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Effectiveness and Challenges of Problem-Based Learning Implemented in Engineering Mathematics Courses

(Keberkesanan dan Cabaran Pembelajaran Berasaskan Masalah yang Dilaksanakan dalam Kursus Matematik Kejuruteraan)

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ABSTRACT

Presently, graduates of institutions of higher learning are found to be passive and not competent in carrying out the tasks assigned to them. The number of graduates that fail in a job interview has increased. One of the contributing factors is their ineffective communication skill during the interview, thus failing to exhibit their generic skills abilities in convincing the potential employer. As a proactive move to improve this issue, an initiative was carried out by the Faculty of Engineering and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM) to introduce and implement problem-based learning (PBL) activities in the engineering mathematics courses. With the PBL method implemented at the early stage of the study period, the student's ineffective communication issue can be addressed effectively. It is anticipated that the deployment of the PBL method can generally improve students' soft skills, especially communication ability in meeting the demand and expectations of industry employers. The objectives of this study are to evaluate the effectiveness of the PBL implementation, thus identifying the benefits and the challenges of the PBL 5 Ladders of Active Learning strategy. In this study, the PBL activity was implemented in the Engineering Mathematics III (Differential Equation) course. To analyse the students' feedback toward the implementation of the Five Ladders of Active Learning strategy and Self-Directed Learning method, the Rasch Measurement Model application software called Winstep was used. The results showed that the challenges faced during the PBL implementation are the readiness of lecturers as facilitators, the acceptance, and the readiness of students towards the learning process of the 5 Ladders of Active Learning strategy, the conducive learning environment, the crafting and constructing of PBL problems/triggers, the students' reflection, and the PBL evaluation methods. To ensure that engineering students can master mathematics and generic skills as intended in the program, these challenges must be tackled effectively.

Keywords: Problem based learning; engineering mathematics courses; self-directed learning; 5 ladders of active learning; Rasch Measurement Model

ABSTRAK

Majoriti graduan di institusi pengajian tinggi masa kini didapati pasif dan tidak dapat melaksanakan tugas dengan cekap. Terdapat peningkatan bilangan graduan yang gagal dalam temu duga kerana mereka gagal berkomunikasi secara berkesan dengan majikan dan juga gagal untuk meyakinkan majikan atas kebolehan kemahiran generik mereka. Sehubungan dengan perkara ini, Fakulti Kejuruteraan dan Alam Bina (FKAB), Universiti Kebangsaan Malaysia (UKM) telah mengambil inisiatif untuk memperkenalkan dan melaksanakan kaedah pembelajaran berasaskan masalah (PBL) dalam kursus matematik kejuruteraan bagi menangani masalah ini di peringkat awal pembelajaran. Dengan harapan agar pelaksanaan PBL dapat meningkatkan kemahiran insaniah pelajar bagi memenuhi tuntutan industri semasa. Objektif *kajian ini adalah untuk mengetahui tahap keberkesanan/faedah dan cabaran dalam pelaksanaan strategi PBL 5 Tangga Pembelajaran Aktif. Model Pengukuran Rasch digunakan untuk menganalisis maklum balas pelajar terhadap strategi PBL 5 Tangga Pembelajaran Aktif dan Pembelajaran Arah Kendiri yang digunakan semasa aktiviti PBL bagi kursus Matematik Kejuruteraan III (Persamaan Pembezaan). Berdasarkan hasil kajian, kesediaan pensyarah sebagai fasilitator, penerimaan, dan kesediaan pelajar terhadap proses pembelajaran 5 Tangga Pembelajaran Aktif, persekitaran pembelajaran yang kondusif, pembinaan masalah/pencetusan untuk proses pembelajaran PBL, refleksi pelajar, dan kaedah penilaian PBL adalah cabaran yang mesti ditangani dalam memastikan pelajar kejuruteraan dapat menguasai ilmu matematik dan kemahiran generik mereka seperti yang dihasratkan.*

Kata kunci: Pembelajaran berasaskan masalah; kursus matematik kejuruteraan; pembelajaran arah kendiri; 5 tangga pembelajaran aktif; Model Pengukuran Rasch

INTRODUCTION

One of the crucial criteria for the graduate to meet the demands of the potential industry employers is the graduate's soft-skills abilities. The Problem-Based Learning (PBL) approach is one of the teaching and learning approaches that aim to improve students' soft-skill abilities. Based on the constructivism theory, the PBL is an innovative teaching & learning process which promotes student creative learning and challenges students to learn and participate through active involvement based on real-life problems and environments. PBL is student-centered learning, and it trains students in the concept of "learn how to learn". It encourages self-directed learning, which is the main criterion in PBL. Moreover, it enables students to be more dynamic, master soft skills, and develop cognitive, emotional, and psychomotor skills. Erikson (1999) stated that the PBL in learning mathematics courses is based on active learning activities where problem-solving provides opportunities for students to think critically, and creatively and can communicate and convey ideas in mathematics. Studying in groups to solve problems is the key learning approach. Among the student activities are interpreting the given problem, gathering information required to solve the problems, identifying all possible solutions, and providing a final evaluation and correct solution. During this learning process. According to Barrows (1988), the practitioner of the PBL approach in the teaching and learning of mathematics will prepare students to be effective problem solvers by learning through investigation. Feedback received from students of the engineering mathematics course has concluded that the PBL activities benefited them in achieving the learning objectives both as individuals and in groups (Ismail et al. 2014)

Mathematics is an essential aspect of both engineering courses and research. Teaching mathematics to engineering students is to find a balance between the practical application of mathematics and a deeper understanding of real-life (Sazhin 1998). The impact of teaching mathematical thinking skills on engineers will enable them to use mathematical knowledge in their workplace (Cardella 2008). In teaching and learning mathematics, the assessment aspect is an essential element. Measuring and providing feedback on students' achievements at the end of the mathematics teaching unit or course is an important aspect of the assessment. (Isabwe et al. 2014). The PBL is considered a learning method where lecturers can assess their students in a systematic procedure manner. PBL is a method that directs students to conduct research and produce, and to ensure they build their learning process (Maulana et al. 2019). Through the PBL, students are in control of their learning process, "learn how to learn", thus the assessment of their performance not only through examination but also through their skills and active participation in their PBL learning process.

The lack of proper learning instruction for students during the implementation of PBL is a few weaknesses faced by the students and lecturers (Othman et al. 2013). In 2011, an innovative PBL approach was introduced named 5 Ladders of Active Learning. Both the PBL learning process and the system were copyrighted in 2012 (Othman et al. 2013). This learning process is recognized by the Academy of Higher Education Leadership (AKEPT), Minister of Higher Education, Malaysia (MOHE). Furthermore, this type of PBL learning process will be adopted and implemented in all higher learning institutions in Malaysia. The learning process and evaluation procedure of the 5 Ladder of Active Learning for PBL are depicted in Table 1. In PBL, one of the most important elements that students need to acquire is self-directed learning where students are expected to learn independently without the assistance or intervention of lecturers. Sundari et al. (2014) studied the self-directed learning method that can improve students' ability to perform their learning process.

The Rasch Measurement Model is a method for assessing the validity and reliability of person and item assessment methods. Zain (2018), Bichi et al. (2019), and Khusaini et al. (2017) have employed the Rasch Measurement Model to study the students' ability based on the score that involves the determination of an item/task classified from easy to difficult. Ismail et al. (2017) and Govindasamy et al. (2019) used this model to analyze the validity and reliability of items. This paper describes the implementation of the Rasch Measurement Model to analyze the students' perception, effectiveness, and challenges of the PBL implemented in KKKQ2123 (DE) course. In this course, the PBL activity is carried out to analyze the student feedback toward the 5 Ladders of Active Learning strategy and Self-Directed Learning method. In addition, this model also has been implemented in the Vector Calculus (KKKQ1123) course at

FKAB, UKM for the reliability evaluation of the final exam questions (Othman et al. 2015). Fuaad et al. (2014) also employed this model in identifying the items' difficulties in Pre-Test based on students' pre-university background, thus guiding lecturers in providing remedial actions for the respective students. Meanwhile, Aziz et al. (2007) revealed that the Persons Item Distribution Map (PIDM) provides an accurate indication of student achievement on a linear scale of measurement. The Rasch Measurement model also has been used to measure the student's performance in the Civil Engineering Design II course in FKAB, UKM (Osman et al. 2012). Moreover, this measurement model was applied in the Mathematics Engineering III (Differential Equation) course to study and analyze the separation of Bloom's cognitive level in the final exam questions (items) (Asshaari et al. 2012).

Considering the aim and anticipation of the AKEPT, MOHE, the Unit of Fundamental Engineering Studies (UPAK), currently known as the Department of Engineering Education (JPK), FKAB has taken a proactive step to implement the PBL method in Differential Equation (KKKQ2123) and Statistical Engineering (KKKQ2023) courses. The 5 Ladders of Active Learning of PBL has been adopted as the strategy for the student learning activity. This paper presents the analysis and discussion of the Differential Equation students' perspective on the effectiveness of the PBL learning approach, especially in the first three ladders of the 5 Ladders of Active Learning. Generally, the first three ladders are the essential strategy of the PBL in finding the learning issues and objectives of the given problem/trigger. Specifically, the first and third ladders are considered group activities, meanwhile, the second one is the self-directed learning activity. Students must be guided before carrying out Self-Directed learning activities (Osman 2015).

This paper also describes and highlights the challenges faced in the implementation of PBL. Some of the challenges encountered are the acceptance of students toward the learning style, providing a conducive learning environment, constructing good PBL triggers, students' reflections on PBL activities, and PBL assessment methods.

TABLE 1. 5 Ladders of Active Learning: Process and Assessment Procedure (Othman et al. 2013)

Ladder	Student Learning Process	Assessment Procedure
1	In groups, students identify the issues related to the problem given by using the "FILA" technique. "FILA" (*Facts*: Identifying facts, *Ideas*: generating ideas, *Learning Issues:* identifying learning issues, *Actions:* identifying action to be executed)	FILA and Reflection Rubric
2	Students perform Self-Directed Learning activities	Reflection Rubric
3	Students regrouping. Holding a meeting to report self-directed learning outcomes. Prepare for presentation document.	Reflection Rubric
4	Group presentation	Peer assessment and Reflection Rubric
5	Exercises and tasks are given.	Self-assessment and Overall Reflection Rubric

TABLE 2. Respondents' distribution by department

Department	Frequency	Percent	Valid Percent	Cumulative Percent
JKAS	44	28.03	28.03	28.03
JKMB	28	17.83	17.83	45.86
JKKP	38	24.20	24.20	70.06
JKEES	47	29.94	29.94	100.0
Total	157	100.0	100.0	

TABLE 3. Coding of the first three of 5 Ladders of Active Learning (PBL): Students' perspectives and feedback.

Items	Code
Ladder 1: Identify the facts, ideas, learning issues, and actions of PBL problem/trigger. (FILA)	
1. I can comprehend the principles and motivation of PBL.	DL_11
2. I can comprehend the procedure of PBL.	DL_12
3. I was effectively able to participate in reviewing and analysing the given problem/trigger.	DL_13
4. I was effectively able to participate in identifying the FILA of the given problem/trigger.	DL_14
5. I was effectively able to participate in the group's brainstorming sessions.	DL_15
6. I was able to recognize the gaps in my understanding and my knowledge of the given problem/trigger.	DL_16
7. I was able to contribute to identifying and refining my group's learning objectives (issues).	DL_17
8. I am certain that my group could do better in selecting appropriate, significant, and effective learning objectives (issues).	DL_18
Ladder 2: Self-Directed Learning	
I was able to assist my group in acquiring the relevant learning resources to achieve my group's learning objectives (issues) during my Self-Directed Learning activities.	DL_21
Ladder 3: Regrouping: holding meetings, providing solutions, and preparing presentations	
I was allowed to deliver my Self-Directed Learning outcomes related to my group's learning objectives (issues).	DL_31
I was allowed to ask questions to my group members regarding their Self-Directed Learning outcomes.	DL_32
I was able to gain knowledge and understanding during the Self-Directed Learning activity.	DL_33
I have issues demonstrating my knowledge and understanding in achieving learning objectives after the Self-Directed Learning activity.	DL_34

METHODOLOGY

This study involved a total of 210 students of KKKQ2123 Differential Equation course from four different departments, namely the Department of Civil Engineering (JKAS), Department of Mechanical and Manufacturing Engineering (JKMB), Department of Chemical and Process Engineering (JKKP), and Department of Electrical, Electronic and System Engineering (JKEES). Out of 210 students, only 157 students responded, and the details are depicted in Table 2. To assess the respondents' opinions towards the first three out of five ladders of PBL, a set of questionnaires in the form of a Likert Scale was given to them. The five Likert Scales indications are "1" as "Strongly Disagree", "2" as Disagree, "3" as "Neutral", "4" as "Agree" and "5" as "Strongly Agree". The data obtained were analysed using the WINSTEPS, Rasch Measurement Model software. Meanwhile, Table 3 depicted Rasch Measurement Model codes for each item.

RESULTS AND DISCUSSION

The analysis begins with the reported statistics summary of the person and items used in this study. The person represents students taking the KKKQ2123 course and items representing the questionnaires in Table 3, which are regarding the 5 Ladder of Active Learning implemented in PBL learning activities. The analysis includes how well the model fits the statistics summary for the person, statistics summary for items, and Person Items Distribution Map (PIDM).

Table 4 shows the statistics summary for the items. The default mean item measure in the Rasch Model analysis is set by default at 0 (Bond et al. 2015). From the result in table 4, the item variation is small, this is depicted by the standard deviation for items measure of 0.31. Furthermore, the items are considered appropriate to measure students' perspectives and feedback towards PBL since the item's reliability is 0.72. Moreover, the items can be separated into two categories, namely "Agreed" and "Not Agreed" and this is shown by the item's separation value of 1.61 (close to 2).

According to Aziz et al. (2007), for the fit diagnosis (infit outfit mean-square standardized), the mean square values are normalised to the Z or t distribution, with a mean of 0 and a standard deviation of 1. Based on the items' statistics summary in Table 4, the item fit is considered very good since the mean of the infit and outfit mean squares are equals to 1, which are close to the Rasch Model expectations (where the mean square value is said to be effective for measurement when it is in the range of 0.5 to 1.5) with the standard deviation for infit mean squares showing little spread (SD = 0.27) compared to the standard deviation for outfit mean squares show greater spread (SD = 0.34).

Moreover, the mean fit Z-standardized (ZSTD) around zero (infit ZSTD = -1 and outfit ZSTD = -1) means that the data have reasonable predictability (acceptable range is -2 to 2), hence all 13 items (in Table 3) are useful and acceptable sample.

TABLE 4. Statistics Summary for Items

	Raw Score	Count	Measure	Model Error	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
Mean	562.2	156.9	0.00	0.16	1.00	-0.1	1.00	-0.1
Standard Deviation	12.9	0.3	0.31	0.00	0.27	2.0	0.34	2.3
Max	583.0	157.0	0.73	0.16	1.78	5.4	2.09	6.9
Min	531.0	156.0	-0.52	0.15	0.75	-2.2	0.69	-2.4
Real RMSE	0.16	Adj. SD	0.26	Separation	1.61	Item Reliability		0.72
Model RMSE	0.16	Adj. SD	0.27	Separation	1.71	Item Reliability		0.75
UMean = 0.000	UScale = 1.000							
Item Raw Score-To-Measure Correlation = -1.00								

Table 5 shows the Statistics Summary for Person. The mean for person measure of 1.25 indicated the students agreed that the 5 Ladder of Active Learning strategy for PBL is beneficial for their learning. The standard deviation for person measures of 1.53 indicates that there is a greater spread of person variation compared to the item. From Table 5, the statistics summary for person, the value of the person reliability is 0.81 and the person separation is 2.08, and according to Aziz et al. (2013), this signifies the high probability of repetition in the outcome of person feedback when the same questions are presented.

From Table 5, statistics summary for person, the value of the person reliability is 0.81 and the person separation is 2.08, and according to Aziz et al. (2013), this signifies the high probability of repetition in the outcome of person feedback when the same questions are presented. As depicted in table 5, the person means fit is considered equally good since the infit mean square is 1.01 and the outfit mean square is 1. The value for the person means fit Z-standardized is within the acceptable range (infit ZSTD = -0.3; outfit ZSTD = -0.4). Hence, this indicates that the data have reasonable predictability.

TABLE 5. Statistics Summary for Person

	Raw Score	Count	Measure	Model Error	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
Mean	46.6	13.0	1.25	0.56	1.01	-0.3	1.00	-0.4
Standard Deviation	5.2	0.1	1.53	0.09	0.97	1.8	0.96	1.8
Max	57.0	13.0	5.06	0.71	6.81	8.4	6.88	8.5
Min	29.0	12.0	-2.61	0.39	0.01	-4.5	0.01	-4.5
Real RMSE	0.66	Adj. SD	1.38	Separation	2.08	Person Reliability		0.81
Model RMSE	0.57	Adj. SD	1.41	Separation	2.47	Person Reliability		0.86
Person Raw Score-To-Measure Correlation = 0.98								
Cronbach Alpha (KR-20) Person Raw Score Reliability = 0.86								

Cronbach Alpha is generally used to measure the internal consistency reliability of the items. When the Cronbach Alpha values exceed 0.7, it indicates that the items have relatively high internal consistency. In most social science research studies, a value above 0.7 or higher is considered "acceptable". The value of Cronbach Alpha in table 5 is 0.86, which exceeds acceptable values (0.7), therefore, these items have relatively high internal consistency, and they are correlated with each other. When the value of Cronbach Alpha increases, the correlation between the items also increases. The high correlation between the items illustrates how closely a set of items is associated or linked as a group.

The Person Item Distribution Map (PIDM) for the person (students) and items is shown in Figure 1. The important features of PIDM are that it can illustrate the relationship between person and items. This study illustrates students' perspectives toward the 5 Ladder of Active Learning of PBL and items agreeable/accepted. The standard scale for the persons' and items' distribution in PIDM is based on the logit ruler (linear interval scale). The location of an item in PIDM can determine whether the

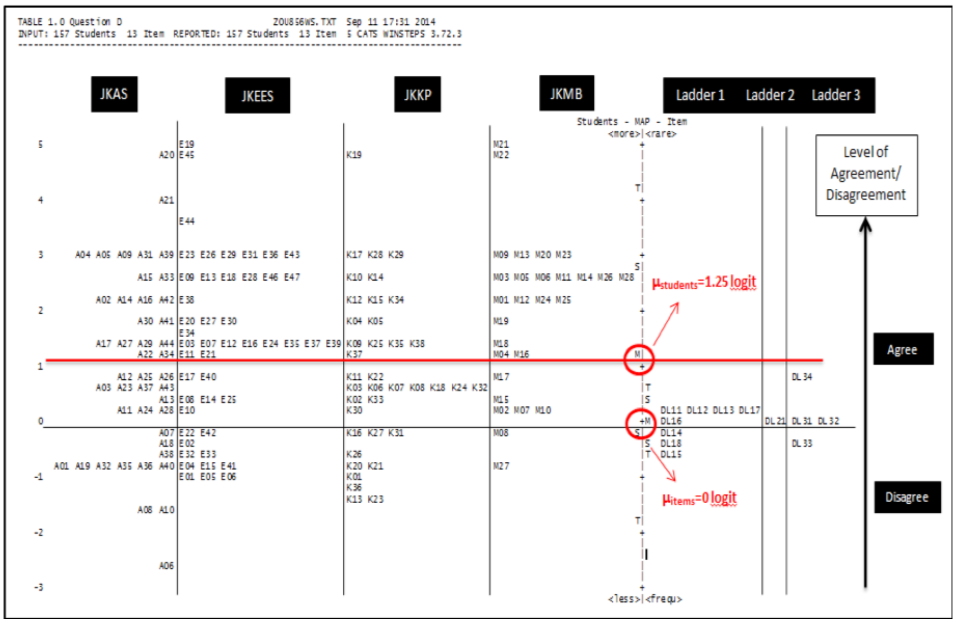

FIGURE 1. Person-Item Distribution Map (PIDM)

item is the most or the least agreed upon. The item in the topmost position is the item that is the most agreed while the item in the lowest position in PIDM is the least or not agreed upon.

Figure 1 depicts the location of the student (person) mean value, M ($\mu_{students}$ = 1.25 logit, as is in Table 5) which is located at a higher position compared to the items mean value, M (μ_{items} = 0 logits, as is in Table 4). Many of the students agreed with the items (questionnaires) in Table 3. This can be seen by the position of items DL16, DL21, DL31, and DL32 which are accumulated at 0 logits (items mean value) on PIDM. According to Bond et al. (2015), for Rasch Measurement interval scales, the mean of the item difficulties is commonly at the zero-scale origin. Meanwhile, the rest of the items are spread above and below 0 logit (items mean value), which describes the level of students' agreement/disagreement toward the items (questionnaire).

Refer to Ladder 1 in Figure 1, which is the strategy to identify the learning issue of the given problem/trigger using the FILA (Facts, Ideas, Learning Issues, Actions) method. Items DL11, DL12, DL13, DL16, and DL17 are located above the item mean value ($\mu_{items} \geq 0$) (below the students (persons) mean value ($\mu_{students} < 0$), this indicates that these items are agreeable by 77.7% of the students. Hence, based on this finding, we can conclude that most students comprehend the PBL principles, PBL motivation, and PBL learning process. Furthermore, students are aware of their capabilities in acquiring knowledge, and abilities to work in a group to determine their group learning objectives. Unfortunately, these students (77.7%) are less agreed or disagreed with items DL14, DL15, and DL18, since these items are situated below the items mean value ($\mu_{items} < 0$). Most students unable to perform well in FILA activities, for which FILA activities can assist students to identify learning issues of the given problem/trigger. They are also unable to participate more effectively in brainstorming activities with their group members. Thus, they feel that they did not perform well in selecting appropriate, significant, and useful learning objectives (issues).

After identifying learning objectives (issues) in Ladder 1, students embarked on Ladder 2 which is Self-Directed Learning activity. Individually, students must conduct investigations and finds solutions to the given problem from the internet, books, and other resources. Most of the students agreed and believed that their effort in acquiring the relevant learning resources could help their group to achieve or solve their group's learning objectives.

Upon completion of Ladder 2 (Self-Directed Learning) activity, students must embark on Ladder 3. Students have to re-group and conduct meeting sessions with their group members. In Figure 1, items DL31, DL32, and DL34 are situated above the items mean value ($\mu_{items} \geq 0$), this indicates that these items are agreed upon by most students as in Ladder 1 and Ladder 2. This finding shows that students are agreed that they are allowed to present and share their Self-Directed Learning outcomes. They also agreed that they are allowed to establish questions and answers sessions among group members. But at the same time, they agreed that as an individual, they have difficulty using the knowledge and understanding which they gather during Self-Directed Learning activity to achieve (solve) their group learning objectives (issues). This can be observed for item DL34 which is situated in the topmost position among other items in Ladder 3, which means that item DL34 is the most agreed upon by most of the students.

Meanwhile, some of the students less agreed with item DL33. This item is located below the items mean value ($\mu_{items} < 0$). This finding suggests that some students are still unable to acquire knowledge and understanding through Self-Directed Learning activities. Findings for items DL33 and DL34 reaffirmed that most of the student still requires assistance and support from their group members to strengthen their understanding and knowledge to accomplish their group learning objectives (issues).

The analysis of the items on the students' perspectives/opinions toward the 5 Ladders of Active Learning strategy for PBL revealed that most of the students are having difficulty doing FILA activity. The main objective of FILA is to do systematic procedures that can identify the learning issues/objectives of the given PBL problem/trigger. They are having difficulty understanding the given problem, consequently, they are unable to generate and define the facts, the ideas, and the learning issues/objectives of the given problem. Most of the students are also unable to participate effectively during brainstorming sessions. They are less confident in conveying their ideas creatively and critically especially when there is the need to communicate mathematically. These findings can be observed from students' feedback on Ladders 1 to 3 as in Table 3 and Figure 1. The outcomes of the Self-Directed Learning activity performed by students revealed that most of the students are unable to apply their previous knowledge to the real-world problem that is given as their PBL task. Furthermore, most of the students are unable to define and achieve their groups' learning objectives (issues) individually. They still need assistance, support, and input from their group members in identifying and achieving their PBL learning objectives. This is supported by research conducted by Osman (2015) where students need to have a systematic preparation and guide to perform and conduct self-directed learning effectively. And, in the study done on medical students by Colliver (2020) revealed no convincing evidence that PBL improves knowledge base and clinical performance.

CONCLUSION

In this study, Rasch Measurement Model was used to analyse and identified the feedback from the students of the KKKQ2123 (Differential Equation) course on their perspectives and opinion toward the learning strategy implemented in their course activity. Hence the effectiveness and the challenges elements of PBL are identified. The 5 Ladder of Active Learning strategy of PBL is implemented and can benefit the students in implementing the PBL method by providing a systematic learning procedure.

This study suggests that, during Ladder 1(FILA: identifying the learning issues/objectives) activity, lecturers' readiness as facilitators plays an important role in which they need to assist students in providing clear and proper instruction for students to understand the learning process of PBL, to identify the learning issues and to achieve their learning objectives. This study also suggests that students must take responsibility for their actions to enhance the outcomes of their PBL activities. They must have a clear and proper understanding of the 5 Ladder of Active Learning strategy, and they must have the willingness, preparation, and integrity in performing Self-Directed learning activities.

Crafting, constructing, and formulating PBL problems or triggers are the most important elements in PBL that need to be addressed. Complex real-world and open-ended problems are the characteristics of PBL problems/triggers, thus the suitability of the PBL problems/triggers for engineering mathematics courses must be crafted, reviewed, and assessed appropriately to obtain the proper learning issues and achieve the learning objectives. However, it is quite difficult to craft and formulate PBL problems/triggers for mathematics courses because it involves basic concepts of mathematics, which are very fundamental and theoretical. Not to mention, the facilities and the conducive environment for PBL activities must be considered for the comfort of the student while conducting the PBL activities. Therefore, the suitable venue and the conducive facilities can bring out interest, stimulate and motivate students to continue enhancing their knowledge along with being able to apply the learned mathematics knowledge.

As overall conclusions, the readiness of lecturers as facilitators, the acceptance, and the readiness of students towards the learning process of the 5 Ladders of Active Learning strategy, the conducive learning environment, the crafting and constructing of PBL problems/triggers, the students' reflection, and the PBL evaluation methods are the challenges facing by the lecturers in implementing PBL in engineering mathematics courses. These challenges need to be addressed and improved to enable engineering students to master and grasp their mathematical knowledge as intended. Furthermore, with proper planning and preparation on PBL learning strategies, which are the 5 Ladder of Active Learning and Self-Directed Learning, it is an effective and beneficial learning strategy to use for engineering mathematics courses.

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