International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 13, Issue 8, 2020

Synthesising a Blended Learning Model with Problem Based Learning for Improving the Computational Thinking of Junior High School Students

Wassana Chachiyo[a], Paitoon Pimdee[b], Aukkapong Sukkamart[c], [a,b,c]Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Email: [a]wassana.y@pkru.ac.th, [b]paitoon.pi@kmitl.ac.th, [c]aukkapong.su@kmitl.ac.th

This study aims to synthesise Problem-Based Blended Learning (PBBL) to improve the computational thinking of junior high school students and evaluate the suitability of PBBL for improving computational thinking. The respondents included 10 experts in computers, digital technology, learning management, and research. The research tool was a suitability assessment form for learning. A group discussion was used to collect data. Mean and standard deviation were used to analyse the data. The research study shows that PBBL for improving the computational thinking of junior high school students consists of five important modules: instruction module, content module, student module, problem-based learning (PBL) module, and assessment module. The elements of PBBL for improving the computational thinking of junior high school students was carried out with a focus group discussion by experts and remained unchanged. The experts agreed on its suitability at the highest level. Therefore, PBBL can be applied for promoting and improving the computational thinking of junior high school students.

Key words: *Blended learning, Problem-based learning, Computational thinking.*

Introduction

In the 21st century, many changes and economic collapses have pushed the world into a creative-innovative economy. Economic inequality has wrecked the quality of life of the majority. The effects of climate change have threatened the existence of mankind. Thus, it is necessary to find solutions by implementing more technological innovations. Also, the educational segment needs to be changed in order to improve the people's understanding of sustainable living and to enhance their proficiency in using technology. The Organisation for Economic Co-operation and Development (2001) is aware that schools must prepare students to fit into a knowledge society by improving their thinking skills and skills in the fast and efficient solving of unpredictable problems. The New Commission on the Skills of the American Workforce (2007) think that students in the new century must become familiar with abstract thinking and thoughts which help students with analysis, synthesis, creativity, innovation, self-discipline, fast learning, good teamwork, and quick self-adjustment capabilities according to the changes of the labour market.

Thailand aims to develop its 4.0 economic model as set out in the Twelfth National Economic and Social Development Plan (B.E. 2560). All economic groups are supported with a digital technology base, so Thailand focuses on developing humans with science and technology knowledge, as well as high-level thinking skills in creating innovation and producing technology. In accordance with The National Education Act of B.E. 2542, Amendment (Rev. 2) B.E. 2545, and (Rev. 3) B.E. 2553, Section 22, the instructor should allow the learner to gain knowledge via activities that require a thinking process, situational simulation, and actual experience. This will enable the learners to think and take action by applying their knowledge to prevent and resolve problems, leading to the pursuit of greater knowledge. In line with this concept, the Basic Education Core Curriculum (B.E. 2551), was revised and updated in B.E. 2560. In particular, technology departments reviewed their computer courses to focus on computational thinking. Therefore, the instructors were able to set activities to enable the learners to apply computational thinking to resolve certain problems. This was similar to developing a thinking process like a computer, i.e., to control and command with computer language. Thus, the Basic Education Core Curriculum B.E. 2560 led technology departments to focus on the production of thinkers and technology inventors (with digital knowledge) to influence information technology and communication.

Wing (2006) views computational thinking as the skill which relies on the problem-solving process. System design, prioritised workflow process, as well as the understanding in human thinking behaviour are related to logic, analysis, and problem solving. Manovich (2013) sees humans as a digital population residing in a digital ecology filled with software-driven objects. The capability in managing computer language is a new skill which allows us to utterly and efficiently take part in the digital world. This new skill or Code Literacy is language

programming with code. Consistent with the Microsoft Cooperation (2015), it is believed that everybody can learn code language, and the computational thinking process is the essential skill which should be assigned in the learning and teaching of all schools with no restrictions to age, sex, or career. Thus, the use of the problem-solving process, consisting of both the problem and situation, is a learning activity which can improve computational thinking for junior high school students.

PBL is a form of learning through which the learner can create new knowledge from the problems encountered. The problem will be analysed to understand it and the problem-solving alternatives will be seen. In practice, the learner will gain experience in checking the problem-solving method. There are screening appropriate decision-making processes toward the selection of problem-solving methods. In addition, learning management in the 21st century (2006) focuses on the application of information technology and communication in education systems to enhance the efficiency and to pursue a standard framework for education management. Additionally, learners have changed from the traditional education era; they are now accustomed to the surroundings in which more technologies are used.

The online learning environment is beneficial for teachers' and students' roles. They can be interacted with online through teachers' class management processes, students' learning processes, and evaluation processes, which allow students to immediately self-evaluate and evaluate others. Blended-based learning is another method which supports online learning and face-to-face learning environments for students. Therefore, when the two concepts are integrated to form a learning format, it is found that the roles in searching for new knowledge by students and the process of improving the computational thinking of junior high school students are consistent.

Based on the reasons explained above, the authors want to synthesise the Blended Learning (BL) Model with Problem Based Learning for improving the computational thinking of Junior High School Students starting from studying documents and research studies in order to form the draft of the learning format. Then, this draft will be proposed to the experts in order to brainstorm opinions and evaluate the suitability of the learning format. This process results in a consistent and applicable form of The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students.

Research Objectives

1. To synthesise a BL Model with Problem Based Learning to Develop Computational Thinking of Junior High School Students
2. To evaluate a BL Model with Problem Based Learning to Develop Computational Thinking of Junior High School Students

Literature Reviews

Blended Learning (BL)

BL allows students to freely receive learning experiences via computer network systems through which they can control the learning variables: time, place, learning path, and self-learning rate (Horn & Staker, 2011). This is in accordance with Bernath (2012) who indicated that BL is a learning program resulting from the integration of e-learning and class learning. The researcher has synthesised this from the concepts of academics including Driscoll (2002); Bersin (2004); Allen et al. (2005); Carman (2005); Singh (2005); Alvarez (2005); Bonk et al. (2006). It's found that BL consists of nine elements:

1) learning environments, learning media and resources, learning objectives, learning substances, learning methods, hierarchy of learning, period of time, and learning assessment.

2) The integration of traditional class learning (face-to-face learning) and online learning which focuses on practical training. Around 30-79 percent of online teaching and the majority of media and learning resources are up to the online method.

3) BL programming might start and end with face-to-face activity in the classroom, depending on its suitability.

4) Learning and teaching activities should be supported with face-to-face practice, such as doing exercises in a textbook. Students may need online content, so it is necessary to prepare this with information technology skills and scaffolding.

5) There are various teaching activities which encourage cooperation and interaction.

6) There is preparation for online media and learning resources such as digital content, documents for download, etc.

7) Prepare tools to support online learning which allow students to cooperatively communicate online, such as chatrooms, webrooms, e-mail, etc.

8) Students are free to choose and perform self-controlled learning by focusing on learning feedback and students' constructivism.

9) Teachers act as learning facilitators who provide learning content and advice on online learning resources and encourage unrestricted student-teacher communication.

These elements of BL have many advantages. Students can freely manage their own learning time, place, and pace. They can communicate with teachers closely. By studying with multimedia, students have more time to search for information. They can analyse and synthesise information effectively, as well as transfer knowledge from one to the others. It allows them to get immediate feedback and creates inspiration in the lesson. It provides teaching and learning guidelines and allows students to review their lessons and search for new knowledge at any time. It can avoid class distractions which in turn helps students to focus on their lessons. It provides teachers and students with an accessible learning channel (Catlin R. et al., 2017).

Problem-Based Learning (PBL)

PBL is the learning process in which a problem is applied to encourage students to set a hypothesis, rationale, and mechanism of that problem. They also search for fundamental knowledge related to the problem which later leads to the solutions. Without knowledge in that topic, students may apply their existing knowledge. PBL is adapted from the theory of constructivism (Caine et al., 1994; 1997a; 1997b; Sylwester, 2005) which allows students to establish new knowledge from the problems occurring in the real world as a learning context. Students will have analytical thinking and problem-solving skills, and, at the same time, acquire knowledge according to their subject field. PBL results from the work process which mainly needs understanding and problem-solving. The problem is the essential element in PBL. Good problems can motivate students to look for knowledge in effectively examining those problems. Teachers need to consider students' basic knowledge and capabilities, experiences, interests, and background as people prefer paying attention to things related to them. They take interest in the meaningful, significant, and interesting things for them. Therefore, the determination of the problem needs to chiefly consider the students themselves, as well as environments and learning resources in and out of school which facilitate the students' knowledge seeking. What happens to the students is the processing of information at higher levels, such as with problem solving, critical thinking, inquiry strategies, and reflection on practice, which lead to deeper understanding (Perkins, 1992), self-direction (McComs, 1991), and enhanced retention and transferability of information and concepts (Bransford et al., 2000; Marzano, 2003; Marzano et al., 1989; 2001). What happens to teachers is the teaching of understandin,g which requires complex intellectual processes such as those involved in PBL including the need to analyse and process information and draw reasonable conclusions (Barell, 1995; 2003; Perkins, 1992).

Computational Thinking

Several academics have paid attention to computational thinking in its application to problem-solving concepts: i.e., Barr & Stephenson (2001); Wing (2006); Brennan & Resnick (2012); Grover & Pea (2013); Selby (2013); Kalelioglu & Gulbahar (2014); Lye & Koh (2014); ISTE (2018); NRC (2012); and IPST (2017). It is summarised that computational thinking is the thinking frame which digests big problems, recognises problem-solving formats and algorithms, and checks failures. It can be used with computers and other tools in order to solve the problems with rational organisation and data analysis procedures, abstract thinking for data analysis, algorithmic thinking, solution identification, and the transferring of this problem-solving procedure to further problems.

Computational thinking is always used in the computer subject because it works logically. Input will be processed for the assigned output if the process is correct. It becomes the root of

the human development concept of "computer-scientists," which needs coding or the correct programming of the computer's grammar and language structure for the desirable processed output. From its significance and benefits, the researchers have conducted the study for improving the computational thinking of students, examining the work of Burke and Kafai (2012); Devis et al. (2013); Franklin et al. (2013); Meerbaum et al. (2013); Hermans & Aivaloglou (2017). The researchers have designed the experiment for students to collaborate in computational thinking with computer tools in the computer subject. The computer will work on loops, under the conditions, variables, and functions as commanded. Students will start using computational thinking with the problem analysis process in order to find the root cause, place the solution plan, convey it into a diagram or chart, program the computer, and check for failure with testing for the most accurate outputs, respectively.

Research Method

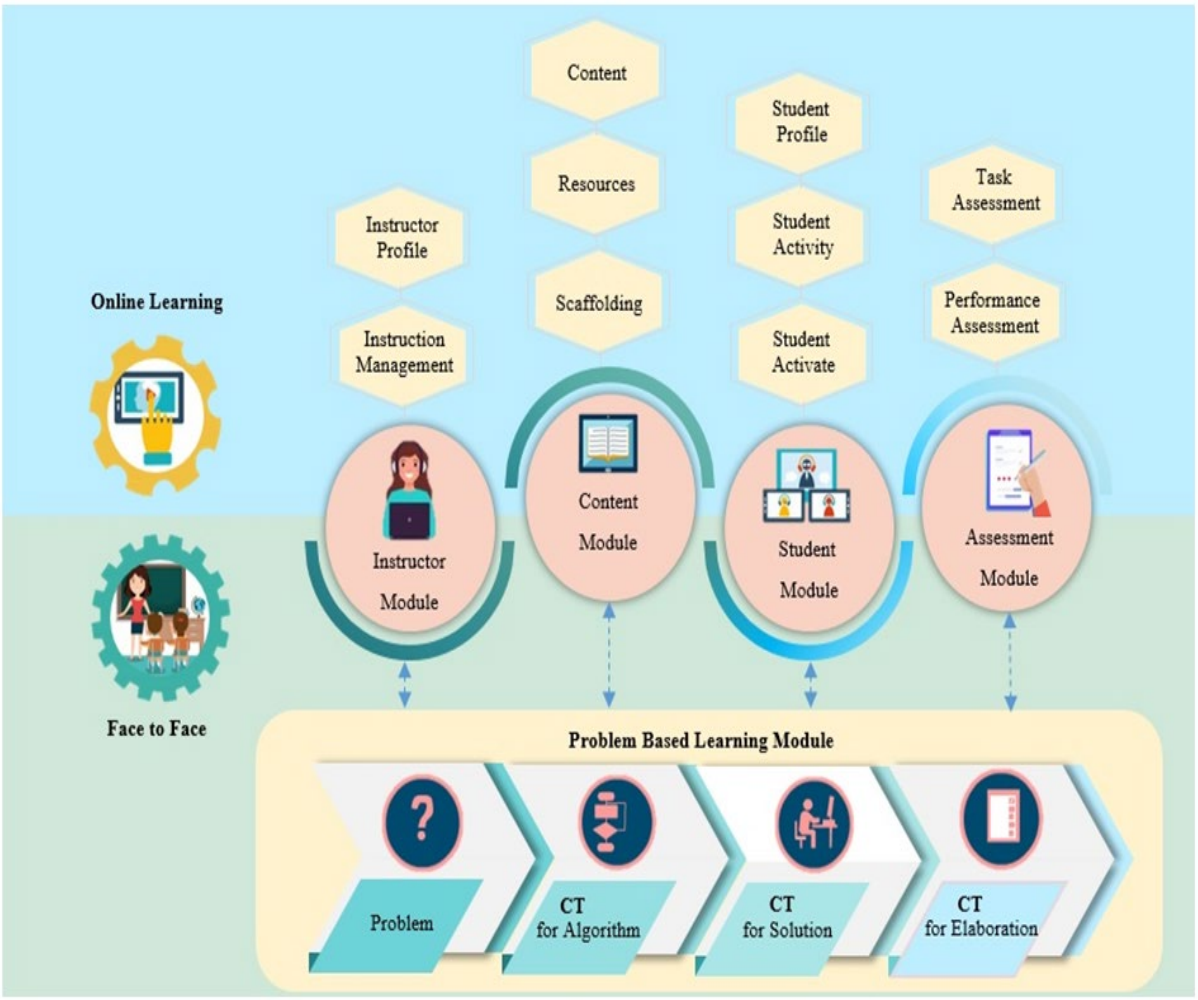
To synthesise Problem-Based Blended Learning (PBBL) for improving the computational thinking of junior high school students, the researcher has reviewed 30 related domestic and international documents. The record form of qualitative research from the document analysis was used to collect data. The form and its quality were checked by experts who analysed the qualitative data from the record form. Content Analysis was applied to synthesise the related documents and research studies. In this synthesis, the researcher has drafted the PBBL format for improving the computational thinking for junior high school students into a graphic model with detailed descriptions in each part.

In evaluating PBBL for improving the computational thinking of junior high school students, the researcher conducted a group discussion. With purposive sampling, the respondents were ten doctoral experts in PBBL for improving computational thinking with experience in computer study, digital technology, learning management, and research both in universities and high schools. The suitability assessment form for PBBL for improving the computational thinking of junior high school students was applied as a tool. It was approved by five experts when the content validity, construct validity, and 3-point rating scale for suitability assessment were checked. In collecting data, the draft of PBBL for improving the computational thinking of junior high school students was brought to the small focus group discussion. The head of the discussion brought up the topics one at a time for the experts to share opinions, suggestions, and criticism. The observer would collect the data of each topic from the first to the last. The data after amendment, as well as the assessment results, would be submitted to the researcher at the appointed time. After collecting assessment results from the experts, the researcher analysed the content. Mean and standard deviation were applied to analyse the suitability level of The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students.

Research Result

1. The synthesis of the BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students consists of five modules: instruction, content, students, PBL, and assessment. The experts give three suggestions: 1) both online and face-to-face formats should be integrated in the five modules as teachers work as facilitators who play important roles in feedback and teaching management, 2) encouragement of group work, and 3) scaffolding.
2. The researcher then adjusted the BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students following the experts' suggestions. The learning format is described in Figure 1.

Figure 1. The BL Model with PBL for improving the computational thinking of Junior High School Students



From Figure 1: The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students. This is described in detail in Table 1.

Table 1: The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students

Module	Keyword	Role
Instruction Module	1. Instruction Profile	Personal information of teachers
	2. Instruction Management	It is the instructional management segment used for managing content, assignments, and learning groups
Content Module	1. Content	Collect learning contents
	2. Resources	Collect learning resources
	3. Scaffolding	Provide help and guidance for learning
Students Module	1. Student Profile	It is the segment for the personal information of students used for recording students' information
	2. Student Activity	It is the segment for students' activities i.e., registration, testing, homework submission, group work.
	3. Learning Progress	It is the segment for recording the learning which is used to record students' performance according to the learning plan. It can also be used to follow up with the assignment as the learning proof. This allows teachers to supervise the advancement of students' learning. It is the collection of students' work behaviours such as log-in time, working hours, log-out time, etc.
PBL Module	1. Problem	It is the beginning of the learning activity in which students' thought is stimulated by the problem and situation. At this level, face-to-face learning will be integrated with web-based learning technology. Learning contents are posted on the website in the form of videos, pictures, and messages via online lessons. It consists of behavioural objectives, suggestions on conducting activities, rules, activity periods, problems, the condition of problems, or the situation of problems in the form of online digital media.
	2. CT for Algorithm	It is the stage of the knowledge survey with the sub-steps as follows: 1. Students analyse problems from the situation by using computational thinking. 2. Students examine if new knowledge is needed for learning from online lessons. 3. Students designs algorithm to design the solution.

Module	Keyword	Role
	3. CT for Solution	1. Solve the problem by programming the computer following the algorithm. 2. Check the results, failure, and amend according to the results.
	4. CT for Elaboration	1. Extensive adaptation by looking for new paths for better efficiency.
Assessment Module	1. Performance Assessment	It is used to assess knowledge; i.e., pre-test, subtest, and post-test.
	2. Task Assessment	It is to evaluate single or group assignments.

Table 2: Assessment results of the experts' opinions

Module	experts (n=10)		Assessment Results
	Mean	S.D.	
Instructor Module	4.54	0.24	Highest
Content Module	4.68	0.46	Highest
Students Module	4.55	0.37	Highest
Problem Learning Module	4.58	0.34	Highest
Assessment Module	4.56	0.36	Highest
Total	4.58	0.35	Highest

Table 2 found that the experts' agreement toward the suitability of The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students, both in overall and module levels, is at the highest level.

Discussion

The synthesis showed that The BL Model with Problem Based Learning for improving the computational thinking of Junior High School Students consists of five main modules: instruction module, content module, student module, PBL module, and assessment module. The researcher has synthesised that format by applying the concepts of several academics such as Hsu et al. (2018), who studied the development of CT for students by synthesising information from 262 academic journals published in SCOPUS and textbooks during 2006-2017. The study of teaching management for secondary school students by each aspect found that computer programming and computer science are the subjects most widely used for teaching management and are related to CT use. The most selected computer program is Scratch. PBL is the learning format most used in arranging activities, which is consistent with the concept of Maria Jose Marceline et al. (2018) and Youngseok et al. (2019), who measured students' knowledge and capability in computational thinking. The activity was prepared for students to learn about computer programming under the terms which focused on the application of PBL to solve problems. Students solved problems by suitably learning and implementing the solution for different situations. Many academics' conclusions are relevant

to the synthesised modules of the researcher; i.e., Scratch is selected by the researcher in the content module to study the computer subject as it allows students to analyse problems by integrating computational thinking with Scratch as the solution tool. It is also consistent with the PBL module which is synthesised by the researcher. This module is about facing the situation for which students need to analyse and find the tools to create suitable solutions.

For the instruction module, student module, and assessment module, the researcher has synthesised them in the form of integrative online and face-to-face interaction. It is relevant to the NETS-T standards, stipulated by ISTE (2008), which say that teachers have a correct understanding of technological works and concepts. The teachers can plan and design an efficient learning environment that supports the use of technology. The teachers apply the teaching plan, which contains the methodology and strategy in using technology for improving students' learning performance. The teachers use technology to facilitate various efficient assessment strategies.

The student module is consistent with NETS-S standards – the National Standard of Educational Technology for Students, which is stipulated by ISTE (2007). It says that students can show creativity, produce knowledge, and develop innovative output and technological processes. Students can utilise the benefits of digital media and environments to collaborate in communication and cooperation, and to support distance learning for themselves and others. Students can use digital tools for collecting, assessing, and using information. Students can show problem-solving and decision-making skills, as well as understand the concept, system, and the work of technology.

The integration of online and face-to-face approaches was used to synthesise these five modules. This is consistent with the research results of Mahalli et al. (2020), which indicated that students gave positive feedback towards BL. They pay attention, create learning awareness, and gain inspiration in an efficient and in-demand online learning environment involving BL management. It is also associated with the research results of Ibrahim et al. (2020), who blended PBL with online learning for improving students' thinking skill, problem-solving skill, communication, and teamwork skills. For society and leadership skills, students learn to cooperate and assign different roles while in a team during the focus group discussion. Problem-solving is the main process which allows students to gain knowledge together with teamwork, and independent learning.

Acknowledgements

This research was supported by Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Thailand.

REFERENCES

Allen, I. E., & Seaman, J. (2005). Growing by Degree : Online Education in the United

States. Online. Available from https://files.eric.ed.gov/fulltext/ED530063.pdf. Retrieved on 24 June 2019.

Alvarez, S. (2005). Blended learning solutions from B. Hoffman (Ed.), Encyclopedia of Educational Technology. Online. Available from http://www.etc.edu.cn/www/ eet/eet/articles/blended learning/ Retrieved on 1 June 2019.

Barell, j. (2003). Developing more curious minds. Alexandia, VA:Association for Supervision and Curriculum Development.

Barr,V.,& Stephenson, C. (2001). Bringing Computational thinking to K-12:What is involved and what is the role of the computer. Science education community. ACM In roads, 2(1), 48-54.

Bernath , R. (2012). Effectives Approaches to Blended Learning for Independent Schools. Online. Available from http://www.testden.com/partner/ blended% 20learn.html

Bersin, J. (2004). The blended learning book: Best practices, proven methodologies and lessons learned. New York.

Bonk, C. J.,and Graham C.R. (2006).The handbook of blened learning:global perspectives, local designs. SanFrancisco,Calif:Pfeiffer.

Bransford et al., (2000). How people learn: Brain, mind, experience and school. Online.

Available from https://participativelearning.org/mod/url/view.php?id=15. Retrieved on

20 June 2019.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. Proceedings of the 2012 annual meeting of the America educational research association. Vancouver. Canada. 1-25.

Burke, Q., & Kafai,Y. B. (2012). The writers' workshop for youth programmers: Digital storytelling with Scratch in middle school classrooms. Proceeding of the 43rd ACM technical symposium on computer science education.North Carolina, US; ACM., 2012.433-438.

Caine, R. N., & Caine, G. (1994). Making connections : Teaching and the human brain. Alexandia, VA:Association for Supervision and Curriculum Development.

Caine, R. N., & Caine, G. (1997). Education on the edge of possibility. Menlo Park, CA: Addison-Wesley.

Caine, R. N., & Caine, G. (1997). Unleashing the power of perceptual change : The potential of brain-based teaching. Alexandia, VA:Association for Supervision and Curriculum Development.

Caine, G., & Caine, R., McClinic, C. (2002). Guiding the innate constructivist. Educational Leadership 60(1):70-73.

Carman, J. M. (2005). Blended Learning Design: Five Key Ingredients.Online. Available from http://www.agilantlearning.com/pdf/Blended%20Learning%20Design.pdf. Retrieved on 20 January 2019.

Catlin R. Tuker, Tiffany Wycoff, Jason T.Green. (2017). Blended Learning in Action A Practical Guide Toward Sustainable Change. United States of America. Cowin. California.

Devis, R., Kafai, Y., Vasudevan. V., & Lee, E. (2013). The education arcade : Crafting, remixing, and playing with controllers for scratch games, Proceeding of the 12th international conference on interaction design and children (439-442). New York, US: ACM

Driscoll, M. (2002). Blended Learning : Let's get beyond the hype. Online. Available from http://www.ibm.com/services/pdf/blended_learning.pdf. Retrieved 19 June 2019.

Franklin, D., Conrad, P., Boe, B., Nilsen, K., Hill, C., Len, M., et al.(2013). Assessment of computer Science learning in a scratch-bases outreach program.

Grover, S., & Pea, R. (2013). Computational thinking in K-12: A Review of the state of the field. Educational Researcher, 42(1), 38-43.

Hermans, F., & Aivaloglou, E.(2017). To Scratch or not scratch? : A controlled experiment comparing plugged first and unplugged first programming lesson. Proceeding of the 12th workshop on primary and secondary computing education (49-56). Nijmegen. The Netherlands: ACM.

Horn , B.M. & Staker , H. (2011). The Rise of K-12 Blended Learning. Online. Available from https://aurora-institute.org/wp-content/uploads/The-Rise-of-K-12-Blended-Learning.pdf. Retrieve on June 2019.

Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. Computers and Education, 126, 296-310. Doi:10.1016/j.compedu.2018.07.004

Ibrahim Hashim, Syakirah Samsudin. (2020). Practices of Problem-Based Learning(PBL) In Teaching Islamic Studies in Malaysian Public Universities. International Journal of Innovation, Creativity and Change, 11(10), 117-129.

Institute for the Promotion of Teaching Science and Technology (IPST). (2017). The instruction of basic science curriculum, technology program (Computing Science).

International Society for Technology in Education. (2007).National educational technology standards for students(2nd ed.) Eugene, OR: Author.

International Society for Technology in Education. (2008).National educational technology standards for Teacher.

International Society for Technology in Education. (2018). Computational Thinking Competency. Online. Available from https://www.iste.org/standards/ computational-thinking. Retrieve on May 2018.

Kalelioglu, F., & Gulbahar, Y. (2014) The effects of teaching programming via scratch on problem solving skills:A discussion from learners' perspective. Informatics in Education, 13(1),33-50.

Lye, S.Y., & Koh, J.H. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? Computers in Human Behavior, 41, 51-61. Doi:10.1016/j.chb.2014.09.012.

Manovich, L. (2013). Software takes command. In International texts in critical media Aesthetics (Vol.5). NY:Bloomsbury Press

Maria Jose Marcelino, Teresa Pessoa, Celeste Vieira, Tatiana Salvador, Antonio Jose Mendes. (2018). Learning Computational Thinking and Scratch at distance.

Journal for Computers in Human Behavior, 80,470-477. doi.10.1016/ j.chb. 2017.09.025

Marzano, R. (2003). What works in schools-Translating research into action. Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. (2001).Classroom instruction that works research based strategies for increasing student achievement. Alexandria, VA: Association for Supervision and Curriculum Development.

Mahalli, Joko Nurkamto, Januarius Mujiyanto, Issy Yuliasri. (2020). Students' Perception of Blended Learning Implementation in EFL Learning. International Journal of Innovation, Creativity and Change, 11(8), 161-172.

McCombs, B. (1991). Metacognition and motivation for higher level thinking. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Meerbaum-Salant, O., Armoni, M., & Ben-Ari, M. (2013). Learning computer science concepts with scratch.Computer Science Education, 23(3), 239-264.

Microsoft Thailand News Center. (2015). Microsoft unveils the survey that Thai students want code writing as main subject in school. Online. Available From https://news.microsoft.com/thth/2015/03/21/codingevent_th/

Ministry of Education. (2017). The Basic Education Core Curriculum B.E. 2551 (Revision B.E. 2560).

Ministry of Education. .(2010). National Education Act. B.E. 2542. and Amendments (Third National Education Act B.E. 2553.

New Commission on the Skills of the American Workforce. (2007). Tough Choices or Tough Times : The Report of the New Commission on the Skills of the American Workforce, Wiley, San Francisco.

NRC.(2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas, The National Academies Press.

Office of the National Economic and Social Development Board. (2017). The 12th National Economic and Social Development Plan (B.E. 2560-2564). Bangkok. 2017.

Organisation for Economic Co-operation and Development. (2001). Schooling for tomorrow : What schools for the future? Paris: Author.

Partnership for 21st Century Skills. (2006). A State leaders action guide to 21st century skills : A new Vision for education. Tucson, AZ : Author.

Perkins, D. (1992). Smart schools. New York:Basic Books.

Singh, H. (2005). Building Effective Blended Learning Programs. Educational Technology archive, 43, 51-54.

Selby, C., & Woollard, J. (2013). Computational thinking: The developing definition. Available from http://eprints.soton.ac.uk/356481. Retrieved on 24 June 2018.

Wing, J. M. (2006).Computational thinking. Communications of the ACM. 49(3), 33-35.

Youngseok Lee, Jungwon Cho. (2019). Quantifying the Effects of Programming Education on Students' Knowledge Representation and Perception in Computational Thinking. International Journal of Innovation, Creativity and Change, 9(4), 27-38.