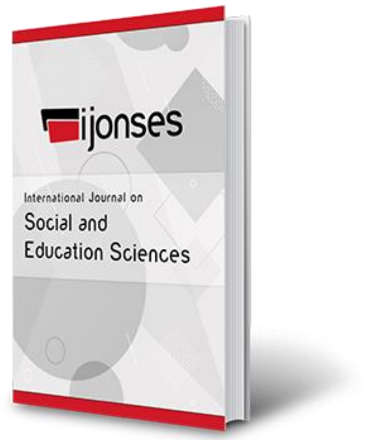

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Enhancing Scientific Literacy of Lower Secondary Students through Technological Pedagogical and Content Knowledge Framework

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Abstract

All students today attach a great deal of importance to having access to a technologically-enhanced education. As a result, teachers are pressured to integrate their teaching, material, and technological expertise into their classes. The TPACK framework was utilized to teach science in lower secondary schools as part of this action research. For this investigation, the most significant individuals were 19-year-old students from on school. As study methods, a test of scientific literacy, observations of behavior patterns, and eight TPAC lesson plans were utilized. During the first academic year of 2022, the spiraling action plan was implemented twice. Results indicated that TPACK played a significant role in increasing students' scientific literacy. The first cycle of instruction, the scientific literacy levels of students were high, and after the second cycle, they were very high. There is potential for TPACK implementation in contemporary schools, however, teachers will need to provide instructional materials that are appropriate for student learning and apply instructional approaches that are adapted to the individual academic pursuits of their students.

Introduction

Technology has become an integral part of our lives for different purposes. We use technology in all areas of education, from learning to teaching. Educational technology helps to educate ourselves and others. Yet, many people have trouble comprehending how technology works or understanding its benefits and risks. Technological advancements have been instrumental in bringing education to almost every person on earth. Schools now have computers, tablets, smartphones, and educational apps. Teachers can easily contact the internet from their classrooms to access educational resources and lessons (Dostál & Prachagool, 2016).

The progress of technology has significantly contributed to not just education but also the growth of scientific knowledge. Science is one way that humans have discovered new information and gained knowledge about the world. Even though this has been of immense benefit to human understanding, it is difficult to predict what risks unanticipated scientific discoveries may entail. Technology is likewise evolving at a rapid rate, far quicker than humanity can respond. Because of this, it is difficult to speculate on the long-term effects it will have on society (Juhji & Nuangchalerm, 2020; Marpa, 2021).

Many people use it for communication purposes as well as keeping in contact with friends and family. Technology has even changed how people interact with each other in online gaming worlds versus real-life settings. The future may reveal many new possibilities that humans haven't yet comprehended or understood the consequences of using. Technology is an integral part of modern life; it's used in both education and science (Dostál et al., 2017). While advances are helpful, new technologies are hard to predict and control. Therefore, it's important to understand how technology works, but it's also responsible to use technology responsibly when interacting with its users.

Today, it is changing rapidly in all dimensions, including social, economic, political, and technological. Technology has influenced changes in education, including the management of science learning. Teaching and learning must integrate technology with their content to reduce abstraction and increase concreteness. It leads to a greater understanding of the student. Mishra and Koehler (2006) proposed the concept of TPACK as a concept for integrating technology content into the pedagogy process with additional content and knowledge to enable learners to learn well. It also enables teachers to develop lessons tailored to the classroom context and approach to teaching through technology, which is the basis of effective teaching and learning with technology. Teaching techniques or classroom management To ensure that content and context are brought to the student's understanding to create optimal learning for students in 21st century learning (Koehler & Mishra, 2009), the organization of the scientific learning process has adopted the TPACK (Akturk & Saka Ozturk, 2019; Kaleli, 2021; Kara, 2021; Koehler et al., 2014; Koyuncuoglu, 2021; Nuangchalerm, 2020; Nithitakkharanon & Nuangchalerm, 2022).

Content about how the solar system and space technology work together is the foundation of teaching and learning with technology, which depends on students' ability to understand how science concepts are presented using technology in the classroom. This content is the basis for teaching and learning with technology that relies on the understanding of the presentation of the concepts of science using technology. Science plays an essential part in the global communities of today as well as those of the future (Nuangchalerm et al., 2021). Education and science are important not only because it is the foundations of economic growth and competition, but also educate people (Kibici, 2022; Yang & Chittoori, 2022). It helps students understand the things that are going on around them in a logical manner, and encourage the creation of new technologies that are beneficial to both day-to-day life and the overall development of the nation.

Based on the results of the PISA 2018 Global Social Performance Assessment, Thailand and the Organization for Economic Co-operation and Development (OECD) worked together to make a program that tests students' skills. The purpose of the Programmed for International Student Assessment, or PISA, is to look at the quality of education systems around the world to see if they prepare students well enough to deal with a changing and unpredictable world. PISA's evaluation focuses on assessment. Reading literacy, mathematical literacy, and scientific literacy are the three types of literacy that measure a student's capacity to apply their knowledge and abilities in the actual world, as opposed to gaining skills and information according to the school curriculum.

Based on the assessment results of the PISA project above, be consistent with the instructor's teaching experience. Students have knowledge of science but lack of understanding and lack of knowledge of science, which is an important goal of teaching and learning that will allow students to gain an understanding of the nature of science. There is no review of the material and no understanding of the material learned. As a result, students lack the application of knowledge in their daily lives in various contexts. In some areas, students already lack understanding. It gives students the idea that this is difficult. And according to the PISA Science Literacy Assessment Test, which includes 3 competencies assessments on interactions in the solar system and space technology, 6 scenarios 20 scores tested with third graders targeted for this study, it was found that all students had a scientific literacy score below 41% at a low level of scientific literacy, so there was a need to modify the learning management model to encourage students to develop scientific literacy.

In scientific literacy classes, the main goal is for students to learn more about science by doing their own research (Abd-El-Khalick et al., 2004). This is to enable students to develop themselves in many areas at the same time, including scientific knowledge, scientific process skills, psych science, and a positive attitude towards science. (Bureau of Academic Affairs and Educational Standards, 2010) These learning outcomes are fundamental for students to live and pursue future careers (Organisation for Economic Co-operation and Development [OECD], 2013). It is the management of learning that corresponds to the workflow of scientists. It gives students the opportunity to research and contribute to the creation of knowledge, helping students understand the nature of science (Abd-El-Khalick et al., 2004; Lederman et al., 2002). Based on the above principles and reasons, therefore, the researchers are interested in development of scientific literacy through science learning management process with TPACK. The findings can also be applied to the advancement of science education and the study of science in schools.

Method

This study utilized action research in order to improve students' scientific literacy in lower secondary schools. This was accomplished by implementing a TPACK framework and teaching a topic titled "Interactions in the Solar System and Space Technology" during the first semester of the academic year 2022. The following provides further information, which is discussed in more detail.

Participants

There were 18 ninth-grade students from a single school in the Thai province of Roi Et who took part in the study. The preliminary research showed that they didn't know much about science in the area that the school had chosen. So that both technology-enhanced learning and pedagogical content knowledge can be achieved, the first semester of the science learning area was spent studying Interactions in the Solar System and Space Technology. This allowed for the successful completion of TPACK in science classroom.

Research Instruments

There are total of four types of research tools utilized in this investigation. The research materials consisted of a strategy for structuring science learning activities based on the conceptual framework for TPACK, as well as questionnaires. The two sets of observations of scientific literacy behavior, the scientific literacy test, and post-teaching notes, served as the observational tools for this study.

Data Collection and Analysis

Action research, which is broken up into two different learning cycles, was used in the study. Each stage of the learning cycle is broken down into the following categories: planning, doing, observing, and reflecting. Altrichter et al. (2002) say that while the data was being collected, which had four steps, there were two learning cycles. These processes were as follows: plan, act, observe, and reflect. In order to foster scientific literacy and growth, the action cycle is carried out using two spirals.

Plan: Conducting problem analysis and solutions to problems of scientific literacy and organizing the science learning process by managing science learning in conjunction with TPACK on solar system interaction and space technology for Grade 9 students, as well as creating tools for collecting data, including scientific literacy behavior, scientific literacy test and post-teaching notes.

Act: Conduct science learning management with science learning management in conjunction with TPACK on solar system interaction and space technology in Grade 9 students according to 8 learning management plans, with sub-tests at the end of 2 operating cycle lasting 1 hour per cycle for a total of 14 hours.

Observe: Observe and gather information about the situation in the classroom, observe the behavior of knowing science in combination with the learning activity log form, to use the information to record after the learning management plan and reflect the learning outcomes.

Reflection: Collect data using different research tools. It is a model for observing the behavior of scientific literacy, a record of learning activities. Once the learning management plan is completed, the end of the operational cycle will be tested, the results of the data collection tool will be analyzed to reflect the learning outcomes and use the data for science learning management in conjunction with TPACK on solar system interaction and space technology.

Statistical basics were used to figure out how to look at the data for this study. The results were then compared and interpreted using percentage, mean, and standard deviation as scientific literacy of the three parts. The very high component scored between 81 and 100, the high component scored between 61 and 80, the medium component scored between 41 and 60, and the very low component scored between 0 and 20.

Results

The First Learning Cycle

The results of observing scientific literacy behavior while organizing knowledge-based learning activities in accordance with the conceptual framework of TPACK in the learning management plan 1-4 as shown in Table 1.

Table 1. The First Learning Cycle: Scientific Literacy Behavior

No	Explain scientific phenomena)6(	Identity scientific issues)8(	Interpret data and evidence scientifically)6(	Total)20(	%	Scientific literacy level
1	3.75	5.50	4.75	14.00	70.00	high
2	3.75	6.50	5.75	16.00	80.00	high
3	3.50	6.75	4.50	14.75	73.75	high
4	3.25	4.00	3.75	11.00	55.00	medium
5	4.75	7.00	5.25	17.00	85.00	very high
6	3.25	5.00	3.75	12.00	60.00	medium
7	3.50	4.75	4.00	12.25	61.25	high
8	3.00	4.75	4.50	12.25	61.25	high
9	4.75	6.00	5.50	16.25	81.25	high
10	4.50	5.75	4.25	14.50	72.50	high
11	3.25	4.25	3.75	11.25	56.25	medium
12	3.25	5.50	3.75	12.50	62.50	high
13	4.50	5.25	3.75	13.50	67.50	high
14	5.50	6.50	4.75	16.75	83.75	very high
15	4.75	5.00	4.75	14.00	70.00	high
16	3.75	4.00	4.00	11.75	58.75	medium
17	4.00	4.50	3.75	12.25	61.25	High
18	4.75	5.75	4.00	14.50	72.50	High
$\bar{X}$	3.99	5.38	4.33	13.69	68.47	High
SD	0.72	0.93	0.64	1.91		

According to the conceptual framework of TPACK, students have the following scientific literacy behaviors: 1) Explain scientific phenomena, students have an average of 3.99, representing 66.50% 2) Identity scientific Issues, students had an average of 5.38, representing 67.25%, 3) Interpret data and evidence scientifically, students had an average of 4.33, representing 72.17%, with a total average of 13.69 out of 20 scores, representing 68.45%. When considering individual students, there are still at least 70% of students who fail to meet the science literacy development criteria.

Scientific literacy test results from scientific literacy test Series 1of Grade 9 students on solar system interaction and space technology. After receiving the science learning management process in accordance with the conceptual framework of TPACK in the learning management plan 1-4 as shown in Table 2. According to the conceptual framework of TPACK, scientific literacy test results from the scientific literacy test (Series 1): 1) Explain scientific phenomena, students have an average of 2.39, representing 59.75% 2) Identity scientific issues, students had an average of 2.06, representing 68.67%, 3) Interpret data and evidence scientifically, students had an average of 2.11, representing 70.33%, with a total average of 6.56 out of 10 scores, representing 65.56 %. When considering individual students, there are still at least 70% of students who fail to meet the scientific literacy development criteria.

Table 2. The First Learning Cycle: Scientific Literacy Test Series 1

No	Explain scientific phenomena)6(	Identity scientific issues)8(	Interpret data and evidence scientifically)6(	Total)20(	%	Scientific literacy level
1	2.00	2.00	3.00	7.00	70.00	high
2	3.00	3.00	2.00	8.00	80.00	high
3	3.00	2.00	2.00	7.00	70.00	high
4	3.00	2.00	1.00	6.00	60.00	medium
5	2.00	3.00	3.00	8.00	80.00	high
6	2.00	2.00	1.00	5.00	50.00	medium
7	2.00	2.00	2.00	6.00	60.00	medium
8	2.00	2.00	2.00	6.00	60.00	medium
9	2.00	3.00	2.00	7.00	70.00	High
10	3.00	2.00	2.00	7.00	70.00	high
11	2.00	2.00	2.00	6.00	60.00	medium
12	3.00	1.00	2.00	6.00	60.00	medium
13	3.00	2.00	2.00	7.00	70.00	high
14	3.00	1.00	3.00	7.00	70.00	high
15	2.00	2.00	3.00	7.00	70.00	high
16	2.00	1.00	2.00	5.00	50.00	medium
17	2.00	2.00	2.00	6.00	60.00	medium
18	2.00	3.00	2.00	7.00	70.00	high
$\bar{X}$	2.39	2.06	2.11	6.56	65.56	high
S.D.	0.50	0.64	0.58	0.86		

The Second Learning Cycle

The results of observing scientific literacy behavior while organizing knowledge-based learning activities in accordance with the conceptual framework of TPACK in the learning management plan 5-8 as shown in Table 3. According to the conceptual framework of TPACK, students have the following scientific literacy behaviors: 1) Explain scientific phenomena, students have an average of 4.60, representing 76.67% 2) Identity scientific issues, students had an average of 5.96, representing 74.50%, 3) Interpret data and evidence scientifically, students had an average of 4.54, representing 75.67%, with a total average of 15.10 out of 20 scores, representing 75.49%. When considering individual students, there are still at least 70% of students who fail to meet the science literacy development criteria.

Table 3. The Second Learning Cycle: Scientific Literacy Behavior

No	Explain scientific phenomena)6(	Identity scientific issues)8(	Interpret data and evidence scientifically)6(	Total)20(	%	Scientific literacy level
1	4.00	5.75	4.50	14.25	71.25	high
2	5.00	6.50	5.75	17.25	86.25	very high
3	4.75	6.50	4.50	15.75	78.75	high
4	4.50	5.50	4.50	14.50	72.50	high
5	5.25	7.25	5.25	17.75	88.75	very high
6	4.00	5.50	4.00	13.50	67.50	high
7	4.00	5.50	4.00	13.50	67.50	high
8	4.50	5.75	4.50	14.75	73.75	high
9	5.00	7.00	5.50	17.50	87.50	very high
10	4.75	6.25	4.25	15.25	76.25	high
11	4.00	5.75	4.00	13.75	68.75	high
12	4.25	6.50	4.75	15.50	77.50	high
13	5.00	6.00	4.00	15.00	75.00	high
14	5.25	6.25	4.75	16.25	81.25	very high
15	5.00	5.50	4.25	14.75	73.75	high
16	4.00	4.50	4.50	13.00	65.00	high
17	4.25	5.25	4.25	13.75	68.75	high
18	5.25	6.00	4.50	15.75	78.75	high
$\bar{X}$	4.60	5.96	4.54	15.10	75.49	high
S.D.	0.49	0.66	0.51	1.42		

Scientific literacy test results from scientific literacy test Series 2 of Grade 9 students on solar system interaction and space technology after receiving the science learning management process in accordance with the conceptual framework of TPACK in the learning management plan 5-8 as shown in Table 4. According to the conceptual framework of TPACK, scientific literacy test results from the scientific literacy test (Series 2): 1) Explain scientific phenomena, students have an average of 2.94, representing 73.61% 2) Identity scientific issues, students had an average of 2.28, representing 75.93%, 3) Interpret data and evidence scientifically, students had an average of 2.28, representing 75.93%, with a total average of 7.50 out of 10 scores, representing 75.00%. When considering individual students, there are still at least 70% of students who fail to meet the scientific literacy development criteria.

Table 4. The Second Learning Cycle: Scientific Literacy Test

No	Explain scientific phenomena)6(	Identity scientific issues)8(	Interpret data and evidence scientifically)6(	Total)20(	%	Scientific literacy level
1	3.00	2.00	3.00	8.00	80.00	high
2	4.00	3.00	2.00	9.00	90.00	very high
3	4.00	2.00	2.00	8.00	80.00	high
4	3.00	2.00	2.00	7.00	70.00	high
5	4.00	2.00	3.00	9.00	90.00	very high
6	2.00	2.00	2.00	6.00	60.00	medium
7	2.00	2.00	2.00	6.00	60.00	medium
8	3.00	2.00	2.00	7.00	70.00	high
9	4.00	3.00	2.00	9.00	90.00	very high
10	3.00	2.00	3.00	8.00	80.00	high
11	3.00	2.00	1.00	6.00	60.00	medium
12	3.00	2.00	2.00	7.00	70.00	medium
13	3.00	2.00	3.00	8.00	80.00	high
14	3.00	3.00	3.00	9.00	90.00	very high
15	3.00	3.00	2.00	8.00	80.00	high
16	2.00	2.00	2.00	6.00	60.00	medium
17	2.00	2.00	2.00	6.00	60.00	medium
18	2.00	3.00	3.00	8.00	80.00	high
$\bar{X}$	2.94	2.28	2.28	7.50	75.00	high
S.D.	0.73	0.46	0.57	1.15		

Discussion

From conducting a research study on the development of scientific literacy through the process of managing science learning according to the conceptual framework of TPACK on interaction in the solar system and space technology, grade 9 students can discuss the findings as follows:

Based on data analysis from scientific literacy data collecting data on interactions in the solar system and space technology, the results from observations of the combined average scientific literacy behavior of operation cycles 1 and 2 accounted for 68.45% and 75.49%, respectively, which had high levels of scientific literacy, and the results from measuring the combined average scientific literacy of operation cycles 1 and 2 were 65.56% and 75.00%, respectively, which had high levels of science literacy. In the first and second cycle, students experienced an increase in scientific literacy scores in all 3 competencies due to the process of managing science learning according to the conceptual framework of TPACK, reducing abstraction and increasing concreteness. The science learning process has adopted the TPACK concept of Koehler and Mishra (2014), a concept that is formed from the integration of technology using applications and websites. How to teach science by providing 5 stages of knowledge-seeking instruction)The institute for the Promotion of Teaching Science and Technology, 2012).

The content of interactions in the solar system and space technology together is the base of technology-based teaching and learning that relies on an understanding of the presentation of the concept of science using technology (İvgin et al., 2019). It also allowed students to explain phenomena scientifically, evaluate and design scientific pursuit processes, and interpret scientific information and testimony. The findings showed that management learns through an argumentative quest method, be able to develop knowledge of science (Soottiwayaylarkul et al., 2016). The findings of knowing science can be discussed as follows:

Explain scientific phenomena in the process of managing science learning according to the conceptual framework by TPACK on interaction in the solar system and space technology. Students have developed this ability to manage learning at each stage of learning, bringing the situation in the application used in everyday life for students to create a scientific explanation of the phenomenon. The interesting problem situations can increase the motivation to solve problems of the students (Belland, 2009). Students will jointly analyze and discuss the results of the problem investigation, leading to conclusions. Students must use their knowledge to relate to the situation and provide evidence for the discussion (Onsee & Nuangchalerm, 2019).

Identity scientific issues in the process of managing science learning according to the conceptual framework. In stage 2, students search for information and then takes the information into account to distinguish which are the sources of testimony and scientific theories and those that are considered reliable. In the learning management plan, students are encouraged to perform experimental activities. It proposes a method of exploring, examining a given scientific problem, and evaluating a given method of exploring and examining a given scientific problem. Learning management through experimental processes is what improves the ability to generate knowledge on its own that help students to meet learning successful (Zimmerman, 2007).

Interpret data and evidence scientifically in the process of managing learning science accordingly. Students have developed this competency in explanation, elaboration, and evaluation which allows students to apply the knowledge they have studied to solve the problem situation and answer questions, analyze and interpret the meaning of scientific data, and then draw conclusions. According to Bybee (2009), the learning management that students have implemented on their own. By conducting research in different ways and using the results of the research to create explanations, students can connect knowledge and apply knowledge in their daily lives.

According to the results of the research, there are differences in the results of the student assessments in conjunction with the Thai and international levels. In 2015, Thailand had the highest to least science literacy scores, including the evaluation and design of scientific quest processes. Interpreting data and using scientific testimony and explaining phenomena in a scientific way. The most developed science literacy is the explanation of scientific phenomena, the assessment and design of scientific knowledge quest processes, and the interpretation of information and the use of scientific testimony, respectively, which can be further developed by organizing learning activities in the process of expanding knowledge (OECD, 2017).

Conclusion

The first cycle, students have scientific literacy behavior scores and scientific literacy test results when considering individual students, there are still at least 70% of students who fail to meet the scientific literacy development criteria. The second cycle, students have scientific literacy behavior scores and scientific literacy test results when considering individual students, there are still at least 75% of students who fail to meet the scientific literacy development criteria. TPACK played its important role to promote level of scientific literacy, students had a high level of scientific literacy in the first cycle and a very high level in the second cycle. TPACK could be used in the modern classroom, but teachers have to designed by suitable tools for learning and pedagogical strategies should be performed based students' nature of learning.

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