

Integrated PBL Approach: Preliminary Findings towards Physics Students' Critical Thinking and Creative-Critical Thinking

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ABSTRACT: *The main purpose of this study was to report the findings on physics students' critical thinking of early implementation of an integrated problem-based learning (PBL) approach. This study was performed on a cohort of 28 Physics with Electronics students from School of Science and Technology at University Malaysia Sabah. The sample was trained by the integrated PBL method for 1 semester (i.e., 14 weeks). Participants' critical thinking was evaluated using a previously validated instrument, the Watson Glaser Critical Thinking Appraisal (WGCTA) (i.e., inference; assumption; deduction; interpretation; evaluation arguments) and their creative-critical thinking (i.e., superior creative thinking style; creative thinking style; balanced thinking style; critical thinking style; and superior critical thinking style) was using the YanPiaw Creative-Critical Thinking. Both tests administered before (pre-test, Form A) and (post-test, Form B) the teaching and learning process.. The result shows that there is significant different in two criterions that from WGCTA test: inference(sig 2-tailed, $t = -3.478$, $p = .001 < .05$) and interpretation(sig 2-tailed, $t = -5.53$, $p = .00 * < .05$). As for the creative-critical thinking skills, the YCreative-Critical Thinking Test shows almost 32% of the students thinking style fall on balanced thinking style.*

Keywords -*Problem-based learning, critical thinking, creative-critical thinking.*

I. INTRODUCTION

Criticism about Malaysian graduates lack of scientific and technical knowledge, critical and creative thinking skills, competency based and communication skills been a keen issue nowadays [1]. Complaint from industrial employer about Malaysian graduates rose up and this indirectly contributed in persistency concern of unemployment among graduates each year (Bagayah et al., 2005; Lim 2005) as mentioned by Lim [2] and the number of unemployment among Malaysian graduates also in critical state [3]. This study was formed as a result for alternative solution of this criticism. Meanwhile, the deficiencies of information about the effectiveness of problem-based learning (PBL) in Physics field also encourage the formation of this study.

PBL start with long story since it first adopted at Faculty of Medicine in McMaster University in Canada [4] while in Malaysia, PBL started at 1981 in Medical Department of University Sains Malaysia (USM) [5]. The operational definition of PBL also act as the process of this teaching method start as cycle with students meet the problem, identify, independent study, tutorial and end with integration of learning [6] [7] [8]. PBL experienced positive development and can be seen as a trustful alternative teaching method to improved students' thinking abilities, problem solving skills and proficiencies not only in medic, teacher and engineering education teaching even in Physics itself [9] [10] [11]. As PBL approach designed as problem focused, centered learning, higher order thinking and life-long learning habits of mind [7] this ascertain many researchers that PBL contributed in enhancing on critical thinking skill [12] [13]. Although some study found that there did not have any positive effect on improving critical thinking skill [14] that might cause by few based point of approach method [15] and contribution of many other factors [16] but some study believed that PBL have a significant effect on the development of critical thinking skills [14] [15] [11].

The focus of this study is the use of PBL online in Physics course and links to students' critical thinking. Tons of literature review regarding PBL online, but the study concerning the implementation of PBL and implication on Physics students' critical thinking very rare specifically in Malaysia education system [17] [18]. An example of research correlate with this focus of study was conducted by [17] shows that the development of students' critical thinking could supported with PBL that careful designed and concerns on critical elements.

This paper presents the findings of early implementation of PBL to Physics students. Within this, it is included answer of research question as follow:

- 1) How is Physics students' critical thinking after early intervention of integrated PBL online?

II. METHODOLOGY

In this study, the implementation of integrated PBL was to investigate the effects of the independent variable (integrated PBL) on dependent variable (WGCTA and YCreative-Critical Thinking score).

1.1 Subjects

This study was performed on 28(i.e., 16 females and 12 males) students from second year of Physics with Electronics program who attended Thermodynamics Physics course in Semester 1 Session 2012/2013 at Universiti Malaysia Sabah. The course was a compulsory course under the programme. They had been exposed by PBL method for 1 semester (14 weeks). The course led by a lecturer who had 10 years of experienced in PBL.

1.2 Instruments

For critical thinking skills, data gathered via Watson Glaser Critical Thinking Appraisal 1980 (WGCTA) test which adapted to Malaysia context by Sulaiman [18]. WGCTA was widely used by researchers represents by 5 tests in total: *inference, recognition of assumptions, deduction, interpretation and evaluations of arguments* was implemented before and after the PBL method. Additionally, for creative-critical thinking skill, data was collected by using The YanPiaw Creative Critical Thinking (YCreative-Critical Thinking) Test developed by Chua [19] to identify student level of thinking styles. In this particular test there were 4 level of thinking that being stated which are: *superior creative thinking, creative thinking, balanced thinking, critical thinking and superior critical thinking*.

The Cronbach's alpha coefficient value for WGCTA test revealed a range of .76 to .85 accordingly while for YCreative-Critical Thinking Test is .90 (total score), .81(critical thinking style) and .85 (creative thinking style).

Data was analyzed using SPSS Windows version 20.

1.3 Procedure

1.3.1 The Online Platform

In order to implement the online activities, Facebook (FB) chat room was used. As widely known, FB is a freely accessible social network on the Internet which would work for anyone[20].FB was developed in 2004 by Mark Zuckerberg accessed by using either on computers or mobile phone and this makes students easy to use everywhere and anywhere they are [20]. This also make student's easy to share document or photo related to their problem anytime they want and each member or facilitator still can view it anytime they use FB not limited to their timetable.

1.3.3 PBL Procedures

The PBL process used in this implementation was summarized as shown in Fig. 1.

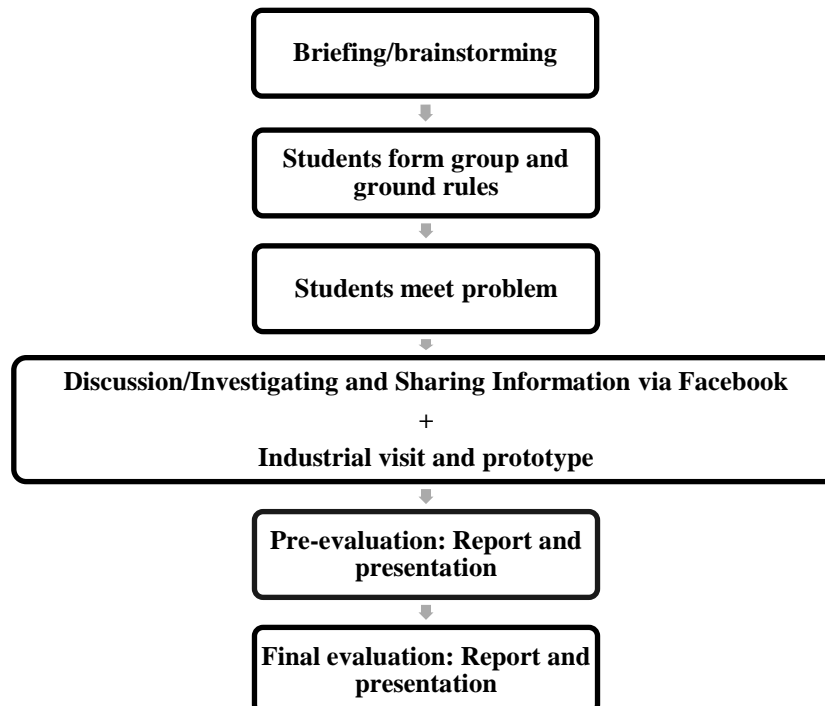


Figure 1: Summary of PBL model used

During the first and second week before PBL implementation, students briefly introduced about course outline. Meanwhile, students formed group about 5 to 6 people in a group and set ground rules. Students were provided with lecture note and act as their main guideline to identify their own problem statement. After brainstorming, students decided their slot time for online chatting: 1 hour per week for every group as this online PBL implementation held almost 3/4 using online chatting.

Students find their own problem statement with the guideline from lecture note and facilitator. During discussions, students were suggested their own idea and also shared the information they gathered during the independent learning. These activities had been monitored by a facilitator via online. Students normally were given with 1 week to settle on and decide their final problem statement and main objective which they will solve throughout the period of PBL implementation. Students usually gathered information from their surroundings, technology (internet), book and journal reading to come up with their problem statement.

The processed of intervention start with students brainstorm and brief about the problem with each other. After that students provide what they know and what they do not know about the problem and objective of problem. Students searched relevant information including book, journal, magazine, notes, manual, internet and other kind of resources. All this give and take or sharing information and idea processed held via Facebook facilitated by lecturer and researcher as facilitator.

Additional compulsory activity that the group need to do was to visit to any government or private agencies related to their problem respectively for interviewing in a way for students understand more and get useful information. This is critical extracurricular such as interview and observation will make students understand more and get useful information. Some of students even make a simple laboratory experiment or prototype after the visit to gain more idea and provide deeper understanding with the member group and other classmates.

To make this implementation more effective, after every 2 to 3 weeks of online class in chatting room (Facebook), students compulsory meet face to face with facilitators to exchange their confusing or dilemma. On the other hand, students also need to provide pre-report and pre-presentation at week 7 or 8 in front of their classmates and facilitator. This pre-evaluation provide them with experience for better communication skills and presenting in front of many people. Final report and presentation also held at the end of implementation in week 14 for final evaluation.

1.3.2 Face-to-face Discussion

Face-to-face discussion in this study held as usual lecture, sit in a class for 1 to 2 hours and facilitator discuss the progress of each group in term of their solution. This discussion held about 2 or 3 weeks after online class. This is important as to provide students with a solid discussion in every chat and they had time to ask facilitator question they found hard to explain during the online chat class. This discussion also provide time between facilitator and students to be little closer and realize the role of facilitator in their online chat class as guide which help students to more open to ask, share their opinion and widen their rationale during online chat. In addition, this discussion also helps each member to solve their misunderstanding and misinterpretation between each other's.

At the end of every face-to-face discussion, facilitator provides some feedback to almost every group member regarding to their level of participations, contributions of opinion or comment and alternative of solving the problem. This was important in helping the students to be to more confidence with the information that they want to share.

III. FINDINGS

The findings in this study performed in two parts. First, WGCTA test showed the significant of students' critical thinking style in five criterions before and after the implementation of PBL and comparison of critical thinking by gender. Second, YCreative-Critical Thinking Test showed the students thinking style and relationship between students' thinking style and their age.

2.1 The Watson Glaser Critical Thinking Appraisal (WGCTA) Test Analysis

Table 1 shows the report of students' critical thinking for pre- and post-test by criterion. These data show that students performed better after the implementation of PBL (mean=44.02, SD=11.40) compared to before implementation (mean=38.31, SD=10.16). This Independent Sample t-Test analyses shows there are statistically significant for *inference* (sig 2-tailed, $t = -3.48$, $p = .00 < .05$) and *interpretation* (sig 2-tailed, $t = -5.53$, $p = .00 < .05$), while there is no statistically significant for other criterion. Meanwhile, both *inference* ($z = -2.97$, asymp. sig (2-tailed) = $.00 < .05$) and *interpretation* ($z = -4.50$, asymp. sig (2-tailed) = $.00 < .05$) appear statistically significant

when data analyses with the more non-parametric Mann-Whitney U-Test. Nevertheless, *interpretation* also has higher mean difference compared to other criterion (mean difference = +3.17, SD difference = +0.72).

Table 1: Report of students' mean marks for critical thinking pre- and post-test by criterion

Critical Thinking Criterion		Approach			
		Pre-Test (N =28)	Post-Test (N =28)		Difference in Post-Test
			Mann-Whitney U Test	Independent Sample t-Test	
Inference	Mean	4.64	6.46		1.82
			z = -2.90 Asymp. Sig = .00	t = -3.49 p = .00	
	SD	1.66	2.22		0.56
Assumption	Mean	9.21	9.71		0.50
			z = -1.21 Asymp. Sig = .23	t = -1.00 p = .32	
	SD	1.97	1.76		-.21
Deduction	Mean	8.89	9.93		1.04
			z = -1.70 Asymp. Sig = .09	t = 1.55 p = .126	
	SD	2.47	2.52		.05
Interpretation	Mean	6.79	9.96		3.17
			z = -4.50 Asymp. Sig = .00	t = -5.53 p = .00	
	SD	1.75	2.47		.72
Evaluation Arguments	Mean	8.79	7.96		-.83
			z = -1.02 Asymp. Sig = .31	t = 1.29 p = .20	
	SD	2.32	2.43		.11
Overall	Mean	38.32	44.02		5.70
			z = -11.33 Asymp. Sig = .63	t = -7.18 p = .65	
	SD	10.16	11.40		1.24

The analysis percentage of pre- and post-test of WGCTA test is provided in Fig. 2. These data shows that *interpretation* achieved the higher improvement by +3.9% while *evaluation of argument* decreased by -0.5%.

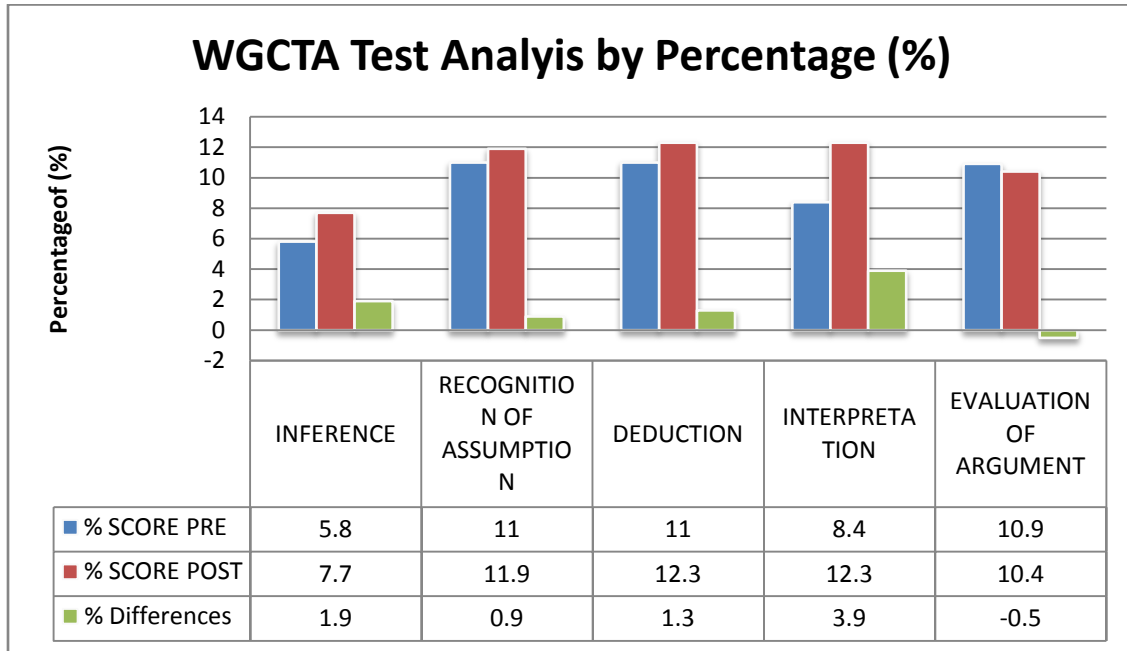


Figure 2: Analysis percentage of pre- and post-test

2.2 The YanPiaw Creative Critical Thinking (YCreative-Critical Thinking) Test Analysis

Fig. 3 shows the distribution of thinking styles among students. It shows that most of the students (67.9%) fall under creative thinking skill while the rest (32.1%) fall under balanced thinking skill. There is no one of the students fall under critical thinking skill, superior critical thinking or superior creative thinking

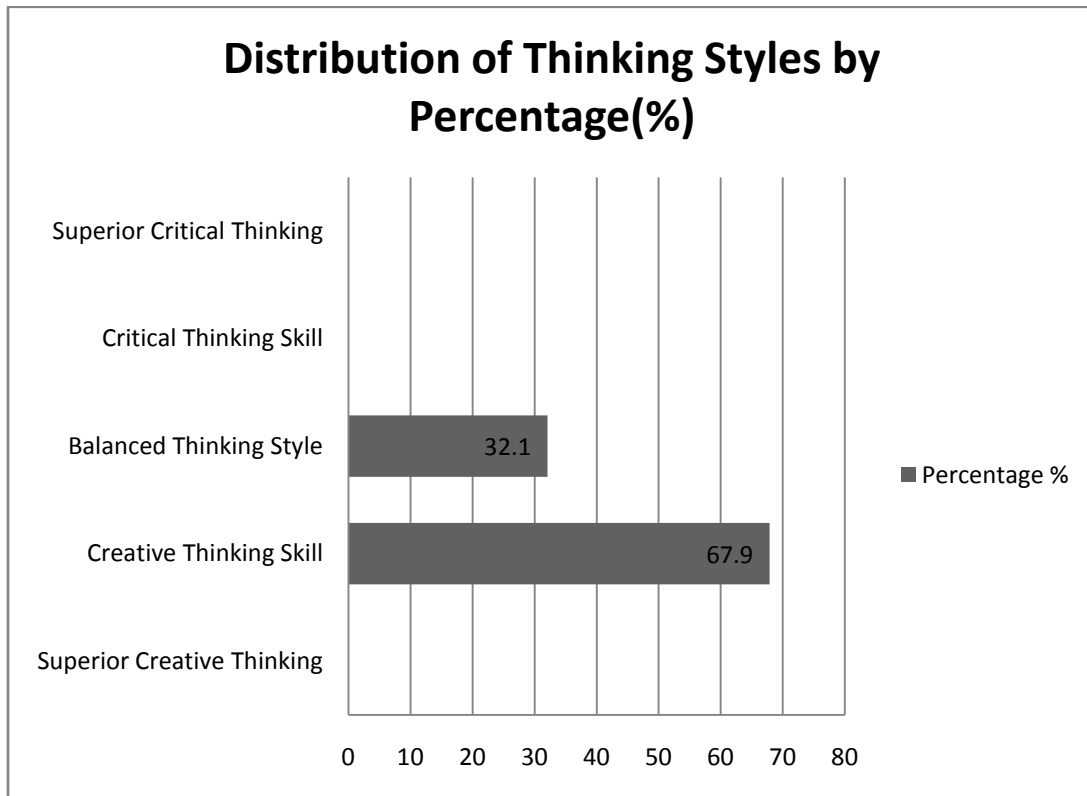


Figure 3: The YCreative Critical Thinking Test Analysis

2.3 Comparison of Critical Thinking by Gender

Table 2 shows the comparison and reports of mean marks for critical thinking before and after the implementation by gender. Overall, there are no statistically significant for both pre- and post-test for all criterions when results were test by Independent Samples t-Test.

Ratings for male were higher both in pre- (M=39.60; SD=9.52) and post-test (M=45.74; SD=13.25), this might because the number of sample for male is small (N=12) than female. Ratings for male were higher in inference, deduction and evaluation of argument both in pre- and post-test while female were higher in interpretation in pre- and assumption in post-test.

Table 2: Comparison of critical thinking by gender

Critical thinking Criteria		Pre-test						Post-test					
		Gender			Independent Samples t-test for equality of means			Gender			Independent Samples t-test for equality of means		
		Male	Female	Total	t (df=26)	Mean difference	Sig. (2-tailed)	Male	Female	Total	t (df=26)	Mean difference	Sig.(2-tailed)
Inference	Mean (SD)	5.00 (1.76)	4.38 (1.59)	4.64 (1.66)	.99	.63	.34	7.33 (2.02)	5.81 (2.19)	6.46 (2.22)	1.90	1.52	.07
Assumption	Mean (SD)	9.83 (1.47)	8.75 (2.21)	9.21 (1.97)	1.47	1.08	.131	9.58 (1.93)	9.81 (1.68)	9.71 (1.76)	-.33	-.23	.75
Deduction	Mean (SD)	9.17 (2.44)	8.69 (2.55)	8.89 (2.47)	.50	.48	.61	10.17 (2.37)	9.75 (2.69)	9.93 (2.53)	.43	.42	.69
Interpretation	Mean (SD)	6.75 (2.01)	6.81 (1.60)	6.79 (1.75)	-.09	-.06	.93	10.33 (3.14)	9.69 (1.89)	9.96 (2.47)	.63	.65	.54
Evaluation of argument	Mean (SD)	8.83 (1.85)	8.75 (2.67)	8.79 (2.32)	.09	.08	.92	8.33 (3.79)	8.31 (1.96)	8.32 (2.83)	.02	.02	.99
Overall	Mean (SD)	39.60 (9.52)	37.38 (10.61)	38.32 (10.17)				45.74 (13.25)	43.37 (10.42)	44.38 (11.80)			

Male, N=12; Female, N=16; Total, N=28)

2.4 Relationship between Students' Thinking Styles and Age

Fig. 4 shows the relationship between students' thinking style and their age when test with the YCreative-Critical Thinking Test. Overall student's age are ranged from 19 to 23 years old. Students with age 20 years old (N=9) show highest number in critical thinking style compared to students with age 23 years old (N=2), this probably cause by the number of sample with the age of 23 years old are lowest among the others age. Meanwhile, for balanced thinking style, students with age 21 and 23 years old placed tied with 3 students. Students with age of 19 years old placed lowest with only 1 student.

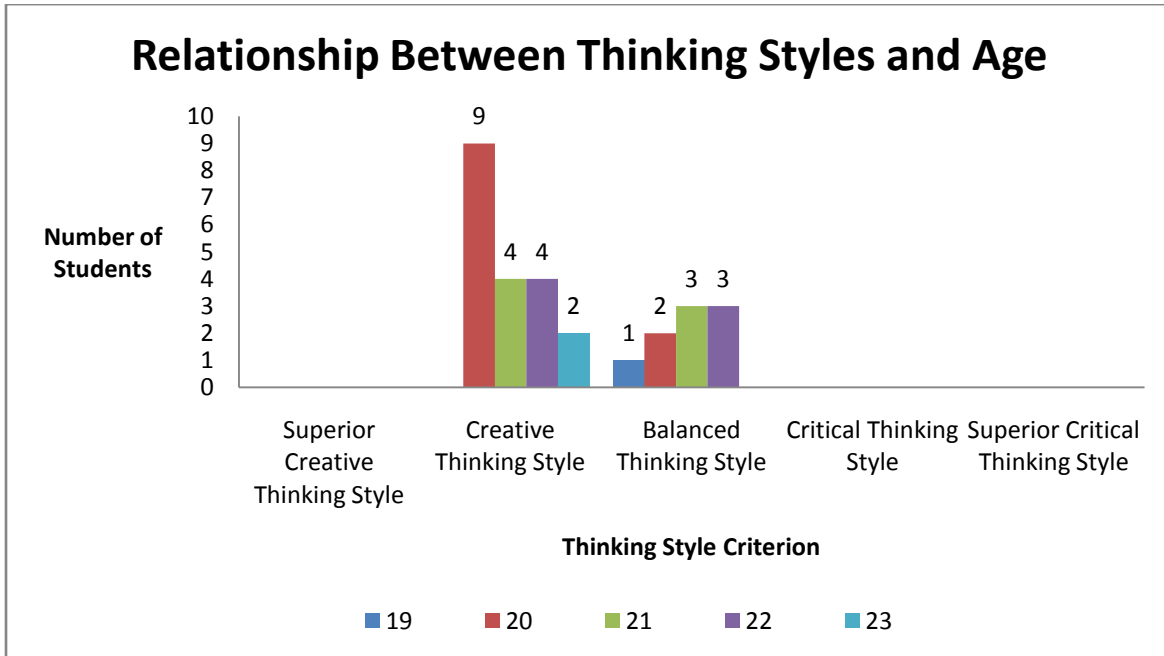


Figure 4: The YCreative-Critical Thinking Test for gender

IV. DISCUSSION

The purpose of this paper was to report the preliminary finding towards Physics students' critical thinking of on-going integrated PBL implementation. From the data analysis, PBL enhanced the critical thinking style of students can be made as an early conclusion for future positive development of PBL implementation.

This part focused only on students' score of balanced thinking style in The YCreative Critical Thinking Test and it correlation with students score in WGCTA Test. Chua (2004) indicates balanced thinking style as "average creative and critical thinking style, where students able to solve problems by using certain whole brain skills", this show that 32% of students in this study has a potential to improved their critical thinking style. This positive development of students thinking styles proved in WGCTA test as it show that there is addition of significant value in WGCTA criterion; *inference* and *interpretation* compared to Sulaiman[18]study which only *inference* showed significant after the implementation of PBL.

Parallel findings with previous study (Lehman, 1953; Jacquish, 1980) as mentioned by Maizam [21] found where students with age ranged from 19 to 23 years old expected has greater percentage as creative thinkers when this study found 68% of students fall on creative thinking style while 32% fall on balanced thinking style.

Perhaps the positive findings in this early implementation can be attributed to the innovation of the implementation itself. Rather than the classes held only via chat room (online), students and facilitator also spent times in face to face class, this helped students get engaged with facilitator and lessen the students lecture boundary. This also helps in improvement of students' self-confidence, communications, students' active engagement in participation and social skills[8] [22]

V. CONCLUSION

This study, as it was its purpose to provide evidence of positive improvement of students' critical thinking after being intervened with integrated PBL approach.

The results show that there is significant in two of critical thinking elements, this answered number 1 research question. Study was expected more encourage results in future as this implementation still in early stage. Main limitation of this study was small sample size.

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