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Perceptions of Computational Thinking in Game Based Learning for Improving Student Problem Solving Skills

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ABSTRACT

Computational thinking (CT) is a fundamental skill which is not limited to professional computing or programming scientists. Instead, CT skill assists teachers and students to think of new ways to understand problem and try to solve it. By using computational thinking skills, students will be guided step-by-step strategy to solve real problems which could be applied to various fields. In this study, game based learning (GBL) is identified as one of the learning approaches that could utilized CT skill in a learning environment. Therefore, a survey has been conducted to get responses from students and teachers on their understanding about CT, and how it relates with GBL, and problem solving

Key words : Computational Thinking; Game Based Learning; Problem Solving.

1. INTRODUCTION

Computational thinking (CT) has been defined as a process of thinking used to formulate a problem for finding solutions that can be translated in a form that can be effectively implemented by an information processing [1], [2], [3]. According to Wing [4], CT is the skill required by each individual to solve problem, and understand human behavior. He added that the CT is also suitable to be applied in various fields which has been focusing on several studies and writing in recent years [5], [6]. In Malaysia, CT was first introduced to teachers and students in 2017 through the subject of Basic Computer Science for Form 1 in secondary school. Studies must be conducted to assess the effectiveness of the implementation. Wing [2] further stated that "computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability."

Wing [2] also has clarified six major concepts of CT, namely: (i) decompose- is a step where a big task is then broken down into smaller tasks to make it easier for others or computers to understand, (ii) pattern- is an ability to view common aspects of equality in a work or problem for the purpose of making a solution, (iii) abstraction- is an ability to filter out unnecessary information to solve problems and generalize the information when appropriate, (iv) algorithm- is an ability to build a step by step strategy to solve the problem, (v) logical reasoning- is an ability to logically draw conclusions from existing information, and (vi) evaluation- is a process to ensure that the solution is accurate according to the actual requirement and think on how it can be improved.

Therefore, this study investigates into how CT could be utilized in educational setting using game-based learning (GBL) where student could learn problem solving skills.

GBL is a learning approach that emphasizes how digital games can be used during teaching and learning [7], [8]. GBL is played for enjoyment which has rules, goals, game world, and interactivity. A player needs to make decision based on rules and interact within the game world in order to achieve the game and learning goals. Many researchers have confirmed that the elements found in digital games can provide students with enthusiasm and motivation to learn naturally [9], [10].

GBL has become more popular in recent years, apart from the mentioned factors; it is because of the widespread available game contents in the market in various formats (PC, consoles, internet, and mobile phones). In fact, it is recommended that teacher who want to adapt their learning environment to meet the students' needs, should implement digital games as learning tools [7]. The games can be utilized in a variety of subjects and ways.

In summary, integrating CT in GBL approaches is to apply the CT concept to improve students' thinking skills to enable them to find solutions to certain problems through digital games. Based on the readings, there is still a shortage of studies illustrating CT-related models or theories integrated in GBL to general subjects in schools.

2. ISSUES AND PROBLEM

The main challenge of the 21st century education system is to make the students with highly skilled and empowered workforce to compete according to the future job market requirements [11]. Hence, the existing education system needs to go through an improvement process to ensure students are equipped with a variety of new skills, especially in technology and computer science [12], [13]. This is because computers and technologies are growing and they become a necessity in all areas. It is also unlikely to have changed the ways and habits of human working and learning culture of students.

To meet this demand, the Ministry of Education Malaysia (KPM) with the support of the Malaysia Digital Economic Corporation (MDEC) has introduced the CT and Computer Science in the education curriculum in Malaysia from January 2017. These skills have been integrated into the Primary School Standard Curriculum (KSSR) and Secondary School Standard Curriculum (KSSM). Apart from Malaysia, the CT has been applied in the education system in most developed countries such as the United States, United Kingdom and Australia [14].

Many studies have been conducted to identify student's methods of learning in either the computer programming curriculum [15], [16] or in other subjects including various levels of study [17], [18]. The findings also state the need to master in CT in the future and have recommended that all students be given the opportunity to learn this skill with the aim of nurturing critical thinking, problem solving and other 21st century skills [19].

In regards, this study investigates how computational thinking been integrated to GBL in improving student's problem-solving skills. In this regard, this paper describes the findings of the study and is one of the processes in developing research focus and supporting the justification of further research. Since CT is a newly introduced skill in education curriculum in Malaysia, it is important to know the perceptions of the people involved in this field. In addition, this study also covers information relating to respondent's demographics and the extent of respondent's opinions on CT, GBL and problem-solving concepts.

The main objectives of this study are to (i) to investigate the perception on CT, GBL and problem solving among students and academicians; and (ii) to get respondent's opinion on CT concept in the process of designing GBL.

3. METHODOLOGY

This study used questionnaire as an instrument for data collection. Data collection period is two weeks starting from April to mid April 2017. The number of respondents is 131 people consisting of teachers, Institute of Teacher Education (IPG) students, school students and lecturers.

The questionnaire has 37 items which consists of closed and open questions and divided into 3 parts. Part A contains items regarding gender, race, status or position and experience. Part B contains 6 items on the existing knowledge of respondents on CT concept for game based learning and problem solving. Part C contains 17 items on CT development process for GBL. Respondent's consent to these items is measured through 5 points Likert scale ie (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, (5) Strongly agree.

4. FINDINGS

4.1. Demographics of Respondents

Table 1 and 2 show that 131 respondents responded to questionnaires distributed. The number comprised 42 males and 89 females representing the Malays (70.99%), Chinese (19.08%), India (5.34%) and others (4.58%).

In addition, the findings show that IPG students are the most respondents with 41.98% followed by school students representing 32.82% of the total respondents. Meanwhile, lecturers and teachers each represented 16.79% and 8.40% respectively. From the experience of teaching among teachers and lecturers, the table shows that majority of respondents have been teaching between 21 to 25 years (8.40%) followed by respondents who have been teaching between 16 to 20 years (6.11%). Only 3.82% of the respondents had 6 to 11 years of teaching experience and the least number of respondents taught between 1 and 5 years with only 1.53%.

Table 1: Demographics of Respondents

Demographics	Male	Female	Total	Percentage
Race:				
Malay	34	59	93	70.99 %
Chinese	3	22	25	19.08 %
Indian	3	4	7	5.34 %
Others	2	4	6	4.58 %
Total	42	89	131	
Status:				
IPG Student	14	41	55	41.98 %
School Student	19	24	43	32.82 %
Teacher	0	11	11	8.40 %
Lecturer	9	13	22	16.79 %
Total	42	89	131	

Table 2: Demographics of Respondents

Experience of teaching				
Year	Male	Female	Total	Percentage
0	33	65	98	74.81 %
1 – 5	0	2	2	1.53 %
6 – 10	2	3	5	3.82 %
11 – 15	0	7	7	5.34 %
16 – 20	2	6	8	6.11 %
21 – 25	5	6	11	8.40 %
Total	42	89	131	

Overall, the findings show that the respondents' demographics of this early study have represented the various races, sex and background of experiences in order to illustrate the purpose of this study.

4.2. Computational thinking concept for game-based learning and problem solving

This section will answer the question of early knowledge and understanding of respondents on the concept of CT, GBL and problem solving as shown in Table 3.

Table 3: Concepts for game-based learning and problem solving learning

Item	M	F	Total	%
Do you know about the concept of CT?				
Yes	4	10	14	10.69
No	38	79	117	89.31
Total	42	89	131	
Do you know about GBL?				
Yes	27	49	76	58.02
No	15	40	55	41.98
Total	42	89	131	
Computational thinking is closely linked to GBL.				
Yes	17	38	55	41.98
No	25	51	76	58.02
Total	42	89	131	
Do you know about problem solving skills?				
Yes	25	64	89	67.94
No	17	25	42	32.06
Total	42	89	131	
Do you apply problem solving skills in teaching or learning?				
Yes	21	46	67	51.15
No	21	43	64	48.85
Total	42	89	131	
Application of computational thinking through GBL can improve the skills of the problem solving skills?				
Agree	31	70	101	77.10
Disagree	11	19	30	22.90
Total	42	89	131	

The data analysis showed that 117 respondents did not know about the CT concept which represented 89.31% of the survey respondents and only 14 people or 10.69% respondents responded otherwise.

This feedback has influenced when 58.02% respondents stated that computational thinking is not closely related to GBL and only 41.98% agree.

Furthermore, 58.02% respondents gave feedback that they knew about GBL and 41.98% respondents stated that they did not know. Table 3 also shows that respondents are more vulnerable to the concept of problem solving. This proved that 89 respondents agreed to know it with 67.94% of the survey respondents and only 42 respondents with 32.06% said they did not know.

However, only 51.15% of respondents stated that they apply problem solving skills in teaching or learning and the remaining 48.85% is the opposite. This low percentage difference of 2.30% indicates that respondents who know the problem solving concept also do not apply it in their teaching and learning. However, respondents gave positive feedback that the application of CT through GBL could improve the skills of the problem solving (77.10%) compared to the disagreed (22.90%).

4.3. Computational Thinking Concept for GBL

Table 4 shows that respondents agree that they will break large tasks into smaller tasks (resolution) with mean 4.16 and standard deviation. 72 indicates that the data point dispersion is not far from the mean. In addition, respondents also agree (M = 4.5, SD = .74) that make a step by step strategy to solve the problem (algorithm).

Table 4: Concepts of Computational Thinking for Game-based Learning

Item	SD	Min
I will break big tasks into smaller tasks.	.72	4.16
I often detail issues to make them easier to understand by others or computers.	.91	3.89
I was able to define the features of the equation in an assignment to make a problem solving prediction.	.79	3.66
I am able to define the characteristic of the difference in an assignment to make a prediction of problem solving	.80	3.68
I am able to filter out unnecessary information to solve the problem	.90	3.72
I will generalize information on troubleshooting methods.	.75	3.55
I make a step by step strategy to solve the problem	.74	4.05
I can make logical considerations by using the information available to solve the problem.	.69	3.98
I can draw a specific conclusion on the problem based on the available information.	.77	3.66
I will make sure the resolution of the problem is correct.	.73	3.99
I will think about how troubleshooting can be improved.	.90	3.90
Average	.79	3.85

Table 5: Computational Thinking for Game-based Learing

Item	**SD**	**Min**
I am interested in using Computational Thinking skills to build GBL software.	.88	3.76
CT skills can help improve the quality of GBL development.	.91	3.72

Generally, the majority of respondents stated that they agreed with each CT concept with an average mean of 3.85 higher than the median (2.50) and the lower standard deviation of .79 showed that the feedback was the same (homogeneous) i.e. not much distant from min. This has demonstrated high reliability of activities in the CT concept.

Meanwhile, Table 5 shows that respondents are interested and agree to use the CT (M = 3.7, SD = .88) and agree (M = 3.72, SD = .91) that the CT can help improve the quality of GBL development.

5. CONCLUSION

This initial study can explain that the majority of respondents have not been exposed to CT concept compared to GBL concept and problem solving. However, they expect the adoption of CT through GBL to increase their resolution of the problem especially in GBL. In addition, the study also found that to apply CT concept for GBL to respondents will not face difficult problems because they have positive

opinions and willingness to accept them. This finding shows that this study is very appropriate.

Generally, computational thinking is not limited to professional computing or professional programming scientists. Instead, CT also helps teachers and students to think of new ways to understand and explain problem solving, especially in GBL. This is supported by Wing [5], which states that the general features of CT are as follows:

i. Emphasizing concepts, not programming.
ii. Emphasizing the foundation of non-memorization skills.
iii. One way people think is not computer thinking.
iv. Complement and incorporate ideas
v. Suitable for everyone everywhere.

This study also demonstrates that CT can be explored more deeply for understanding concepts and practices across various levels and subjects. This is because of the importance of CT recognized as a set of essential skills in the 21st century [20].

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REFERENCES

1. Bundy A (2007), **Computational Thinking is Pervasive, Journal of Scientific and Practical Computing**, Vol.1, No.2, 67–69.
2. Wing JM (2006), Computational Thinking**: What and Why?** The link - The Magazine of the Varnegie Mellon University School of Computer Science, March 2006, 1–6, available online: http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why, last visit 28.02.2010.
3. Selby CC (2014), **Refining an Understanding of Computational Thinking, Technology, Pedagogy and Education**, 1–23.
4. Ioannidou A, Bennett V, Repenning A, Koh KH & Basawapatna A (2008), Computational Thinking Patterns. Online Submission, 2, 1–15, http://doi.org/10.1098/rsta.2008.0118.
5. Wing JM (2006), Computational thinking. Communications of the ACM. http://doi.org/10.1145/1118178.1118215.
6. Brackmann C, Barone D, Casali A, Boucinha R, & Munoz-Hernandez S (2016), **Computational thinking: Panorama of the Americas, Proceedings of the 2016 International Symposium on Computers in Education** (SIIE), 1–6, http://doi.org/10.1109/SIIE.2016.7751839, 2016.
7. Zaibon SB, & Shiratuddin N (2009), **Towards developing mobile game-based learning engineering model, Proceedings of the 2009 WRI World Congress** on Computer Science and Information Engineering, IEEE, Vol.7, 649-653.
8. Zaibon SB, & Shiratuddin N (2010), **Mobile game-based learning (mGBL) engineering model as a systematic development approach, Proceedings of the Global Learn 2010,** Association for the Advancement of Computing in Education (AACE), 1862-1871.
9. Erhel S, & Jamet E (2013), **Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness,** Computers & Education, Vol.67, 156–167. http://doi.org/10.1016/j.compedu.2013.02.019.
10. Woo JC (2014), **Digital game-based learning supports student motivation, cognitive success, and performance outcomes,** Educational Technology and Society, Vol.17, No.3, 291–307.
11. Gretter S, & Yadav A (2016), **Computational Thinking and Media & Information Literacy**: **An Integrated Approach to Teaching Twenty-First Century Skills, TechTrends,** 1-7, DOI: 10.1007/s11528-016-0098-4.
12. Hung CM, Huang I, & Hwang GJ (2014**), Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics,** Journal of Computers in Education, Vol.1, No.2-3, 151-166.
13. Papadopoulos Y, & Tegos S (2012), **Using microworlds to introduce programming to novices**, Proceedings of the 2012 16th Panhellenic Conference on Informatics (PCI), IEEE, 180-185.
14. Peters-Burton EE, Cleary TJ, & Kitsantas A (2015), **The Development of Computational Thinking in the Context of Science and Engineering Practices:** A Self-Regulated Learning Approach, International Association for Development of the Information Society.
15. Kazimoglu C, Kiernan M, Bacon L, & Mackinnon L (2012), **A serious game for developing computational thinking and learning introductory computer programming**, Procedia-Social and Behavioral Sciences, Vol.47, 1991-1999.
16. Lu JJ, & Fletcher GH (2009), **Thinking about computational thinking**, ACM SIGCSE Bulletin, Vol.41, No.1, 260-264.
17. Barr V, & Stephenson C (2011), **Bringing computational thinking to K-12: what is Involved and what is the role of the computer science education community?** ACM Inroads, Vol.2, No.1, 48-54.
18. Cooper S, Pérez LC, & Rainey D (2010), **K-12 computational learning, Communications of the ACM**, Vol.53, No.11, 27-29.
19. Yadav A, Hong H, & Stephenson C (2016), **Computational thinking for all: pedagogical approaches to embedding 21st century problem solving in K-12 classrooms,** TechTrends, Vol.60, No.6, 565-568.
20. Mohaghegh M, & Mccauley M (2016), **Computational Thinking:** The Skill Set of the 21st Century, International Journal of Computer Science and Information Technologies, Vol.7, No.3, 1524–1530.