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Research Article

Uncovering Barriers: Why Students in Science Education Struggle with Technology and Engineering Literacy Tests

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ABSTRACT

This study aimed to determine the obstacles that hinder the achievement of technological and engineering literacy among science students. The design used in this study was a mixed research method. Data collection techniques include interviews and questionnaires. The purposive sampling technique was chosen to determine the sample in this study, taking into account students who were declared incomplete/unable to complete the technological and engineering literacy test, resulting in a total of 6 students. The results of the study indicate that the most significant challenges faced by students are the lack of direct experience with technology-based experiments, limited access to technical resources, and teaching approaches that still prioritize theory over practice. Other obstacles contributing to low technological and engineering literacy include low intrinsic motivation, lack of support when developing technological solutions, and poor communication skills in a technology-based environment. These findings highlight the importance of reforming learning approaches, particularly by balancing aspects of theory and practice such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL), design-based learning 6E, and others, as well as (STEM) in the science education curriculum. Strengthening communication skills in the context of technology is also necessary to better prepare students for challenges in the world of industry and technological innovation.

Keywords: Technological and engineering literacy, Science education, Difficulty factors

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Introduction

Given the rapid breakthroughs in science and technology, technical literacy and engineering have become major parts of science education in the modern era. Students in the science education program are expected not only to understand basic scientific concepts but also to apply the principles of technology and engineering in their teaching practice. Expertise as future scientific educators will be greatly influenced by mastery of technological and engineering literacy [1, 2].

Science education needs to keep changing in order to be relevant in preparing students for the future, particularly in light of the quick advancements in technology. There is frequently disconnect between classroom education and the demands of the real world since traditional curriculum are unable to keep up with technology advancements [3]. This condition will impede their ability to integrate technology and engineering into their lessons because many science instructors lack a solid understanding of these subjects (American Association for the Advancement of Science, 2019). Therefore, it is necessary to highlight the need for technological and engineering literacy in science education and to find practical ways to integrate it into the curriculum [4, 5].

Modern science education should not be limited to textbooks and classrooms, but should also provide opportunities for students to understand and engage with the practical applications of science and technology. The development of Technological and Engineering Literacy (TEL) is a fundamental element of this approach. In the digital age, students must be able to identify gaps in their knowledge of technology [6, 7]. Academic discussions and literacy on engineering can enhance students' understanding of engineering practice itself [8]. While many other countries have not adopted comparable assessments, some, including the United States, have used the National Board of Directors Assessment to assess technological and engineering literacy. As a result, a method for evaluating TEL can be created by modeling it on the methods used by developed and technologically advanced countries [9].

In an increasingly digital world, scientific education students struggle to access, evaluate, and manage rapidly evolving information technology. Studies show that the lack of digital and information literacy skills is a significant obstacle to improving literacy. In addition, the existing curriculum structure does not adequately support the integration of technology and engineering in science education in many institutions [10, 11]. Despite the importance of understanding technological and engineering ideas, the learning process frequently relies on theoretical knowledge rather than actual experience.

In the professional sector, science graduates must be proficient in technology and engineering. Students who do not have enough preparation during their studies may struggle to compete in the job market [12-14]. Therefore, strengthening technological and engineering literacy is an important aspect of science education, as these subjects influence practically every decision made in daily life [15].

Figure 1 shows the relationship between Technology and Engineering and how they affect various areas of literacy [15]. Technology and Engineering have a common goal, which is to improve the quality of life and are used in almost every decision we make every day. Engineering is often the process behind the development of technology. Furthermore, understanding technology and engineering is important not just in engineering, but also in everyday life and other disciplines.

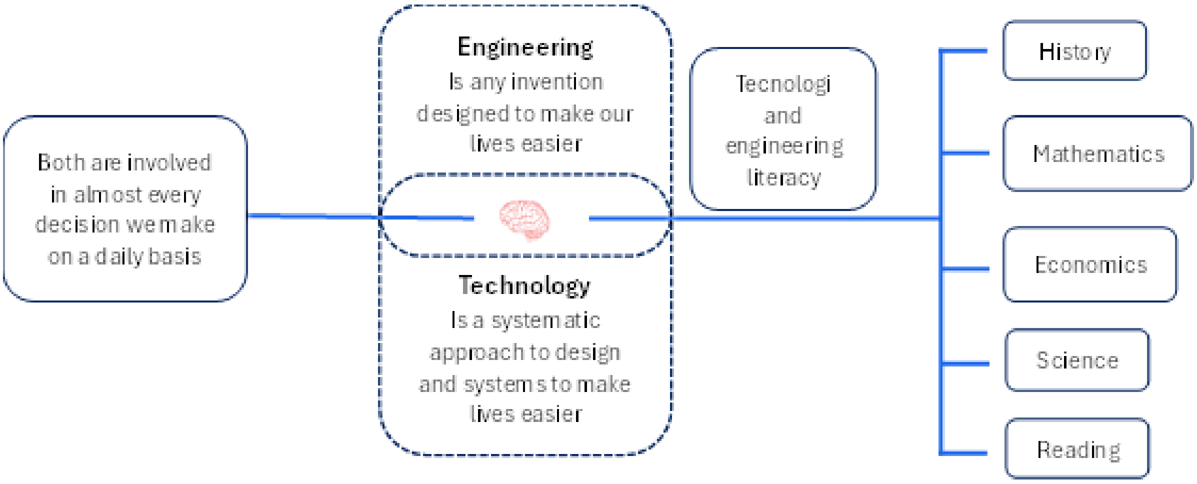

Figure 1 The relationship between Technological and Engineering aspects.

To improve the quality of science education, it is critical to identify the impediments that lead to students failing technological and engineering literacy tests. Analyzing these test failures can reveal specific elements that students are still struggling to grasp. For example, could the problems they face be due more to a poor understanding of basic concepts, an inability to use certain technologies, or other issues such as ineffective instruction [16, 17]. Furthermore, uncovering these barriers might help in the development of more effective learning strategies for students. Project-based learning, virtual labs, or technology-based simulations can be more effective solutions if students have difficulty connecting theory to practice. Thus, higher technological and engineering literacy depends not only on the students themselves, but also on how prepared the education system is to provide a supportive learning environment [18, 19]. In other words, studying the causes of students' failure in technological and engineering literacy tests is an important step in the effort to reform science education [20]. By identifying current problems, educational institutions can take more targeted actions to improve learning strategies, improve teaching materials, and increase students' access to technology and engineering tools. All of this will have a positive impact on the quality of its graduates.

Based on the problems identified, the main objective of this study is to determine the obstacles that cause low achievement of technological and engineering literacy in science students. This study focuses on the research questions: "What are the obstacles faced by students, resulting in low technological and engineering literacy among students?" and "What kind of solutions are effective in improving student readiness in improving technological and engineering literacy in the field of science education?".

Theoretical Framework

The theoretical framework in this study is built on a variety of relevant theories and models to better understand the factors that cause science education students to have difficulties in technology and engineering literacy tests. Some of the theories and concepts that can be used to build this framework include:

Technology and Engineering Literacy

Technology and engineering literacy (TEL) is defined as an individual's ability to understand, apply, and evaluate concepts and applications of technology and engineering principles in both everyday life and the professional world [21]. Technology and engineering literacy refers to the capacity to use, understand, and evaluate technology, as well as understand the principles and strategies of technology needed to develop solutions and achieve goals. In other words, TEL can solve problems, understand the principles and engineering of a technology needed to achieve goals, and, ultimately, apply, understand, and evaluate technology [16]. This framework covers three areas: Technology and Society, Design and Systems, and Information and Communication Technology. Thus, TEL addresses cognitive aspects, practical skills, and attitudes towards technology and engineering. Since the International Association for Technology Education (ITEA) was renamed the International Association of Technology & Engineering Educators (ITEEA) in 2010, technology and engineering literacy have been revitalized; demonstrating the TEL assessment system's innovative nature. In 2014, the National Assessment Board collaborated with NAEP to develop a framework for assessing engineering and technology literacy. By combining technical literacy and technological literacy that were previously independent, the focus on TEL began to ensure and enforce their literacy levels.

Figure 2 shows the relationship between the practice, context, and assessment areas in technology and engineering are shown [15]. In practice, one must understand the principles of technology, develop solutions to achieve goals, and be able to effectively communicate and collaborate. These abilities are essential in the process of innovation and application of technology to maximize societal benefits. On the other hand, the context of technology encompasses a number of external factors that influence its development. Social issues, design goals, and problems encountered by schools and communities are key considerations in creating appropriate technological solutions. These two aspects of practice and context are interrelated and serve as the foundation for the assessment areas, which include three main areas: technology and society, which emphasizes how technology affects and is affected by social life; design and systems, which concentrates on how technological systems are designed and operated efficiently; and information and communication technology (ICT), which includes the use of digital technologies for communication and information processing. A deeper understanding of these contexts can help technological innovations better meet societal needs and address environmental challenges.

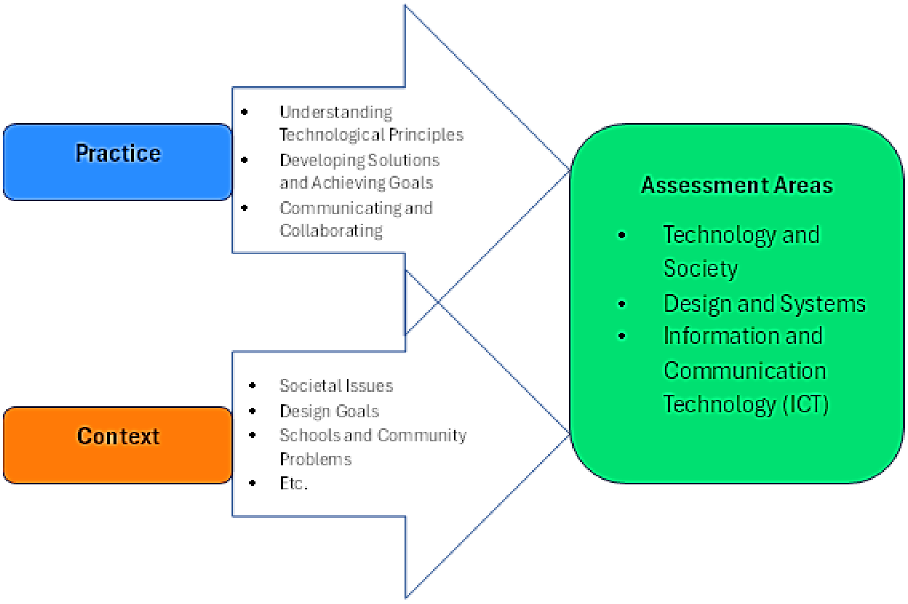

Figure 2 Elements of NAEP Technology and Engineering Literacy Assessment.

STEM Learning Model and Technology Integration

In the learning process, there are several approaches, models used. STEM (Science, Technology, Engineering, and Math) based learning emphasizes the importance of interconnection between science and the application of technology and engineering in solving real-world problems [22]. However, many studies show that science education students often face challenges in understanding STEM integration, especially in technology and engineering aspects [23].

Problem-Based Learning (PBL) and Project-Based Learning

The (PjBL) approach is widely applied in STEM education to improve technology and engineering [24, 25]. This model emphasizes critical thinking and problem-solving skills in real-world contexts. The integration of technology in STEM learning results in a more interactive, applicable, and industrial-friendly learning environment. With the appropriate approach, students may not only learn the theory but also apply it in real-world situations.

Constructivism Theory in Technology Learning

The constructivist approach emphasizes that students construct their understanding through direct experiences and social interactions [26]. In the context of technological and engineering literacy, students should be given the opportunity to directly explore technology and grasp engineering principles through practical acitivities. However, obstacles to constructivist-based learning in science education often arise due to the lack of technology laboratory facilities and the limited number of instructors who are competent in technology and engineering. The constructivist approach to technology learning encourages students to learn actively, connect theory with practice, and develop 21st century skills. Students can get a deeper understanding of technology and become more equipped to handle the problems of industry and technological innovation by utilizing project-based learning, inquiry-based learning, and collaborative learning.

The causative factors that contribute to a problem are shown in Figure 3. These factors could be relevant to science and technology education. Three major factors influence: lack of experiential learning, high cognitive load, and lack of technology integration in the science curriculum. Students do not have enough opportunities to learn through direct experience, experiments, or practical projects that might help them understand concepts more deeply. As a result, learning becomes more theoretical and less applicable, which can hinder their understanding of science and technology concepts. With high cognitive load, the material being taught may be too complex or presented in a way that does not match the information processing abilities of students. This can result in difficulty understanding new concepts, frustration, and decreased learning effectiveness. In addition, the lack of technology in the science curriculum indicates that technology is not being used well as a learning tool. The use of technology in education can engage students more, allow them to learn broader concepts, and make classes more interactive and interesting.

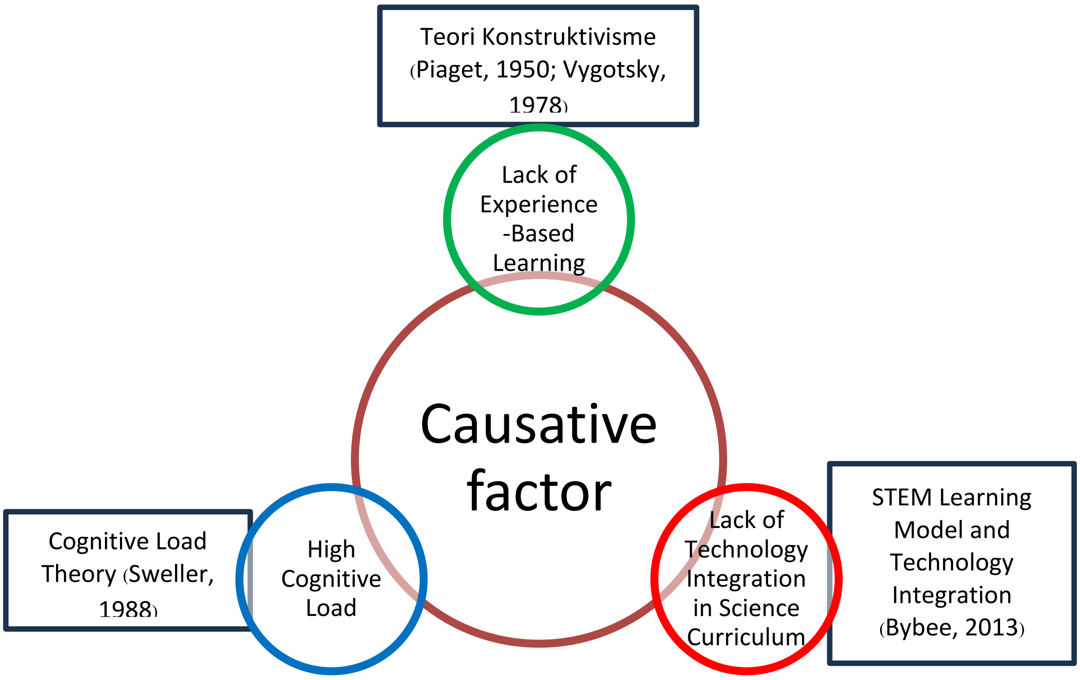

Figure 3 Theoretical framework of the causes of student failure related to technological and engineering, Literacy.

Materials and Methods

Research Methods

The purpose of this study is to describe the obstacles faced by science education students related to technological and engineering literacy tests. This study used a mixed research method with a convergent parallel design. This study combined interviews as qualitative research and questionnaires as quantitative research. Thus, quantitative and qualitative data obtained simultaneously can be compared or combined to obtain a more complete understanding [27].

Sample Research

This study involved 6 respondents from the Science Education study program. Sampling was determined using the purposive sampling technique, taking into account the study's purposes, which was to acquire more information on the challenges that students face when taking the technology and engineering literacy test. The determination of 6 sample people in this study came from 10 students who took the technology and engineering literacy test. The technology literacy test uses the TEL assessment instrument developed by NAEP 2018. Students must indicate that they have completed and passed numerous courses, including basic physics, science mathematics, basic biology, theory, and measuring techniques, in order to take the test. This requirement is set with the aim that test participants have acquired the knowledge and skills to face integrated science courses. Thus, from the 10 students who took the student test, a sample was obtained for which information was collected as many as 6 students as respondents. These students are those who obtained technology and engineering literacy results in the Unsatisfactory/ Incomplete category. The demographic profile of the participants is presented in Table 1.

Table 1 Demographic profile participants.

No	Respondent Code	Gender	Devices owned	Access to the internet	Internet usage	Accessed apps
1	R4	Male	Laptops and Smartphones	Exist	Every day	YouTube, Facebook and Instagram
2	R5	Famale	Smartphone	Exist	Every day	Facebook and Instagram
3	R7	Famale	Laptops and Smartphones	Exist	Every day	YouTube, Facebook and Instagram
4	R8	Famale	Smartphone	Exist	Every day	Youtube, Facebook and Instagram
5	R9	Male	Smartphone	Exist	Every day	Youtube, Facebook and Instagram
6	R10	Male	Smartphone	Exist	Every day	Youtube, Facebook And Instagram

Data collection

Data were collected through questionnaires and interviews to identify the obstacles faced by science education students that cause students to have difficulty in taking the technology and engineering literacy exam. Some aspects explored in the questionnaire and interviews include understanding the principles of technology, developing solutions and achieving goals, communication and collaboration in technology, as well as studying internal and external factors that influence the exam. Five experts in scientific education reviewed the questionnaire instrument and validated its content. For the score assessment scale, an interval of 1-4 is used, with options for very appropriate, less appropriate, appropriate and not appropriate. The validation process was carried out using the Aiken's V statistical method.

Table 2 shows the results of the Aiken's V calculation on 10 items that have been validated by experts. All items have an Aiken's V value □ 0.75. Thus, it can be concluded that all items are valid and suitable for use in research. Next, construct validity was conducted on 31 students. The students' answers were then analyzed using the Rasch model using the WinStaps Version 3.73 application. The analysis was carried out in two stages: 1) testing Outfit and Infit Mean Square (MNSQ) and 2) Item Reliability [28]. The following are the results of the validity and reliability of the instrument.

Table 2 Aiken's V statistical method for questionnaire instrument.

Item	**Aiken V**	**Category**
Item 1	0.90	Valid
Item 2	0.95	Valid
Item 3	0.90	Valid
Item 4	0.85	Valid
Item 5	0.80	Valid
Item 6	0.95	Valid
Item 7	0.85	Valid
Item 8	0.90	Valid
Item 9	0.95	Valid
Item 10	0.95	Valid

The criteria for validity of the items are as follows, ideal criteria for MNSQ value: 0.5 □ MNSQ □ 1.5; ZSTD value: -2.0 □ ZSTD □ 2.0; and Corr(P) value: 0.4 □ Corr(P) □ 0.8. According to Figure 4 and the assessment criteria, all items (I1-I7) met the valid requirements as instrument items.

MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
.44	.31	1.39	1.7	1.37	1.6	A .11	.19	11.1	40.4	I7
-.04	.25	1.32	1.8	1.33	1.8	B .05	.18	22.2	38.6	I3
.64	.29	1.01	.1	1.19	.9	C .06	.16	36.4	38.9	I2
-.04	.27	1.16	.9	1.16	.9	D-.30	.17	39.1	38.8	I1
.13	.28	.95	-.2	.94	-.3	E .42	.18	40.9	40.3	I4
1.53	.37	.94	.0	.92	-.1	e .21	.08	69.6	70.4	I8
-.38	.26	.92	-.4	.91	-.4	d-.40	.16	50.0	36.4	I5
-1.51	.36	.87	-.2	.74	-.6	c .59	.14	77.4	76.7	I10
-.56	.27	.80	-.9	.79	-1.0	b .45	.17	39.3	36.4	I6
-.20	.26	.68	-1.9	.68	-1.9	a .52	.18	50.0	37.8	I9
.00	.29	1.00	.1	1.00	.1			43.6	45.5	
.76	.04	.21	1.1	.23	1.1			18.7	14.2	

Figure 4 Results of validity tests with the Rasch model for each item.

The decision-making criteria for item reliability values are as follows, item quality: item reliability; Special: □ 0.94; Very Good: 0.91-0.94; Good: 0.81-0.90; Sufficient: 0.67-0.80; and Weak: □ 0.67. Thus, Figure 5 shows that the reliability item has a value of 0.84, indicating that the item quality is Good

CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .84

SUMMARY OF 10 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	77.2	24.8	.00	.29	1.00	.1	1.00	.1
S.D.	19.5	3.7	.76	.04	.21	1.1	.23	1.1
MAX.	116.0	31.0	1.53	.37	1.39	1.8	1.37	1.8
MIN.	51.0	18.0	-1.51	.25	.68	-1.9	.68	-1.9

REAL RMSE .31 TRUE SD .69 SEPARATION 2.27 Item RELIABILITY .84
MODEL RMSE .29 TRUE SD .70 SEPARATION 2.38 Item RELIABILITY .85
S.E. OF Item MEAN = .25

Figure 5 Results of reliability with the Rasch model for each item.

Results and Discussion

Questionnaire results

In accordance with the research objectives, which are to determine the description of the obstacles faced by students that cause the results of the TEL test of science students to be incomplete, data collection was carried out through questionnaires and interviews. The questionnaire was administered in person to students whose technological and engineering literacy test results were incomplete. The aspects covered include understanding the principles of technology, developing solutions and achieving goals, communication and technological collaboration. The following Table 3 shows the results of the questionnaire given to students.

Table 3 Aspects of understanding technology principles based on the results of the questionnaire.

Responder	Difficulty Understanding Technology Principles	Lecture Assistance	Additional Learning Resources	Need a Practical Example
R4	Quite difficult	Quite helpful	Sometimes	Yes
R5	Not too difficult	Quite helpful	Sometimes	Yes
R9	Quite difficult	Very helpful	Often	Yes
R10	Very difficult	Less helpful	Infrequently	Yes

According to Table 3, some students have difficulty understanding the principles of technology, with two finding it quite difficult and one finding it very difficult. Although the level of assistance provided in lectures varies, most students feel that the assistance is sufficient, while one student feels that the lecture assistance is not effective enough. The majority of students use supplementary learning resources on a regular basis, although not always. All respondents stated that they need practical examples to facilitate their understanding while learning. These findings show that, despite the efforts of lecturers in providing additional assistance and resources, students require more practical examples to strengthen their understanding of technology.

Table 4 shows that some students are rarely involved in solving technological problems, and some considered technological concepts quite difficult to apply. To solve these problems, they took various approaches: some students preferred to ask for help from lecturers, while others referred to discuss with their friends. However, other students found that they did not know how to solve technological problems. This suggests that active participation in problem solving to enhance their comprehension of technology and engineering concepts remains a difficulty, as does the provision of direction and practical examples in the learning process.

Table 4 Aspects of solution development and goal achievement.

Responder	Involvement in problem solving	Difficulties in implementing concepts	How to solve technology problems
R5	Infrequently	Very difficult	Ask the lecturer
R9	Sometimes	Quite difficult	Discuss with friends
R10	Never	Very difficult	Do not know

Table 5 shows that some students engaged in teamwork for technology projects; the number of students involved varied. The majority of students experienced communication difficulties, which ranged from moderate to very difficult. Student responses to technology varied; some students felt somewhat comfortable, while others did not feel comfortable at all. This variation suggests better communication strategies for team projects and more efficient methods for increasing students' comfort with technology.

Table 5 Aspects of communication and collaboration in technology.

Responder	Teamwork in technology projects	Difficulties in communication	Convenience of using technology
R4	Sometimes	Quite difficult	Quite comfortable
R5	Infrequently	Very difficult	Less comfortable
R7	Sometimes	Quite difficult	Less comfortable
R8	Never	Very difficult	Not comfortable at all
R9	Sometimes	Quite difficult	Quite comfortable
R10	Never	Very difficult	Not comfortable at all

Interview results

The use of interviews in this study is intended to collect detailed information about the information needed. Interviews were conducted face-to-face with each student who was included in the incomplete category according to the results of the technological and engineering literacy tests obtained. Interview questions were designed to explore information related to topics or aspects of assessment on technological and engineering literacy tests, including understanding the principles of technology, developing solutions and achieving goals, communicating and collaborating in technology. The questions consisted of 8 questions. The findings revealed that respondents' responses regarding the theory of technology acceptance, practical applications, use of additional resources, and involvement in direct practice were found to contain several patterns and challenges faced in understanding and applying technology in learning.

Table 6 summarizes the interview findings. It shows that most respondents have difficulty understanding technology theory when it is presented in the form of abstract concepts. R4 argued that he understands the theory well. However, giving it theoretically will be problematic. R5 and R9 stated that the two main obstacles in accepting the theory are educational background and lack of real examples. R10, on the other hand, emphasized that understanding theory without practical experience becomes difficult. In addition, the practical application aspect of respondents shows that people differ in applying technology theory in practice. R4 and R5 stated that if there is a direct application, the material will be more understandable. However, R9 had difficulty connecting theory with practice and needed additional guidance and practice. R10 admitted that because he did not have direct experience, he could not apply the theory. In the Use of Additional Resources, R4 and R9 were found to actively seek online resources, tutorials, and articles. R5 sought additional sources occasionally when concepts were unclear. R10 relied only on lecture materials, avoiding external sources due to complexity and inconsistency with class content. While in Involvement in Practice, R4, R5, & R9 emphasized that direct practice is very important for understanding theory. However, R10 felt that a well-explained theory was sufficient, and practical involvement was unnecessary.

Table 6 Description of the results of the interview on aspects of technological principles.

Responder	Code	Interview Results
R4, R5, R9 & R10	Acceptance of Technology Theory	Q1: "How do you receive the theory taught in the technology material? Do you find it easy to understand the theory?" R4: "I feel that I understand the theory of technology quite well, although sometimes it is difficult when only given theory." R5: "It's hard to accept technology theory because of my background from vocational school." R9: "I find it difficult to understand the theory taught in the technology material, especially when the concept is conveyed without a clear example. If it's just text or verbal explanations, I often have trouble connecting it to real applications, so the understanding becomes less in-depth." R10:"I have difficulty in accepting technological theories without hands-on practice, I find the theories taught difficult to understand and apply in real situations."
	Practical Applications	Q2: "To what extent do you feel you can apply technology theory in practice or hands-on projects?" R4: "I find it easier to understand the material if there is a direct application in the field, not just theory." R5: "The practical application material is very helpful, I feel I understand it better if I can try it right away." R9: “I find it difficult to apply technology theory in practice or direct projects. I need more practice and guidance to be able to relate the theory to its application in the real world." R10:"I haven't felt able to apply technology theory in practice because of my lack of hands-on experience.
	Use of Additional Resources	Q3: "Are you looking for additional resources outside of the course material to deepen your understanding of technology? What resources are you using?" R4: "I often look for additional sources outside of the lecture material to deepen my understanding." R5: "Sometimes I feel the need to look for additional sources because some concepts are not very clear." R9: "Yes, I searched the internet for tutorials and articles online to deepen concepts I didn't understand yet." R10:"No, I am not looking for additional resources because I rely more on the material provided by the lecturer. Looking for other sources is often confusing because a lot of the information is too technical or different from what is taught in the classroom."

Table 6 Description of the results of the interview on aspects of technological principles. *(cont.)*

Responder	Code	Interview Results
R4, R5, R9 & R10	Involvement in Practice	Q4: "How important is it to understand the principles of technology through hands-on practice? What benefits do you get from it?" R4: "The hands-on practice really helped me in understanding the theory taught in class." R5: "I find it difficult without practice. I would prefer if there was more applied teaching." R9: "Very important. Hands-on practice makes the theory taught easier to understand and apply." R10:"I feel that involvement in hands-on practice is not very important because theory is enough to understand the principles of technology. As long as the material is explained well, I can understand it without having to do hands-on practice."

Next, information on solution creation and objective achievement was acquired through questions 5–8. Table 7 below shows the result of interviews on the aspect of solution development and goal achievement.

Table 7 Description of the interview results aspects of developing solutions and achieving goals.

Responder	Code	Interview Results
R5, R9, R10	Problem Analysis	Q5: "How do you analyze the technology problems in the project? Do you find it difficult in this?" R5: "I feel like I'm pretty good at analyzing problems, even though some tasks require more guidance." R9: "Sometimes I have a hard time analyzing problems, especially when it comes to new technologies." R10: "I feel like I'm pretty good at analyzing problems, even though some tasks require more guidance."
	Application of Technology Concepts	Q6: " Can you apply the technology concepts learned in developing solutions for tasks or projects?" R5: "Technology concepts are difficult to apply to practical tasks, but if I give examples, it's easier for me to understand them." R9: " Using the concepts taught in assignments is sometimes confusing, I need more guidance." R10: " I have not been able to apply technology concepts well in assignments or projects due to my lack of practical experience. The material taught is more theory, so I have a hard time connecting it with actual applications."

Table 7 Description of the interview results aspects of developing solutions and achieving goals. *(cont.)*

Responder	Code	Interview Results
R5, R9, R10	Challenges in Solution Development	Q7: "What are the biggest challenges you face in developing technology-based solutions?" R5: "I find it difficult when the task involves technology that I have never used before." R9: "The main challenge is limited knowledge and lack of experience with the tools used." R10: "My main challenge is limited technical knowledge, so developing solutions becomes more difficult."
	Use of Tools and Technology in Projects	Q8: "What is your experience in using tools or technology in technology-based projects?" R5: "I feel less familiar with some of the tools, so I need more time to get the hang of them." R9: "The use of technological tools in projects is very helpful. However, some tools are not easily accessible." R10: "My experience was not pleasant because I felt unfamiliar with the tools used. In addition, limited access to technology devices meant that I didn't have enough time to practice, so I had a hard time completing projects effectively."

Table 7 shows that in the ability to analyze technological problems, respondents showed variation. R5 and R10 felt quite capable of analyzing problems, but still needed guidance in some tasks. Meanwhile, R9 had difficulty, especially in dealing with new technology. Most respondents had difficulty applying technological concepts to assignments or projects. R5 said that concepts were easier to understand if given concrete examples. R9 found that providing examples made things easier to understand. Students struggled to develop technology-based solutions because they lacked familiarity with technological tools and limited engineering skills. R5 struggled with new technology, while R9 and R10 considered limited knowledge as the main obstacle in developing solutions. The majority of responders felt unfamiliar with the project's technological tools. R5 took longer to understand new tools, R9 felt that the use of technology was helpful but had limited access to the tools, and R10 struggled due to lack of access and time to practice.

The last part of the aspect of technological and engineering literacy to be explored is the aspect of communication and collaboration. Based on the results of the interview in this specification, Two codes were determined relating to the obstacles faced, including Communicating Using Technology and Collaboration in Technology-Based Teams. Table 8 shows the result of the interview conducted. Some respondents feel comfortable using technology for communication, such as email and online platforms (R4). However, some students experienced difficulties, especially in understanding new technical terms (R5), facing obstacles in the features or operation of the platform (R7), and feeling insecure in digital-based formal communication (R8, R9). In addition, technical constraints such as unstable networks and lack of experience in using certain applications are also factors that hinder effective digital communication (R10). Collaboration in technology-based teams is faced with various challenges. Some respondents (R4, R7) reported that disparities in technological awareness among members often impede teamwork, resulting in more time spent overcoming technical problems rather than completing critical tasks. Ineffective coordination is also a problem, as some team members are unresponsive in online communication (R9) or lack understanding of their respective roles in technology-based projects (R5). In addition, technical glitches such as unstable internet connections and malfunctioning software are also major obstacles in teamwork (R10).

Table 8 Description of the interview results aspects of communication and collaboration.

Responder	Code	Interview Results
R4, R5, R7, R8, R9, R10	Communicating Using Technology	Q9: "To what extent do you feel comfortable communicating using technology, such as email, online platforms, or other applications?" R4: "I feel comfortable communicating using technology, such as email and online platforms." R5: "Sometimes I have difficulty in technical communication, especially if the discussion takes place using new terms." R7: "I feel uncomfortable communicating using technology because I often have difficulty understanding the features and use of online platforms. Sometimes, I also feel anxious if there is a technical error or if the message I send is not conveyed clearly." R8: "I'm not very comfortable using technology to communicate, especially in formal discussions and have doubts about whether the way I'm getting my message across." R9: "I find it difficult to adjust to technology- based communication. I also lack confidence in using formal language in digital communication, so I prefer direct communication." R10: "I feel uncomfortable communicating using technology because I often experience unstable network constraints or difficulties in operating certain applications. In addition, I am more used to face- to- face communication than digital communication."

Table 8 Description of the interview results aspects of communication and collaboration. *(cont.)*

Responder	Code	Interview Results
R4, R5, R7, R8, R9, R10	Collaboration in Technology-Based Teams	Q10: "What is your experience in collaborating in a team that uses technology? What are the challenges faced?" R4: "Working in a technology-based team is quite challenging, especially with members who are less tech-savvy." R5: "I find it easier to work in a team if there is a clear division of tasks related to technology." R7: "I find it difficult to work in a technology-based team because sometimes not all members have the same understanding as me. As a result, a lot of time is wasted just overcoming technical constraints rather than focusing on the main task." R8: "One of the biggest challenges I faced was the lack of effective coordination within the team. While technology is supposed to make it easier to work together, it can sometimes make differences in technical skills between team members more noticeable and hinder work progress." R9: "My experience in collaborating with teams that use technology is quite challenging because there is often miscommunication. Some team members are less responsive in online communication, so work is often delayed and it's difficult to put together understanding." R10: "Collaboration in a technology-based team is difficult for me because there are often technical glitches, such as unstable internet connections or software that doesn't run properly. This makes communication and task division less efficient."

Conclusions

According to the findings of this study, students have varying levels of difficulty in understanding technology concepts varies. Most students feel that theoretical explanations are sufficient to understand the material. Some students find lecture guidance helpful, while others feel that they lack guidance. The use of additional learning resources is also not ideal; only a few students are actively looking for additional materials. However, all respondents agreed that improving their understanding needed practical examples. Students are less involved in resolving technology issues; in fact, most are rarely or never involved. In addition, implementing technology concepts becomes a significant barrier, particularly for students who have never used it. Student involvement in teamwork on technology projects remains low; most are participating either sometimes or not at all. The majority of students find it difficult to communicate while working in a technology team.

The results of these questionnaires and interviews show that it is difficult for students to understand and apply technology theory, particularly when it is not accompanied by hands-on practice. Those that seek sources more often and engage in hands-on experiments tend to understand technology better. Strategies such as intensive feedback, the use of analogies to explain concepts, and the reduction of communication distractions are necessary to improve communication in technology-based learning. [29, 30]. Integrating organized teamwork activities and providing training on the use of technology tools can help address these challenges and can improve students' learning experience in technology-related courses [31, 32]. A more practice-based approach to learning, increased access to purposeful resources, and better guidance are needed. Students continue to struggle with grasping technology and applying it to their study. Activities created by lecturers utilizing these technologies have a significant impact on learning because practically all online learning that takes place nowadays uses the internet and technical instruments like laptops and smartphones. Students' cognitive talents can be developed with the use of technology [33].

Furthermore, students still struggle to communicate and work with people who use technology. One of the most significant hurdles to communication is the inability to understand technical terms, limitations in digital formal communication, and technical constraints. Meanwhile, the most significant challenges in technology-based teamwork are digital mismatches, lack of coordination, and technical glitches. Therefore, improved technical support and a more project-based approach to learning are urgently needed to help students acquire better technological literacy [34, 35]. A learning strategy that focuses on improving digital communication skills, building efficient collaboration with technology, and organizing teams can help students succeed in a technology-based learning environment [36-38]. Students require additional opportunities to practice teamwork in a technology environment, as well as training in digital communication to collaborate more effectively. Improved access to supplementary learning resources is also required so that students can overcome their difficulties in comprehending technological principles on their own.

Research Limitations

This research is in accordance with the objectives to be achieved. The sample size of only six students is a limitation of this study. The limited sample size may affect the generalization of research results as the data collected may not fully reflect the broader experiences and perceptions of all students. Therefore, further research with larger and more diverse samples is required to obtain more representative findings that can be generalized to a wider student population.

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