A Comparison of Integrated Problem-Based Learning Approach in Theoretical and Mathematical Courses in Physics towards Students' Critical Thinking:

A Case Study in University Malaysia Sabah

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ABSTRACT This paper aim to discuss the findings of integrated Problem-based learning (PBL) implementation onPhysics students' critical thinking. Discussion will be focusing on performances and perceptionsof Physics student critical thinking skills after implemented for 28 weeks. Based on results revealed prior of this study, itshow students able to develop their critical thinking skills when integrated PBLimplemented in more theoretical course (i.e., Thermodynamic and Modern Physics) rather than course with moremathematical such as Statistical Physics. Detailed discussion on students' performances and perceptions was revealed in this paper.

Keywords *Critical thinking skill, problem-based learning*

1. INTRODUCTION

Demands from most employers looking for employees who have highly employability skill (i.e., creative and critical thinking)in workplace mainly for fresh graduate of tertiary level (Azami*et al*., 2009)andapart to aim for raise awareness of the importance of Physics courses to students was become the main course the formation of this study.

Study ofproblem-based learning (PBL) influence on students' from various field other than medical (i.e., sociology, sciences, engineering, language) soft skills was developing in recent years (Rosalind *et al*., 2013; Elizabeth *et al*., 2012; Faridah*et al*., 2011;) this probably caused by currently there are a large number of higher education institutions transforming their traditional educational approaches to PBL. Summarizefrom Mehmet *et al*. (2009) study, students had mind setting believes that physics purely based on memorizing, while some students believes physics not connected to the real world, these was some factors there are still many students does not interesting study on Physics. Malaysian students for example, mostly students in tertiary level taking Physics as their major was because either there are no other option or choose Physics as their save path.

This paper mainly will present the findings on students' critical thinking skill after intervened with integrated PBL online with some perceptions from students on what and how they think about implementing integrated PBL in science courses mainly in Physics course.

1.1 PBL APPROACH ON PHYSICS COURSE: STUDENTS' PERFORMANCES AND PERCEPTIONS

Overall, from previous literature review, PBL approach on physics environment show positive influences whether they were implemented and compared with traditional group (Selçuk*et al*., 2013; Fauziah*et al*., 2013; Sahin*et al.,* 2009) or it was implemented alone (Elnetthra*et al*., 2013a; Ahmad *et al*., 2012; Erdal*et al*., 2011). These show a positive acceptance on PBL learning style on physics students.

Thermodynamics physics was a theory of impressive range of validity and describes all system forms in exactly the same form as they were originally formulated (Galperin*et al*., 2004).The understanding of thermodynamics was included the properties and states of a system, the process occurs in system and the cycle of process, with highly understandable in this topic students would have a reasonably clear idea of what is thermodynamics about.

Based from Tatar *et al*. (2011) study, PBL was shows positive effects on students' learning abilities and increasing their science process skills.PBL was implemented in thermodynamics course by some study, where Fauziahand Saturi(2012) was one of it showing that PBL have potential in improving students' grade.

On the other hand, statistical physics was a rational understanding of the thermodynamics in terms of microscopic particles and their interactions(Galperin*et al*., 2004). Statistical physics also known as unfinished and active part of physics which also describe as subtle, intellectually and mathematically demanding. Statistical was not only allowed calculations of temperature dependence of thermodynamics quantities, but also of transport properties. In other word, statistical physics was could describe as course required technical, statistical and mathematical (Vidic, 2010).

Statistical in engineering course in University Kebangsaan Malaysia on Nopiah*et al*. (2009) study was introduced to PBL to overcome the lack of problem solving and application knowledge in mathematics and basic statistics among the engineering students and it revealed that PBL improved student interest, critical thinking and problem solving. As from Vidic (2010) study shows how PBL introduced to statistics course and it seems that the PBL significantly improved students' competences in planning and organization of learning.

Based fromKhairiyah et al. (2011) study of practical cooperative problem-based learning (CPBL) on engineering students on UniversitiTeknologi Malaysia, student stated that by learning using CPBL the way of their thinking have matured in term of their emotion and discovering on what they need to improve during learning. Contrary, from same study, students stated that when they learn using the old way which is just included purely reading, they are more happy rather when they are learning using CPBL approach, they claimed that in CPBL approach, the more they read, the more they got confused and this lead some students to choose traditional learning as their main learning process.

2. METHODOLOGY

In this study, the implementation of integrated PBL was to investigate the effects of the independent variable (integrated PBL) on dependent variable Watson-Glaser Critical Thinking Appraisal (WGCTA score). WGCTA is one of the established critical thinking test that been used all across country.

This study was performed on Phase 1: n=28 (i.e., 16 females and 12 males); Phase 2: n=25 (i.e., 16 females and 9 males) students from second year of Physics with Electronics program (as shows in Table 1) who attended Thermodynamics Physics course and Statistical Physics in Semester 1 and Semester 2 accordingly, for the 2012/2013 session in University Malaysia Sabah. The courses were compulsoryunder the programme. They had been exposed with PBL method for 2 semesters (28 weeks). The course led by a lecturer who had 10 years of experienced in PBL.

Table 1 Number of Samples for Two Phases of Integrated PBL Implementation

	Phase	
PBL Group of students	Phase 1	Phase 2
	28 (i.e., 16 females and 12 males)	25 (i.e., 16 females and 9 males)

Data gathered via Watson Glaser Critical Thinking Appraisal 1980 (WGCTA) Form A and From B test which adapted to Malaysia context by Sulaiman (2011) while Form C of WGCTA was developed by researcher based from Form A and B. 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. The Cronbach's alpha coefficient value for WGCTA test revealed a range of .76 to .97 accordingly. Data was analyzed using SPSS Windows version 20.

The procedure of this study was discussed separately into three main parts: PBL procedures using during implementation, the online platform and face-to-face discussion.

2.1 PBL PROCEDURES

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

Table 2 Summary of PBL process used in this study

Stage	Activities
Briefing/ Introduction	➢ Briefing about outline of courses (by power point or word), marking system (quiz, midterm & final exam) and simple introduction of PBL process
Formation of group	➢ 5 to 6 groups are formed (about 6 to 7 members in a group). Students are given a freedom to choose and decide who and who in their group. ➢ Ground rules formed
Facing problem scenarios	➢ 1 week given to every group to come up with their own scenario of problem related to courses, scenarios usually from daily life which they can relate, facing every day or read everywhere. Information could gather from daily life problems, technology (internet), book and journal readings. ➢ The formation of problem scenarios was discussed with each member and was revised by lecturer with 10 years of experiences in PBL). The processed of discussion summarized as followed: i. Students brainstorm and brief about problem with each other. ii. Students provide what basic knowledge they know and don't know regarding their issue iii. Each member searched relevant information including book, journal, magazine, notes, manual, internet and other kind of sources. iv. Additional compulsory activity for every group in this study is they need to make an industrial visit to any government or private agencies related. v. Some students even make a simple laboratory experiment or prototype after the visit to gain more idea and provide deeper understanding.
Pre-evaluation	➢ Held about after week 7 or 8 of implementation. Students need to provide simple report for half of their findings and also held a presentation for everyone including lecturer. This experience will provide students a self-confident when speak in front of many people.
Final-evaluation	➢ Held on week 13 and 14 of every phase of intervention. A full report and full presentation will provided by students.

2.2 THE ONLINE PLATFORM

In order to implement the online activities, Facebook (FB) group chat room was used. As widely known, FB is a freely accessible social network on the Internet which would work for anyone (Collier *et al*., 2012).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 (Collier *et al*., 2012). This also make student's easy to share document or photo related to their problem anytime they want. Furthermore each member or facilitator could be able to view it as well, at anytime and anywhere.

2.3 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 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 students to bemore confident with the information that they want to share.

3. RESULTS AND FINDINGS

As presented in Elnetthra*et al.* (2013a), students' critical thinking ability during first phase (N=28) of integrated PBL implemented, there is significant difference in two of the criterion from Watson Glaser Critical Thinking Appraisal test; *inference(sig 2-tailed, t=-3.478, p=.001<*.05)* and *interpretation(sig 2-tailed, t=-5.53, p=.00<*.05)*. This was supported by overall mean and standard deviation score was higher on pre-test than post-test 1. However,results show in Elnetthra*et al.*(2013b), although there is significant difference in *inference(sig 2 tailed, t=5.57, p=.00<*.05)* but mean and standard deviation score reversal as score on post-test 2 was lower than post-test 1 for second phase intervention (N=25).

All results of both phases (pre-test -> post-test 1 -> post-test 2) for this study was summarised in Table 1 and Figure 1.

Table 3 Students' critical thinking skills for two phases of PBL intervention

WGCTA Criterion	Pre-test - Post-test 1 (N=28)	Post-test 1 – Post-test 2 (N=25)
Inference	√ *(sig 2-tailed, t=-3.478, p=.001<*.05)*	√ *(sig 2 tailed, t=5.57, p=.00<*.05)*
Assumption	-	-
Deduction	-	-
Interpretation	√ *(sig 2-tailed, t=-5.53, p=.00<*.05)*	-
Evaluation of Argument	-	-

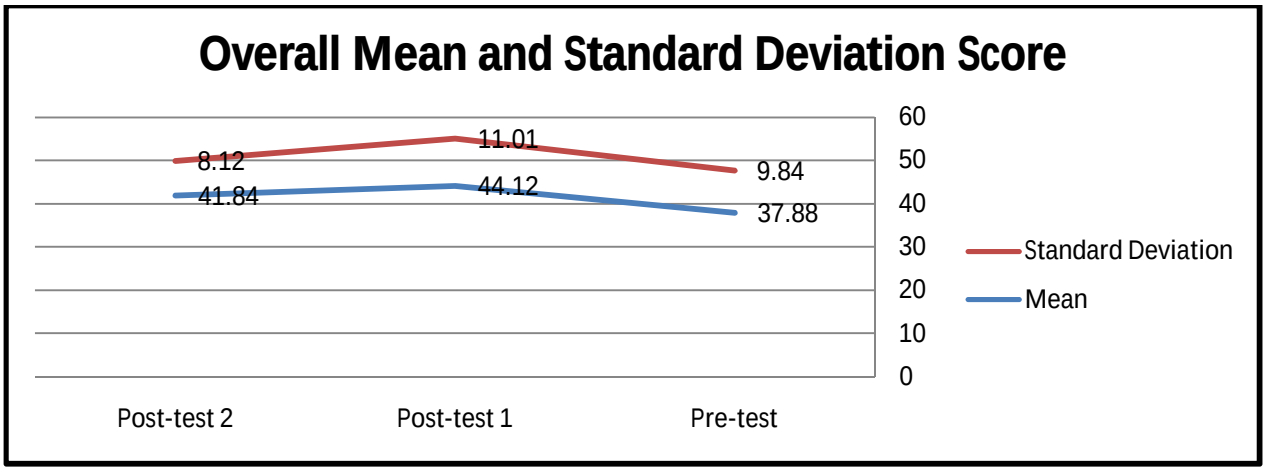

Figure 1 Overall mean and standard deviation score of pre-, post-1 and post-2

4. DISCUSSION

Students' score on critical thinking after intervened with integrated PBL online were compared and present in this study. The results of the study indicate that there are significant difference on two of the criterion on the first phase while one criterion on the second phaseof intervention. The mean and standard deviation score also indicates that students' critical thinking ability was shiftily decreasing after the second phase on intervention.

After being intervened with integrated PBL online for 14 weeks, students show they were able to differentiate between true and false facts that being been given to them (*inference*), they also show the ability to considers the evidence given and determines whether data provided are warranted (*interpretation*), which shows students are showing they have been able to cope with

PBL online learning and show potential in future development mainly in students' soft skills. Findings on first phase of intervention of this study was compared to nearest finding study by Fauziah (2011) with the similarity of duration of integrated PBL implemented, it is found that result in this study was developed compare to study by Fauziah (2011) as there only one of the criteria was found there is significant difference; *inference*, while in this study students show development as they show ability in *interpretation* criteria.

Contrary, when intervention was extended to another fourteen (14) weeks in different course of Physics (e.g., Statistical Physics), it shows that there is significance difference in one criterion from the test; inference, but based from mean and standard deviation score for the criteria shows the decline of score. Without taking into account that the results shown in this study decreased or diminished students' soft skills, although the results not only demonstrated that students' critical thinking nor developed neither their interpretation skill disappeared but students' final grade shows otherwise as students' achieve higher grade in final exam after the second phase of integrated PBL online implemented compared to previous grade.

Several factors based from students' feedback on their interview which contributed to the findings during their second phase of intervention such as the nature of Statistical Physics course itself which not lend itself to PBL and students' preferred discussion involves mathematical presented in traditional way. This feedback was in line with Norngain*yet al*. (2012) study, describes that students agree the important and preferred Mathematics and Statistics courses delivered through traditional way (i.e., lecture class, face-to-face discussion).

In respect of that, students stated and opine that PBL online was not really suitable in physics courses with rooting more in mathematics. Students also suggest that PBL online might be more suitable in physics courses such as thermodynamics as this subject was easily related to real life problem.

5. CONCLUSIONS

This study presents finding on how students' critical thinking after being intervened with integrated PBL online in two different outline of main subjects in Physics courses (i.e., Thermodynamics and Statistical Physics). Even though based from the findings on quantitative data in this study show decreasing in students ability on critical thinking which caused by some factors that explained using qualitative data (i.e., interview), it is believed that PBL online could still be very promising learning style to substitute traditional learning in tertiary level mainly in sciences course with proper and well planned approach. In addition, PBL still has apromisingpotential of learning approach in developing students' soft skills during their 3 to 4 years study in higher education.

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