A Tangible Game-Based Approach for Introducing Programming to Elementary School Students

Rashidah Mokhtar, Mohd Lezam Lehat, Nora Mohd Basir, and Yusnita Sokman

***Abstract*—Critical thinking should be taught as early as childhood stage. The skill is very important meant for developing creative and innovative minds. Hence, it can be introduced through programming substance. However, there is a lack of study on introducing programming substance at the elementary school level especially using tangible game approach. Thus, this study is to determine students' tendency toward tangible game-based approach in introducing learning programming. A survey has been distributed to forty-nine elementary school students aged 11 to 12 years old. The students need to play a tangible game-based on critical thinking namely "*Beat the clock – Sorting Networks*". The result shows that students tend to enjoy a tangible outdoor game play with friends and it is help in developing their problem solving skills. Therefore, we suggest to design a tangible game-based that suitable with the elementary school students deliberate for emerging and sharpening their critical thinking skills.**

***Index Terms*—Tangible game-based, introductory programming, elementary school.**

I. Introduction

The increasing popularity of game-based has been a motivational tool and an innovative approach in introducing programming course in diverse ways. The issues on its benefits and effect have been discussed by a lot of researchers [1]-[3] since the 1960s [4]. Game-based approach is divided into three types: digital game-based, tangible game-based and hybrid game-based. Digital game is involving computer usage while the hybrid game is a combination of digital and tangible elements. Some researchers [5], [6] define tangible as a physical interaction mediators to the computer functions. It is almost similar to the concept of hybrid. On the contrary, in this paper we define tangible game-based as an augment the physical elements and real environment without computer use. There are a lot of interesting and useful, tangible game-based produced by researchers such as Tangicons, Robo-Blocks, Tern, T_ProRob, Quetzal and Tangible Programming Brick. These games boost critical thinking, problem solving and creative thinking skill. These skills are very important in education to produce students who highly innovative and creative thus it is in line with the Malaysian Vision 2020. Therefore, we believe that introduce a programming, substance in early age will help in producing a very good generation in the future. However the challenge taken into place where the issue on how to introduce programming course to the children need to be highlighted. What are the suitable mechanisms should be adopted to make sure programming course easy to understand and fun. In the first place, why programming course is so important? As we have mentioned before, programming is one of the course that teach critical thinking and problem solving skill, which is very essential in their real life. In this research, we adopt tangible game-based approach to introduce programming to children because the game is one of the best approaches that can influence children to learn fast. We strongly believe that it will create fun and exciting during learning programming. Another motivation to pursue this research is because there is limited research centering on the tangible game-based in this context. Thus, objective of this paper is to determine the students' tendency of tangible game-based on introducing programming at the elementary school level. The next section, discuss more detail on tangible game-based and the advantages, methodology used, result and findings, future work and conclusion.

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II. Tangible Game-Based

Ever since early childhood, there are so many types of games either tangible or physical game like a ball, letters, cube, Lego and block or digital game (whether use computer or built-in computer system in the game) has been exposed. These games are created according to level of age. There are a lot of creative games created to attract children, develop their cognitive, social and physical [7]. It shows that the game is one of successful techniques that can stimulate human mind. The game also has fun elements that can attract children who easily get bored and it also can develop children experience constructively. Game trend nowadays is more in the direction of digital game or a game using android operating system. There are so many games can be downloaded free through Play Store for android user. From our experience and observation, game has its own education value according to the type of game and level of the game. Looking at the enormous influence of game among people nowadays, we are enthusiastic to expose tangible game approach to children for introducing programming course.

Why tangible or physical game-based? According to Scharf [8], tangible game will reduce cognitive disconnect between the task and the game goal because children can

work directly with physical programming elements. Thus, children can learn directly to the game itself and have their own experience. While Verhaegh [3] also agree that tangible interface is easier to understand and use compared to the virtual interface. Thus, learning programs through physical material give good logic and make children more understand while they are relating the game task to real environment. This type of game also is suitable for young children and children with disabilities. Beside problem solving skill, there are other skills children can gain from the game such as interaction, collaboration, exploration, risk taking and decision making. There are many tangible game have been created by experts. Table I shows an example of tangible games for children, according to level, approach and category of game.

TABLE I: EXAMPLE OF TANGIBLE GAME-BASED FOR CHILDREN

Game	Level	Approach	Category
Tangicons [8]	Kindergarten and first grade students	Individual / group	Cube
Criticality – board game [9]	University	Individual	Board
Computer Science Unplugged Activities through games and puzzle [10]	Elementary	Group / individual	Puzzle, board
Hunting the Snark [11]	7-9	Group	Puzzle, board
Read-it [12]	5-7 years old	Group	Board
Tern [13]	Middle school and late elementary school students	Individual / group	Block and Jigsaw puzzle
Robo-Blocks [14]	8- 9 years	Individual / group	Maze
Curlybot [15]	> 4 years	Individual	Board
Tangible Programming Bricks [16]	Children lower age	Individual / group	Card

III. METHODOLOGY

The study was conducted during the weekend (Saturday) at Sekolah Kebangsaan Jementah Segamat, Johor. The school is located approximately 25km from Segamat city. This school is categorized as a rural school. In order to investigate students' tendency in learning programming through tangible game-based approach, we have designed two different surveys given before and after tangible game conducted. This is not pre-test and post-test method. Before we conducted tangible game-based, there is a briefing session given by a researcher for this event. After that, students need to fill in the first survey that consists of twelve questions. The first survey is to get students' background. Then, the students have been asked to perform a group of 10 members that divide them into five groups. We use the tangible game, namely "Beat the clock – Sorting Networks" as in Fig 1. This game is taken from Computer Science Unplugged Activities through games and puzzle [10]. Before beginning, students need to follow instruction given. Then, they are given a set of 6 numbers unsorted, means that only six students require accomplishing this game. In a group, they should sort the numbers in ascending order based on the instructions given. Each group is given only 10 minutes to sort the numbers with only three attempts to finish the game. After that, each student who plays the game need to answer a survey that consists of twelve questions which embed five Likert Scales (strongly agree – agree - not sure – not agree – strongly disagree). The questions are adapted from Ibrahim [17].

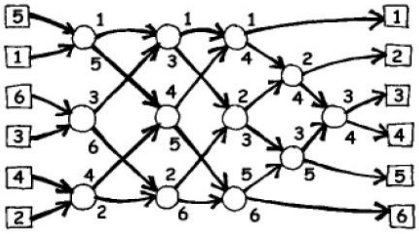

Fig. 1. Example of beat the clock – sorting networks game.

IV. RESULTS AND FINDINGS

In this section discuss the analysis of findings and results derived from the research. The first analysis done is to overview the demography and information technology (IT) background of the participants' as in Table II. There are forty-nine students age 11 and 12 years participate in this study. It is approximately (90%) of overall upper elementary school students at the school. From that, (69.4%) of them are male and the rest are female. From the 49 participants, (73.5%) of the them have personal computer. The computer has been used mostly to find information from the internet (48.2%). Beside that, computers are used to play games (37.6%), to do homework (14.1%), and other purposes (3.5%). The occurrence of play is more than once a day, which contributes (31%). Time used in every session mostly less than 30 minutes and more than one hour has the same frequency (36.4%). The usage is seemed contradict maybe because their parents control their play time even they have their own computer. About (32.9%) of participants play games because of hobby and (27.6%) to fill their leisure time. It is significantly shown that children like to play games during their free time. This is a great opportunity to design a game for academic purpose which combines education and entertainment.

TABLE II: TABULATION OF OVERALL PARTICIPANTS' IT BACKGROUND

IT Background	Frequency	%
Personal Computer		
Yes	36	73.5
No	13	26.5
Usage		
Do homework	12	14.1
Find information from internet	41	48.2
Playing games	32	37.6
Others	3	3.5
Time used in every session		
Less than 30 minutes	16	36.4
30 - 59 minutes	12	27.2
More than 1 hour	16	36.4
Play for		
Learn / explore	20	26.3
Hobby	25	32.9
Leisure time	21	27.6
Academic	10	13.2

We also have found that most of the participants preferred outdoor games, subsequently board game, block game, traditional game and others with percentage (58%, 26%, 9%, 5% and 2%) respectively. It shows clearly in Fig. 2, that students' tendency toward tangible game is more of the outdoor activities. It's supported by 83.7% of the participants like to play a tangible game in a group or with friends compare to individual (16.3%).

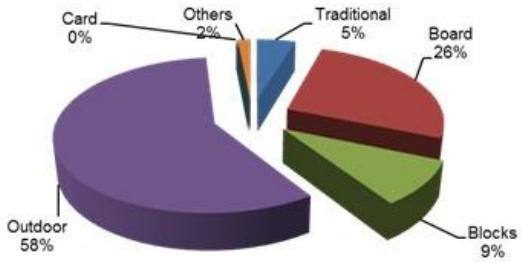

Fig. 2. Pie chart shows types of tangible games.

The next analysis of the findings is to excavate more detail on the participants' tendency of the game. There are twelve questions have been asked in the survey to measure the tendency. Reliability test has been done with these items. In general, reliabilities less than 0.6 are considered to be poor, those in the 0.70 range, acceptable, and those over 0.80 good. From the test, Cronbach's Alpha value is 0.902, which is more than 0.8. Thus, the internal consistency reliability of the measures used in this study can be considered to be good to measure the participants' tendency towards the tangible game-based which has significantly impacted in introducing fundamental of programming and develop critically and problem solving skills to elementary school students. Table III explains the participants' level of tendency toward tangible game-based.

Overall, all the participants 'strongly agree' and 'agree' that this tangible game is fun. It shows that participants really enjoy the game and its benefits them. It is supported by 94% agree, this game helps them in their study. Furthermore, 40 participants who contribute 81.6% find this game help them learn better learning by them self. 85.7% of the participants also agree that the games give them the opportunity to choose their learning style, even though 6% of them do not agree with the statement. It shows that, games can be one of the alternative tools in teaching and learning, however choosing the right game for the specific user is an important aspect in determining the efficacy of the game. As the cognitive development, this tangible game-based is perceived helping them in critical thinking, make them excited to solve the problem given and challenge their understanding with all of the 43 participants (87.8%) give the same percentage of agreement for those statements. From this analysis, we can say that tangible game really inspires them in developing their logical thinking level in the way to expose them to the programming language.

Discussing on the game interface, 41 of the participants agree that the content of the game is fun, but there is about 10% find really difficult to play the game. Surprisingly, about 90% of the participants need only a short time to understand the game and 87.8% like to play this tangible game based. However, there is still some of the participant need more time in understanding the game and do not like this game, 6.1% and 8.2% respectively. It is a good feedback for researchers to look at when designing a tangible game in the forthcoming. The instructions must be straightforward and the elements of tangible game must be interesting enough for targeted user. From the student expectation, we can see that more than almost 90% is interested in using games for learning and 83.6% are really agreeing that they learn a lot from the game. However, there is quite a big percentage (12.3%) of disagree on the learning input from the game for the participant that must be considered in developing the right games to help them in learning a programming language.

TABLE III: PARTICIPANTS' LEVEL OF TENDENCY TOWARDS TANGIBLE GAME-BASED

Statement		SD	D	NS	A	SA	Total
I think this game is fun	n	0	0	0	14	35	49
	%	0.0	0.0	0.0	28.6	71.4	100
I think this game helps in my study	n	0	0	3	22	24	49
	%	0.0	0.0	6.1	44.9	49.0	100
I think I can learn better by myself	n	1	1	7	15	25	49
	%	2.0	2.0	14.3	30.6	51.0	100
I prefer to choose my learning style	n	3	0	4	18	24	49
	%	6.1	0.0	8.2	36.7	49.0	100
The game helps in critical thinking	n	0	0	6	16	27	49
	%	0.0	0.0	12.2	32.7	55.1	100
I am excited to solve the problem given	n	0	2	4	15	28	49
	%	0.0	4.1	8.2	30.6	57.1	100
The game challenges my understanding	n	2	1	3	13	30	49
	%	4.1	2.0	6.1	26.5	61.2	100
The content of the game is fun	n	4	1	3	12	29	49
	%	8.2	2.0	6.1	24.5	59.2	100
I need a short time to understand how to play the game	n	2	1	2	15	29	49
	%	4.1	2.0	4.1	30.6	59.2	100
I like to play this game	n	3	1	2	16	27	49
	%	6.1	2.0	4.1	32.7	55.1	100
I am interested in using games for learning	n	0	2	3	15	29	49
	%	0.0	4.1	6.1	30.6	59.2	100
I learn a lot from this game	n	2	4	2	18	23	49
	%	4.1	8.2	4.1	36.7	46.9	100

SD – Strongly Disagree; D – Disagree; NS Not Sure; A – Agree; SA – Strongly Agree

The discussion shows, the students' tendency toward tangible game is because the easiness and interesting interface of the game will influence students' motivation in developing cognitive skill. They also can challenge their problem solving skill in the game. Thus, the learning process can be done in relax and fun way.

V. FUTURE WORK

Looking at the influence and the positive effect of game-based learning, we are enthusiastic to propose a design of tangible game-based using the board in introducing programming to elementary school students. The design of the game must consist of a very simple and clear instruction, have fun and interesting interface and the content must suitable with level of students. The game will be tested and implemented in the elementary school level. It will be a fundamental subject of problem solving, critical thinking and cognitive development from the elementary school level.

VI. Conclusion

In this paper, we discuss on the tendency of tangible game-based among elementary school students. For that, we use tangible game 'Beat the clock – Sorting Networks' that teach the algorithm on how to sort numbers in ascending order. The uniqueness of this research is we are using outdoor game, differing from other researchers mostly uses indoor tangible-game approach. The result's proposition of our study consists in designing a new tangible game-based that suitable to elementary school level. The details of our results will give full insights for developers, curriculum maker and teachers in considering tangible game-based approach in teaching and learning. Developers will get information regarding the possible factors in improving the design of tangible game-based. While for curriculum maker and teacher can use this finding as a guideline in introducing programming to children. The results of finding prove, tangible game can be a creative approach in introducing programming to elementary school students. It is also shown students' tendency toward the game because of easiness and attractive interface of the game.

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