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LEVELS OF FACTORS INFLUENCING THE 21ST-CENTURY MATHEMATICS TEACHING CHALLENGES FOR SECONDARY STUDENTS IN THE SECONDARY EDUCATIONAL SERVICE AREA OFFICE OF LOPBURI: A STRUCTURAL EQUATION MODELING APPROACH

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Abstract

Student's attitude towards 21st-century mathematics teaching is affected by factors such as content knowledge, knowledge of teaching and learning activities, attitude towards mathematics and technology knowledge. The aim of this study was to construct structural equation models for investigating 21st-century mathematics teaching and learning among secondary mathematics students in the Secondary Educational Service Area Office Lopburi (SEAOL). Quantitative research used the 21st-century TPACK framework. The research sample consisted of 400 SEAOL students from the 1/2022 semester using multi-stage sampling. A questionnaire was used to assess 21st-century secondary school mathematics teaching and learning with a 0.934 confidence of. The data was analyzed using the appropriate software and revealed key components and their relationships. The results show that teaching and learning, fundamental technology capability, content knowledge, specialized technology use, and mathematical content implementation all affected mathematics teaching in the 21st-century for SEAOL students. Influence was .89, .70, .63, .25, and .21. School technology support has a .59 effect on students' basic technological skills. Technology's role in learning influenced students' technology use by .21. This research shows how each aspect affects 21st-century mathematics education at the SEAOL, and math overload had the least effect. Teachers and stakeholders should investigate and innovate to improve the use of specialized technology in teaching to help students acquire higher-level mathematical content and apply it in their daily lives.

Keywords: *mathematics secondary students, mathematics teaching, structural equation model, Thailand*

Introduction

This synthesis encompasses findings from six research studies conducted by Chariyamakarn and Sukpan (2018); Hanhaw (2018); Saethow (2019); Sirithon et al (2020); Sripongpird (2018) and Soythong (2019) on the factors influencing the teaching and learning of mathematics in contemporary times. The collective results highlight that content knowledge, knowledge of teaching and learning activities, attitude towards mathematics, and technology

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knowledge are the primary factors impacting mathematics instruction. Furthermore, to align with the principles of 21st-century teaching and learning, it is essential to adapt the teaching methods from passive learning to a more interactive process. This involves engaging students in reading, listening to lectures, and actively utilizing content from books and textbooks. Traditionally, teachers would provide comprehensive explanations while students took notes, with knowledge assessed through exams. This approach is commonly known as a teacher-centered method. However, in the 21st-century, there has been a shift in the learning process, transforming the role of teachers from lecturers to facilitators who design activities to stimulate student learning (pedagogy). The emphasis is now on empowering students to explore and construct knowledge independently. Teachers play a supportive role by providing guidance and suggesting various tools, particularly through the integration of technology. This approach requires teachers to be adept at designing learning activities that integrate technology, known as TPACK, to facilitate efficient and extensive access to knowledge. Moreover, collaborative learning with classmates, where knowledge is exchanged, is emphasized as an active learning process, placing students at the center of their learning experience. According to the Office of the Basic Education Commission (OBEC) (2017), this student-centered approach promotes active learning and encourages students to take an active role in acquiring knowledge.

Furthermore, the researcher conducted a study analyzing the factors influencing mathematics teaching and learning in the 21st-century among students under the Secondary Education Area Office Lopburi (SEAOL). Factor analysis was employed to examine these factors. The research findings revealed seven key factors impacting the teaching and learning of mathematics in this context: They are as follows: (1) Supporting the use of technology from schools; (2) Demand for technology in teaching and learning; (3) Basic technology proficiency; (4) Specialized technology proficiency; (5) Content knowledge; (6) Excessive mathematics content for implementation; and (7) Teaching and learning approaches. These findings were identified by Tiengyoo (2023), as presented in Appendix 1.

In this research, our focus was to delve deeper into the examination of the seven factors that impact the teaching and learning of mathematics in the 21st-century among school students under the SEAOL. The aim is to determine the extent of influence each factor holds in the present context. To achieve this structural equation models that elucidate the factors influencing mathematics teaching and learning, the Analysis of Moment Structure (AMOS) software package was utilized for confirmatory component analysis and to ensure model consistency.

Research Problem

Despite existing research and interest in the factors influencing mathematics teaching and learning among students in the 21st-century, which has provided insights into the factors affecting mathematics teaching and learning among these students, the research has not adequately demonstrated the varying degrees of importance of these factors on teaching and learning. Additionally, the characteristics of students in each region exhibit differing influences from these factors. Therefore, the goal was to investigate the impact levels of these factors on mathematics teaching in the 21st century for students in SEAOL.

Research Focus

(1) Factors that impact mathematics teaching and learning in the 21st-century encompass various variables expected to influence the effectiveness of instructional practices. These factors include: 1) Awareness about the use of technology: This refers to the understanding and perception of the necessity and benefits of integrating technology into mathematics teaching; 2) Technology knowledge: This entails the proficiency in utilizing different technologies

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for teaching mathematics, such as word processors, electronic spreadsheets, presentations, geodynamics, programming languages, internet access, data storage, and modern technology implementation; 3) Content knowledge: This refers to the comprehension and mastery of mathematical content necessary for effective teaching, including the ability to explain concepts and understand the origins of mathematical content; 4) Teaching and learning activities: This encompasses the instructional styles and methods employed by teachers in mathematics teaching and learning. These dimensions have been explored in previous studies conducted by Koehler et al. (2013), Saethow (2019), Sirithorn et al. (2020), and Sripongpird (2018). To measure these factors, the researcher developed a questionnaire specifically designed to assess the impact of these variables on mathematics teaching and learning in the 21st-century.

(2) The factors that influence students' teaching and learning of mathematics in the 21st-century are observational variables, which include: 1) Supporting the use of technology from schools (Access_FAC1); 2) Requiring technology for teaching (Access_FAC2); 3) Relating to basic technology proficiency (TK_FAC1); 4) Associated with specialized technology proficiency (TK_FAC2); 5) Relating to content knowledge (CK_FAC1); 6) Pertaining to the mathematical content deemed more essential for implementation (CK_FAC2); and 7) Influencing teaching and learning (IA_FAC1). These factors have been identified through an analysis of the variables impacting students' teaching and learning of mathematics in the 21st-century, as conducted by Tiengyoo (2023).

(3) Secondary Education Service Area Office Lopburi (SEAOL) is an educational institution in Thailand responsible for overseeing secondary education in the Lopburi province.

(4) The term 'school' under the SEAOL refers to educational institutions within the office's jurisdiction. These schools are typically medium-sized or larger, with a total student population of 500 or more (SEAOL, 2022).

(5) In the context of the SEAOL, a 'student' refers to an individual enrolled in a medium-sized or larger school under its jurisdiction. These schools are classified as medium schools or higher in terms of their size, and students are aged between 13 and 18.

Research Aim and Research Questions

The general objective of the study is to revalidate the instruments in the SEAOL context and to propose a structural model that will portray the influences of teaching and learning, fundamental technology capability, content knowledge, specialized technology use and mathematical content implementation all affected mathematics teaching in the 21st-century for SEAOL students. School technology support has an effect on student's basic technological skills. Technology's role in learning influences students' technology use.

Research Methodology

Background

This research adopts a quantitative approach and employs literature reviews and relevant theoretical frameworks to make the findings more comprehensive. Descriptive statistical analysis and Factor Analysis (Tiengyoo, 2023) are used, along with SEM. The results are discussed, summarized, and supplemented, with recommendations for additional research. The AMOS software program was used to analyze SEM.

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Sample

The population for this research consisted of 17,916 secondary school students from 13 schools affiliated with the SEAOL (2022), which are classified as medium-sized or larger schools. The sample size used in the study comprised 400 secondary school students selected from seven schools affiliated with the SEAOL, specifically from the first semester of the academic year 2022. The sample was obtained using multistage sampling. The sample size was determined using the Yamane formula (Yamane, 1970) with a sampling error of 0.5. For statistical analysis using *SEM*, the research followed the recommendation of Kline (2010) to have a sample size of at least 200 in the study. This is in line with Hair et al. (2010), who suggested that a minimum sample size of 300 is suitable for *SEM* analysis when the number of latent variables is less than or equal to seven. Therefore, the sample size chosen for this research was considered appropriate.

Instrument and Procedures

In this research, questionnaires were used to assess the factors influencing the teaching and learning of mathematics in the 21st century among secondary school students. The questionnaire comprised 37 items, which were measured using a 5-point rating scale. The overall reliability of the questionnaire was assessed using Cronbach's alpha coefficient, yielding a confidence value of .934 (Tiengyoo, 2023).

Data Analysis

The statistical tests employed to assess the fundamental assumptions for *SEM* analysis included examining Skewness, Kurtosis, and Multicollinearity. These tests involved assessing measures such as Tolerance and Variance Inflation Factor (*VIF*) statistics. The research employed statistical techniques such as confirmatory factor analysis and structural equation modeling. The assessment of model fit was based on various model fit index values, as recommended by Hair et al. (2010) a p-value of 0.05, $CMIN/DF \leq 2.00$, $GFI \geq 0.90$, $TLI \geq 0.90$, $CFI \geq 0.90$, $NFI \geq 0.90$ and $RMSEA \leq 0.08$. Additionally, construct reliability (*PC*) and average variance extracted (*PV*) were considered, with *PC* values higher than 0.60 and *PV* values higher than 0.50 considered acceptable and having a loading score value greater than 0.3, following the guidelines proposed by Kaiwan (2013). To collect the necessary information, we obtained permission from the seven schools included in the sample to administer the questionnaires. The questionnaires were distributed online via Google Forms from May 30 to June 30, 2022. We ensured the accuracy, completeness, and validity of the collected data through data validation procedures. The data was then coded and processed using appropriate computer programs.

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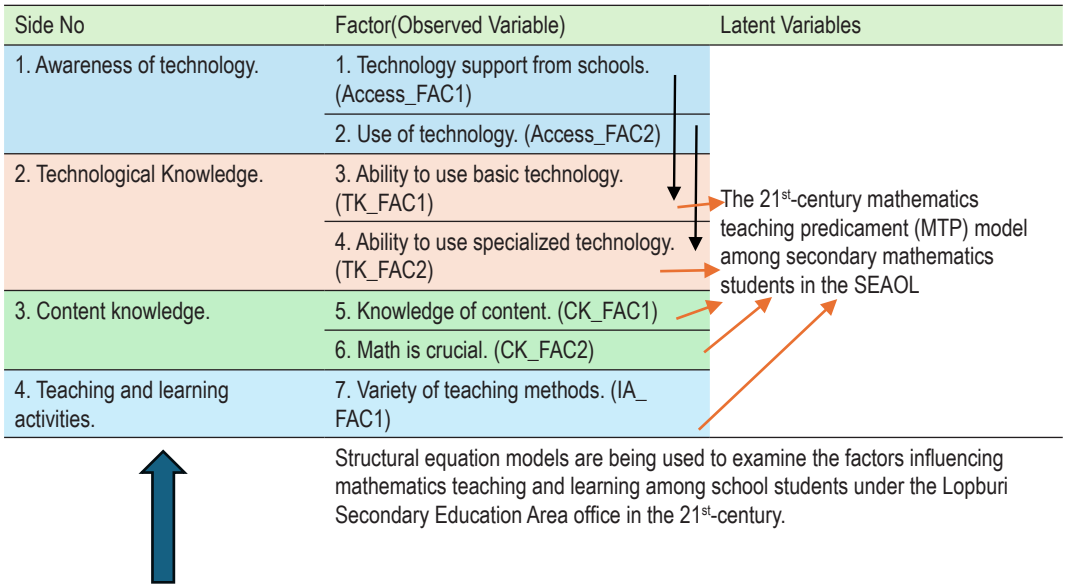
Research Conceptual Framework

Figure 1
Research Concept



Research Results

The distribution analysis of the data revealed that the Skewness values ranged from -0.869 to -0.146, while the Kurtosis values ranged from -0.410 to 1.819. These values indicate that the variables exhibit Skewness within the acceptable range of -3 to 3 and Kurtosis within the range of -10 to 10. Therefore, the variables demonstrated a normal distribution, as illustrated in Table 1.

Table 1
Presents the Values of Skewness, Dominance, Tolerance, and VIF for the Observed Variables

Observational variables	Skewness	Kurtosis	Tolerance	*VIF*
Access_FAC1	-0.622	-0.027	0.531	1.882
Access_FAC2	-0.869	1.819	0.718	1.394
TK_FAC1	-0.659	0.394	0.454	2.201
TK_FAC2	-0.157	-0.410	0.702	1.425
CK_FAC1	-0.146	0.440	0.553	1.808
CK_FAC2	-0.204	0.190	0.872	1.147
IA_FAC1	-0.369	-0.202	0.430	2.324

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The tolerance values range from 0.430 to 0.872, while the *VIF* values range from 1.147 to 2.324. The tolerance values are all above the minimum threshold of 0.1, and the *VIF* values are all below the maximum threshold of 10. These findings indicate that there is a low level of correlation among the observed variables. Therefore, it can be concluded that the observed variables are independent of each other, and there is no issue of excessive correlation (multicollinearity) among the variables and (3) The *SEM* analyzing the factors influencing the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL were analyzed for their affirmative composition. The analysis considered standard element weight values and observed variables from the conformity analysis of the *SEM*. The results of the analysis indicate that the *p*-value index of χ^2, *CMIN/DF*, *GFI*, *TLI*, *CFI*, *NFI*, and *RMSEA* all meet the criteria. Therefore, it can be concluded that the *SEM* of factors influencing the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL is in accordance with the empirical data. These results are summarized in Table 2.

Table 2
Statistics for Model Conformity Check

Index	Acceptable value of consistency (criteria)	Statistics obtained
χ^2	$p > .05$	0.283
CMIN/DF	≤ 2.00	1.238
GFI	≥ 0.90	0.995
TLI	≥ 0.90	0.994
CFI	≥ 0.90	0.998
NFI	≥ 0.90	0.991
RMSEA	≤ 0.08	0.024

Table 3
Standard Element Weight Values of Observational Variables in SEM for Factors Influencing Mathematics Teaching in the 21st-century of Secondary School Students under the SEAOL

Organization/Variable	Standardized factor loading	*SE*	R^2	*PC*	*PV*
Students				0.80	0.500785
TK_FAC1	0.70	0.812	0.49		
TK_FAC2	0.25	0.388	0.06		
CK_FAC1	0.63	0.797	0.39		
CK_FAC2	0.21	***	0.05		
IA_FAC1	0.89	1.092	0.79		
TK_FAC1					
Access_FAC1	0.59	0.040	0.35		
TK_FAC2					
Access_FAC2	0.21	0.046	0.09		

Note: *** Mandatory parameters (Constrain)

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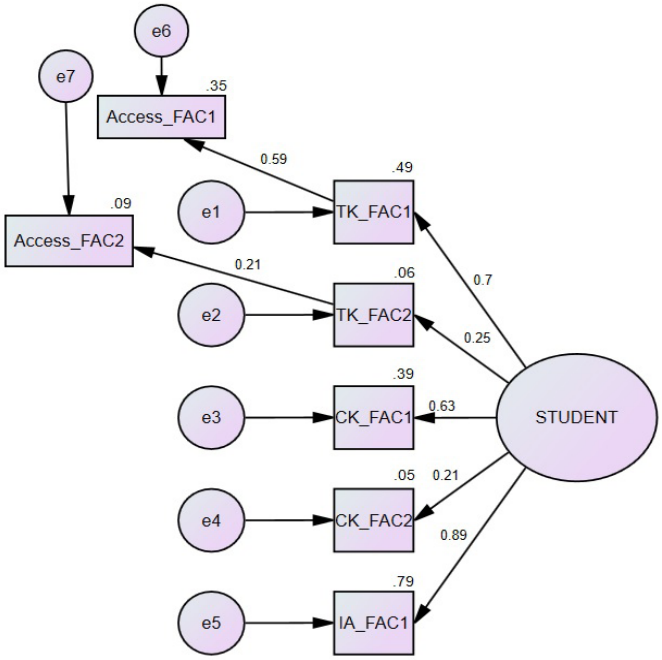
From the analysis presented in Table 3, the results indicate affirmative elements of the model. The *PV* was calculated to be 0.500785. Moreover, considering the precision statistics of the *PC* being greater than 0.60, it demonstrates that the teacher variable accurately captures 80% of the factors influencing mathematics teaching in the 21st-century among secondary school students. Additionally, the *PV* being greater than 0.05 signifies that the teacher variable accounts for 50% of the description of the factors influencing mathematics teaching among secondary school students. Factors supporting the use of technology from schools had a minimal influence 0.05 on students' ability to use basic technology. On the other hand, the demand for technology for learning showed a stronger influence 0.21 on students' ability to use specific technologies.

Figure 2
SEM of Factors Influencing Mathematics Teaching in the 21st-century



Chi-square = 7.429, df = 6, p = .283, Chi-square/df = 1.238, GFI = .995
TLI = .994i, CFI = .998, NFI = .991, RMSEA = .024

Figure 1 illustrates the influential elements on the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL. These elements include the ability to use technology from schools, content knowledge, the ability to use specialized technology, and mathematics content beyond what is necessary for implementation. Their respective levels of influence, in descending order, are .89, .70, .63, .25, and .21. School technology support has a .59 effect on students' basic technological skills. Technology's role in learning influenced students' technology use by .21.

Discussion

The research results indicate that, currently, the factors of teaching and learning exert the greatest influence on the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL. This can be attributed to the Ministry of Education's

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policy aimed at enhancing the quality of teaching management. The policy emphasizes reducing the duration of academic or theoretical classes while maintaining essential curriculum content that students should grasp according to established standards. It also grants teachers the flexibility to adapt teaching methods and organize learning activities, allowing students to engage in more practical and meaningful learning experiences. Under the initiative of the "reduced study time, moderate class, more knowledge" project, which aligns with the teaching and learning reform in the Thai era 4.0, the emphasis is placed on fostering meaningful learning for students. The focus is to create a relaxed and stress-free classroom environment where students have ample time for age-appropriate activities and explore their potential. Memorization of texts is no longer the sole focus; instead, teachers assume a reduced role in delivering direct messages to students. Their primary responsibility lies in organizing learning processes and activities that stimulate students' enthusiasm for learning and promote a diverse range of learning activities. Teachers are encouraged to adopt an active teaching approach, wherein they become facilitators of learning rather than mere information providers. This approach, known as active learning, involves organizing teaching activities based on established standards and indicators across all subject areas. Active learning methods are employed not only within the classroom but also in student development activities and other learning enhancement initiatives (Churches, 2016; Kharbach, 2015; March, 2012; & OBEC, 2019). Furthermore, Mazen (2021) has posited an alternative methodology for pedagogy and acquisition of knowledge that aligns with the OBEC Ministry of Education's principles, namely, the implementation of a constructivist approach to teaching and learning. The paramount objective is to direct the attention of pupils towards the acquisition and investigation of knowledge through the utilization of technology as the primary instrument for pedagogy and scholarship. The objective is to cultivate an ambience conducive to learning and foster a sense of curiosity that will enable students to independently generate novel insights. According to Gilakjani et al (2013) perspective, the limited involvement of teachers as mere mentors may pose certain obstacles for students in their pursuit of learning and executing tasks. Moreover, it affords learners the chance to engage in deeper contemplation or action at the crux of the topic, free from the encumbrances of computations or any extraneous elements that do not contribute to the learning process.

The second most significant factor influencing the teaching and learning of mathematics in the 21st-century among school students under the SEAOL is the integration of information technology in education and the effects of the COVID-19 situation on the educational landscape (Cristóbal et al, 2020). To effectively incorporate technology into teaching and learning and enhance teachers' abilities, three approaches are recommended. Firstly, policy guidelines should promote comprehensive and ongoing training programs that equip teachers with the necessary skills to effectively utilize technology as a medium of instruction. Secondly, educational institutions should encourage teachers to embrace information technology in their daily lives and integrate it into their teaching practices. Finally, this can be achieved by providing support and professional development opportunities for teachers in different subject areas and age groups who may require additional technology skills. By leveraging technology across various platforms, teachers can create learning environments that connect students to the outside world, fostering curiosity and enabling them to explore new and engaging content beyond the scope of traditional lessons. This approach emphasizes the importance of using technology as a tool to stimulate students' curiosity and prepare them for acquiring essential skills in today's era (Promsatien & Nettananomsak, 2021). The aforementioned statement aligns with the research conducted by Martinez (2022) and Paul and Tendeukai (2015), which suggested that incorporating diverse technological tools in the process of teaching and learning can expedite students' comprehension and improve their overall learning efficacy. Moreover, it facilitates the development of self-assurance among students and promotes an enjoyable learning experience. The utilization of technology in tandem with mathematical concepts must be achieved before progress can be made.

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The COVID-19 pandemic has presented an opportunity for innovative approaches in teaching and learning. As people were confined to their homes, remote learning became a prevalent method. As the situation improved, a blended learning model emerged, combining in-person and remote classes. It was observed that blended learning was the most suitable approach during the pandemic (Schvenger, 2018). Teachers had to adapt their teaching methods and processes accordingly. They transitioned from traditional classroom settings to a blended approach, requiring them to design and experiment with new teaching strategies. This shift had implications for various aspects, including classroom arrangement, teaching materials, instructional sessions, and assessments. It highlighted the need for improvements in learning assessment protocols and criteria (Promsatien & Nettananomsak, 2021).

Content literacy factors play a significant role in the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL. A strong foundation in mathematics content is crucial for successful learning outcomes in this era. Mathematics fosters creativity, logical thinking, systematic problem-solving abilities, and the capacity to analyze and determine solutions accurately. Moreover, mathematics serves as a vital tool for studying science, technology, and other disciplines, contributing to the development of skilled human resources and economic growth on an international scale. Consequently, continuous development of mathematics education is essential to remain current and aligned with economic conditions. With rapid advancements in science and technology in the era of globalization, achieving success in mathematics learning poses a significant challenge. Students need to be prepared to acquire knowledge, pursue career paths, or pursue higher education upon graduation. Therefore, educational institutions should tailor learning experiences to match the potential of individual learners. Mathematics is divided into three strands: number and algebra, measurement and geometry, and statistics and probability. These strands cover various topics such as the real number system, algebraic expressions, geometric figures, statistical analysis, and probability calculations. Additionally, mathematical skills and processes are essential for effectively applying knowledge in daily life. These skills encompass problem-solving abilities, communication through mathematical language and symbols, the utilization of mathematical knowledge as a learning tool, reasoning and critical thinking, and the cultivation of creativity to expand existing ideas and generate new knowledge (Institute for the Promotion of Teaching Science and Technology, 2019; OBEC, 2017).

Conclusions and Implications

Teaching and learning, fundamental technology capability, content knowledge, specialized technology use, and mathematical content implementation all affected mathematics teaching in the 21st-century for SEAOL students. Influence was .89, .70, .63, .25, and .21. School technology support has a .59 effect on students' basic technological skills. Technology's role in learning influenced students' technology use by .21. The factors of the ability to use specialized technology and mathematical content go beyond what is merely required for implementation. These factors, at the fourth and fifth levels of influence, significantly impact the teaching and learning of mathematics in the 21st-century among secondary school students under the SEAOL. This suggests that teachers' utilization of specialized technology to support teaching and learning is currently at a relatively lower level. However, it is crucial for teachers to incorporate specialized technology as it can enhance students' understanding of advanced mathematical concepts and their practical application in real-life situations.

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Recommendations

Recommendations for Utilization of Research Results

The findings of this research indicate the varying levels of influence of factors affecting the teaching and learning of mathematics in the 21st-century among school students under the SEAOL. Among these factors, the excessive mathematics content necessary for application has the least impact. It is recommended that teachers and relevant individuals engage in research and innovation to effectively integrate specialized technologies into teaching and learning practices. By doing so, students can better comprehend complex mathematical concepts and apply them in real-life situations. The introduction of technology as a valuable tool in teaching and learning should be facilitated through teachers who play a crucial role in guiding students' educational journey.

Suggestions on Conducting the Next Research

(1) For future research, it is recommended to collect data from larger populations, including regional and national samples. By comparing the differences in the influence of each factor on the teaching and learning of mathematics in the 21st-century across different regions, it will be possible to develop mathematics teachers in various areas of Thailand based on the specific strengths and weaknesses identified within each region.

(2) Another avenue for investigation would involve studying the relationship between each factor influencing mathematics teaching and learning in the 21st-century through the analysis of Structural Equation Models (*SEMs*) within different regions of Thailand.

(3) Additionally, exploring the readiness of mathematics teachers in educational institutions regarding the integration of technology, teaching methods, and content knowledge can be achieved through the analysis of *SEM*.

(4) Teachers and relevant stakeholders should conduct research and innovation in the utilization of specific technologies to enhance teaching and learning. For example, exploring the use of graphing calculators in mathematics instruction can be a valuable area of focus.

(5) Furthermore, it is suggested that teachers and related individuals conduct research on active learning approaches within different mathematics subject areas, considering grade levels. This could involve exploring Activity-Based Learning, Project-Based Learning, Experiential Learning, Problem-Based Learning, and other similar methodologies. The organization of these learning activities should revolve around a central concept: empowering learners to play an active role in their own education. When designing learning experiences, careful consideration should be given to the learner's characteristics, setting clear instructional goals, employing appropriate teaching methods and learning activities, and implementing effective assessment strategies.

Declaration of Interest

The authors declare no competing interest.

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Appendix 1

Factors Affecting Current Mathematics Teaching and Learning in SEAOL of Students

Effective mathematics education required	Variable, (Load score)	Factor
Awareness of technology (AC)	AC_215: Does your school or organization have a printer? (.695)	1. Technology support from schools. (Access_FAC1)
	AC_212: Does your school or organization support cloud storage, such as Google Drive or Microsoft OneDrive? , (.694)	
	AC_217: Does your school or organization prioritize programming in a particular language, such as Python, C, C++, or Java? , (.680)	
	AC_211: Does your school or organization have enough computers for use? , (.640)	
	AC_213: Does your school or organization support teaching software, such as Microsoft Office or Zoom Meeting? , (.625)	
	AC_214: Does your school have projectors? , (.624)	
	AC_216: Does your school or organization have high-speed internet access or Wi-Fi? , (.615)	
	AC_2111: Do you want to use technology in teaching because it helps create learning innovation and improves teaching and learning? , (.858)	2. Use of technology. (Access_FAC2)
	AC_2110: Do you want to use technology for teaching because it makes it easier for students to research and find information? , (.836)	
	AC_219: Do you want to use technology for teaching because it serves as an intermediary for communication both inside and outside the school or organization? , (.817)	
	AC_218: Do you want to use technology to teach because it helps students understand the lesson more concretely? , (.755)	
	AC_2112: Can knowledge of technology contribute to the efficiency of teaching and learning? , (.738)	
Technological Knowledge (TK)	TK_226: Can you communicate via the internet using tools like email, Line, or Messenger? , (.773)	3. Ability to use basic technology. (TK_FAC1)
	TK_221: Can you use a word processor such as Microsoft Word or Google Docs? , (.744)	
	TK_223: Can you use a presentation program such as PowerPoint or Google Slides? , (.693)	
	TK_2210: Do you believe that technological knowledge affects the teaching and learning of mathematics today? , (.689)	
	TK_228: Do you keep up with modern technology and constantly study its use? , (.644)	
	TK_227: You have the option to store a wide range of data, including flashcards, CDs, DVDs, Google Drive, or Dropbox., (.635)	
	TK_225: Can you program in a specific language, such as C, C++, Python, or Java?, (.823)	4. Ability to use specialized technology. (TK_FAC2)
	TK_224: Can you use dynamic geometry software such as GSP or GeoGebra? , (.809)	
	TK_229: Can you use specialized software as a medium for teaching mathematics, such as Scratch? , (.628)	
	TK_222: Can you use an electronic spreadsheet such as Microsoft Excel or Google Sheets? , (.605)	

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Effective mathematics education required	Variable, (Load score)	Factor
Content knowledge (CK)	CK_233: Can you apply your knowledge correctly? , (.838)	5. Knowledge of content. (CK_FAC1)
	CK_232: Can you explain the origin of the teachings? , (.835)	
	CK_231: Can you identify or explain the meaning of the subject matter being taught? , (.786)	
	CK_236: What do you think is the current content of mathematics instruction? Does it respond to learners' needs? , (.722)	
	CK_234: Are you always seeking more knowledge from up-to-date sources? , (.692)	
	CK_237: Do you believe that having complex math problems will affect the effectiveness of teaching and learning mathematics? , (.460)	
	CK_235: What do you think is the content of mathematics in secondary school that is currently being taught? Is there more than necessary for the future use of learners? , (.939)	6. Math is crucial. (CK_FAC2)
Teaching and learning activities (IA)	IA_246: Is technology important for stimulating and creating ideas to help learners better understand the subject matter of mathematics? , (.815)	7. Variety of teaching methods. (IA_FAC1)
	IA_247: Do you consider the selection of teaching techniques or methods suitable for presenting mathematics subject matter to make it easier for learners to grasp the concept of a lesson? , (.806)	
	IA_245: Do you believe that learners will feel more interested in the lesson when combining teaching styles with the use of technology? , (.802)	
	IA_248: Can using technology to create teaching materials that are appropriate to the context of mathematics content help learners build their own knowledge of those contents? , (.802)	
	IA_243: Are you satisfied when organizing teaching and learning activities that emphasize the exchange of knowledge between learners and learners or learners and teachers? , (.753)	
	IA_244: Are you satisfied when organizing teaching and learning activities where learners can create their own predictive messages? , (.710)	
	IA_242: Are you satisfied when organizing teaching and learning activities that focus on students practicing on their own?, (.613)	
	IA_241: Do you enjoy the narrative teaching method? , (.329)	

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