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The Development of An Integrated Design-based learning Model, Based on Computational Thinking for Undergraduate Students with Participatory Action Research

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The objectives of this research were to synthesise knowledge about the components of integrated design-based learning based on computational thinking and to develop the integrated design-based learning model based on the computational thinking of the undergraduate students with participatory action research. A total of 42 Thai and international books, research studies, articles, and relevant documents to the research were synthesised and analysed with a systematic review technique. The integrated design-based learning model based on the computational thinking of the undergraduate students with participatory action research was acquired from this research. It was found that this learning model was integrated with three aspects of knowledge: design-based learning (DBL), computational thinking (CT), and participatory action research (PAR).

Keywords: *Participatory, Integrate, Design-Based Learning*, *Computational Thinking*

Introduction

Recently, Thai education has stepped into the 21st century which is the era of information technology. Global society has changed rapidly which is the result of the influence of 21st century skills which play significant roles and affect the instructional component, a fundamental part of learning. Teachers in the 21st century must adjust their teaching and learning techniques by encouraging the learner to engage in lifelong learning and contributing to their life, thinking, and IT skills which need practice and experimentation. Moreover, the teacher should have the appropriate theories for instructional management for the learners in higher education according

to the required standard, such as constructivism and cooperative learning which are very significant to the development of instructional management. This instructional management puts the students in groups to collaborate and interact aiming for the achievement of all members (Randy, Ken & Alan, 2014). Another interesting concept is instructional management applying design-based learning that emphasises the students' participation in the process of development, creation and evaluation of the designed work. It is considered the new learning pattern of Thai education, so the learning activities focus on work and design which makes the students proud of their learning achievement and they become more confident. The learning activities are a form of interdisciplinary integration which requires creative and technological innovation to resolve problems systematically. It might include the collaborative learning technique to create the interaction among the students that leads to active learning.

For the undergraduate students in the computer studies program, program coding is a required skill because it can be applied to advanced learning and enhance self-development for one's further career. Therefore, the design of the learning model is to develop the students in the computer studies program. These students must use critical thinking and problem-solving skills to identify the problem, develop the process to solve the problem and code the program for instructional management. Learning behaviour is the attribute of the student derived from learning via the activities based on the curriculum objectives. Moreover, the learning method depends on the teacher. The teacher should be capable in applying different components to create instructional management and reinforce the desired learning behaviour (Kantathanawat, 2020). Integrated teaching allows the student's brain to link all fields and subjects, and facilitates the learning of the entire brain which would encourage complete learning in terms of cognitive domain, psychomotor domain, and affective domain in order to apply knowledge and experience (Jedsadawiroj, 2003). There are many educational concepts that enhance the key skills of the students in this group and computational thinking is one of the skills which supports the students to have problem solving skills, such as logical sorting, data analysis and systematic problem solving.

From the significance mentioned above, the researcher studied the relevant literature and selected design-based learning management and computational thinking to synthesise and design the integrated design-based learning model based on computational thinking for the undergraduate students. However, the most crucial factor of instructional management is the learner or student who is at the centre of learning. Thus, the researcher applied participatory action research (PAR) in order to acquire the model to develop the achievement levels of students in the computer studies program.

Research Objectives

1. To synthesise knowledge about the factors of the integrated design-based learning of computational thinking.
2. To develop the integrated design-based learning model based on computational thinking for the undergraduate students with participatory action research.

Literature Review

Design-Based Learning (DBL)

Design-based learning (DBL) is a learning model which aims to allow the student to take part in the process of development, creation, and evaluation of the designed task. DBL, which is a new model in Thailand, is a form of instructional management involving interdisciplinary integration which requires creativity and technological innovation to resolve problems systematically. The activities focus on working and design to delight the student and make them proud of their performance and build their confidence as thinkers, designers, and practitioners. Numerous researchers have studied DBL and its process and illustrated the different steps (Kolodiner, 2002; Garden, 2010; Seitamaa-Hakkarain, 2011; Gerber & Marie, 2012). A summary is shown in Table 1.

Table 1: Synthesis of the design-based learning process

Design-based learning process	Proposed by			
	Seitamaa Hakkariainen	Garden	Vartiaimem *et al.*	Researcher
Identify needs		✓	✓	✓
Design review	✓	✓	✓	✓
Collect information	✓	✓	✓	✓
Prototype		✓		
Select the solution		✓		
Develop the model	✓	✓	✓	✓
Create the model	✓			
Production	✓		✓	✓
Evaluate		✓	✓	✓

From Table 1, the researcher summarised and classified the process into six steps: 1) Identify needs, 2) Design review, 3) Collect information, 4) Prototype, 5) Production, and 6) Evaluate.

Computational Thinking

Partovi (2006) defined that computational thinking was the practice of problem solving using computational thinking where the learner was the tool user and creator who could apply the thinking process to daily life and other fields. Program coding was an important tool for fostering fundamental skills such as systematical thinking, logical thinking, and error inspection which led to the development of computational thinking skills. The researcher synthesised and analysed the components from the related documents as shown in Table 2.

Table 2: Synthesis of computational thinking components

Proposed by	Components											
	Decomposition	Pattern	Abstraction	Algorithm	Tinkering	Collaborating	Creating	Debugging	Persevering	Logical	Representation	Evaluation
Hadi Partovi	✓	✓	✓	✓								
Wing, J. M.	✓	✓	✓	✓		✓			✓	✓		
Hylke H. Faber et al	✓		✓	✓	✓	✓						
Mark Dorling. Et al.	✓	✓	✓	✓								✓
Donna Kotsiopoulos	✓		✓	✓			✓				✓	
Aho, A. V.	✓		✓		✓			✓		✓		
David Barr, John Harrison el al			✓	✓						✓	✓	
Karen Brennan, Mitchel Resnick el al			✓					✓				
Aman Yadav, Chris Stephenson el al			✓	✓		✓					✓	
Peter J. Denning	✓	✓	✓	✓		✓				✓	✓	✓
Ljubomir Perkovic, Amber Settle			✓	✓		✓	✓				✓	✓
Cagin Kazimoglu, Mary Kiernan el al	✓		✓	✓			✓					✓
Ugur Kale, Mate Akcaoglu el al	✓	✓	✓	✓								
Lbrahim Cetin, Ed Dubinsky	✓		✓	✓						✓		
Mark S Goldman, Michale S Fee	✓		✓	✓	✓							
Bers, M. U., Flanney, L. Et al.	✓	✓	✓	✓								
Betal C. Czerkawski. Et al.	✓	✓	✓							✓		
Yu-Hui Ching, Yu-Chang Hus el al	✓	✓	✓	✓					✓			
Donna Kotsopoulos, Lisa Floyd el al							✓	✓	✓	✓	✓	✓
Sarah Gretter, Aman Yadav			✓	✓			✓			✓		✓
Manfred Eppe, Ewen Maclean	✓	✓	✓	✓								

Larisa Yu Ismailova	✓	✓	✓	✓		✓			✓	✓		
Leonard Albringht	✓		✓	✓	✓							

Table 2: Synthesis of computational thinking components

Proposed by	Components											
	Decomposition	Pattern	Abstraction	Algorithm	Tinkering	Collaborating	Creating	Debugging	Persevering	Logical	Representation	Evaluation
Jhon F Sanford	✓	✓	✓	✓								✓
Michael Kolodziej	✓		✓	✓			✓			✓		✓
Adriano Barate , Luca A Ludovice	✓	✓	✓	✓	✓			✓		✓		
William A Booth			✓	✓						✓	✓	
Wolfengagen, V. et al.	✓	✓	✓	✓				✓				
Denning, P. et al.			✓	✓		✓					✓	
Fabber, H. et al.	✓	✓	✓	✓		✓				✓	✓	✓
Kong, s. c. et al.	✓		✓	✓			✓					✓
Voogt J. et al	✓	✓	✓	✓			✓	✓				
Angelo, C. et al.	✓		✓	✓						✓		
Chalmers, C.	✓	✓	✓	✓					✓			
Atmatzidov, S. et al.	✓	✓	✓	✓					✓			
Suwanathat, P.	✓	✓	✓	✓								
Poolsawat, P. et al.	✓	✓	✓	✓								
Total	28	18	35	31	5	7	8	6	5	14	10	10

From Table 2, 37 relevant studies were analysed and synthesised to find out the components of computational thinking skills. It was found that most researchers prioritised four key components: 1) Problem decomposition - to facilitate problem solving, 2) Problem recognition - to consider the same solution to resolve similar situations, 3) Abstraction - to sort the significant quality from the details of the problem or task to obtain sufficient and precise components, and 4) Algorithm - the step of solution or the process of problem solving that can be explained in clear steps; what are the input and output. It was consistent with the concept proposed by Partovi (2006) except for the logical rationale. When considering the consistency with Component 4, the definition of the solution methodology was similar. Therefore, the researcher chose it to use in this research and renamed it as logical algorithm. Study results indicated that the computational thinking framework promoted the student to have different problem-solving processes such as logical sorting, data analysis, and solution creation. The integration of computational thinking and computer studies would help the student to solve and analyse the problem to finally reach the stage of program coding.

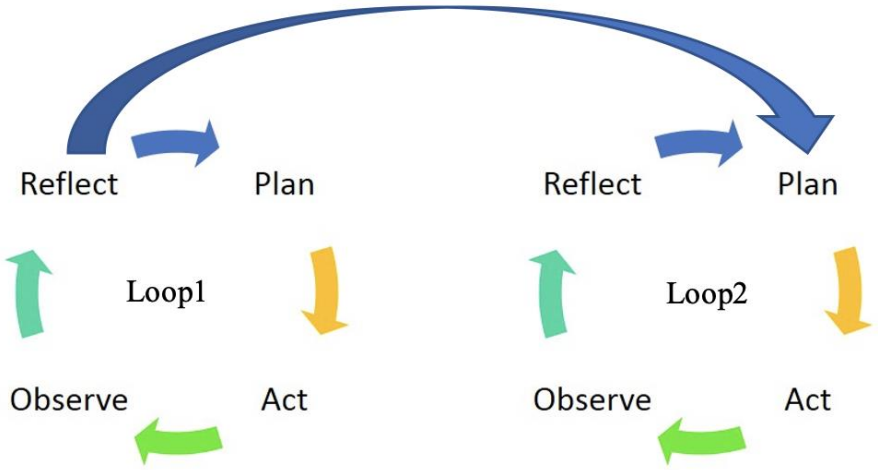
Participatory Action Research (PAR)

Participatory action research (PAR) is the research methodology which can assist everyone to gather together in groups, such as a group of students, teachers, or the owners of the problem, to collaborate efficiently. The application of this methodology is pure because it emphasises the participation of all people. PAR generally uses simple descriptive statistics and descriptive analysis to clarify data while quantitative and qualitative data are collected. The researcher who utilises PAR must take part in the activity from the beginning to the end as if he has the role in problem solving using experience to deal with the problem, or promoting something that aims to resolve the problem (Marrow, 1977; McTaggart, 1977; Kemmis *et al*., 2013).

From the above definitions, the researcher applied the concept of Kemmis and McTaggart (1998) that is the key theory in the cycle comprising four steps. First, Plan is to determine the learning activity and the expected learning plan via which the student gains knowledge from such activities involving the student and teacher. Second, Action is to implement the plan. Third, Observing is to compile data by observation during the implementation step. Fourth, Evaluating or Reflect is to reflect upon the observation result if there is any change or development by reporting to the relevant people.

Thus, the researcher summarised that participatory action research or PAR was the research in which the researcher took part and there was collaboration between the student and teacher, who had equal roles, to think and design the learning activity, and evaluate the performance. All the problem owners participated to find out the learning activity model and solutions from studying general information and in-depth information by analysing the problem and finding solutions, planning, and processing all steps together to obtain the optimal solution. The summary is shown in Figure 1.

Figure 1: Participatory Action Research (PAR) (Kemmis & McTaggart, 1988)



Research Methodology

This qualitative research applied a documentary research technique by studying the relevant documents, textbooks, research studies, and literature on design-based learning (DBL), computational thinking (CT) and participatory action research (PAR). The steps were as follows:

The researcher compiled documents, books, textbooks, research studies, and literature related to DBL, CT, and PAR in order to synthesise the information to obtain the key components of program coding skills development. The researcher retrieved the information from reliable online resources such as EBSCO, eBook Collection, ProQuest, Dissertation Theses, SpringerLink Science Direct eBook, and Scopus. The study was classified into two levels: the study from the books and the study from the research studies, articles, and academic papers which had been verified for reliability by considering the sources; it involved 5 Thai titles and 37 international titles. The key searching words were Design-Based Learning (DBL) and Computational Thinking (CT). All documents were issued during 2010 to 2020 only. The sources of information used in this research are shown in Table 3.

Table 3: Sources of data

Source	Type of Source	No. of Titles	Total
In Thailand	1. Research	4	5
	2. Article / Textbook / Book	1	
From other countries	1. Research	10	37
	2. Article / Textbook / Book	27	
		Total	42

5.2 The researcher studied the research studies and summarised the information before synthesising the content by linking it to DBL, the computational thinking framework, and PAR.

5.3 The researcher summarised the synthesis of knowledge about the components according to DBL, the computational thinking framework, and PAR. The analysis used the keywords and their definitions followed the systematic analysis process. The researcher collected and synthesised all information and summarised core knowledge.

Results and Discussion

The researcher summarised and discussed the synthesis results of knowledge about the integrated design-based learning based on computational thinking for the undergraduate students with participatory action research in three parts as follows:

1. Synthesis of design-based learning steps - From Table 1, the researcher synthesised the steps into six steps (Gerber & Marie, 2012; Seitamaa-Hakkarain, 2011; Garden, 2010; Kolodiner, 2002). (i) First, Identify needs, which was to understand the situation and problem in detail by analysing the conditions or limitations to choose the need to resolve and to determine the scope of needs that would lead to the solution. (ii) Second, Design review, which was to survey the readiness of teaching and learning comprising the learning environment, tools and equipment, and resources to develop the students. (iii) Third, Collect information, which was to compile all information and knowledge about the problems and needs such as knowledge about science, mathematics, and technology. Results should be recorded in order to use for developing the solution. The aspects to be researched should be determined before data collection which might involve questioning about the required items for the solution under the determined needs using a brainstorming technique. (iv) Fourth, Prototype, which was to apply the needs and information to develop the system or task so the student could trial before developing it for the actual work. (v) Fifth, Production, was to develop the work from the prototype step. (vi) Sixth, Evaluation, was to test and evaluate the efficiency of the method to determine whether it could resolve the problem or had any faults. Testing results might be used to improve and develop the work. The list of testing should be consistent with the objectives of the created work or method (Rattama, 2016; Gerber & Marie, 2012; Seitamaa-Hakkarain, 2011; Garden, 2010; Kolodiner, 2002).

The researcher recognized that the research methodology was consistent with the instructional management using design-based learning which enhanced the student achievement. The researcher synthesised the steps which are illustrated in Figure 2.

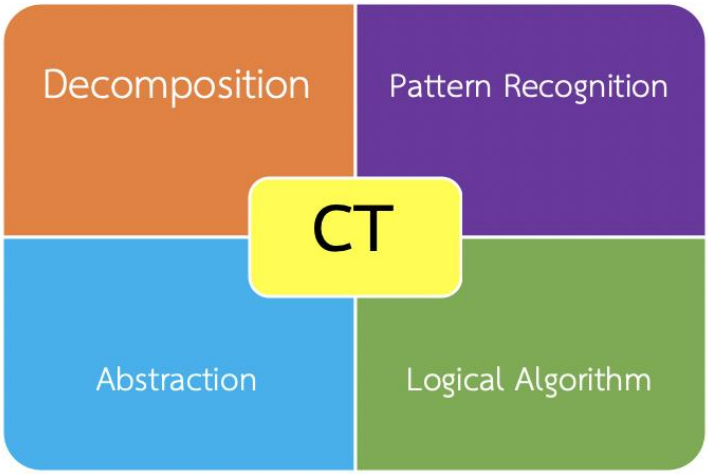
Figure 2: Steps of instructional management with design-based learning

2. Synthesis of computational thinking components - the researcher analysed and synthesised 37 relevant documents and found that they comprised four key components: Decomposition, Pattern Recognition, Abstraction, and Algorithm. However, when considering the consistency

of Component 4, Algorithm, it had a similar definition so it was used in this research and renamed as “Logical Algorithm”.

From the studies of various researchers (Chachiyo *et al*., 2020; Goldman & Fee, 2017; Pulsawat & Dokprakhon, 2016; Chalmers, 2015; Voogtj *et al*., 2015; Partovi, 2006), the researcher viewed that computational thinking was a useful skill that promotes the students to have analytical and rational thinking to resolve problems, such as logical sorting, data analysis, and systematic problem solving, as well as problem decomposition that can assist the student to deal with complex or open-ended problems. Computational thinking was very important for computer applications development. Meanwhile, it could be applied to resolve the problems in other subjects. Consequently, when computational thinking was integrated with the computer studies course, where the students must understand and have knowledge about program coding and information technology, the researcher believed that if the student had studied and understood its concept, they would be able to analyse and resolve the problems that would effectively lead to the step of program coding. The summary of the computational thinking concept is shown in Figure 3.

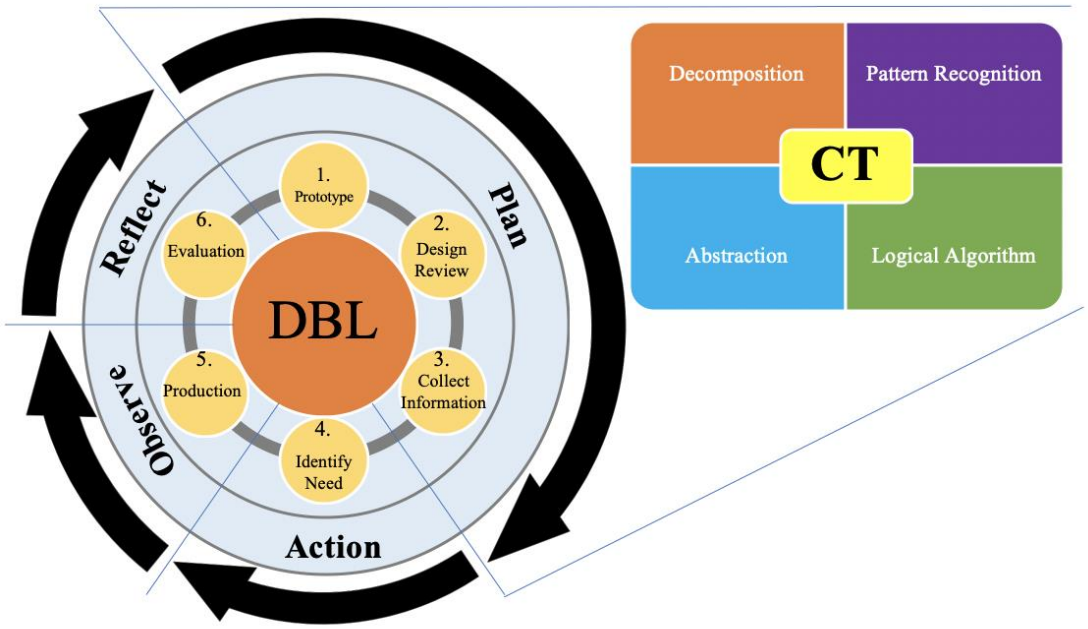
Figure 3: Components of the computational thinking concept



3. From the analysis results of the documents related to the instructional management using design-based learning (DBL), computational thinking (CP) and participatory action research (PAR), it was an interesting research methodology. Its fundamental feature was that everyone participated in all steps. Thus, the beneficiaries determined the goal to collaborate to make decisions, and to process and verify the results. Four steps were applied into this research based on the concept of McTaggart (1977), Kaewpikul (2016), Chaiakkarakal (2016), and Witsawakulwanitch (2014) which included Plan, Action, Observation, and Evaluation. Numerous researchers have applied PAR to their studies and obtained the optimal solutions. When integrating PAR to DBL and CT to develop the integrated design-based learning model

based on CT for the undergraduate students with PAR, the model could be summarised as shown in Figure 4.

Figure 4: The integrated design-based leaning model based on computational thinking (CT) for the undergraduate students with the participatory action research (PAR)



The integrated design-based leaning model based on computational thinking (CT) for the undergraduate students with the participatory action research (PAR) integrated three core aspects of knowledge. Firstly, Design-Based Leaning (DBL) that involved identifying needs, design review, collecting information, prototype, production, and evaluation. Secondly, Computational Thinking (CT) that utilised the four components as the fundamentals to deliver knowledge to the student including decomposition, problem recognition, abstraction, and logical algorithm. Thirdly, Participatory Action Research (PAR) which included the four steps of plan, action, observation, and evaluation or reflection. Consequently, the instructional management model was acquired to be used for the undergraduate students.

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