Quantitative Study: Assessing Technological Problem Solving and Thinking Skills Among Primary School Children

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This program was conducted to analyze the effect of a robotic program in assessing technological problem-solving among primary school children. The content of learning module, which consist of technological problem-solving as well as visible thinking activities, had gone through expert validation before the analytical calculation commenced. Technological Problem Solving Inventory (PSI-TECH) was utilised to measure the technological problem solving. Quasi-experiments were implemented in this study, involving experimental and control group which were equal and homogeneous in selected characteristics. The robotic and basic visual coding program was conducted for five months, with an hour of lesson each week, consistent with the school syllabus and activities. Results were obtained by collecting the data before and after the program following a quantitative analysis of t-test and MANOVA. Result had shown a significance positive value for the experimental group after the program. This study contributes in the field of education, in investigating the technological problem-solving skills among students. In addition, help to diversify the studies in the field of robotics.

Keywords: robotic in education, technological problem solving, coding for children.

Educational robotics, has been taken seriously by society in addressing computational thinking (CT) in the concept of graphical programming among the children. Theoritically, using robotics for learning embedded around constructionist learning. Hence, constructionism is connected with experiential learning; builds on Jean Piaget's epistemological theory of constructivism (Papert,1993a; 1993b).

Furthermore, CT related to higher order thinking Bloom’s taxnomomy in application, analyze, synthesis and evaluation (Voskoglou & Buckley, 2012), encouraged problem solving in more creative way (Dede et al., 2013). Hence, CT was closely related to technological problem solving (Atmatzidou & Demetriadis, 2014) which involved programming/coding terms such as *(sequences)*, *(loops)*, *(parallelism)*, *(events)*, *(conditionals) and (operators)* (Brennan & Resnick , 2012).

On the other hand, the issue of lacking problem solving skills among Malaysian students spur the concern for higher order thinking skills implementation among students. Therefore, problem-based learning encourages students to use their knowledge content, applying critical thinking and problem solving skills in the real world which emphasize that learning occurs in the process of solving problems and not only by memorizing content but also applying knowledge and collaborate with others (Baek & An, 2011).

Meanwhile, technological problem solving approach involves a computer that thinks like a human being or encourage others to think like a computer; is achieved through computational thinking. The technological problem is usually assisted by a system or gadgets (Mioduser, D. 2009; Voskoglou & Buckley, 2012; Varnado, 2005). In educational robotics and programming, graphical programming is becoming increasingly popular among students through concepts that are easy to use by students, such as Scratch while applying technological problems (Brennan & Resnick, 2012; Harvey & Monig, 2010; Eguchi, A. 2014; Afari & Khine, 2017). Technological Problem Solving Inventory (PSI-TECH) is an instrument to measure technological problem solving, adapted from PSI-PSYCH-*Problem Solving Inventory (*Wu et al., 1996) and MacPherson (1998).

Hence, solving problem which involves technology was called technological problem solving. Technological problem solving usually solved by utilizing a electronic gadget or a computer. The solving process involved thinking and tinkering, seeking for the best solutions (Mioduser, 2009). Technological Problem Solving Inventory (PSI-TECH) is an instrument to measure technological problem solving, adapted from PSI-PSYCH-*Problem Solving Inventory* (Wu, *et al.,* (1996) and MacPherson (1998). PSI-PSYCH was invented by Heppner (1988), to accesss problem solving confidence, personal control and problem avoidence. Even Custer, Valesey and Burke (2001) mentioned that the difference between PSI-PSYCH and PSI-TECH was that PSI-TECH focused more on technological problem solving.

There were various studies done in the areas of ability between genders in solving problems. The study of D’Zurilla, Maydeu-Olivares & Kant (1998) also discusses the differences in the ability to solve the problem between genders. Women often think they are less technology savvy as reported in Sawaros & Nathan (2017). The topic on difference in academic achievement between gender is also often discussed, not only locally but also internationally. However, on average, the percentage of female graduates is higher than male (Olivia, 2007, Meltam & Serap, 2004; Nik Syuharul, 2014). Soumela & Stavros (2016) stated that girls need more time in tranining to acquire computational skills in robotics rather than boys. Furthermore, the issue of gap between gender in motivation and interest towards robotic is no longer an issue because robotic technology clearly enhances the motivation and interest of female students as well as boys (Christiane, Deller & Maria, 2016; Pedro & Elio, 2016). This issue has attracted the current study to investigate further on the gender differences in technological compentacy, particularly in problem solving skills.

Thinking skills activities were assesed through the module in stimulating "visible thinking" (Ritchhart & Perkins, 2008). The overall score of individual training is taken into account for data analysis after the program (Siti Asmah Md Yusof & Saemah Rahman, 2015; Fazzlijan Mohamed, 2015).

In this study, the research questions involved are:

(i) Is there a significant difference in the performance level of participants' in technological problem solving between control group and treatment group before and after module training?

(ii) Is there a significance difference in the performance level of technological problem solving and the achievement of training module scores according to the gender of the student after attending the training program?

In order to answer these research questions, several hypotheses were created as stated in Table 1:

Table 1

Hyphothesis of the study

Alternative hypothesis	Null hypothesis
1. There are significant differences in the level of performance of technological problem solving treatment group participants after participating in a training program with graphical programming with robotics.	1.There is no significant difference in the level of performance of technological problem solving treatment group after participating in a graphical programming training program with robotics.
2.There are significant differences in theperformance level of the technological problem solving and the achievement of the training module score according to the gender of the student after attending the training program.	2. There is no significant difference in the performance level of the technological problem solving and the achievement of the training module score according to the gender of the student after attending the training program.

Method

This study applied a quantitative approach, which involved Techonological Problem Solving Inventory, PSI-TECH. Application of robotics and programming module for primary school (RPGsr) was the intervention for technological problem solving performance in the treatment groups. The quasi-experimental design was implemented; consist of pre-post test among the control group dan experimental group (Ghazali & Sufean, 2016) (Table 2). This design was selected after considering the particiants can’t be distributed randomly prior to school requirements and the robotics programme duration.

Table 2

The study design

Study design	Group	Action
Quasi experimental	Experimental	Pre-test – intervention – post test
	Control	Pre-test – no intervention – post test

Purposive sampling was used to form 2 groups consisted of experimental and control. Creswell (2009) recommend choosing a sample in total or by taking the entire sample in a class was very appropriate to carry out a quasi-experimental for minimizing the interference with classroom learning. The homogenous sample intended that students following the syllabus of the selected graphical programming Scratch; two classes of 6A and 6B are selected in the study as a treatment and control group with an average number of 35 participants. Control group intervention and treatment was done within 5 months continuously with 1-2 contact hours every week. After taking into consideration of school requirements (based on the daily class period, school holidays, additional class and extra-curricular activities) this robotic programme was run through 5 months, began from February until beginning of July. The entire selected participant is homogenous in term of STEM subjects' performance and they are currently immersed in the same standard curriculum of Malaysia primary school (Pálinkás, et al., 2013). However, the effects of external variables need to be controlled so as not to confuse the effects caused by independent variable, so randomized division of subjects is done in the population is uniform and homogenous (Lauren, Allen & Mark, 2015).

Results

Descriptive and inference statistics are used in testing the research hypotheses. To test the hypothesis I, paired t-test was used to analyse the performance of technological problem solving differences in the control group before and after the program. Table 3 (a) and (b) below shows the results of the pair sample t-test for the analysis of test score mean difference of the control group before and after the program. The group consisted of 39 respondents. The scores for the control group before the program had only a slight decrement at the end of the study. As the value of alpha (.831) is more than the level of regulation (.025), the null hypothesis is accepted; namely that there was no significant difference in the mean score for the control group before and after the program. This conclusion was made on the level of significance alpha = .05 (5%) or the level of confidence (95%). This decision means that the control group who did not follow the program does not receive any effect because the teaching is to follow the normal teaching methods in the classroom.

Table 3(a)

Descriptives analysis for control group

		M	N	*SD*	*SE*
Pair 1	Pre-test	230.692	39	24.11612	3.86167
	Post-test	230.667	39	24.01242	3.84507

Table 3(b)

T-test for control group.

		Paired Differences							
					95% Confidence Interval of the Difference				
		M	*SD*	*SE*	Lower	Upper	*t*	df	Sig. (2-tailed)
Pair 1	Pre-test Post-test	.02564	.74294	.11897	-.215	.266	.216	38	.831

Paired t-test was also used to test the performance of technological problem solving in treatment group; whether have increased significantly after participating in the programme, to prove the effectiveness of this treatment. Table 4 (a) and (b) below display the results of the test score mean difference of treatment group before and after the program. The group consisted of 30 respondents. As the value of alpha (.003) is less than the level of regulation (.025), then the alternative hypothesis is accepted and hypothesis null is successfully rejected; that there are significant differences in the mean scores for the treatment group before and after the program. This conclusion was made on the level of significance alpha = .05 (5%) or the level of confidence (95%). This result may indicate that the treatment group had received a positive impact of teaching modules for technological problem solving since their performance level was observed to be increasing.

Table 4(a)

Descriptives analysis for experimental group

		M	N	*SD*	*SE*
Pair 1	Pre-Intervention	217.6000	30	33.05231	6.03450
	Post-Intervention	236.1000	30	25.96729	4.74096

Table 4(b)

T-test for experimental group

		Paired Differences							
					95% Confidence Interval of the Difference				
		M	*SD*	*SE*	Lower	Upper	*t*	df	Sig.(2-tailed)
Pair 1	Pre-Intervention Post-Intervention	-18.5	31.53	5.76	-30.27	-6.73	-3.21	29	.003

Independent sample t-test was used to examine the differences in technological problem solving score level participants between the control group and the treatment group before and after the training modules. Table 5 is the result of analysis for the control group and the treatment group before the program schedule and Table 6 is the analysis of the treatment and control groups after the program.

Table 5

T-test value before the program, for control and experimental group

	Paired Differences							
				95% Confidence Interval of the Difference				
	M	*SD*	*SE*	Lower	Upper	*t*	df	Sig. (2-tailed)
Pre-Control – Pre-Intervention	14	46.05	8.41	-3.19	31.19	1.67	29	.107

Based on the table 5 above, since the probability obtained (.107) is more than the specified alpha value (.025), then the null hypothesis stated there is no significant differences in score level technological problem solving performances between the control group and the treatment group before training module was failed in rejection and accepted. It was confirmed that the group of students was at the same level of performance before the program. It shown, a fair comparison was done to monitor the effect of the program before and after the program.

Table 6

T-test value after the program, for control and experimental group.

	Paired Differences							
				95% Confidence Interval of the Difference				
	M	*SD*	*SE*	Lower	Upper	*t*	df	Sig. (2-tailed)
Post-Control – Post-Intervention	-16.2	26.81	4.90	-26.21	-6.19	-3.31	29	.003

Based on Table 6 above, the probability value obtained (.003) is less than the specified alpha value (.025), the null hypothesis stated there is no difference score level in technological problem solving performance between the control group and the treatment group after training module was successfully rejected and the alternative hypothesis is accepted. Mean value that is a difference in score level technological problem solving between the control group and the treatment group after the training modules. The program has managed to have an impact on student achievement for technological problem solving. Table 7(a) and (b) below are the results of the descriptives analysis and Levene's test for equality of means between gender for treatment group.

Table 7(a)

Descriptives analysis between genders for treatment group

	Gender	N	*M*	*SD*	*SE*
Post-Intervention	Male	14	226	25.625	6.848
	Female	16	239	25.972	6.493

Table 7(b)

T-test value between gender for treatment group

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	*t*	df	Sig. (2-tailed)	*M* Difference	Std. Error Difference	Lower	Upper
Post-Intervention	Equal variances assumed	.13	.72	-1.38	28	.180	-13	9.45	-32.35	6.349
	Equal variances not assumed			-1.38	27.57	.179	-13.	9.44	-32.35	6.345

Based on the Table 7(b) above Levene test for equality of variances are not significant (p = .719> .05) showed that both groups of boys and girls have the same variance. That is, the null hypothesis that the variance of the group of boys is equal to the variance of the group of female students failed rejected. Thus, the results of t-test for equality of means of two groups independent of the sample which has the same population variance is taken into account (equal variances assumed).

Given the specified alpha (.18) is more than the specified alpha value (.025), the null hypothesis rejection was fail. That is, there was no significant difference in mean scores between technological problems solving group of boys than girls. Group of boys had a mean score of (226) while the female students had a mean score of (239). However, the mean difference was not significant at the .05 level of significance alpha (5%).

To test the hypothesis II, MANOVA was used to examine the differences in technological problem solving score and training modules score in thinking skills between genders.

Table 8(a)

The number of male and female participants

Gender	N
Male	14
Female	16

Table 8(a) shows the number of male students (N = 14) and the number of female students (N = 16) whom achievement was compared.

Table 8(b)

Descriptive statistics

	Gender	*M*	*SD*	N
Technological Problem Solving	Male	242.0000	22.85069	14
	Female	253.2500	24.10118	16
	Total	248.0000	23.81393	30
Module score	Male	77.9286	7.25857	14
	Female	81.4375	6.07694	16
	Total	79.8000	6.77419	30

Table 8 (b) shows the mean and standard deviation for technological problem solving (post treatment score) and scores of training modules by gender. According to the analysis, the mean of the technological problem solving for boys (242) is lower than female students (253.25). So is the case with a score of training modules, with a mean of boys (77.92) than girls (81.44).

Table 8(c)

Box's M analysis.

Box's M	2.752
F	.846
*df*1	3
*df*2	397445.475
Sig.	.469

Box's M test is used to test the homogeneity of variance-covariance matrix of the dependent variables. Box's M test is not significant (.469) in excess of 0.001 demonstrates the variance-covariance matrix is homogeneous between the dependent variable being studied.

Based on Table 8(d), in view of the probability obtained (Pillai's Trace = .380, for gender) more than the specified alpha (.05), the rejection of null hypothesis failed. There is no strong evidence to conclude that there are significant differences in the mean combination of technological problem solving and module score between genders.

Table 8(d)

Multivariate tests

Effect		Value	*F*	Hypotesis *df*	Error *df*	Sig.
Intercept	Pillai's Trace	.994	2070.307[b]	2.000	27.000	.000
	Wilks' Lambda	.006	2070.307[b]	2.000	27.000	.000
	Hotelling's Trace	153.356	2070.307[b]	2.000	27.000	.000
	Roy's Largest Root	153.356	2070.307[b]	2.000	27.000	.000
Gender	Pillai's Trace	.069	1.002[b]	2.000	27.000	.380
	Wilks' Lambda	.931	1.002[b]	2.000	27.000	.380
	Hotelling's Trace	.074	1.002[b]	2.000	27.000	.380
	Roy's Largest Root	.074	1.002[b]	2.000	27.000	.380

a. Design: Intercept + Gender

b. Exact statistic

Discussion

The study was conducted to analyse the effect of a robotic programme for primary school children. By evaluation research, via quasi experimental research procedure the result obtained was positive. The findings and analysis from the study show a positive benefit of using robotic module in assessing technological problem solving. It is clear that the students in the intervention group performed better in the post-test compared to the sutdents in the control group. Parametric tests revealed that the students who were exposed to the robotic programme demonstrated significantly better post-test mean scores, compared to their counterparts in the control group.

In the intervention group, constructionism learning was activated through collective discussion in the problem solving. This strategy seems to help the construction of knowledge among the students. The collective discussion approach, derived from the social constructivist view of learning, which help the students to recognize and evaluate their own ideas, as compared to the new concepts.As students are aware of the strengths and weaknesses of their ideas, they become more ready to restructure it.As the study was conducted based on cognitive and social constructivist perspectives,the findings showed how learning is considered as an active process in which learners construct knowledge through practically problem solving in robotic and programming.

However, the overall result may be varied depending on demographical and geographical data. In this program, the focus group was primary school students in Miri, Sarawak only. To obtain more rigorous analysis for cross-sectional studies, the program can be run in other district and the result within district can be compared. Moreover, results may be varied depending on demography and geography of the study. However, the overall program was much more depending on the time length and budget provided. Other than that, longitudinal studies can be considered by changing the time series. Meanwhile,the analysis involved three variables which were genders, technological problem solving and module scores. Alternatively, other variables can be consider such as motivation and interest level.

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