue is cognitive overload, which can occur when students face an excess of technological tools and platforms, resulting in reduced concentration and efficiency. Moreover, unequal access to technology could worsen current educational inequalities, since not every student has the same resources or chances to use these tools successfully. Digital exhaustion is another significant concern, as ongoing interaction with technology can result in burnout and decreased motivation, ultimately obstructing the learning experience.

Additionally, there is a danger of superficial learning arising from gamification and simulations, as students might concentrate excessively on the functionalities of the tools instead of gaining a deeper grasp of the content. This occurrence might weaken the innovative ideas that these technologies aim to encourage. Regarding analytical skills, the research also highlights the importance of data visualization tools like Tableau in improving students' capabilities to analyze and convey intricate data, especially in data science classes. This corresponds with the increasing acknowledgment of the importance of data visualization in the digital era. De Leon et al.[17] contend that these tools assist students in presenting complex information visually and clearly, enhancing their capacity to share their results successfully. In a similar vein, Zhang et al.[15] emphasize that practical experience with data visualization enhances students' theoretical knowledge while also equipping them for real-world applications in data science.

Research Objectives 2. Determine technology-based strategies that can enhance the innovative behaviors of science and ICT learners.

The research examines how technology can be utilized in teaching methods to foster an innovative mentality and behavior in higher education students within science and ICT. It emphasizes the essential importance of high-quality technology-driven learning tools—like top-notch coding platforms, comprehensive research databases, and engaging e-learning modules. These resources are essential for promoting self-directed learning, enabling students to investigate subjects at their own speed and with more depth. Similarly, Dziuban et al.[8] noted that having access to these resources promotes self-directed learning and enhances the overall educational experience. Ocholla[20] emphasizes the importance of offering high-quality digital resources, especially as online learning platforms become more essential in modern education.

Nonetheless, although the incorporation of technology in education offers considerable prospects, it is crucial to recognize various constraints. Cognitive overload may occur when students are overwhelmed with

too much information or complicated tools, which could obstruct their learning experiences. In addition, unequal access to technology can worsen disparities among students, especially in disadvantaged communities where access to high-quality digital resources might be restricted. This disparity may create a digital gap, ultimately impacting students' capacity to wholly interact with and gain from technological progress in education. The research also highlights creative teaching approaches like project-based learning and virtual simulations, which align with studies that support the transformative power of technology in education. These approaches foster a vibrant and adaptable learning atmosphere that improves critical thinking and problem-solving abilities[3]. Bower et al.[7] emphasize that these methods enable students to interact with real-world scenarios outside conventional classroom environments, enhancing their comprehension of acquired concepts.

However, it is crucial to acknowledge the risk of superficial learning that may arise from gamification or simulations, where the emphasis might transition from deep understanding to simply interacting with the technology, which could jeopardize the educational goals. Working together among students via tools such as group assignments and online forums is another important feature of the research, enhancing communication, knowledge exchange, and teamwork abilities vital for today's job market. Huang et al.[11] claim that collaborative learning settings enable students to cultivate these skills. Collaborative tools can offer instant feedback, fostering ongoing enhancement and creativity[19]. However, digital fatigue can also be a worry since extended use of online collaborative tools might cause burnout, affecting students' motivation and their overall educational experience.

Finally, the study supports individualized exploration, enabling students to dedicate their projects to topics of personal significance. This method is consistent with current research on the advantages of personalized learning, which encompasses encouraging creativity and enhancing problem-solving skills. Kim and Frick[9] argue that when learners are allowed to investigate subjects of their preference, they are more inclined to participate in innovative problem-solving. Nonetheless, as pointed out by Chavez[25], the growing dependence on AI-powered tools for individualized learning experiences requires a careful equilibrium, making sure that students maintain their inherent motivation to learn at their own speed amid algorithm-guided routes. In summary, although incorporating technology into higher education provides significant advantages for fostering an innovative mindset and behavior in students, it is important to tackle the related challenges. These factors encompass cognitive overload, unequal resource availability, digital fatigue, and the risk of superficial learning, all of which need to be addressed to establish an effective and fair educational setting.

6. Conclusion

The incorporation of technology in higher education greatly influences the development of innovative skills in science and ICT students. This research emphasizes advantages including improved teamwork, analytical abilities, and independent learning via resources like digital collaboration tools, project management applications, and interactive online learning modules. Nevertheless, crucial constraints need to be resolved. Cognitive overload can inundate students, obstructing successful learning, whereas unequal access to technology leads to disparities in educational chances. Constant screen exposure can cause digital fatigue and potential burnout, while shallow learning due to gamification might hinder deeper comprehension. In summary, although technology can foster vibrant learning settings that equip students for the 21st-century job market, it is essential to tackle these challenges. Future studies ought to emphasize partnerships between educational bodies, industry experts, and tech firms to improve the efficient application of technology in learning, ensuring students are equipped to excel in a swiftly evolving digital environment.

Conflict of interest

The authors declare no conflict of interest.

References

1. Newton, E. (2023, October 24). 7 Amazing Ways Technology Is Changing Higher Education for the better. Innovation & Tech Today. https://innotechtoday.com/7-amazing-ways-technology-is-changing-higher-education-for-the-better/
2. Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2018). NMC Horizon Report: 2018 Higher Education Edition. EDUCAUS
3. Martin, F., Sun, T., & Westine, C. (2019). A systematic review of research on online teaching and learning in higher education. Distance Education, 40(2), 303-329.
4. Dong, H. (2021). Adapting during the pandemic: A case study of using the rapid prototyping instructional system design model to create online instructional content. The Journal of Academic Librarianship, 47(3), 102356. https://doi.org/10.1016/j.acalib.2021.102356
5. Lee, J. J., Huh, K., & Reigeluth, C. M. (2020). Blending social constructivism and digital affordances for self-regulated learning in higher education. Educational Technology Research and Development, 68(2), 271-289.
6. Gikandi, J. W., Morrow, D., & Davis, N. E. (2019). Online formative assessment in higher education: A review of the literature. Computers & Education, 64, 94-104.
7. Bower, M., Dalgarno, B., Kennedy, G., Lee, M. J. W., & Kenney, J. (2021). Blended synchronous learning environments: Using technology to facilitate learning beyond the classroom. Educational Media International, 58(2), 97-115.
8. Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: The new normal and emerging technologies. International Journal of Educational Technology in Higher Education, 15(1), 1-16.
9. Kim, K. J., & Frick, T. W. (2019). Changes in student motivation during online learning in Korea: A longitudinal study. Educational Technology Research and Development, 67(1), 225-245.
10. Lynch, M., Sage, T., Hitchcock, L. I., & Sage, M. (2021). A heutagogical approach for the assessment of Internet Communication Technology (ICT) assignments in higher education. International Journal of Educational Technology in Higher Education, 18(1). https://doi.org/10.1186/s41239-021-00290-x
11. Huang, R., Liu, D., & Tlili, A. (2020). Teacher adaptation and adoption of ICT: Lessons from COVID-19 for inclusive education. Computers in Human Behavior, 111, 106510.
12. Richardson, K. E. (2024, August 23). How has technology changed education? Purdue University College of Education. https://education.purdue.edu/2024/01/how-has-technology-changed-education/
13. Bakar, S. (2021). Investigating the Dynamics of Contemporary Pedagogical Approaches in Higher Education through Innovations, Challenges, and Paradigm Shifts. Socialsciencechronicle, 1(1). https://doi.org/10.56106/ssc.2021.009
14. Ascione, L. (2023, December 8). The impact of technology on education. eSchool News. https://www.eschoolnews.com/it-leadership/2023/12/11/the-impact-of-technology-on-education/
15. Zhang, L., Basham, J. D., Carter, R. A., & Zhang, J. (2021). Exploring Factors associated with the implementation of student-centered instructional practices in U.S. classrooms. Teaching and Teacher Education, 99, 103273. https://doi.org/10.1016/j.tate.2020.103273
16. Chavez, J., & Lamorinas, D. D. (2023). Reconfiguring assessment practices and strategies in online education during the pandemic. International Journal of Assessment Tools in Education, 10(1), 160–174. https://doi.org/10.21449/ijate.1094589
17. De Leon, A., Jumalon, R., Chavez, J., Kairan, M., Abbas, K., Radjuni, A., Kadil, H., Sahirul, J., Tantalie, E., Hussin, A., Amlih, M., & Albani, S. (2024a). Analysis on the implementation of inclusive classroom: perception on compliances and obstructions of selected public-school teachers. Environment and Social Psychology, 9(9). https://doi.org/10.59429/esp.v9i9.2537
18. Sanusi, I. T., Oyelere, S. S., & Omidiora, J. O. (2021). Exploring teachers' preconceptions of teaching machine learning in high school: A preliminary insight from Africa. Computers and Education Open, 3, 100072. https://doi.org/10.1016/j.caeo.2021.100072
19. Inoferio, H. V., Espartero, M., Asiri, M., Damin, M., & Chavez, J. V. (2024). Coping with math anxiety and lack of confidence through AI-assisted Learning. Environment and Social Psychology, 9(5). https://doi.org/10.54517/esp.v9i5.2228
20. Ocholla, D. N. (2021). Echoes down the corridor. Experiences and perspectives of library and information science education (LISE) during COVID-19 through an African lens. Library Management, 42(4/5), 305–321. https://doi.org/10.1108/lm-02-2021-0016

21. Del Mundo, M. A., Reyes, E. F. D., Gervacio, E. M., Manalo, R. B., Book, R. J. A., Chavez, J. V., Espartero, M. M., & Sayadi, D. S. (2024). Discourse analysis on experience-based position of science, mathematics, and Tech-Voc educators on generative AI and academic integrity. Environment and Social Psychology, 9(8). https://doi.org/10.59429/esp.v9i8.3028
22. Calzada, K. P. D. (2024). Anti-dependency teaching strategy for innovation in the age of AI among technology-based students. Environment and Social Psychology, 9(8). https://doi.org/10.59429/esp.v9i8.3026
23. Carpio, L. B., Caburnay, A. L. S., Nolledo, S. M., Ongchua, C. A., & Orquia, J. A. (2024). Technology-based teaching among nursing instructors: Confidence and apprehension in using simulation equipment for training. Environment and Social Psychology, 9(8). https://doi.org/10.59429/esp.v9i8.2591
24. Quisay, A. R. C., & Aquino, M. E. C. (2024). Stress levels of science teachers when delivering distance education instruction in a state college during the COVID-19 pandemic. Environment and Social Psychology, 9(9). https://doi.org/10.59429/esp.v9i9.2916
25. Chavez, J. V. (2020). Academic and health insecurities of indigent students during pandemic: study on adaptive strategies under learning constraints. Journal of Multidisciplinary in Social Sciences. https://doi.org/10.47696/adved.202035
26. Garil, B. A., Abbas, T. S. C., & Limen, M. V. (2024). Analyzing the demographic-based grammatical competence and its relationship to academic performance in higher education setting. Forum for Linguistic Studies, 6(3), 343–356. https://doi.org/10.30564/fls.v6i3.6453
27. Stefan, I., Barkoczi, N., Todorov, T., Peev, I., Pop, L., Marian, C., Campian, C., Munteanu, S., Flynn, P., & Morales, L. (2023a). Technology and education as drivers of the fourth Industrial Revolution through the lens of the new science of learning. In Lecture notes in computer science (pp. 133–148). https://doi.org/10.1007/978-3-031-34411-4_11
28. Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2021). Balancing technology, Pedagogy and the new normal: Post-pandemic Challenges for Higher Education. Postdigital Science and Education, 3(3), 715–742. https://doi.org/10.1007/s42438-021-00249-1
29. Murro, R. a. R. A., Lobo, J. G., Inso, A. R. C., & Chavez, J. V. (2023). Difficulties of parents with low educational attainment in assisting their children in modular distance learning during pandemic. Environment and Social Psychology, 9(1). https://doi.org/10.54517/esp.v9i1.1957
30. Ebenezer, J., Kaya, O. N., & Kassab, D. (2018). High school students' reasons for their science dispositions: Community-Based Innovative Technology-Embedded Environmental Research projects. Research in Science Education, 50(4), 1341–1365. https://doi.org/10.1007/s11165-018-9735-6
31. Turner, D., Ting, H., Wong, M. W., Lim, T. Y., & Tan, K. L. (2021). Applying qualitative approach in business research. Asian Journal of Business Research, 11(3), 1-13.
32. Chavez, J. V., & Prado, R. T. D. (2023, May). Discourse analysis on online gender-based humor: Markers of normalization, tolerance, and lens of inequality. In Forum for Linguistic Studies (Vol. 5, No. 1, pp. 55-71).
33. George, T. (2022). Types of Interviews in Research | Guide & Examples. Scribbr [Online]. https://www.scribbr.com/methodology/interviews-research/ (accessed on 21 July 2023)
34. Sikov, J. (2020). Asking the Right Question: Qualitative Research Design and Analysis. Boston University [PowerPoint]. https://www.bumc.bu.edu/crro/files/2020/02/RPNQualitative Presentation-2.11.20.pdf (accessed on 21 July 2023)
35. Taherdoost, H. (2022). How to conduct an effective interview; a guide to interview design in research study. International Journal of Academic Research in Management, 11(1), 39-51.
36. Mendoza, D. V. (2023). Analysis of the Filipino brand of customer service in the accommodation sector. Journal of Namibian Studies: History Politics Culture, 33, 4685-4704.
37. Muylaert, C. J., Sarubbi Jr, V., Gallo, P. R., Neto, M. L. R., & Reis, A. O. A. (2014). Narrative interviews: an important resource in qualitative research. Revista da Escola de Enfermagem da USP, 48, 184-189.