

Exploring Student Technology and Engineering Literacy in Science Learning: an Overview of the Initial Study

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Abstract: Technological and engineering literacy is a capability that must be imparted to students in order to be able to compete globally and be able to solve 21st century problems. This study aims to describe aspects of technological and technical literacy of junior high school students. This type of research is descriptive quantitative analysis. Data were obtained from technological and technical literacy test instruments. The test instrument is adopted from tests issued by NAEP. Data were analyzed quantitatively. The research results show that 69.2% in the complete category, 15.4% in the Partial category and incomplete in the Understanding of Technology Principles aspect. The aspect of Developing Solutions and Achieving Goals as many as 54.8% of students fall into the complete category, 19.2% in the Satisfactory category, 15.4% the Essential category, 7.7% the Partial category, and 26.9% incomplete category. Meanwhile, the Communication and Collaboration aspect, 65.4% were in the complete category, and 34.6% were in the incomplete category three types of assessment targets in the three main TEL assessment areas, with the most complete category being Gather and Organize data and information, followed by Identification of examples of systems or processes and Representation of alternative analysis and solutions. Science learning involving real experiences and design and engineering processes related to technological principles will make students technologically and engineering literate and can improve students' critical thinking and problem solving abilities.

Keywords: Technology and Engineering Literacy; 21st century Skills; Science Learning

Introduction

In an increasingly interconnected and technology-driven world, the ability to understand, navigate, and harness the power of technology and engineering is paramount (Beogard, 2021; Teo, 2019; Pellegrino & Hilton, 2013; Han et al., 2015). In this way, understudies must fulfill the Another level of instruction to compete viably inside the work grandstand, where technological knowledge and skills are dynamically underlined (Avsec & Jamšek, 2018). Understanding and mastery of technology plays an important role in various aspects of

life, including in the field of education (Avsec & Jamšek, 2016; Ahmad & Wibawa, 2021). One of the abilities that must be possessed and mastered is technological and engineering literacy (Julia & Isrokatun, 2019). Technological and engineering literacy is a capability that must be imparted to students in order to be able to compete globally and be able to solve 21st century problems. Technological and engineering literacy, or TEL, is not just a skillset but a fundamental literacy that empowers individuals to understand, analyze, and actively engage with the ever-evolving technological landscape.

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In this age of rapid innovation, TEL equips us with the knowledge and proficiency to make informed decisions, solve complex problems, and contribute to the development of cutting-edge solutions. Whether it's understanding the principles behind a smartphone, designing sustainable infrastructure, or using artificial intelligence for business optimization, technological and engineering literacy opens doors to endless possibilities (Williams & Beam, 2019; Buckler et al., 2018; K. Y. Lin et al., 2021).

Science education today goes beyond the confines of textbooks and classrooms. It's about equipping students with the tools to understand and engage with the real-world applications of science and technology. One crucial aspect of this modern approach to science education is fostering technological and engineering literacy, or TEL. Today's students are required to be able to identify any gaps in their technology literacy (Julia & Isrokatun, 2019; Techataweewan & Prasertsin, 2018). Engineering-centered literacy and academic discussions are effective methods for expanding meaningful learning in engineering practice (Aguirre-Muñoz & Pantoya, 2016).

Technology and engineering literacy have been renewed since 2010 when the International Technology Education Association (ITEA) was changed to the International Technology & Engineering Educators Association (ITEEA), this demonstrates just how creatively advanced the TEL grading system must be. In 2014, NAEP developed a framework to measure technology and engineering literacy through the National Assessment Governing Board. The focus on TEL started to determine whether they had literacy and to impose whether they had literacy by linking engineering literacy and technology literacy, which had previously been autonomous (ITEEA, 2020; National Assessment Governing Board, 2018; Shakrani, S. M., & Pearson, 2012). Tel is the ability to develop problem-solving solutions, understand the technology principles and strategies necessary to achieve goals, and use, understand and evaluate technologies (Nation Assessment Governing Board, 2018).

The National Assessment of Educational Progress (NAEP), a congressionally mandated project run by the National Center for Education Statistics (NCES) inside the Department of Education and Science Institute (IES), includes the TEL assessment in the United States. There are several initial goals for carrying out TEL evaluations. Although the world of technology is currently experiencing rapid growth and has long been taught in seminars, it was impossible to determine the precise level of awareness among academics regarding the efficient use and comprehension of technology. In this

setting, the assessment was started with the intention of evaluating the significance of TEL scholars (Lee, 2021).

Despite the fact that technology and engineering are very different from each other, they are closely related, so it is important to train students (Techakosit & Nilsook, 2018; Miska et al., 2022). Some research results found that even while technology is available in particular at universities that train teachers, there is still a paucity of instruction in learning (Voogt & McKenney, 2017; Fraile et al., 2018; Ceha et al., 2016). Technology can also be a solution to train critical thinking skills, creative thinking, collaboration, communication and several other skills (Sriyanto, 2021). Critical thinking abilities can be enhanced by incorporating engineering concepts into approaches to science, technology, engineering, and mathematics (Sulistiowati et al., 2019). As thus, scientific, mathematical, and linguistic literacy share many similarities with technology and engineering literacy. Similar to these other types of academic literacy, technology and engineering literacy entails mastering a set of skills required to contribute meaningfully and wisely to society. Although the means are different, the end result is the same.

Technological and engineering literacy in science learning is about preparing the next generation to be scientifically savvy and technologically adept problem solvers. It encourages students to explore not just the "what" and "why" of scientific phenomena but also the "how" and "what if." It's an educational journey that immerses learners in the intersection of science, technology, and engineering, where they can investigate, design, and innovate (Sommer & Ritzhaupt, 2018; National Assessment Governing Board, 2012).

As students embark on this journey, they'll find themselves unraveling the mysteries of the natural world while gaining the skills to create and enhance it. TEL emphasizes the practical applications of scientific knowledge, promoting hands-on experimentation, and encouraging students to think like engineers and technologists (Anjarsari et al., 2020)

This introduction sets the stage for an exciting exploration of technological and engineering literacy in science learning. Together, we'll discover how TEL bridges the gap between theory and practice, empowering students to become informed, inquisitive, and innovative contributors to the scientific and technological advancements that shape our future.

Students' initial knowledge of technological and engineering literacy is needed to deepen the research base in order to develop learning models that can serve the development of students' engineering and technological knowledge. This research aims to describe a tool for testing students' technological and engineering

knowledge and initial understanding of technology and engineering.

Method

This study is a descriptive quantitative study. The testing tool measuring students' technology and engineering knowledge has been adapted to the dimensions and indicators included in the 2018 National Assessment of Educational Progress (NAEP) (Nation Assessment Governing Board, 2018). This test tool is given to 8th grade Junior high school students at Pekanbaru. The populations were all Class VIII students of Junior high school students at Pekanbaru, with 31 students as sample taken using random sampling technique. The test instrument has been adjusted to technology and engineering literacy indicator. Data was also collected through interviews with students to explore in-depth information regarding the teacher's learning process. The NAEP test topic used is the Chicago water problem. The data was obtained from a tool that tests technology and engineering knowledge. The data obtained were analyzed descriptively.

The aspects which are measured are understanding technological principle, developing solutions and achieve goals and communicating and collaborating. Understanding technological principle expects students have ability to explain features and processes of a system (technology) and make a prediction, comparison, and evaluation of a technology. Developing solutions and achieve goals expects students to use knowledge on technology, device and skill to solve a device issue, implement knowledge possessed to solve, design and make a product through an appropriate process and by using relevant device. Communicating and collaborating are focused students will be expected to be fluent in the use of information and communication technologies. Technology literacy scores are informed in the form of complete, satisfactory, essential, partial and unsatisfactory / incomplete criteria. In order to obtain students' technology and engineering literacy data, scoring towards students' answer from 6 questions is measured technological and engineering literacy criteria for each student are categorized.

Result and Discussion

This research is a preliminary study conducted to determine the initial technological and engineering literacy abilities of junior high school students. The method used in this research is a descriptive analysis method to describe a phenomenon that exists at the research location in a systematic, realistic, accurate and original manner. Information that is considered

important is collected as a basis for developing further research. The Technology and Engineering Knowledge Checker is designed to absorb students' initial knowledge of technology and engineering.

There are three aspects of technology and engineering literacy which is measured in this research. First, aspect of understanding technological principles which focuses on knowledge and understanding of students on technology and their ability to think and reason by using the technology knowledge. Second, aspect of developing solution and achieve goals are focused on the implementation of knowledge of technology, device and skill of students to solve a problem and reach the goal as presented in the social, curriculum, design, and realistic context and aspect of communicating and collaborating are focused students will be expected to be fluent in the use of information and communication technologies. Referring to the technology and engineering literacy test framework developed by NAEP 2018, on the topic of the Chicago water problem, with a content area consisting of: technology and society, design and systems, and a practice area consisting of: understanding technological principles, developing solutions and achieving goals, communicating and collaborating. The technology and engineering literacy test consists of six questions, with each question having a different scoring guide. The first question consists of three scores (Complete, Partial, Incomplete), the second question (Complete, Essential, Partial, Incomplete), the third question (Complete, Satisfactory, Essential, Partial, Incomplete), the fourth question (Complete, Partial, Incomplete), fifth question (Complete, Incomplete), and sixth question (Complete, Incomplete). The conditions/descriptions for each score are as follows: 1) complete, that is if the answer or all answer choices are answered correctly, 2) satisfactory, that is if one of the total answer choices is wrong, 3) essential, that is if two of the total answer choices incorrect, 4) partial, namely if only one of the answer choices is correct, and 5) incomplete, namely if there is no correct answer. Third aspects are divided into six indicators which refer to NAEP TEL 2018, which identify examples of a system or process, select appropriate technology to solve a societal problem, develop a plan to investigate an issue, gather and organize data and information, analyze and compare advantages and disadvantages of a proposed solution and represent alternative analyses and solutions.

Based on the Table 2 the percentage of technology and engineering literacy of students for each Aspect, it is known that for understanding technological principles 69.2% students are in complete category, 15.4% in partial and incomplete category, for developing solutions and achieving goals 54.8% in complete category, 19.2% in

satisfactory category, 15.5% in essential category, 7.7% in partial category, 26.9% in incomplete category, and for communicating and collaborating the 65.4% in complete category and 34.6% in incomplete category.

Table 1. The percentage of technology and engineering literacy of students for each Aspect

Aspect of Technology and Engineering Literacy	Score	Percentage
Understanding Technological Principles	Complete	69.2
	Partial	15.4
	Unsatisfactory / Incomplete	15.4
Developing Solutions and Achieving Goals	Complete	54.8
	Satisfactory	19.2
	Essential	15.4
	Partial	7.7
Communicating and collaborating	Unsatisfactory / Incomplete	26.9
	Complete	65.4
	Unsatisfactory / Incomplete	34.6

Based on the table 3 the percentage of technology and engineering literacy of students for each indicator, it is known that for identify examples of a system or process 69.2% students are in complete category, 15.4% in partial and incomplete category, for select appropriate technology to solve a societal problem 53.8% in complete category, 30.8% in essential category, 7.7% in partial category, 7.7% in incomplete category, for develop a plan to investigate an issue 42.3% in complete category, in Satisfactory category, 19.2%, in partial category, 15.4% and 23.1% in incomplete category. For gather and organize data and information 76.9% in complete category, 23.1 % in incomplete category, for analyze and compare advantages and disadvantages of a proposed solution 46.2% in complete category, 53.8% in incomplete category. For represent alternative analyses and solutions 65.4% in complete category, 34.6% in incomplete category.

The results of the research show that although the majority of students' technological and technical literacy are in the complete category, there are still students in the incomplete category. For example, in the aspect of communication and collaboration, the percentage of incomplete scores is quite large, this could happen because students are not used to being trained in these abilities and skills. Likewise with the Developing Solutions and Achieving Goals aspects. Thus, technological and engineering literacy skills should be a priority for students to train. The results of the research show that although the majority of students' technological and technical literacy are in the complete category, there are still students in the incomplete

category. For example, in the indicator of analyze and compare advantages and disadvantages of a proposed solution, the percentage of incomplete scores is quite large, this could happen because students are not used to being trained in these abilities and skills. These results are supported by conducting interviews with students regarding how the learning process has been carried out so far by teachers, most of them answered that learning is still dominated in the form of presentations using power points and using existing textbooks. In the future, students should be trained more often to compare the advantages and disadvantages of the solutions they are trying to propose through more directed studies. Actions that can be taken by continuously training students in the use of technology so that this becomes a habit (López-Meneses et al., 2020).

Table 2. The percentage of technology and engineering literacy of students for each indicator

Types of assessment targets	Score	Percentage
Identify examples of a system or process	Complete	69.2
	Partial	15.4
	Unsatisfactory / Incomplete	15.4
Select appropriate technology to solve a societal problem	Complete	53.8
	Essential	30.8
	Partial	7.7
Develop a plan to investigate an issue	Unsatisfactory / Incomplete	7.7
	Complete	42.3
	Satisfactory	19.2
Gather and Organize data and information	Essential	0.0
	Partial	15.4
	Unsatisfactory / Incomplete	23.1
Analyze and Compare advantages and disadvantages of a proposed solution	Complete	76.9
	Partial	0.0
	Unsatisfactory / Incomplete	23.1
Represent alternative analyses and solutions	Complete	46.2
	Unsatisfactory / Incomplete	53.8
	Complete	65.4
	Unsatisfactory / Incomplete	34.6

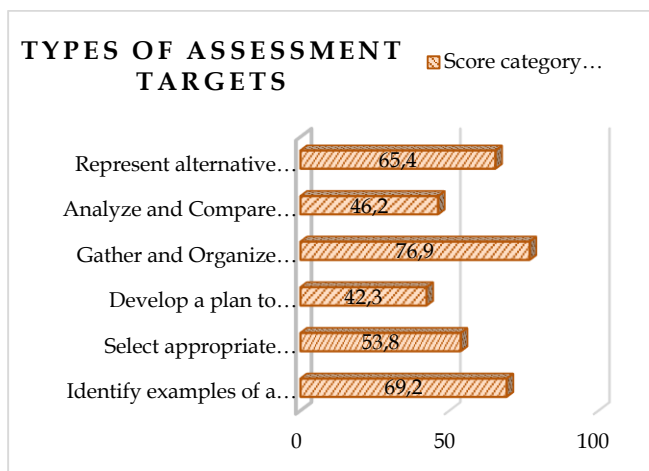


Figure 1. Achievement Type of assessment target in the complete category score

The effort to increase technology and engineering literacy is required. A correct learning method can influence technology and engineering literacy of students. The research Firman et al. (2016), Anjarsari et al. (2020), Apriyani et al. (2019), Pramasdyahsari et al. (2023), indicates that natural science learning which is based on Science, Technology, Engineering, and Mathematics positively affect STEM literacy and technology and engineering literacy of students. This means that appropriate learning approaches and models, for example, STEM, can be used in the learning process (Jackson et al., 2021; Shukshina et al., 2021). It means that by integrating the four knowledge, technology and engineering literacy of students will be increased. A learning which involves design and technique process should be attuned to improve students' critical thinking, creative thinking and problemsolving skills (Ridlo, 2020; Purwaningsih et al., 2020; Sumarni & Kadarwati, 2020; Nugroho et al., 2019). Besides, natural science learning by involving real experience on principles of technology will make students to literate in technology and engineering. According to Anjarsari et al. (2020), Firman et al. (2016), Long et al. (2020), Usnia et al. (2021), C. L. Lin & Chiang, (2019), Simarro & Couso (2021), K. Y. Lin et al. (2020), The integration of the engineering design process and STEM-PjBL approach in natural science education empowers students with a comprehensive understanding of science and its relevance to the world around them. By engaging in this type of learning, students are able to utilize scientific principles and technological advances to solve real-world problems.

Conclusion

Included in complete category, but there are also incomplete ones. Besides, technology and engineering

literacy of students for each indicator are divided into complete category. Likewise, there are also incomplete ones. These results also show a functional relationship between enjoying learning activities and motivation to participate in discussions. Overall, engineering-centered literature and academic discussions are effective methods for extending meaningful learning in engineering practice. The increase of technology and engineering literacy can be done by using a learning method that involves science and principles of technology and engineering. Science learning involving real experiences and design and engineering processes related to technological principles will make students technologically and engineering literate and can improve students' critical thinking and problem solving abilities.

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Author Contributions

Defrizal Hamka: writing-original draft preparation, result, discussion, methodology, conclusion, and editing; Riandi and Irma Rahma Suwarna: analysis, review, and proofreading.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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