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ผลสัมฤทธิ์ทางการเรียนและความพึงพอใจของนักเรียนในการเรียนรู้แบบสะเต็มศึกษาโดยผ่านกระบวนการสร้างสังคมแห่งการเรียนรู้ทางวิชาชีพในรายวิชาเคมีสำหรับนักเรียนระดับชั้นมัธยมศึกษาตอนปลายในภาคใต้ของประเทศไทย ในช่วงที่มีการระบาดของโคโรนาไวรัส (Learning Achievement and Student Satisfaction in the STEM Education through Professional Learning Community in the Chemistry Class of Secondary School Students in the Southern Region of Thailand during Pandemic)

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Learning Achievement and Student Satisfaction in the STEM Education through Professional Learning Community in the Chemistry Class of Secondary School Students in the Southern Region of Thailand during Pandemic

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บทคัดย่อ

การจัดการเรียนรู้แบบสะเต็มศึกษายังไม่ถูกนำมาใช้ในโรงเรียนอย่างแพร่หลาย โดยเฉพาะโรงเรียนในสามจังหวัดชายแดนภาคใต้ ดังนั้นการวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลสัมฤทธิ์ทางการเรียนวิทยาศาสตร์และความพึงพอใจของผู้เรียนที่มีต่อการเรียนด้วยแผนการจัดกิจกรรมการเรียนรู้บูรณาการแบบสะเต็มศึกษากับนักเรียนระดับชั้นมัธยมศึกษาตอนปลายโดยใช้กระบวนการสร้างสังคมแห่งการเรียนรู้ทางวิชาชีพ (Professional Learning Community: PLC) โดยมีนักเรียนจากโรงเรียนในภาคใต้จำนวนสี่แห่งที่เข้าร่วมโครงการห้องเรียนพิเศษคณิตศาสตร์วิทยาศาสตร์ (SMP) จากนักเรียนทั้งหมด 120 คนในโรงเรียนเหล่านั้น มีเพียง 9 คนที่ได้รับการคัดเลือกโดยใช้วิธีการสุ่มตัวอย่าง ผลการประเมินโดยรวมพบว่ากิจกรรมการเรียนรู้แบบสะเต็มศึกษาที่ใช้ประกอบการเรียนการสอนรายวิชาเคมีเกี่ยวกับความเข้มข้นของสารละลายนั้นสามารถเพิ่มความสนใจของนักเรียนในการศึกษาวิชาเคมีและความเข้าใจต่อบทเรียนได้ดี เห็นได้จากคะแนนเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของคะแนนจากแผนการเรียนรู้แบบสะเต็มศึกษาหลังการทดสอบมีค่าอยู่ในระดับสูงสุด ค่า E1/E2 ของการจัดการเรียนรู้แบบสะเต็มศึกษาในรายวิชาเคมีเท่ากับ 90.46/82.50 ซึ่งสูงกว่ามาตรฐานที่กำหนด และยังพบว่าค่าเฉลี่ยโดยรวมนั้นสูงมากเมื่อใช้แผนการจัดการเรียนรู้เพื่อสร้างชั้นเรียนชุมชนการเรียนรู้ผ่านกระบวนการสร้างสังคมแห่งการเรียนรู้ทางวิชาชีพ รวมถึงประสิทธิภาพของการสร้างชุมชนการเรียนรู้ทางวิชาชีพยังได้รับการจัดอันดับอยู่ในเกณฑ์ดี อย่างไรก็ตามควรมีการศึกษาถึงตัวแปรอื่น ๆ นอกเหนือจากผลสัมฤทธิ์ทางการเรียนก่อนที่จะนำไปขยายผลการพัฒนาการจัดการเรียนรู้กับรายวิชาอื่น ๆ ต่อไป

Learning Achievement and Student Satisfaction in the STEM Education through Professional Learning Community in the Chemistry Class of Secondary School Students in the Southern Region of Thailand during Pandemic

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Abstract

The STEM education has not yet been implemented in schools, particularly those in the three southern border provinces. Consequently, the purpose of this research is to study the science learning achievement and satisfaction of students who learned with integrated learning activities based on STEM education designed by using the Professional Learning Community (PLC) method as a professional development tool. Secondary school students from four southern Thai schools who participated in the Science Mathematic Program (SMP) Special Classroom Project from a total of 120 students in those schools, 9 were chosen using a deliberative sampling method. The overall assessment results revealed that STEM activities used in the teaching and learning of chemistry subjects on the Solution concentration can increase students' interest in studying chemistry and their understanding of the learning content by displaying the mean scores and standard deviation of the scores from the STEM Learning Plan post-tests at the highest level. The E1/E2 efficiency of the STEM Education Program in Chemistry was 90.46/82.50, which was higher than the specified standard. We also discovered that the overall average was very high when we used the learning management plan to open a class to create the PLC process learning community. Furthermore, the effectiveness of establishing a professional learning community was rated favorably. However, factors other than academic achievement should also be investigated before applying to other subjects.

Keywords: STEM education, the Professional Learning Community (PLC) method, Secondary school students

Introduction

The emphasis in the modern era is on applying the knowledge gained in solving daily problems correctly and appropriately in accordance with the learners' interests and aptitudes. Practicing skills and applying knowledge to prevent and solve problems, as well as managing learning to occur at any time and from any location, in order to develop students collaboratively based on their potential. As a result, teachers must be able to develop students while keeping up with the changing world. The world is rapidly changing in the twenty-first century. Good practice allows you to be sharp, quick, and patient. People with advanced skills have more opportunities. Life has progressed and will continue to benefit society and the world. Consequently, education management in the twenty-first century must be developed to be more pragmatic. Learners must be prepared to live in a world where social change trends have a substantial impact on their way of life (Ball et al, 2016).

To prepare students for today's increasingly complex world of work, learning management must encourage students to acquire learning skills. Innovation is a fundamental skill that every person in the

twenty-first century must learn. Because the world is becoming more complex and changing at a faster rate. The advancement of science, technology, research, and innovation aims to enable Thailand to become an innovative society and to prepare the country for its future as a high-income country. The importance of scientific and technological infrastructure in accelerating the country's development toward the aforementioned goals. Teaching and learning with activities that create inequality for students is ineffective in driving scientific and technological infrastructure and cannot help drive the country's development toward its goals unless teachers have access to appropriate and effective learning management based on the learner's context. Management of science education remains a contentious issue in both the teaching and learning processes of teachers. It typically emphasizes students memorizing theory content rather than allowing students to study and research to build their own body of knowledge. As a result, students are unable to solve problems that differ from the theory mentioned by the teacher (Ball et al., 2016; Hanfi et al., 2019).

Chemistry is not only a fundamental concept for everyday life; it is also one of the most crucial parts of innovative development, indicating how it has become an essential part of the high school curriculum. Despite the fact that chemistry courses are interdisciplinary, students must take the chemistry course as part of their university entrance examination. However, according to the report on the basic statistics of the general subject test, Academic Year 2018–2021, Chemistry, Grade 12, a full score of 100 was required, but the students' average scores were 27.43, 28.40, 29.03, and 22.6%, respectively (National Institute of Educational Testing Service (Public Organization), 2020). As can be seen, the average score was quite low. Thus, it is critical to develop a model of chemistry teaching and learning for students as soon as possible. According to the findings of That is to say, teachers have a lot on their plates. Teachers teach based on their previous knowledge and experiences. The teaching method emphasizes lecturing with less creative media. Teaching activities do not prepare students to conduct research from a variety of learning sources and are not relevant to real life. Students demonstrated negative attitudes and behaviours toward science education, such as boredom. unwillingness to study due to a lack of interest in learning. There is a negative attitude toward science when students have a negative attitude toward studying science. As a result, teaching management will fall short of its goals (Landa et al, 2020).

"STEM" is an abbreviation for four disciplines: Science, Technology, Engineering, and Mathematics. It refers to the body of knowledge. Academics of the four sciences that are interconnected in the real world require different bodies of knowledge to be integrated in life and work. Based on research into the learning management model, it was discovered that organizing learning activities according to STEM Education guidelines can encourage learners to learn on their own. They design learning challenges. It's an intriguing learning experience. and the integration of scientific, technological, engineering, and mathematical knowledge. It influences the development of the creative process of creativity in various inventions of learners; the ability to apply knowledge to connect and solve problems in real life; and development. The STEM learning process, 21st century skills Students will participate in activities to expand their scientific

knowledge and skills. It has brought knowledge to design work pieces to meet needs or to obtain technology, which is a product of the engineering design process (Kennedy & Odell, 2014).

Building a Professional Learning Community (PLC) is a change-making process that involves learning from the practice of collaborative and supportive working groups of people. The goal of the learning exchange process is to develop learners' learning together, set learners' learning goals, and examine and reflect on both individual and overall performance. As a result, the researcher recognized the significance of developing students' creative thinking skills for learning through the use of learning activities that adhere to STEM Education guidelines, which will facilitate the learning process (Fulton & Britton, 2011).

According to the Institute for the Promotion of Teaching Science and Technology (IPST), STEM Education is an educational management approach that integrates four interdisciplinary areas, namely science, engineering, technology, and mathematics, with an emphasis on applying knowledge to solve real-life problems, including developing new processes or products that are beneficial to life and work. Killian and Bastas (2015) studied the impact of team-based proactive learning on student attitudes and performance in introductory sociology courses. The study compared final exam and attitude survey scores between two groups at a branch campus of a large Midwestern university: team learning vs. lecture group. The findings revealed that students who studied as a group had a more positive attitude toward the discipline. Furthermore, students who studied in groups scored 3% higher on final exams than those who took lectures. but not statistically significantly different due to the erratic nature of final exam scores. The standard deviation of descriptive classroom test scores contains more words than the standard deviation of team classroom test scores. This indicated that the test scores of the two groups differed far too much. Students in team classes preferred classroom teaching methods over students in lecture classes, demonstrating a favourable attitude toward the team learning process. Rahmawati et al. (2020) conducted a study with 15 Year 10 students in a private secondary school. The data was analysed according to the chemical literacy criteria of mastery, competence, development, emerging, and absence. According to the findings, the project piqued students' interest in exploring scientific concepts and improved their conceptual understanding of chemistry, critical thinking, and collaborative skills. Students' enthusiastic participation in this novel STEM PBL approach improved their chemical literacy development. Tunkham et al. (2016) reported a high efficiency level in STEM education activities (E1/E2 = 85.65/89.52) observed among 42 students in grade 12 during the first semester of the academic year. Other skills acquired by the students, such as learning and innovation, information media and technology, and life and career skills, were all rated excellent. Sari et al. (2020) investigated Grade 12 students' STEM literacy and problem solving in chemistry materials using a qualitative method. According to the findings, the majority of students lack STEM literacy as well as problem-solving skills. Students' STEM literacy and problem-solving abilities would be lacking because they were unfamiliar with STEM literacy and problem-solving in chemistry. This outcome appears incompatible with 21st-century learning. As a result, it was suggested that specific steps be taken to improve STEM literacy skills and problem-solving abilities. In addition, Tomperi et al. (2022) investigated the feasibility of using the STEM Career Interest Survey (STEM-CIS) to assess secondary school students' interest in STEM

subjects and careers. To assess the initial structural validity of the adapted STEM-CIS survey, a confirmatory factor analysis (CFA) was performed, with the science subscale expanded to four science disciplines to align with how science is taught in Finland and Russia. The findings show that interest in STEM subjects is low across the board in all countries. It implies the need to expand informal learning opportunities both inside and outside of the classroom, as well as improve career counselling for students to better inform them about STEM career opportunities (Kennedy and Odell, 2014).

The Coronavirus disease 2019 has caused the largest educational interruption at a global level. Over 94% of the world's student population in more than 190 countries were affected in which mostly were from low-and middle-low-income countries (UNESCO, 2020). Given that more than 13 million Thai students were affected, the Thai government and educational sectors went through a significant digital transformation to establish relevant technologies and modify their curricula. Thailand's education system has also been compelled to migrate from physical classroom teaching to various virtual online learning platforms (Pal et al, 2022).

Objectives

The four main goals of this study are as follows: to establish an effective vocational learning community (PLC) in 10th Grade that meets the 75/75 criteria, to develop a STEM-style learning management system in chemistry about solution concentration, to compare academic achievement of students before and after studying STEM learning management, to evaluate student satisfaction with STEM learning management in Grade 10 students, and to determine the efficacy of establishing a PLC.

Methodology

Participants

The four schools chosen for this study were Grade 10 students, Science Mathematic Program (SMP) Special Classroom Project. All of the schools chosen for this study were chosen voluntarily and based on the laboratory infrastructure's readiness for schools and teachers. Teachers' STEM knowledge to support the development of effective STEM teaching and learning management, as well as ease of opening a demonstration classroom observation management learning and reflection on learning exchange results from learning plans and learning management activities. By using a deliberate sampling technique, based on home internet access, 9 students were chosen from among 120 students from those schools.

The Professional Learning Community (PLC)

The SMP Special Classroom Project at Yala Rajabhat University (SMP-YRU) has implemented the essential steps for conducting research on Developing STEM Education through the establishment of Professional Learning (Professional Learning Community, PLC) in Chemistry for Grade 10 student. A Memorandum of Understanding (MoU) was created jointly by the research plan and the 12 network schools, a project to establish a special classroom for science and mathematics on March 5, 2021 in the Luhui Conference Room (6th Floor, Information Library Center), Yala Rajabhat University with the goal of

assisting in the establishment of vocational learning communities in schools, as well as providing additional important activities for science teachers in high school chemistry courses to improve their knowledge and assertive skill sets, resulting in higher quality students in the SMP-YRU program, and ensuring that this established PLC is continuously and sustainably developed. The SMP-YRU project surveyed teachers' and stakeholders' needs and held a meeting on June 24, 2021, with the school director, deputy director, Head of Chemistry Department, teachers, and scientists from 12 schools on a committee board. Teachers' skills and expertise in teaching practice, as well as imitations of teaching management imposed by the pandemic, a lack of a platform to exchange teachers' experiences, students' lack of enthusiasm and motivation to learn, and other issues were discussed at the meeting. It was decided at the joint operation meeting to develop a solution to the problem within the framework of the research focus, specifically the development of a quality learning management plan by integrating learning management techniques into the development of STEM learners by choosing the Solution Concentration as a research subject participating in the PLC process learning plan. On August 7, 2021, the research team organized an online workshop with external speakers on the preparation of PLC plans in Chemistry at the Grade 10^{th} level to educate administrators and teachers on how to correctly and completely implement the creation and development of professional learning communities in accordance with the PLC process. Teachers took part in developing a STEM-style learning management plan focused on the concentration of solutions. By establishing a professional learning community (PLC) in 10^{th} Grade with a six-step learning process, one learning management plan, and a study time of 2 hours and 30 minutes, the STEM Education Management Plan for the Solution Concentration Chemistry course was created as outlined in Table 1.

Table 1

General Structure of the Lesson

Steps	Action Plan
Preparatory Stage: Student engagement & Knowledge check (15 min)	1. Teacher assists student with the online pre-test (10 min). 2. Class is divided into a group of three students then teacher demonstrates the experiment using three glasses containing different quantity of food coloring (Red).
Main topic introduction (15 min)	1. Teacher randomly asks the students to compare the volume and concentration of three glasses of water and encourage students to discuss of “concentration”. 2. The teacher simulates a situation to improve students' problem-solving abilities; Most convenience stores are closed during a lockdown; how would you create a giant bubble recipe that is as effective as a store-bought product?
Problem solving, collecting empirical evidence, activity	1. Teacher advises the activity.

planning and execution (95 min)	2. Teacher distributes the worksheet: Solutions and Hydrocolloid to students. 3. Teacher gives instruction and equipment. 4. Students start experiment.

Table 1 (Cont.)

General Structure of the Lesson

Steps	Action Plan
Conclusion and Discussion (15 min)	Teacher facilitates students to discussion the practical use of what they learned.

Expert panels

The experts participating in this study were chosen according to their expertise. The study purpose, the selection reason and their role in the study were explained to the experts before obtaining their agreement to take part in the study. The list of professional expert panels was outlined in Table 2.

Table 2

List of Professional Expert Panels

Expert Code Name	Area of Expertise	Years of Experience
E1	STEM Education	5
E2	Chemistry	7
E3	Statistics and Assessment	13
E4	PLC planning	5

Assessment of student's learning achievement and satisfaction

The expert evaluation found that the learning management plan's suitability was at the highest level with the score of 4.59. Thus, this learning management plan was implemented and online classes were started with the target group, which was Grade 10 students, SMP Special Classroom Project. This STEM Education Management Plan was evaluated by 5 expert panels using a 5-point Likert scale that included strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5) (Likert, 1932). The same group of teachers then created a test to assess students' learning achievement in the subject of Solution Concentration in accordance with the content and expected learning outcomes. The test had ten multiple-choice questions. To ensure consistency with the Index of Item Objective Congruence (IOC) and linguistic validity, the test was given to the same expert panels. According to the experts, the consistency index (IOC) of the chosen test must be between 0.67 and 1.00, and the assessment of the achievement test yielded an IOC of 0.86 on average. The teachers also created a 9-item satisfaction survey for Grade 10 students who participated in the STEM learning management system. The assessment of teaching and learning

management in STEM from Grade 10 students, SMP Special Classroom Project to analyze the data using the following assessment criteria: very dissatisfied (1), dissatisfied (2), neutral (3), satisfied (4), and very satisfied (5). The teacher also developed a five-item evaluation form for the effectiveness of establishing a professional learning community for the promotion and development of STEM-style teaching and learning in the classroom and submitted it to the expert panels for review, using the following assessment criteria: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5).

Data Analysis

Data analytics were used in this study to evaluate the effectiveness of the STEM management plan (E1/E2) by averaging the scores, standard deviation, and percentage of test results using a pre–post-test design. A variety of inferential statistics were used for quantitative studies (e.g., student learning achievement, satisfaction before and after STEM learning management plan, and efficacy of establishing a professional learning community to promote and develop STEM-style teaching and learning).

Results and Discussions

The efficacy of the Professional Learning Community lesson plan based on the STEM learning management for the subject of Solution concentrations in Chemistry for Grade 10 students was 90.46/82.50, which was higher than the threshold setting of 75/75 (Table 3).

Table 3

Efficacy of a STEM-based Professional Learning Community lesson plan for Grade 10 students on Solution concentrations in Chemistry.

Efficacy	Total Score	*M*	*SD*	%
Process efficacy (E1)	55	49.75	1.75	90.46
Result efficacy (E2)	10	8.25	0.71	82.50
The lessoning efficacy (E1/E2) = 90.46/82.50				

The findings demonstrated that after implementing STEM learning management, students' learning achievement was higher indicating that the student's achievement before and after studying STEM learning management was statistically significant at $p > 0.05$ (Table 4). This finding demonstrated similar trends to what Banhan et al. (2017) previously reported on the efficacy of implementing the STEM education method for Grade 10 students, with an effectiveness level of 80/80. Khummanee (2021) also reported that using the STEM training course resulted in an efficiency of E1/E2 of 86.38/84.83 percent, which was higher than the criteria defined. A similar trend was observed in Poonputta's (2021) report, which revealed that the efficiency of STEM lesson plans for undergraduate students' processing performances was 87.12% and the performance results were 74.17% (87.12/74.17), meeting the set criteria of 75/75.

Table 4

Comparative analysis of Grade 10 student achievement before and after studying STEM learning management

Test	N	*M*	*SD*	T	p-value
Pre-test	9	5.75	1.04	7.64	0.000
Post-test	9	8.25	0.71		

The overall level of satisfaction of Grade 10 students with STEM education was found to be very high; the mean was 4.50, the standard deviation was 0.68, and when each aspect was considered, the students were satisfied with the teaching process; for example, participation in extracurricular activities, creativity with learning potential, the ability to individually practice and complete assignments until they are successful, and enjoyable activities. The mean was 4.64, and the standard deviation was at its peak of 0.74 as shown in Table 5. This is consistent with the findings of Ros et al. (2022), who highlighted the importance of STEM in Elementary Education and were successful in fostering its benefits on self-regulation skills and creativity. This finding validates what Killian and Bastas (2015) discovered previously: students in Team-based learning classes have much more positive attitudes toward students in Lecture-based learning classes. Furthermore, the STEM Student Attitude Survey results indicated that the impact of interdisciplinary STEM courses appeared to be very positive in a variety of ways (Mayes and Rittschof, 2021).

Table 5

The overall level of satisfaction of Grade 10 students with STEM education

	M	*SD*	Satisfactory Rate
Students can easily follow a simple teaching process	4.7	0.67	Very satisfied
Students take part in educational activities.	4.7	0.71	Very satisfied
Students are delighted with this method of education.	4.4	0.53	Satisfied
Student's creativity has reached its pinnacle of potential and efficiency.	4.6	0.78	Very satisfied
Students gain knowledge from teaching and learning activities.	4.3	0.53	Satisfied
Students have evidenced desirable traits.	4.4	0.78	Satisfied
Teachers encourage students to think creatively.	4.2	0.6	Satisfied
Students can individually practice and complete assignments until they are successful.	4.6	0.78	Very satisfied
Teaching activities are engaging and stimulating.	4.6	0.78	Very satisfied
Overall Satisfaction level	**4.5**	**0.68**	**Satisfied**

Table 6 demonstrated that the assessment of the effectiveness of establishing a professional learning community in promoting and developing STEM instructional management in the classroom as a whole was at a high level. The standard deviation is 0.48 and the mean is 4.22. According to the findings, it raised awareness of the value of participating in the PLC process and organizing PLC activities. The mean was 4.64, and the standard deviation was 0.51. For the other three items, the efficiency in establishing a

learning community was excellent. The mean was 3.94, with a standard deviation of 0.47. According to Trevallion and Trevallion (2020), the implementation of STEM in schools has resulted in increased student engagement, and teachers are seeing the benefits of implementing an applicable and more relevant STEM lesson plan. STEM education broadens a student's learning experience while also encouraging creativity, inquisitive thinking, and teamwork.

Table 6

The effectiveness of establishing a professional learning community for the advancement and improvement of STEM classroom instruction and learning management.

	M	*SD*	**Satisfactory Rate**
You understand and value the significance of participating in the Professional Development Process (PLC).	4.54	0.49	Very satisfied
You have the knowledge and understanding to design activities to promote and develop learners in your community based on the learning exchange process.	3.82	0.38	Satisfied
You can disseminate knowledge to fellow teachers and apply it in teaching and learning activities in subject groups by using the creative process of creating professional learning communities (PLC) within the school.	3.91	0.53	Satisfied
The outcomes of the Professional Learning Community (PLC) development process can be used to develop and promote classroom teaching and learning activities.	4.09	0.49	Satisfied
Do you believe the process of establishing a professional learning community (PLC) within the school is worthwhile and should be continued?	4.73	0.53	Very satisfied
Overall Satisfaction level	**4.22**	**0.48**	**Satisfied**

Conclusions

Our findings indicate that the STEM Education is a learning management system that encourages problem solving. As a result, it should emphasize the speed of thought. The event should be subject to certain deadlines and restrictions. Other learning-related variables should be investigated using a STEM-style learning management plan. Aside from academic achievement, such as the use of technology in online STEM learning management, etc. Learning outcomes using other teaching methods should be compared to learning outcomes using a STEM-based learning plan. The integration of cross-disciplinary STEM approaches, namely science, technology, engineering, and mathematics subject areas, should be prioritized so that students can relate to solving problems in everyday life. Educators should conduct research on learning

management guidelines that incorporate STEM subjects as a guideline for correct teaching in schools in order to generalize the findings to other subjects. STEM education can connect inquiries by articulating questions that can be answered through investigation in order to educate individuals prior to engaging in problem-solving tasks. Leading educators should concentrate on developing a strategy to improve discipline teaching, as well as innovations to connect STEM at the secondary level to higher education and the workforce.

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