Best Practices of Problem-Based Learning Implementation for IT Courses from Students Perspectives

Norida Muhd Darus, Haslina Mohd, Fauziah Baharom, Mohamed Ali Saip, Nurnasran Puteh, Zaharin Marzuki @ Matt, Mohd Zabidin Husain, Azman Yasin
Human Centered Computing Research Lab, School of Computing, Universiti Utara Malaysia, Malaysia.
nor854@uum.edu.my

***Abstract*— Problem-based learning (PBL) is a powerful learning approach that leads to enhance and sustain learning towards student centered, problem focused, self-reflective learning, and self-directed learning. This may improve student ability in problem solving, critical thinking, work as a teamwork, and leadership. All these soft skills are important to IT students as a preparation for their future career development. Unfortunately, there is no statistical evidence to support the effectiveness of the PBL implementation as claim by many researchers. Therefore, the top management of Higher Education Institution (HEI) is really concerned with the effectiveness of the Problem-based Learning (PBL) implementation of certain courses in the university. The effectiveness of the PBL implementation is actually depends on the best practices of the PBL implementation of the IT courses. Thus, this study aims to identify the factors and the relationship among factors that influence the best practices of PBL implementation of IT courses from students' perspectives. The student perception of the PBL implementation of IT courses also take-in consideration as one of the effective measurement in this study. The student's perception is important to ensure the successfulness of the PBL implementation. The study involved three (3) main phases: firstly PBL implementation factors are identified, secondly, a PBL model of IT courses is constructing, and finally, the proposed PBL model is validated using statistical analysis. Four main factors are identified: PBL Course Assessment, PBL Characteristics, PBL Practices, and Students' Perception. Based on these four factors, a PBL model is constructed. Then, based on the proposed PBL model, six hypotheses are formulated and analyzed to validate the model. The results show that all hypotheses are significantly acceptable. The result also shows that the PBL Characteristics and PBL Course Assessment factors are significantly influenced the PBL Practices and indirectly influenced the Students' Perception of the PBL Implementation for IT courses. This PBL model can assist instructors, decision makers in enhancing the PBL learning strategy of IT courses. It is also can be tested to other courses in various educational domains in the future.**

***Index Terms*—Problem-Based Learning; IT Courses; PBL Course Assessment; PBL Characteristics; PBL Practices; Students' Perception; Soft Skills; Problem Solving; Critical Thinking; Teamwork; Leadership.**

I. INTRODUCTION

The Problem-based Learning (PBL) has been implemented in this faculty since year 2000, there are a few IT courses involved in this learning approach such as System Analysis and Design (SAD), Software Engineering Project 1 and Software Engineering Project 2. Normally, students are grouped in 4 to 5 members for each group. They are allowed to choose their group members. One of the group members is appointed as a group leader then the roles of the leader is interchangeable among group member every two weeks. This to ensure every student has the experienced as a group leader. The students are given three phases of problems: Analysis Phase, Design Phase, and User Interface Design (SAD course) or Development Phase (Software Engineering Project 1and 2 courses). For each phase, they have to deliver PBL Documentations, PBL1, PBL2, and PBL3. The PBL1 Documentation is on the Analysis Artifacts. The artifacts that they have to deliver in PBL1 are: a list of requirements, Use case Diagram, Use case Specifications, and Activity Diagram, the PBL2 Documentation is on Design Artifacts which comprises three artifacts: Sequence Diagram, Collaboration Diagram, and Class Diagram, and PBL3 Documentation is on User Interface Design for SAD course or Prototype Documentation for Software Engineering Project 1 and 2. For each PBL Documentation, students must also attach peer evaluation forms. The peer evaluation form is a form to evaluate their group members based on their contribution and commitment during group discussion in completing the PBL tasks. Students are closely supervised by their lecturer. They have to present their progress every week and update their documentation based on the feedback given by their lecturer, group members or classmates. At the end, an assessment of every PBL Documentation is given by the lecturer for further improvement before they can submit the final version of the PBL documentations. Finally, students are given a form to evaluate their lecturers who conducting the PBL courses. This to ensure, the lecturers can improve their approach in conducting the PBL courses for the next semester.

Even though the PBL approach has been implemented nearly 16 years in this faculty, there is no statistical evidence on the effectiveness of the PBL implementation of the IT courses. Therefore, this study aims to identify the factors and the relationship among factors that influence the best practices for the PBL implementation of IT courses from students' perspectives. The student perception of the PBL implementation of IT courses is take-in consideration as one of the effective measurement in this study.

Many PBL researchers noticed that the PBL is a powerful

approach of learning that leads to enhance and sustain learning towards problem focused, student centered, self-directed and self-reflective learning [1]. The PBL core characteristics factor is important to be considered as part of the effective PBL factors to ensure the effectiveness of the PBL implementation. On the other hand, the PBL assessment, PBL practices, and students' perception also play important roles in measuring the effectiveness PBL implementation as a whole. Unfortunately, there is no PBL model existed that integrate these factors and investigate the relationship among the factors. Thus, it is important to identify the relationship among the factors by formulating the hypotheses between the observed factors. The acceptable hypotheses may prove the importance of the factors towards the PBL implementation in IT courses among IT students.

In any learning approach including PBL, students' perception of knowledge in an environment can be very significant because they are expected to be creators of knowledge in an environment they seldom have experienced before [2]. In the model of understanding learning and teaching in higher education [3], one of the model's components for students' perception is the investigation of the subjective learning environments. This is important in order to understand the nature of the students' learning outcomes. In this context, the investigation involves the study of students' perceptions of the key design characteristics in a problem-based learning environment: Self-Directed Learning, Self-Reflective, and Perception on Facilitator. The SDL is one of the key features of the PBL implementation. SDL implies independence and freedom of choice on the part of the students to determine their own learning objectives and activities.

The main decision on the part of the learning process is the responsibility of the students, which varies among individual students. Even though this is true in majority of the cases, the teacher can also take the role as the initiator who defines the problem and provides the guidelines and the students use them as the starting-point [4]. Assessment of PBL needs to focus on the objectives of the educational course objectives. In an effort to appropriately assess the PBL course, it requires the use of alternative assessment tools such as tutor assessment of students, self-assessment, and peer-assessment [5]. In sum, based on the above discussion on the PBL implementation by previous researchers, the PBL implementation factors must consider PBL Characteristics, PBL Assessment, PBL Practices, and PBL Perception in examining the success factors of the PBL implementation.

There are five practices of PBL have been asked on this stud, namely constructivism, group formation, knowledge sharing, group activity, and task assignment. Firstly, constructivism refers to the theory that human knowledge is constructed by individuals and within social communities, and that the disciplines, or bodies of knowledge, are also human constructions [6]. It produces students not only with more hands-on approach but better communication and team-working skills [7]. By using constructivism in PBL, it enables teachers to reflect on the goals of teaching, how the classroom is organized, and the pedagogical strategies and methods adopted to promote learning.

Several studies have been conducted to investigate on students' perception on PBL. A study with 28 nursing students in Macao and 23 nursing students in Shanghai was conducted to explore the students' view on the effectiveness of PBL. Most Macao students indicated that PBL fostered self-directed learning and thinking in different ways, improved application of knowledge, and extended thinking [8]. Overall, it is considered to be moderately effective for their learning and thought PBL improved their understanding of knowledge, and helped them apply theoretical knowledge to real practice situation. They were encouraged to brainstorm concerning the situations, analyze the situation critically, frame the issues in different ways, and seek out the resources they needed [9]. Meanwhile, the majority of students felt that, the PBL sessions were better at fulfilling learning objectives, gave better factual knowledge of anatomy, promoted better student participation in the learning process, provided more learning fun, ensured more students team work and interpersonal skills acquisition and enabled more students' reflective or critical thinking and reasoning of anatomy, as compared to traditional teaching methods.

II. METHODOLOGY

The research methodology composed of three phases: initial study, modeling, and validation. In the initial study phase, focused on theoretical study and identifying the PBL effective implementation factors. Followed by modeling phase, which involved model construction based on the identified factors, formulating the hypotheses, designing the questionnaire, performing the pilot study, and finally conducting the data collection. Next involved the validation phase, where the collected data are analyzed using SPSS version 19. The correlations among the factors are tested using Pearson's correlation coefficient. The research model is constructed based on the identified factors as shown in Figure 1.

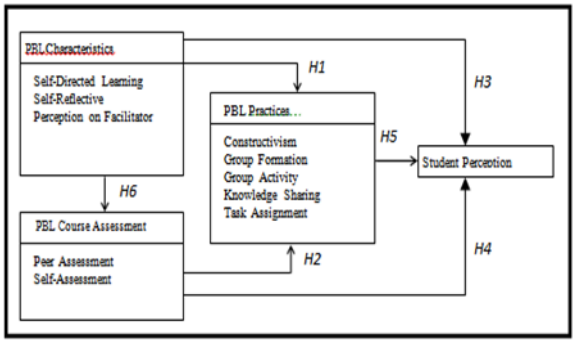

Figure 1: A Problem-Based Learning Model

The research hypotheses are formulated based on the above constructive framework as presented below.

H1 - PBL Characteristics may significantly influence PBL Practices by the lecturer.
H2 - PBL Course Assessment may influence the PBL Practices given by instructors.
H3 - PBl Characteristics may influence the Student Perception by the lecturer.
H4 - PBL Course Assessment may influence the Student Perception given by instructors.
H5 - PBL Practices may influence the Student Perception

among students.

H6 - PBL Characteristics may significantly influence PBL Assessment.

The PBL instrument was designed using five likert scale of measurement (Strongly Disagree to Strongly Agree). Then the instrument is tested via pilot study to ensure the validity of the instrument.

The pilot study was performed to 71 eligible respondents to test the reliability and validity of the measurement items in the questionnaire. The criteria of the respondents are based on students who had attended the PBL courses at least one semester. In this case the respondents are taken from undergraduate programs, Bachelor of Information Technology (BIT), Bachelor of Multimedia (BMM), and Bachelor of Education (it majoring) (B.Edu IT). Students from these programs had enrolling the STID3023 system analysis and design (SAD) because this is one of the core courses for the selected program. The SAD course is totally applied the PBL approach in teaching and learning process for more than 16 years in the School of Computing, College of Arts and Sciences, Universiti Utara Malaysia.

Based on the results from reliability test and cronbach's alpha value, the instrument was updated. The data collection was done using self-administered questionnaires towards 191 eligible respondents. The respondents were taken from undergraduate programs, Bachelor of Information Technology (BIT), Bachelor of Multimedia (BSc. MM), and Bachelor of education (IT majoring) (B.Edu it). The questionnaires are collected back from 191 respondents (100% feedback). After going through the process of data-filtering to eliminate invalid responds due to failure of completing the questionnaires, leaving a total of 117 questionnaires for data analysis. Then the data from the valid questionnaires (117) were analyzed using SPSS ver. 19.0.

III. RESULTS

The reliability test was based on 71 eligible respondents in the pilot test. Figure 2 shows the results of reliability test for the overall cronbach's value which approximately .882, indicating a high standard of reliability of the overall corresponding items in the questionnaire.

Kaiser-Meyer-Olkin of Sampling Adequacy	Barttlet's Test of Sphercity		
	Approx. Chi-Square	Df	Significant
.882	8081.665	2485	.000

Figure 2: Results of reliability test

Its show the internal consistency reliability that reflects the stability of individual measurement items across replications from the same source of information; it was assessed by computing cronbach's alpha whose coefficients for the four main factors were above 0.6, indicating a reasonable level of internal consistency among the items [10]. Results of factor analysis show the factor loading value of each observed factor in this study are in between 0.8 to 0.6. The results show that all sub-factors are loading perfectly in each observed factor: PBL Characteristics, PBL Assessment, PBL Perception, and Student Perception.

Research hypotheses are tested using Pearson's correlation coefficient to investigate the relationship among various constructs to verify the significance and influence of the relationships. The results show that all hypotheses are acceptable. The correlations among the observed factors are significantly strong, as seen in the summary in Table 2.

Table 2
Results of Hypotheses Testing

Hypotheses	Influence	Correlation (r)	Significant value (p) – 2 tailed
H_1	PBL Characteristics → PBL Practices	0.829**	P<0.001
H_2	PBL Course Assessment → PBL Practices	0.830**	p<0.001
H_3	PBL Characteristics → Student Perception	0.810**	p<0.001
H_4	PBL Course Assessment → Student Perception	0.826**	p<0.001
H_5	PBL Practices → Student Perception	0.828**	p<0.001
H_6	PBL Characteristics → PBL Course Assessment	0.887**	p<0.001

A. Results of Analysis of Varians (ANOVA) and Multiple Regression Analysis

Figure 3 to 4 shows the results of ANOVA, Multiple Regression Analysis and Descriptive Analysis generated by SPSS. All listed models show good results with each significant value is less than 0.01 (p<0.01). The results show that the most appropriate model that fit into the PBL underlying theories as discusses in Literature Review section and also the PBL Model as presented in Figure 1 is Model 3, whereby all the PBL factors are included in the model, PBL Assessment (CA), PBL Characteristics (CORECHAR), and PBL Practices (PBLPTS) and PBL Perception (PBLPEC).

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.810[a]	.656	.653	.32199	.656	219.122	1	115	.000
2	.824[b]	.679	.674	.31210	.024	8.404	1	114	.004
3	.868[c]	.753	.746	.27536	.073	33.445	1	113	.000

a. Predictors: (Constant), CA

b. Predictors: (Constant), CA, CORECHAR

c. Predictors: (Constant), CA, CORECHAR, PBLPTS

d. Dependent Variable: PBLPEC

Figure 3: Results of Analysis of Variance (ANOVA)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	.748	.216		3.465	.001	.321	1.176
	CA	.793	.054	.810	14.803	.000	.687	.899
2	(Constant)	.550	.220		2.496	.014	.113	.986
	CA	.567	.094	.579	6.043	.000	.381	.753
	CORECHAR	.282	.097	.278	2.899	.004	.089	.475
3	(Constant)	.128	.208		.617	.538	-.283	.539
	CA	.319	.093	.326	3.426	.001	.135	.504
	CORECHAR	.166	.088	.164	1.888	.062	-.008	.341
	PBLPTS	.486	.084	.445	5.783	.000	.319	.652

a. Dependent Variable: PBLPEC

Figure 4: Results of Multiple Regression Analysis

Descriptive Statistics

	Mean	Std. Deviation	N
PBLPEC	3.9144	.54646	117
CORECHAR	3.9057	.53751	117
CA	3.9911	.55785	117
PBLPTS	3.8312	.50033	117

Figure 5: Results of Descriptive Analysis

Table 3 shows a result summary based on the results from Descriptive Statistics, and Multiple Regression as presented in Figure 3.

Table 3
Summary of Desriptive Statistics, and Multile Regression Analysis.

Factors	Mean	Std	Weight (β)
PBLPEC (Dependent Var)	3.91	.546	-
CA	3.99	.557	.319
CORECHAR	3.91	.538	.166
PBLPT	3.83	.500	.456

Note: PBLPEC –Student Perception of PBL, CORECHAR – PBL Characteristics, CA – PBL Assessment, PBLPTS – PBL Practices

Based on the results from Multiple Regression Analysis as shown in Figure 4 and the results of descriptive analysis in Table 3, a PBL model is constructed as below:

Student Perception of PBL = (0.319 * average of PBL Assessment) + (0.166 * average of PBL Characteristics) + (0.456 * average of PBL Practices) + 0.128

The model can be used to predict the PBL Perception level as calculated below:

Student Perception of PBL = (0.319 * 3.99) + (0.166 * 3.91) + (0.456 * 3.83) + 0.128 = 3.91

Therefore, the student perception of the PBL implementation of IT Courses in this study is 3.91 which considered as satisfied (1- Strongly not satisfied, 2- Not Satisfied 3- Average, 4 – Satisfied, and 5 – Very Satisfied).

IV. Discussion and Conclusion

This study has achieved the objectives where the effective factors of the PBL implementation are identified: PBL Characteristics and Course Assessment as independent factors, PBL Practices as mediated factor, and Student Perception of PBL as dependent factor. The hypotheses that have been formulated from the research model are tested and proven significantly acceptable. Thus, the investigation factors in the model are valid and this shows that the PBL Characteristics and Course Assessment factors are significantly influencing the PBL Practices and indirectly influencing the students' perception on the PBL implementation of IT courses. Hence, the finding shows that the independent factors: PBL Characteristics which composed of Self-Directed Learning, Self-Reflective, and Perception on Facilitator, and Course Assessment that consists of Facilitator Assessment, Peer Assessment, and Self-Assessment, can be improved to ensure the effectiveness of the PBL implementation. It is important to understand the nature of the students' learning outcomes. In this context, the investigation involves the study of the students' perceptions of the key design characteristics in a problem-based learning environment. The students' perception of PBL the implementation for IT courses in UUM significantly influenced by the nature or PBL Practices during teaching and learning process for the observed IT courses. Finally, based on the results of descriptive statistics, ANOVA, and Multiple Regression Analysis, the PBL Model is constructed.

Student Perception of PBL = (0.319 * average of PBL Assessment) + (0.166 * average of PBL Characteristics) + (0.486 * average of PBL Practices) + 0.128

The model showed that, the PBL Practices (0.486) give more significant impact to the Student Perception of the PBL implementation, followed by PBL Assessment (0.319), and PBL Characteristics (0.166). Therefore, it is important to strengthen the PBL Practices among IT instructor, by giving to them continuing PBL training.

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