Journal of Education and Learning; Vol. 14, No. 2; 2025
ISSN 1927-5250 E-ISSN 1927-5269
Published by Canadian Center of Science and Education

The Development of a Blended Instructional Model Using Problem-Based Learning with Graphic Organizers to Enhance Systems Thinking Skills in Computational Science for Students in Lower Secondary School

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Received: June 9, 2024 Accepted: August 19, 2024 Online Published: November 29, 2024

doi:10.5539/jel.v14n2p209 URL: https://doi.org/10.5539/jel.v14n2p209

Abstract

The research objectives were to 1) study the current conditions, problems, and good practices regarding teaching and learning 2) develop a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school and 3) study the results of using the instructional model. The research and development process was divided into 3 phases. Phase 1; study the current conditions, problems, and good practices regarding teaching and learning, the sample group included 368 teachers and 11 teachers. Phase 2; develop a blended instructional model, the sample consisted of 8 and 7 experts, and Phase 3; study the results of using the instructional model, the sample consisted of 35 grade 7 students. Data were analyzed using basic statistics and hypothesis testing statistics. The research results found that 1) Current conditions and overall problems were moderate level. The good practices included blended learning methods, problem-based learning, and instructional media with graphic organizers 2) The blended instructional model using problem-based learning along with graphic organizers included 4 core components: principles, objectives, management of teaching-learning processes, and measurement and evaluation. Five experts evaluated and certified this instructional model as appropriate in all aspects at a high level. 3) The results of using the instructional model found that (1) the systematic thinking skills of students who studied using the instructional model overall post-test were significantly higher than pre-test at the .05 level. (2) Measuring students' learning achievement overall score post-test was significantly higher than pre-test at the .05 level. (3) students' post-test scores of the experimental were significantly higher than the control group at the .05 (4) students' post-test scores of the experimental were significantly higher than the control group at the .05.

Keywords: blended learning, graphic organizers, instructional model, problem-based learning, systems thinking skills

1. Introduction

Systems thinking is an important intellectual skill for learners in the 21st century. Learners who can think systematically and look deeper than what is happening and see the structure of that event. Systems thinking involves looking holistically and seeing the interconnectedness of various components and their cause-and-effect relationships that affect each other. This helps the person have a deeper understanding of the problem and its structure, which leads to decisions to solve problems that are different from before. It is a solution that does not cause new problems or make the problem more severe than before (Chidmongkol, 2017) related to the concept of Anderson and Johnson (1997) mentioning the principles of systems thinking characteristics that is thinking that looks at the big picture, creates a balance between short-term and long-term perspectives, accepts dynamism complexity related to the nature of the system, accept and use information from both quantitative and qualitative factors, remember that every component of the system is important and, the function of each part affects the whole. Steers (1977) defined systems thinking as seeing the overall picture, seeing the whole thing with a framework that sees related relationships rather than just seeing the cause and effect and seeing trends. The type of change is more

than just being seen superficially or superficially. This is in line with Senge (1994) who mentioned the importance of systems thinking as a universal language. It is a powerful problem-solving tool for communicating ideas on complex stories or issues. According to its definition and importance, systems thinking is a necessary skill for living in today's world. Thai people as global citizens should develop skills in this area as well. Moreover, systems thinking is also a component of a person's learning skills. 21st century (Panich, 2012).

However, Thai society state of still at a critical stage, which is a result of a lack of thinking skills. Many reasons or obstacles cause Thai children to lack thinking skills, starting with teaching styles and methods that emphasize teacher-centered. Most teachers still do not understand teaching methods to promote thinking skills in students. and lack of awareness of the importance of promoting thinking skills for students in courses that are unable to encourage and develop students to think. Most students still learn by memorizing and memorizing rather than analyzing the content of what they have learned (Susaoraj, 2013). In this regard, in organizing teaching and learning, the teaching and learning process does not allow students to use their full potential, especially without the cultivation of thinking and systematically seeking knowledge. Systems and procedures part of the problem of systems and procedures comes from the teaching style that emphasizes lecturing rather than practice to follow the specified content without consideration. The learner's learning ability results in the learner becoming bored, lacking enthusiasm for learning, not wanting to study that subject, and having lower academic achievement (Petcharak et al., 2012), which is consistent with the institution. National Institute of Educational Test Service (2014) found that at present the classroom atmosphere under traditional learning activities is teacher-centered. Play a role in providing knowledge by telling or describing student's lack of participation in learning. There is a lack of cooperation in working and the use of existing information technology in organizing teaching and learning activities is not effective. It is an important cause of students' lack of creativity, enthusiasm for studying and learning, and lack of systematic thinking. As a result, when teachers assign work in the form of pieces in every subject group. The student was unable to complete it on time or did not complete it as expected.

The encountered problems show that systems thinking is important to develop in students. The Ministry of Education has revised the basic education curriculum for the year 2008, science subject group. Revised edition (2017) to be consistent with the world of today especially the subject of computational science. It focuses on developing thinking skills, analyzing, and solving problems systematically, and step-by-step manner, and applying knowledge in computer science and information and communication technology to solve encountered problems effectively in real life (Institute for the Promotion of Teaching Science and Technology, 2017). From a study of concepts, principles, theories, and related research documents, it was found that integrated teaching and learning using problems as a basis and the use of graphic organizers as a teaching tool affects systems thinking through blended teaching and learning, Bonk and Graham (2006) stated that blended teaching and learning requires effective teaching and learning that combines face-to-face teaching and online teaching, it is a combination of various learning systems to solve various problems in learning. This is consistent with Donald (2003) who gave the meaning of blended teaching that is a combination of classroom learning and E-learning, Therefore, blended teaching is a teaching arrangement that is created from a combination of face-to-face teaching and online teaching. Taking into account the learner, environment, content, and situation in order to respond to learning and individual differences. The importance of problem-based teaching is organizing learning using problems as a tool to stimulate learners to be interested in knowing and wanting to study and research information to solve problems. The teacher may arrange situations for students to face problems and practice the process of analysis and problem-solving so that students will have a clear understanding of the problem and be able to use process skills that lead to problem-solving (Sintaphanon, 2015). Problem-based learning is a learning model that challenges students to "learn how to learn" to find solutions to real-world problems (Kasuga et al., 2022), Khaemmanee (2021) stated that teaching and learning are organized by using problems as a base. The teaching and learning environment uses problems as a tool to help students achieve learning goals. The teacher may lead students to face real problem situations. The teacher may arrange conditions for students to face problems and practice the process of analyzing problems and solving problems together as a group. This will help students gain a clear understanding of the problem. Palupi et al. (2020) concluded that from the results of their research the PBL model can be used as a framework that can improve students' cognitive skills. Teachers can choose the right strategy and create cooperative and problem-based learning to create interactive conditions in the classroom (Putri & Simbolon, 2022). Moreover, Barrows and Roblyn (1980) stated that teaching and learning using problems as a basis is teaching that aims to create understanding and find solutions. Problems are the starting point of the learning process and act as a motivator. Moreover, in the previous study of related research, it was found that problem-based teaching helps to promote higher-order thinking well. Systematic thinking is advanced thinking that requires complex thought processes and has a step-by-step thought process. Moreover, the graphic diagram, Khaemmanee (2021) explained the meaning that a graphic organizer is a mental map consisting of important ideas or information linked together in various

formats, which makes it possible to see the structure of knowledge or content. It is a technique that learners can use in studying, knowing a lot of different content to help understand the content easier, faster and remember for a long time. Dechakupt (2001) said that graphic organizers are a form of communication to present information obtained from systematic collection and understand easily, concisely, and clearly. Graphical maps are derived from raw data presentation or knowledge from various sources on a particular subject to compile information. Organizing data requires thinking skills. Samba, et al. (2020) found that the use of a graphic organizer strategy turns out to be more effective in improving students' critical thinking in basic science and technology. Graphic organizers helped students to learn meaningfully. The study also revealed that graphic organizers increased students' achievement in basic science. Despres (2004) mentioned the use of graphic organizers as a tool for teaching systems thinking. He stated that learners should consider practicing systems thinking including the objectives of thinking. Important causative factors and the criteria for consideration will be important in helping students understand the details of the content learned. The students must think and use graphic organizers as tools to connect ideas logically and expand the details of the knowledge according to the topic. The graphical layout will be complete, complete, and correct. In addition, the practice of creating graphic organizers also helps students develop valuable ideas in analyzing various causes. Therefore, the researcher developed a blended instructional model that integrated problem-based learning with graphic organizers to enhance systems thinking skills in the course of computational science for students in lower secondary school.

2. Method

2.1 Research Objectives

- to study the current conditions, problems, and good practices regarding teaching and learning that enhance systems thinking skills in computational science for lower secondary school
- to develop a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school
- to study the results of using the instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school

2.2 Research Hypothesis

- Students who learned with the instructional model had post-test scores on systems thinking skills measures higher than pre-test.
- Students who learned with the instructional model had post-test scores on academic achievement tests higher than pre-test.
- Experimental group students who learned with the instructional model had post-test scores on systems thinking skills measures higher than students in the control group.
- Experimental group students who learned with the instructional model had post-test scores on academic achievement tests higher than students in the control group.

2.3 Research Method

Research and development were used in this research that were conducted in 3 phases as follows.

Phase 1: Study of current conditions problems and good practices regarding teaching and learning that enhance systems thinking skills in the course of computational science for students in lower secondary school. There were divided into 3 steps: 1) study documents, principles, and concepts related to theories and research to synthesize the elements of the teaching model. 2) question teachers' opinions about the current condition. Problems of organizing teaching and learning that enhances systems thinking skills in the course of computational science for students in lower secondary school. The inquiry was collected from a sample of 368 people who were teachers in the course of computational science, at the lower secondary school level, under the Office of the Basic Education Commission. It uses multi-stage random sampling 3) Interview computational science teachers about good practices in teaching and learning that enhance systems thinking skills in computational science for students in lower secondary school. It interviewed the sample group consisted of 11 people who were teachers in the course of computational science for students in lower secondary school. It is under the Office of the Basic Education Commission, which is a leading school in teaching computational science. The cluster random sampling was selected for a sample group.

Research Instruments

- The opinion questionnaire for teachers who have been teaching computational science to students at the lower

secondary school level. The questionnaire consists of 5-point rating scale questions using the Likert type (Tairuakham, 2012). The consistency between the questions and the objectives and content by 5 experts, it was found that all questions could be used with an IOC value of 0.60–1.00.

- The interview for a Computational science teacher. It was a semi-structured interview concerning teaching and learning that enhances systems thinking skills in computational science to students at the lower secondary school level. The consistency between the questions and the objectives and content by 5 experts, it was found that all questions could be used with an IOC value of 0.80–1.00.

Data Collection and Data Analysis

- Phase 1: the sample group was selected to collect data. Then, separate the sample according to affiliation, and educational area level and proceed with data collection. Coordinators collected data through questionnaires and interview forms. The results of the questionnaire responses were analyzed by percentage, mean ($\overline{X}$), and standard deviation (S.D.) The results of the interview responses were analyzed by percentages and descriptive discussion.

Phase 2: Development of a blended instructional model using problem-based methods combined with graphic organizers to enhance systems thinking skills in computational science for lower secondary school students. There were 4 steps in proceeding as follows: 1) Creating (drafting) a blended problem-based instructional model combined with graphic organizers to enhance systems thinking skills. 2) Prepare a manual for using the instructional model. 3) Evaluate the suitability of the (draft) instructional model by experts. The 8 experts evaluated the appropriateness of the (draft) instructional model and were experts in Educational Technology and Communications, Curriculum, and Teaching of Computational Science, and Measurement and Evaluation. Experts were obtained by specific methods based on qualifications according to specified criteria. 4) Evaluate and certify the instructional model by 7 experts. Evaluate and certify the instructional model who were experts in Educational Technology and Communications, Curriculum, and Teaching of Computational Science, and Measurement and Evaluation. The qualified expert graduated with a doctorate degree and has teaching or working experience of more than 5 years, or is an author of academic textbooks or research whose work is accepted in the academic part. Qualified experts are obtained by specific methods according to qualifications and specified criteria.

Research Instruments

- The questionnaire to evaluate and certify the instructional model. The questionnaire consists of 5-point rating scale questions using the Likert type (Tairuakham, 2012). The consistency between the questions and the objectives and content by 5 experts, it was found that all questions could be used with an IOC value of 0.80–1.00.

Data Collection and Data Analysis

- Data were collected by the questionnaire to evaluate the appropriateness of the (draft) instructional model. Coordinators collected data with 8 experts via mail and online meetings according to appointments. Then, improved (drafted) the instructional model, and contacted and coordinated with 7 experts to evaluate and certify the instructional model via mail and online meetings according to appointments. Data were analyzed by percentage, mean ($\overline{X}$), and standard deviation (S.D.).

Phase 3: Study the results of using a blended instructional model using problem-based methods combined with graphic organizers to enhance systems thinking skills in computational science for lower secondary school students. This instructional model was conducted with grade 7 students, semester 2, the academic year 2022, of Phuphaman School, Phu Pha Man District Under the jurisdiction of the Khon Kaen Secondary Educational Service Area Office. A purposive sample was selected by purposive sampling. Then, a sample was randomized from grade 7 students in all 4 classrooms. There were 2 groups which were the experimental group and another control group. The experimental group was 35 students and the control group was 32 students. The content was computational science for grade 7 level which consisted the topics 1: Designing and Writing Algorithms, topic 2: Basic Design and Programming, Topic 3: Information Management, and Topic 4: Using Information Technology Safely. The experimental time was 20 hours.

Research Instruments

- The teaching plan with a blended teaching model using problem-based methods combined with graphic organizers to enhance systems thinking skills in computational science for lower secondary school students who were Grade 7 students. The time was 20 hours, 10 plans. The teaching plans were checked for quality by 5 experts. They evaluated the appropriateness of the learning management plan by the 5-level rating scale form based on the Likert method (Tairuakham, 2012). It was found that, overall, the determination of the

elements of the learning management plan has the highest level ($\overline{X}$ = 4.60, S.D.= 0.63), and the overall composition of the learning management plan has the highest level ($\overline{X}$ = 4.50, S.D.= 0.53).

- The measurement of students' systematic thinking skills pre-post learning. It is a subjective test that has 2 problem situations, divided into 6 problem situations. The scores were 2 points each. There was a total of 12 questions which were 24 points. The consistency between the questions and the objectives and content by 5 experts, it was found that all questions could be used with an IOC value of 0.80–1.00. This measurement was tried out with 33 students who studied in grade 7 and not in the sample. This set of exams had a difficulty level (P) between 0.44–0.69 and discrimination power (D) between 0.25–0.69. The confidence value using Cronbach's method (Srisa-at, 2010) The whole set has a reliability value of 0.71.
- The test to measure academic achievement for pre-post learning. It is a multiple-choice test with 4 options. The consistency between the questions and the objectives and content by 5 experts, was 40 questions that could be used with an IOC value of 0.60–1.00. This test was tested with 33 students who studied in grade 7 and not in the sample. This set of tests had a difficulty level (P) between 0.39–0.79 and discrimination power (B) between 0.25–0.69. The confidence value using the KR-20 test (Srisa-at, 2010). It was found that the reliability value was 0.97.

Data Collection and Data Analysis

- Data were collected in the following steps: 1) preparation stage, 2) experimentation and data collection stage, and 3) data collection and further data analysis. The scores of measuring systems thinking skills. and academic achievement measurements were analyzed by the mean ($\overline{X}$), standard deviation (S.D.), and percentage. The comparison of results of the pre-study and post-study tests by Hypothesis t-test dependent. It was analyzed by comparing post-study scores between the experimental group and the control group by testing the hypothesis t-test independently.

2.4 Ethical Considerations

This research study was approved by Mahasarakham University Ethics Committee for Research Involving Human Subjects (No. 270/2020, issued on 13 November 2020). All data were kept confidential.

3. Results

1) Study results of current conditions, problems, and good practices regarding teaching and learning that enhance systems thinking skills in computational science for lower secondary school students.

Current conditions regarding teaching and learning that enhance systems thinking skills. It was found that in the overall 3 aspects, the average was at a moderate level. ① Teaching methods ($\overline{X}$ =2.96, S.D.= 0.74), ② Teaching media ($\overline{X}$ =3.25, S.D.=0.53), ③ Measurement and evaluation ($\overline{X}$ = 3.26, S.D.=0.56).

Problems concerning teaching and learning that enhance systems thinking skills. Overall teaching methods were found that the average was at a high level ($\overline{X}$ = 3.50, S.D.=0.68). ① Teaching media was at a moderate level ($\overline{X}$ =2.75, S.D.=0.59), and ② Measurement and evaluation was also at a moderate level ($\overline{X}$ =3.24, S.D.=0. 63).

Good practices regarding teaching and learning that enhance critical thinking skills include blended teaching methods, Problem-based teaching and learning, and Teaching media with graphic organizers.

2) Development Results of a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school.

The blended instructional model using problem-based learning with graphic organizers model as in Figure 1 below.

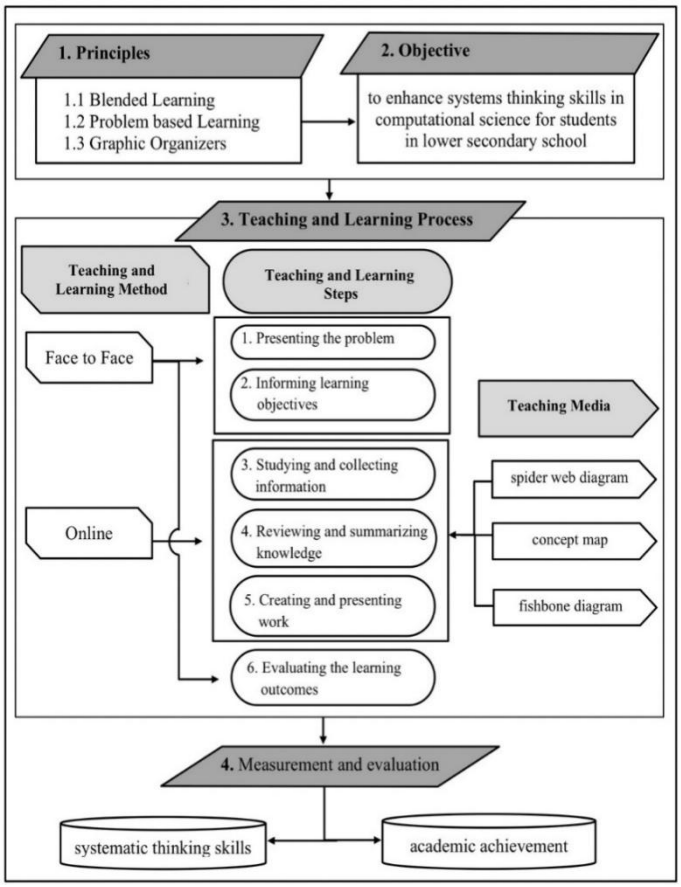

Figure 1. The blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school

This model Consisted 4 components including ① the principles of the teaching model, objectives of the teaching model, teaching and learning process, and measurement and evaluation. ② a blended teaching method that included face-to-face teaching and online teaching. ③ a problem-based teaching method with 6 steps including step 1: Presenting the problem, step 2: Informing learning objectives, step 3: Studying and collecting information, step 4: Reviewing and summarizing knowledge, step 5: Creating and presenting work, and step 6: Evaluating the learning outcomes. ④ Teaching media were 3 formats of graphic organizers: format 1: spider web diagram, format 2: concept map, and format 3: fishbone diagram. ⑤ Measurement and evaluation that included measuring systematic thinking skills and measuring academic achievement.

The results of the evaluation and certification of this blended instructional model using problem-based learning with graphic organizers model by 7 experts. Overall, every aspect was appropriate at a high level ($\overline{X}$ = 4.38, S.D. = 0.61).

3) Study results of using a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school.

Results of comparing the average scores measuring systematic thinking skills of students who studied using this blended instructional model between Pre-test and Post-test as in Table 1.

Table 1. The results of comparing the average scores measuring systematic thinking skills of students who studied this blended instructional model between the Pre-test and Post-test in the experimental group

Scores	n	$\overline{X}$	S.D.	df	t	p-value
Pre-test	35	13.97	2.26	34	20.87	.00
Post-test	35	21.54	2.02			

Table 1, shows the results of comparing the average scores measuring systematic thinking skills between the Pre-test and Post-test in the experimental group. It found that students who learned this blended instructional model had average scores post-test that were significantly higher than those Pre-test at the .05 level.

Results of comparing the average scores on the learning achievement test of students who studied using this blended instructional model between Pre-test and Post-test as in Table 2.

Table 2. The results of comparing the average scores on the learning achievement test of students who studied this blended instructional model between the Pre-test and Post-test in the experimental group

Scores	n	$\overline{X}$	S.D.	df	t	p-value
Pre-test	35	15.71	3.52	34	45.22	.00
Post-test	35	35.40	2.79			

Table 2, shows the results of comparing the average scores on the learning achievement test of students who studied using this blended instructional model between the Pre-test and Post-test in the experimental group. It found that students who learned this blended instructional model had average scores post-test that were significantly higher than those Pre-test at the .05 level.

The results of comparing the average scores measuring systematic thinking skills of students who studied this blended instructional model between Pre-test and Post-test in the experimental group and the control group students who studied normally as in Table 3.

Table 3. The comparison between the average systematic thinking skills scores of students in the experimental group and the control group students

	Experimental group			Control group			t	p-value
Scores	n	$\overline{X}$	S.D.	n	$\overline{X}$	S.D.		
Pre-test	35	13.97	2.26	32	13.50	2.24	.86	.36
Post-test	35	21.54	2.02	32	15.75	1.80	12.36	.00

Table 3 shows the results of comparing the average scores measuring systematic thinking skills of students who studied this blended instructional model between Pre-test and Post-test in the experimental group and the control group students who studied normally. It found that students' pre-test scores of the experimental and control groups were not different. Regarding students' post-test scores of the experimental and control groups. It found that students' post-test scores of the experimental were significantly higher than those of the control group at the .05.

The results of comparing the average learning achievement scores of students who studied this blended instructional model between Pre-test and Post-test in the experimental group and the control group students who studied normally as in Table 4.

Table 4. The comparison between the average learning achievement scores of students in the experimental group and the control group students

	Experimental group			Control group			t	p-value
Scores	n	$\overline{X}$	S.D.	n	$\overline{X}$	S.D.		
Pre-test	35	15.71	3.52	32	15.00	2.44	.96	.34
Post-test	35	35.40	2.79	32	25.41	4.19	11.59	.00

Table 4 shows the results of comparing the learning achievement scores of students who studied this blended instructional model between Pre-test and Post-test in the experimental group and the control group students who studied normally. It found that students' pre-test scores of the experimental and control groups were not different. Regarding students' post-test scores of the experimental and control groups. It found that students' post-test scores of the experimental were significantly higher than those of the control group at the .05

4. Discussion

1) Study results of current conditions, problems, and good practices regarding teaching and learning that enhance systems thinking skills in computational science for lower secondary school students.

Current conditions regarding teaching and learning that enhance systems thinking skills. The overall average was at a moderate level. Problems concerning teaching and learning that enhance systems thinking skills. Overall teaching methods were at a high level. Nowadays, teaching and learning management is based on student-center. Teachers design instruction with aptitude, interests, and individual differences. However, using technology in teaching and learning still has many limitations. Including, teaching and learning processes that help enhance thinking process skills at a low level. In particular, systematic thinking skills could support thinking, problem-solving, reasoning, and linking knowledge. Communication and presentation are necessary for living today and in the future, as Kochon et al. (2020) found administrators, teachers, and school personnel were aware of how to develop students' higher-order thinking. However, they still have the main problems due to the budget aspect. Lots of the content of the curriculum, and extra-curricular activities. Lecture-based instruction was approached in classes that did not support students' thinking. Moreover, Suwannasri (2017) found that science learning management still focuses on concepts in lesson content. Students lack opportunities for synthesis thinking to connect and create knowledge by themselves. They cannot answer using various methods based on new, different, and interesting ideas. They still lack self-confidence and interaction with classmates.

Good practices regarding teaching and learning that enhance critical thinking skills include blended teaching methods, problem-based teaching and learning, and teaching media with graphic organizers. Experts' interviews found that the guidelines used include ① blended teaching methods. Fitria Rahmawati (2019), found that the blended learning model was appropriate learning for students. Most students want to study online because of learning media, and interactive and challenging activities with many levels according to the learner's abilities. The curriculum is flexible. ② Problem-based teaching and learning. Lapuz and Fulgencio (2020), also found that problem-based learning is effective in improving student thinking skills, increasing the level of thinking skills, and improving the teaching-learning process. ③ Teaching media with graphic organizers. Lascaster (2013) studied the testing of using graphic organizers in teaching writing: A case study. The results found that graphic organizers were an effective technique for teaching writing. Students have better attitudes towards writing and have improved in word selection and organization.

2) Development Results of a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school. The results of the evaluation and certification of this blended instructional model by 7 experts. Overall, every aspect was appropriate at a high level. This is because this blended instructional model has been developed in a systematic, step-by-step manner. Each step is related to each other. This blended instructional model has developed based on concept synthesis, basic theory, and related research to be used as information for developing a blended teaching model using problems as a basis together with graphic organizers and to determine the elements. It is comprehensive and suitable for promoting systems thinking skills for students at the lower secondary school level. This blended instructional model has also developed from the research data in the first step concerning current conditions and teaching conditions that enhance systems thinking, good practices regarding teaching and learning that enhance critical thinking skills include blended teaching methods, problem-based teaching and learning, and teaching media with graphic organizers that each component is related. This concept is consistent with Vishwanath (2006), Dechakupt and Yindeesuk (2012) have explained that the teaching model represents systematic relationships of various processes The important processes or steps in teaching and learning are based on theory, principle, or concept. The model must be proven, tested, or otherwise adopted as effective. Determined according to the objective. Comprehensive design based on the elements to get the output according to the objective. This learning process is consistent with Ekthamasuth et al. (2022), who developed an instructional DGR model based on design thinking and reflective practice approaches. DGR model consists of the following five steps: preparation and inspiration, data discovery and problem identification, information retrieval and verification solutions, development and inspection of innovation prototypes, dissemination, and reflection on learning. Additionally, Sukkerd (2020) developed a history-teaching model to enhance systematic thinking for grade 9 students. The research results found that the History teaching model enhances systems thinking. There were 5 elements namely; principles of the model, objectives of the model, content, learning management, and measurement and evaluation. The evaluation results of the models' quality by experts including correctness, suitability, possibility, and usefulness that was at a high level. Onnang (2021) has also developed a teaching model by integrating learning concepts that focus on activities to enhance being an innovation creator in the Thai language subject which has 6 elements: principles, objectives, steps for organizing learning activities, media, and learning resources that support the use of the model, roles of learners and teachers, Measurement and evaluation with the results of the suitability assessment at the highest level. Husin et al. (2016) studied the POPBL model with a STEM education approach that supports students' 21st-century skills. The study results provided evidence that the application of the POPBL model in STEM education programs can help increase students' 21st-century skills by teaching them how to solve problems

and gain experience through project work that is based on accuracy and real life.

3) Study results of using a blended instructional model using problem-based learning with graphic organizers to enhance systems thinking skills in computational science for students in lower secondary school. The results of measuring systematic thinking skills and the learning achievement of students who studied using this blended instructional model between pre-test and post-test in the experimental group. Both systematic thinking skills and learning achievement post-test were significantly higher than those pre-test at the .05 level. This is because the instructional model is conducted through a design process and systematic operation. The instructional model used has a clear sequence of steps and coherent elements. In addition, teaching methods are used to write learning plans that help students be enthusiastic and interested in learning. Students learn systematically and problem-solving practice thinking, and clear planning, including the use of graphic organizers to make students develop systematic thinking skills, holistic thinking, causal thinking, and creative problem solving are improved, as Stephan, et al. (2018) developed systems thinking within the area of Education for Sustainable Development (ESD) using the Practice problem-solving skills. The research results found that systems thinking was an important competency in Education for Sustainable Development (ESD) because it can help students understand the complexity and dynamics of natural systems, social, and economic, and was tested on their systems thinking and content knowledge which was a different test. It found that both variables would be promoted effectively. This depends on the model of teaching and learning. Moreover, Raved and Yarden (2014) developed a model of systems thinking in biology by combining three models. The research results found that students learned through the aforementioned teaching tools and strategies, and students were significantly more capable of analyzing system components and processes. Including, being able to identify relationships between levels of the system. Fanta et al. (2020) developed students' systems thinking by designing activities in 3 courses to enhance systems thinking. It was found that the activities helped to strengthen systems thinking in all curriculum groups that were designed to be compared with the control group. Bara and Xhomara (2020) show the correlation between problem-based learning and academic achievement. It shows that student-centered learning and problem-based learning significantly affect academic achievement.

5. Conclusion

The results of this research show that a blended instructional model using problem-based learning with graphic organizers could enhance systems thinking skills and academic achievement of students effectively. The instructional model can also be applied to provide students with other necessary skills in the twenty-first century. They should study the manual for using the instructional model to understand. There should be preparation in various aspects before using the model, such as the readiness of the network system, media, equipment, and technology to ensure smooth teaching and learning. Prepare learners for using the online learning system, using applications, using programs to design graphic organizers and presentations to make teaching and learning as efficient as possible.

Acknowledgments

This study is a part of the researcher's doctoral degree. The dissertation has been thoroughly reviewed and advised by the dissertation advisor and the dissertation committee. The researcher has incorporated their valuable suggestions and recommendations to improve and finalize the dissertation.

Authors' contributions

Pimdee, S.: Conceptualization, data acquisition, drafting the manuscript, Data analysis, translation of the manuscript, and editing/reviewing. Seechaliao, T.: Editing/reviewing, supervision, and critical revision of manuscript.

Funding

Not applicable.

Competing interests

Not applicable.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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