Active Problem-Based Learning through Cloud Technology to Promote the Computational Thinking of Grade 12 Students

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ABSTRACT: *Active problem-based learning through cloud technology aims to promote the computational thinking of Grade 12 students to effectively meet the demands of learners in the technological era and to align their learning with the curriculum. This approach enhances students' knowledge and the skills needed for the 21st century through the use of cloud technology. This research aims to: (1) design a problem-based active learning process using cloud technology to promote the computational thinking skills of Grade 12 students, and (2) evaluate the implementation of the problem-based active learning model through the use of cloud technology to enhance the computational thinking skills of Grade 12 students.*

The research findings revealed that the design of a problem-based active learning approach through the use of cloud technology to promote computational thinking, as evaluated by experts, was deemed highly appropriate overall (M = 4.68, SD = 0.47). It can be concluded that the design of problem-based active learning through the use of cloud technology to enhance the computational thinking skills of Grade 12 students is highly suitable in terms of meeting their needs, and can serve as a framework for learning management aimed at promoting students' ability to seek knowledge and create their own understanding effectively through the use of cloud technology.

Keywords: Problem-based Learning, Active Learning, Cloud Technology, Computational Thinking

1. Introduction

In the digital era, where technology plays a critical role in every sector of society, the development and use of computational thinking skills have become increasingly essential. The development of this ability not only helps students solve problems in an organized and creative manner but also serves as a crucial foundation for learning and working in the 21st century, a time filled with change and innovation. This is especially true for high school students, who are preparing for higher education and entering a highly competitive workforce. At this stage, understanding system thinking, data analysis, and model creation will give them an advantage in facing real-life situations. However, despite its significance, the development of such skills remains a major challenge in the Thai educational system, in that it faces numerous obstacles such as curricula that do not respond to new learning approaches, or a shortage of teachers with expertise in these techniques. Therefore, it is time for us to collaborate in improving the education system to fully support and promote these skills, preparing students to confidently step into the future and succeed (Office of the Education Council, 2017).

Problem-Based Learning (PBL) and Active Learning are recognized teaching methodologies that are effective in developing higher-order thinking skills (Panlumlers & Wannapiroon, 2015). Including computational thinking, these learning methods not only help students practice problem analysis, but also promote systematic thinking and establish a strong foundation for developing creative problem-solving skills (Kanoknitanunt et al., 2021). These components are crucial elements of the computational thinking process that can be applied in various everyday situations, including in work and being involved in complex decision-making. Developing these skills will enable learners to view problems from multiple perspectives and encourage them to experiment with new methods for finding solutions or approaches to problems (Phunaploy et al., 2021). Furthermore, it can lead to valuable innovations and increased creativity in the future. Therefore, emphasizing these learning methods is crucial in preparing learners to be capable individuals who can confidently face the challenges of the modern world (Rattanakha & Chatwattana, 2023).

At the same time, cloud technology has played a significant role in the reform of education by providing learners with the opportunity to access learning resources anytime and anywhere. Additionally, it supports collaboration and knowledge sharing among learners (Iamboonyarit et al., 2020). This aligns with the principles of Active Learning and Problem-Based Learning, as well as the integration of these approaches with cloud technology. (Phoyen, 2021). Promoting computational thinking skills remains an area urgently needing further research, particularly within the context of secondary education in Thailand. This phase of schooling is crucial for the development of students' skills and capabilities. The challenges faced in this area are multifaceted, including curricula that do not adequately respond to the real needs of the digital age, teaching methods that may be outdated or inappropriate, and assessment systems that lack flexibility and fail to truly reflect analytical thinking abilities.(Golov & Myl'nik, 2022) For example, the current Thai secondary curriculum may focus too heavily on academic content without connecting to real-world situations or the use of modern technologies, causing students to feel that their learning lacks relevance (Wannapiroon et al., 2023). Moreover, traditional teaching methods often lead to boredom and a lack of motivation for learning. Many students find themselves uninspired, while the evaluation system may rely solely on surveys, without considering the thinking process and problem-solving methods (Chimmalee & Anupan, 2022) used by the students. Therefore, further research into approaches for presenting content, developing innovative teaching methods, and designing appropriate assessment systems is crucial. This will enable students to develop computational thinking skills effectively, and prepare them for the future world (Amornrit et al., 2018).

Therefore, research to develop a learning model that integrates problem-based learning and active learning with cloud technology is crucial for enhancing the computational thinking skills of Thai students. This will prepare young people to cope with the rapidly changing and dynamic digital world, while contributing to the sustainable development of the nation in the future. Providing young people with proper training and skills in information technology, such as using online tools or social media platforms, will enable them to adapt effectively to various situations. Furthermore, they can become a driving force for presenting innovative ideas that will positively impact on society and on the economy of the country. This will not only help young people grow into responsible citizens, but also contribute to building a bright and stable future for everyone in society (Office of the Basic Education Commission, 2019).

2. Purpose of the Research

1. To design the Active Problem-based Learning through cloud technology to promote the computational thinking of Grade 12 students in Thailand.
2. To evaluate the Active Problem-based Learning through cloud technology to promote the computational thinking of Grade 12 students in Thailand.

3. Literature Review

3.1 Problem-based Learning (PBL)

Problem-based Learning (PBL) refers to a learning environment in which problems drive the learning process in a context in which students are presented with problems they must solve, requiring the access of new knowledge to arrive at a solution. This approach emphasizes active participation and critical thinking on the part of students, and is an adaptation of traditional learning methods (Panlumlers & Wannapiroon, 2015). PBL focuses on encouraging students to research and understand a particular problem, followed by planning their learning and creating solutions based on the curriculum or on relevant content. The knowledge gained in answering these questions, while utilizing research findings to address societal issues, helps students discover new alternatives in the process and solve the problem under consideration (Kanoknitanunt et al., 2021). PBL also encourages students to engage with complex,

poorly-structured problems, fostering a deeper understanding and the retention of knowledge. By working in groups, PBL helps develop teamwork skills and encourages learning supported by peers in the classroom (Rattanakha & Chatwattana, 2023).

3.2 Active Learning

The Office of the Basic Education Commission defines active learning as a learning approach that emphasizes student interaction with the teaching process through higher-order thinking, which involves analysis, synthesis, and evaluation. Students are not only passive listeners. Rather, they are required to read, write, ask questions, and engage in discussion. Active participation is encouraged, where students engage in practical tasks while making use of previous knowledge and being aware of individual learning needs. As a result, students shift from being passive recipients of knowledge to active contributors to the creation of knowledge (Iamboonyarit, et al., 2020). It is stated that teaching and learning management refers to the conditions or characteristics of an organized teaching process based on philosophies, theories, principles, concepts, or beliefs. The process or steps in the teaching and learning process involve the use of various teaching methods and techniques to ensure that those working in the learning environment follow established principles (Phoyen, 2021). It outlines the processes and steps used in the research, and indicates that the procedure involves five main steps. These are as follows 1) Define the Problem 2) Understand the Problem 3) Conduct Research 4) Engage in Synthesis and 5) Evaluate the Results (Amornrit et al., 2018).

3.3 Active Problem-Based Learning

Problem-Based Learning combines with Active Learning it creates a comprehensive learning experience in which learners think critically, analyze, take action, and reflect independently. This integration fosters deep understanding and enables the authentic application of knowledge in real-life contexts.

3.4 Cloud Technology

Cloud technology refers to the use of cloud services in support of teaching and learning processes which have advanced significantly in terms of technology. Examples of cloud-based tools used in education include Gmail, Hotmail, Yahoo Mail, Wordpress.com, Slideshare.net, YouTube, Google Docs, Pixlr.com, Facebook, Wiki, and Google Group (Wannapiroon et al., 2023). Cloud-based learning management refers to the use of the internet network to facilitate learning anytime and anywhere, allowing students to access information independently. It also enables sharing and collaboration with others within an online environment, using various devices without time restrictions. Examples of cloud-based tools used in teaching and learning (Børte et al., 2023).

3.5 Computational Thinking

Computational thinking is the ability to solve problems. This process begins with understanding the problem using logical reasoning, leading to a problem-solving process with a sequence of steps that can be followed (Kheawkham et al., 2022). Computational thinking is a thinking process that requires the use of skills and techniques to solve problems, with a step-by-step approach and solutions that must be presented in a way that the problem solver can follow efficiently. This approach allows the stepwise concept to be applied in solving abstract problems involving large amounts of data, and enables reasoning based on this data (Srichamnong et al., 2020). Computational thinking is foundational knowledge for the field of computer science found in introductory programming courses. It is a fundamental process in developing problem-solving skills that will help improve student understanding of programming (Richardo et al., 2023).

Based on the related documents and research, the research framework is summarized, and the framework used in the research is shown in Figure 1.

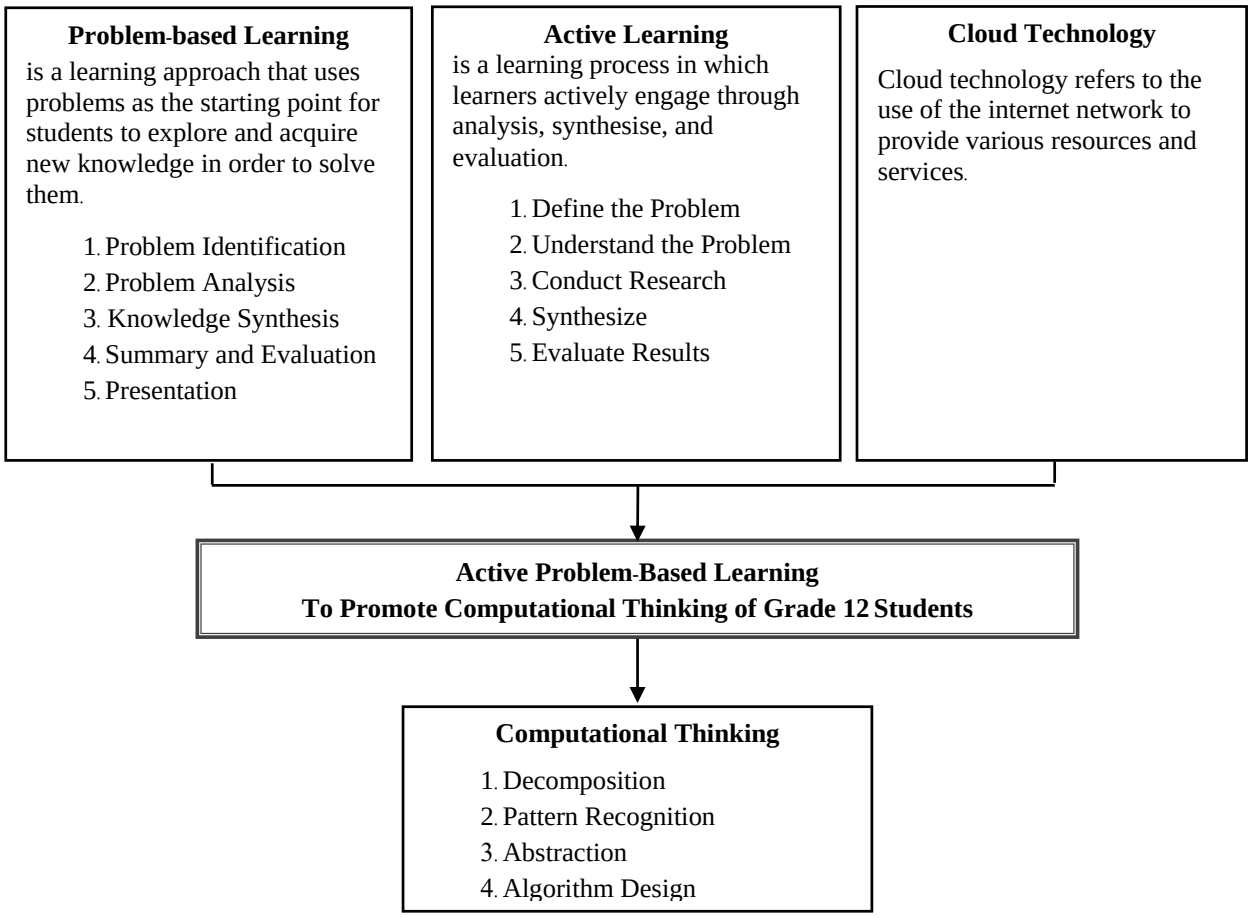

Figure 1. The conceptual framework active problem-based learning through cloud technology to promote computational thinking of Grade 12 students

4. Methodology

In conducting the research to develop active problem-based learning through the use of cloud technology to promote computational thinking of Grade 12 students, the researcher divided the research process into a number of discrete steps. The synthesis of active problem-based learning through the use of cloud technology to promote computational thinking of Grade 12 students can be divided into 5 parts as shown in the table 1-5.

4.1 Synthesis of the Problem-Based Learning Process

Table 1. Synthesis of the Problem-Based Learning Process

Problem-Based Learning	(Rattanakha & Chatwattana, 2023)	(Panlumlers & Wannapiroon, 2015)	(Kanoknitanunt et al., 2021)	(Phunaploy et al., 2021)	(Amin et al., 2021)	(Simanjuntak et al., 2021)	(Sari et al., 2021)	(Aryan et al., 2023)	**Synthesis Results**
1. Problem Identification	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Problem Definition	✓	✓	✓	✓	✓	✓	✓		
3. Problem Analysis	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. Understanding and Discussion	✓	✓	✓	✓	✓	✓	✓	✓	
5. Collaboration and Research	✓	✓	✓	✓	✓	✓	✓		
6. Knowledge Synthesis	✓	✓	✓	✓	✓	✓	✓	✓	✓
7. Application of Knowledge	✓	✓	✓	✓		✓	✓		
8. Summary and Evaluation	✓	✓	✓	✓			✓	✓	✓
9. Presentation	✓	✓	✓	✓	✓		✓	✓	✓

As shown in table 1., the process of problem-based learning, synthesized by the researcher from a review of research documents, serves as a framework. The researcher has developed a problem-based learning approach consisting of five distinct steps.

Step 1) Problem Identification. The instructor will define problems that align with the learning objectives, course plan, study content, or topics of interest to the students. This preparation aims to engage students and help them analyze and understand the issues at hand.

Step 2) Problem Analysis. The step involves examining the root causes of the problem under consideration. Identifying the causes helps students to plan solutions more effectively. Analysis is considered a process of gathering data.

Step 3) Knowledge Synthesis. Students begin the process of independently examining the required data, using various research methods that encompass different strategies for solving the problem under consideration.

Step 4) Summary and Evaluation. Each student group will summarize their collaborative efforts and evaluate the quality of their work to confirm the relevance of the data they have researched.

Step 5) Presentation. It is essential for students to organize the data they have collaboratively researched in a systematic manner. Then, each group presents their research findings and the outcomes are evaluated by the instructor.

4.2 Synthesis of the Active Learning Process

Table 2. Synthesis of the Active Learning Process

Active Learning	(Amornrit et al., 2018)	(Wannapiroon et al., 2023)	(Phoyen , 2021)	(Iamboonyarit et al., 2020)	(Eickholt et al., 2021)	(Børte et al., 2023)	(Vale & Barbosa, 2023)	(Buitrago-Flórez et al., 2021)	**Synthesis Results**
1) Define the Problem	✓	✓	✓	✓	✓	✓	✓	✓	✓
2) Understand the Problem	✓	✓	✓	✓	✓	✓	✓	✓	✓
3) Create Evaluation Criteria	✓	✓		✓		✓		✓	
4) Conduct Research	✓	✓	✓	✓	✓	✓	✓	✓	✓
5) Reflect and Discuss	✓	✓	✓	✓	✓	✓	✓	✓	
6) Apply Knowledge	✓	✓	✓		✓	✓	✓		
7) Synthesis	✓	✓	✓	✓	✓	✓	✓	✓	✓
8) Make Suggestions for Improvement	✓	✓	✓	✓			✓	✓	
9) Collaborate and Engage in Ongoing Learning	✓	✓	✓	✓	✓	✓	✓	✓	
10) Continuously Improve	✓	✓	✓	✓			✓	✓	
11) Practice by Example	✓	✓	✓	✓	✓	✓	✓		
12) Make Group Presentation	✓	✓		✓	✓	✓		✓	
13) Close Discussion	✓	✓	✓		✓		✓	✓	
14) Evaluate the Results	✓	✓	✓	✓	✓	✓	✓	✓	✓

As shown in table 2., this active learning process, synthesized by the researcher from a review of research documents, serves as a framework. The researcher has defined a total combination of five steps.
Step 1) Define the Problem. The instructor will identify problems that align with the learning objectives, course plan, study content, or topics of interest to the students. This preparation aims to engage students and serve as the starting point for the process, stimulating their interest.

Step 2) Understand the Problem. Students need to use their thinking skills to examine the root causes of the problem under consideration. Identifying these causes will help plan the solution more effectively. Analysis is a process of gathering data. Therefore, students must have sufficient information to analyze the causes of the problem effectively.

Step 3) Conduct Research. Active learning is a process whereby students seek knowledge independently through questioning, information searching, analyzing, and synthesizing knowledge from diverse sources, leading to a deeper understanding. This enables them to find solutions and apply them in real-world situations.

Step 4) Synthesis. Advanced thinking processes involve students collecting, linking, and integrating data, knowledge, or ideas from various sources to create new understanding, develop concepts, or solve problems creatively through active participation in the learning process.

Step 5) Evaluate the Results. This is an important process for the instructor when it comes to evaluating students. It includes assessing both academic achievement and the students' skills in problem-solving. It does this through tests or demonstrations of how they address and solve the problem under consideration.

4.3 Synthesis of the Problem-Based Learning Process with the Active Learning Process

Table 3. Synthesis of Problem-Based Learning Process with the Active Learning Process

Problem-Based Learning	*Active Learning* / Classroom	Define the Problem	Understand the Problem	Conduct Research	Synthesis	Evaluate Results
Problem Identification	✓	✓	✓			
Problem Analysis	✓		✓	✓	✓	
Knowledge Synthesis	✓		✓	✓	✓	
Summary and Evaluation	✓			✓	✓	✓
Presentation	✓					✓

As shown in table 3., the Problem-Based Learning combines with Active Learning it creates a comprehensive learning experience in which learners think critically, analyse, take action, and reflect independently. This integration fosters deep understanding and enables the authentic application of knowledge in real-life contexts. In this research, the researcher has summarized the steps and methods in five steps. These are as follows:

1) Problem Identification. The instructor plays a key role in identifying problems that align with the learning objectives, lesson plans, course content, or the students' interests, with the aim of stimulating interest and promoting active participation. This process helps students analyze and recognize relevant issues effectively. and serves as an important starting point for fostering active learning.

2) Problem Analysis. Problem analysis is a process focused on examining and identifying the root causes of the problem under consideration. It enables effective planning for solutions. Students must gather sufficient data to form the basis for analysis and gain a deep understanding of the problem. This process is an essential step in developing systematic problem-solving skills.

3) Knowledge Synthesis. The focus is on encouraging students to seek knowledge independently, starting with questioning, verifying information, researching, analyzing, and synthesizing knowledge from various sources. This process aims to develop a deep understanding, enabling students to use the knowledge they obtain as a guide for effectively solving problems, and applying it in real-world contexts.

4) Summary and Evaluation. Each student group will collaboratively summarize their learning outcomes and evaluate the quality of their work to confirm the relevance of the data they have researched. This process reflects advanced thinking, where students gather, link, and integrate knowledge from various sources to create new understanding, develop ideas, or solve problems creatively.

5) Presentation. In this step, presentation and evaluation are crucial processes whereby students must organize the data from their collaborative research systematically before presenting their work to the instructor. This will serve as the basis for evaluating both academic achievement and the development of problem-solving skills, taking into account the methods of analysis, proposed solutions, and the individual student's participation throughout the entire process.

4.4 Synthesis of the Organizing of the Problem-Based Learning Process with the Active Learning Process

Table 4. Synthesis of Organizing Problem-Based Learning Process with the Active Learning Process

Problem-Based Learning Process with the Active Learning Process	**Instructor Role**	**Learner Role**
1) Problem Identification 1.1) Define the Problem 1.2) Understand the Problem	Define problems that align with the learning objectives, lesson plans, course content, or students' interests.	Analyze and recognize the relevant issues effectively.
2) Problem Analysis 2.1) Understand the Problem 2.2) Conduct Research 2.3) Synthesis	Problem analysis is a process focused on examining and identifying the root causes of the problem under consideration, which enables effective planning of solutions, along with the use of cloud technology.	Students need to gather sufficient data to serve as a foundation for analysis and a deeper understanding of the problem under consideration. They should also utilize cloud technology to analyze the problem using technological tools.
3) Knowledge Synthesis 3.1) Understand the Problem 3.2) Conduct Research 3.3) Synthesis	Assign problems to students and encourage them to collaborate and solve the problem as a group, while utilizing cloud technology.	Seek knowledge independently with the use of cloud technology, starting with questioning, verifying information, researching, analyzing, and synthesizing knowledge from various sources.
4) Summary and Evaluation 4.1) Conduct Research 4.2) Synthesis 4.3) Evaluate Results	Evaluate students' group work, reflection, and the use of various technological tools that contribute to summarizing the results.	Each student group will collaboratively summarize their learning outcomes and evaluate the quality of their work to confirm the relevance of the data they have researched.
5) Presentation 5.1) Evaluate Results	Consider the methods of analysis, the presentation of proposed solutions, and the students' participation throughout the entire process.	Each student group organizes the data from their collaborative research systematically and presents their work, followed by evaluation.

4.5 Synthesis of Computational Thinking Skills

Table 5. Synthesis of Computational Thinking Skills

Computational Thinking Skills	(Valls Pou et al., 2022)	(Boom et al., 2022)	(Richardo et al., 2023)	(Voon et al., 2022)	(Songkhram et al., 2020)	(Srichamnong et al., 2020)	(Kheawkham et al., 2022)	(Stewart et al., 2021)	**Synthesis Results**
1) Summarize and eliminate unnecessary data	✓	✓	✓		✓	✓	✓	✓	
2) Decompose	✓	✓	✓	✓	✓	✓	✓	✓	✓
3) Recognize Patterns	✓	✓	✓	✓	✓	✓	✓	✓	✓
4) Abstract	✓	✓	✓	✓	✓	✓	✓	✓	✓
5) Think Algorithmically	✓	✓	✓	✓	✓	✓	✓	✓	✓
6) Evaluate	✓	✓	✓		✓	✓	✓	✓	
7) Formulate General Principles	✓	✓		✓		✓	✓	✓	

As shown in table 5., the computational thinking skills synthesized by the researcher from a review of research documents serve as a framework for creating a problem-based active learning process. The researcher has defined a total of four steps for the development of computational thinking skills:
1) Decomposition**.** This involves breaking down a large problem into smaller, manageable parts**.** This helps in visualizing the problem structure clearly and solving it step-by-step**.** The instructor prepares a problem for students to engage their interest and helps them break down a larger problem into smaller issues**.**

2) Pattern Recognition**.** This involves identifying patterns or recurring trends in the problems or data, which helps predict outcomes or create effective solutions**.**

3) Abstraction**.** This involves extracting the key elements of the problem and ignoring unnecessary details**.** This allows for creating models or solutions that can be applied to similar problems**.**

4) Algorithmic Thinking**.** This involves designing a clear sequence of steps to solve the problem under consideration, allowing for writing code or explaining the problem-solving process systematically**.**

5. Results

5.1 The process of the design active problem-based learning through cloud technology to promote the computational thinking of Grade 12 students is as shown in Figure 2.

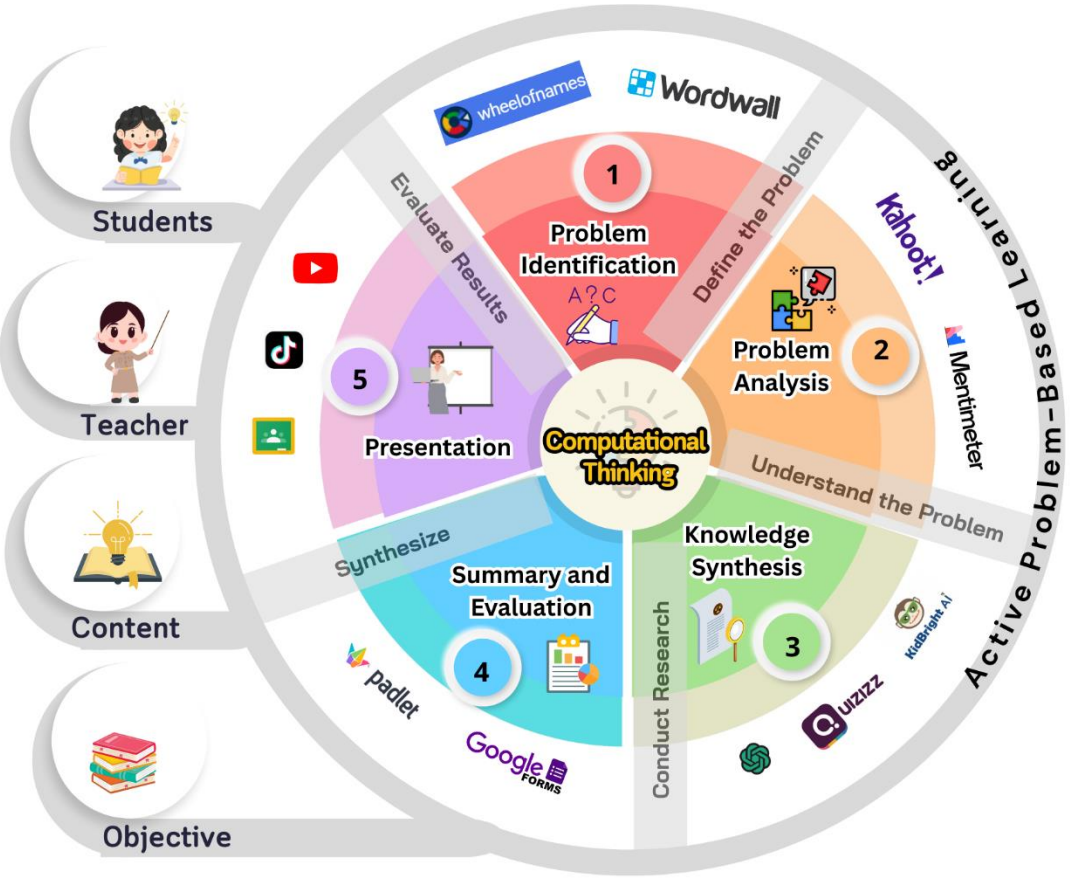

Figure 2. Active Problem-Based Learning

Figure 2 illustrates the process of active problem-based learning. It consists of four main components with the following details:
Component 1. Input: Step 1) Students, Step 2) Teacher, Step 3) Content, and Step 4) Objective

Component 2. Process of active problem-based learning. This is a process resulting from the integration of problem-based learning theory and active learning theory, with the following details:
2.1) Problem-based learning is divided into five steps as follows: Step 1) Problem Identification, Step 2) Problem Analysis, Step 3) Knowledge Synthesis, Step 4) Summary and Evaluation, and Step 5) Presentation

2.2) Active Learning is divided into five steps as follows: Step 1) Define the Problem, Step 2) Understand the Problem, Step 3) Conduct Research, Step 4) Synthesise, and Step 5) Evaluate Results

Component 3. Output. This is a direct outcome of the learning process that integrates problem-based learning with active learning to promote computational thinking skills. Computational thinking is divided into four steps as follows: Step 1) Decomposition, Step 2) Pattern Recognition, Step 3) Abstraction, and Step 4) Algorithmic Thinking.

Component 4. Feedback. The data collected, along with the analysis of student outcomes, expert feedback, and results from the learning process, will be reflected back into active problem-based learning to improve and refine the learning model, ensuring its suitability and the provision of maximum benefit.

5.2 The evaluation results of the suitability of the design and development of the learning process using active problem-based learning involving five experts. The experts involved possess qualifications in terms of knowledge, skills, and educational expertise, specifically in the following areas: Curriculum and Instruction and Computer Education.

Table 6. Evaluation results of the suitability of the design and development of the learning process

Assessment Issues	***Evaluation Results***		***Results***
	M	***SD***	
1. Input			
1.1 Students	4.60	0.55	Highest
1.2 Teacher	4.60	0.55	Highest
1.3 Content	4.40	0.55	High
1.4 Objective	4.60	0.55	Highest
2. Process			
2.1 Problem-Based Learning			
2.1.1 Problem Identification	4.80	0.45	Highest
2.1.2 Problem Analysis	5.00	0.00	Highest
2.1.3 Knowledge Synthesis	4.60	0.55	Highest
2.1.4 Summary and Evaluation	5.00	0.00	Highest
2.1.5 Presentation	4.80	0.45	Highest
2.2 Active Learning			
2.2.1 Define the Problem	4.60	0.55	Highest
2.2.2 Understand the Problem	4.60	0.55	Highest
2.2.3 Conduct Research	4.60	0.55	Highest
2.2.4 Synthesise	4.60	0.55	Highest
2.2.5 Evaluate Results	4.60	0.55	Highest
3. Output			
3.1 Computational Thinking	4.70	0.47	Highest
4. Feedback			
4.1 Result of Evaluation on Computational Thinking	4.80	0.45	Highest
Overall	**4.68**	**0.47**	**Highest**

As shown in table 6., the evaluation of the suitability of the design and the development of the learning process using active problem-based learning on the part of five experts indicated that they were highly suitable (M = 4.68, SD = 0.47). It can be concluded that the design and development of active problem-based learning through cloud technology to promote the computational thinking of Grade 12 students has suitable components that can be used as a

guideline for effective learning management, stimulating students to develop their computational thinking skills efficiently.

6. Discussion

Based on the results with regard to the design of active problem-based learning through cloud technology to promote the computational thinking of Grade 12 students, using PBL can be divided into five steps. These are as follows: Step 1) Problem Identification, Step 2) Problem Analysis, Step 3) Knowledge Synthesis, Step 4) Summary and Evaluation, and Step 5) Presentation. These steps align with the statement of Panlumlers & Wannapiroon (2015) and Rattanakha & Chatwattana (2023) who indicated that active learning is divided into five steps as follows: Step 1) Define the Problem, Step 2) Understand the Problem, Step 3) Conduct Research, Step 4) Synthesise, and Step 5) Evaluate the Results. This aligns with the statement of Amornrit et al. (2018) and Wannapiroon et al. (2023). This results in a teaching and learning model that is suitable for the curriculum and also meets the demand for the skills required in the 21st century. The research findings indicate that this learning model enhances computational thinking and aligns with the statement of Kheawkham et al. (2022) and Leela et al. (2019) and means that students are able to effectively use cloud technology at a basic level. They gather information and collaborate within their peer groups to find methods that they can use in order to create projects or works that can be applied in practice.

7. Conclusions

The evaluation of the learning process associated with active problem-based learning through cloud technology to promote the computational thinking of Grade 12 students, was conducted with the support of experts who assessed and provided recommendations for the design of the research. The findings revealed that this learning model enhances computational thinking on the part of students. The students were able to effectively use cloud technology at a basic level, and the results were efficient in terms of dealing with projects or works that could be applied in practice, directly addressing the problem under consideration and offering potential for further development. Moreover, it benefits both learners and instructors in education programs, aligning well with current contexts and technologies while also enhancing more effective learning.

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