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Improving University Students' Critical Thinking and Problem-Solving Skills: How Problem-Based Learning Works during COVID-19 Pandemic?

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ABSTRACT

With the COVID-19 pandemic spreading all around the world, higher learning institutions were forced to shut down or limit the people in contact to control the spread of diseases. Under this circumstance, remote learning that emphasized learning via online setting was embraced in higher education to replace the physical classroom during the pandemic time. This study designed a single Problem-Based Learning (PBL) module using remote learning to examine the students' experience in PBL, and to what extent the PBL module helps students improve their critical thinking and problem-solving skills. The remote learning PBL module was conducted using the reflection method to assess the students' experiences in PBL learning. On the other hand, a set of survey questionnaires was distributed to 34 undergraduate students to gather the responses for the assessment of critical thinking and problem-solving skills. This study employed both quantitative and qualitative analysis to investigate the students' critical thinking, problem-solving skills and their experience in remote learning PBL. Using paired sample t-test to test the difference between pre- and post- remote learning PBL class, results indicated that there was a significant improvement in students' critical thinking and problem-solving skills after remote learning PBL class. On the other hand, thematic analysis of students' feedback on remote learning PBL class- first, second, and third meetings, indicated that students gradually improved their critical thinking and problem-solving skills. Although students implied positive feedback on the class, however, some of them were facing difficulties in understanding the module or physical disruptions that distracted their learning. The findings gave insights for the lecturers to design a suitable learning course during the pandemic time. Moreover, the findings highlighted challenges that gave insights for the lecturers to look at the students' feedback from time to time to improve the learning mechanisms and to create a better learning environment.

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1. Introduction

The employers in Malaysia were facing challenges in finding the right candidates with the skills that meet their operational requirements. According to Hays Asia Salary Guide 2019, there were 46% of employers not confident in recruiting candidates who have the required skills [1]. Indeed, this report cited that employers in Malaysia were looking for candidates' aptitudes in problem-solving, teamwork, and critical thinking. The report indicated that problem-solving skills are featured in the top three priorities as the most desirable employability skills. Problem-solving skills require critical thinking ability. However, a study on the state of critical thinking among Malaysian students ranged from low to moderate levels [2]. The disparities between the employers' expectations and students' abilities revealed that there was a gap in employability skills and suggested that universities were necessary to nurture students to develop abilities that are critical to the labour market.

The COVID-19 pandemic has resulted in the public university shutting down temporarily across the country. The virus recorded high transmission risks because it was spread between people via the fluid produced by sneezing, coughing, and talking. This so-called airborne virus resulted in people keeping social distancing and caused the university to shut down temporarily to control the spread of the disease. The temporary shutdown of universities caused teaching and learning to be disrupted, and the lecturers were urged to find learning methods that suit the current situation [3]. Remote learning was seen as an alternative solution for lecturers and students to an immediate problem [4,5].

Remote learning was closely related to distance education. In general, remote learning employed a similar pedagogy to distance education whereby the distance in time and space between learners and learning resources exists between lecturers and students, but, Bozkurt and Sharma [6] argued that remote learning and distance learning are not equal. Indeed, distance learning was more systematic where the teaching and learning were designed to encourage learners' interaction and learning was enhanced with the use of wide-spectrum technologies during the process [7].

During the pandemic, the teaching methods in higher education institutions were forced to adopt remote learning immediately without proper planning and the learning system was not ready in place [6]. In this regard, remote teaching was the temporary solution during the pandemic to provide access to instruction and instructional support quickly during the crisis [8]. The shift from face-to-face instructional mode to remote learning mode has placed technology as the technology-centric solution [9]. Weller [10] indicated that we must be cautious and not set hopes on technology and wish it acts as the only solution to cure all education problems. Technology was only a tool, and students should not learn from technology, but rather, learn with technology. In this regard, remote learning is not just a tool to solve the current crisis, but it should be designed in a way that emphasizes the learners' learning experiences that can enhance the learning of the learners.

The world is changing, and we do not know when the pandemic will end, or maybe there will be another pandemic that will hit our lives and change our lifestyles. Thus, remote learning should not be treated as a temporary solution. Designing a good remote learning education setting is a must to ensure the sustainability of the education system. In the current situation, remote learning is more on one-way interaction, where lecturers instruct the learning module in front of a webcam and the students are simply being bombarded with the information provided by the lecturers.

Problem-based learning (PBL) was the approach that complemented the weakness of remote learning. PBL was a constructivist pedagogy based on hands-on, active learning that worked on developing real-life problem-solving skills, flexibility, creativity, and productivity [11]. Due to this active learning nature, the PBL empowered students' engagement in solving real-world or open-ended problems, and thus enhanced students' critical thinking and self-regulated learning [12].

Besides, two-way communication between students and lecturers, and among students, occurred during the discussion session on the problems. This approach contributed to strengthened students' responses to the learning situation [13].

PBL was the learning strategy to enhance critical thinking and problem-solving skills through students' hands-on, active learning in solving a real-world problem. PBL requires technology support [14]. PBL confronted students with authentic problems and these helped the students to practice through hands-on learning and gain higher-order thinking skills, as well as increasing the students' ability to transfer problem-solving processes into new and more complex circumstances [15]. This was aligned with the outcome of the public management program to produce graduates with competitive knowledge, principles, and critical thinking skills in linking theoretical and practical foundations for designing, implementing, and managing information technology solutions and resources.

The teaching issues in this study were critical thinking and problem-solving skills, which related to the fifth learning outcome of the subject GMGM2023 Human Resource Management in Public Sector, which was to evaluate the level of effectiveness of human resource management. In the current practice, students were given a case study to solve. Based on the result, most of them lack of critical thinking and problem-solving skills.

Based on our observations, the remote learning PBL was limited in Malaysian Higher Education Institutions. In Universiti Utara Malaysia (UUM), to the best of our knowledge, there were a limited number of classes that implemented remote learning PBL in their program module. Hence, this research attempted to investigate the impact of the remote learning PBL approach in the Public Management Program on students' performance in terms of their critical thinking and problem-solving skills as well as their feelings and attitudes toward the remote learning PBL approach. The research objectives are

i. to investigate the effect of remote learning PBL in improving students' critical thinking skills;
ii. to investigate the effect of remote learning PBL in improving students' problem-solving skills;
iii. to assess the impact of remote learning PBL based on students' answer based on a set of open questions.

2. Literature Review

The Covid-19 pandemic has now forced higher education institutions to engage in remote learning. In Asia countries, higher education impacted academic activities and this caused the short-term switch to remote learning rather than face-to-face tutorials [16]. According to a report concluded by Cham [16], the challenges for remote learning involved the "hardware" limitation such as internet accessibility and assessment tools to access students' study performance. Internet accessibility or assessment tools were tools used in implementing remote learning. Although the tools were important, however, the core for learning and teaching focused on students' interests and the quality of course instructions.

Remote learning's biggest challenges were to attract student's interest in learning and to maintain the quality of instructions [17]. Poor time management and students' failure to engage in learning remained the issue for remote learning. Khan *et al.,* [18] stated that incorporating an active learning model in remote learning helps to enhance students' interest in learning and improves students' thinking and knowledge level. In addition, an active learning curriculum design maintained

the quality of instructions that actively engaged students in the learning process. Hence, it is important to design a curriculum that incorporates active learning using PBL approaches in remote learning to create a better online education environment.

2.1 Problem-Based Learning (PBL) in Remote Learning Environment

PBL was part of active learning that emphasized the instructional method that engaged students in the learning process [19]. Savery [20] defined PBL as "instructional learner-centred approach that empowers learners to conduct research, integrates theory and practice, and applies knowledge and skills to develop a viable solution to the defined problem" (p. 7). In this regard, PBL was a pedagogy in which students learn to think critically, define the problem, analyse and provide solutions to solve real-world problems. PBL begins with a complex, ill-structured problem that describes the real-world problem. Students engaged in knowledge construction with self-directed learning by constructing an understanding of the problem and discussing the problem, brainstorming the possible explanations and solutions, self-study, sharing and critically evaluating their findings after self-study, assessment, and reflection on the learning [21,22].

Bloom's taxonomy was a multi-level model for classifying learning objectives in cognitive, affective, and sensory domains. During the year 2001, Bloom's taxonomy was revised into six cognitive levels; remember, understand, apply, analyse, evaluate and create [23]. The revised Bloom's taxonomy provided the measurement of the thinking level. Indeed, the taxonomy was cumulative hierarchical in nature with each cognitive level requiring the prior skill or ability before the next. For instance, before reaching the understanding level, one should remember the context. The cumulative level started from the lower level until the upper level on top of the hierarchy level. Intensively, the higher the level, the more complex it was, and it required a higher level of thinking.

Bloom's taxonomy was closely linked to problem-solving and critical-thinking skills [24]. PBL aimed to develop students' critical thinking and problem-solving skills through organized problem-based activities. Problem-based activities require a higher cognitive thinking level. Indeed, the lowest level cognitive level (remember, understand, apply) was not enough in this case, and the students were required to climb to a higher level of cognitive level (analysis, evaluate, create) to develop a viable solution to a defined problem.

Since PBL requires a higher-level cognitive level, the traditional classroom had a limitation in implementing PBL. Indeed, the traditional classroom provided limited time for students to get involved in practical activities in the classroom. Moreover, in the traditional classroom, during class time, students were busy taking notes from the lecturer's lecture in explaining the theoretical materials resulting in them having limited time to discuss the issues or ask questions to the lecturer or peers. Due to this fact, students suffered from a lack of understanding of critical issues, and this resulted in a lack of critical thinking and knowledge-building skills (higher thinking levels required students to fulfil the lowest cognitive level).

The online classroom has overcome the limitations of the traditional classroom. This approach incorporated technology into the education process, and this made the interactions with the lecturer and peers more effective and fruitful. Hence, it created a better learning environment. In an online classroom, reading or learning materials are provided to students prior to the class, and during class time, students expand the material studied by solving practical tasks. Consequently, this improved students' understanding of the learning content and helped to develop critical perspectives on the topic. After class time, students were given time to continue working with electronic sources to test their knowledge and this triggered their cognitive skills. Figure 1 illustrates the PBL in the remote learning setting with Revised Bloom's Taxonomy.

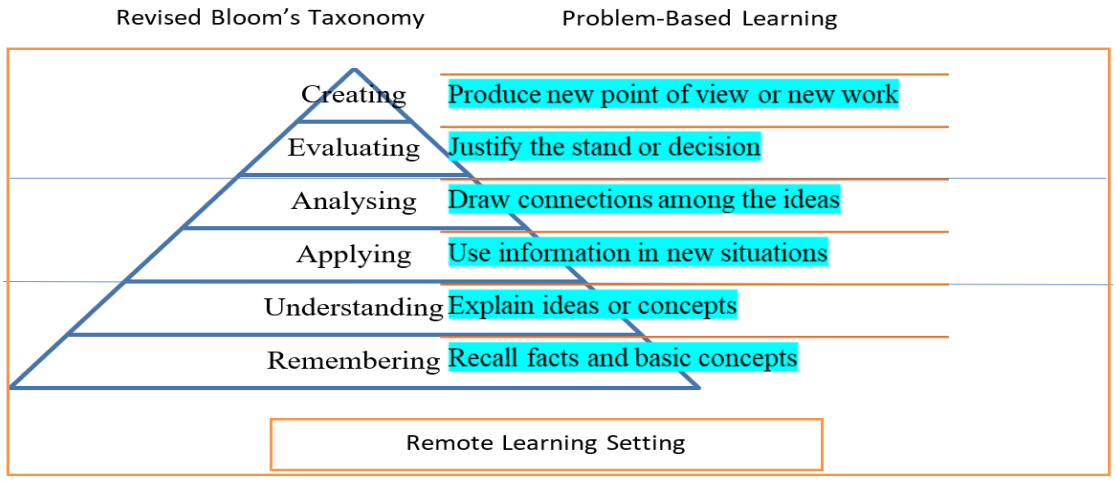

Fig. 1. Revised Bloom's taxonomy and PBL in a remote learning setting

PBL can be applied in remote learning settings. In fact, past research indicated positive feedback from students regarding remote learning PBL courses [25-29]. Cheaney and Ingebritsen [26] found a statistically significant difference between the students with lower exam testing and PBL using remote learning, whereby the performance of students in PBL remote learning was better compared to the traditional lecture-based approach. Likewise, Chen [27] integrated an online platform to support the PBL course, and they found that PBL using remote learning was as effective as the traditional in-class PBL. Moreover, research indicated students were more focused in class using remote learning PBL. The more passive students would have room to contribute in discussion freely and the use of emoticons in chat aids in ice-breaking, as well as encouraging the students to feel more comfortable to share their opinions in the group.

In the PBL approach, the students participated as active learners. In this sense, the lecturer served as an instructor to guide the students in learning rather than playing the central role of knowledge and information delivery. Remote learning PBL fostered students to actively search for information and learning materials to solve the problem posed by the lecturer. Moallem and Igoe [29] employed Top Hat as the web based PBL approach to develop the instructional materials. They incorporated scaffolds in Top Hat modules to develop a series of hard scaffolds in the form of consecutive questions that assist students in problem identification and analysis processes. They found that PBL using remote learning instructions encouraged students to think deeper and students were more actively engaged in searching for learning materials.

3. Methodology

Current research employs both quantitative and qualitative approaches to answer research questions. The quantitative assessment used the 5-Points Likert scale to measure the students' critical thinking and problem-solving skills before and after the remote learning PBL module. To measure critical thinking skills, the questionnaire items were adapted from Al-Mazroa [30]. On the other hand, to measure problem-solving, the questionnaire items were adapted from Chis *et al.,* [31]. The questionnaire items of critical thinking and problem-solving skills were set in the Google Forms for the students to answer before the start of the remote learning PBL module (pre-test), and after completing the remote learning PBL module sessions (post-test). Statistical analysis for comparing the pre-test and post-test scores is the Paired Student's T-Test.

A qualitative assessment was conducted to determine the remote learning PBL module's impact on the student's feelings and attitudes. In this study, open questions were designed and set in Google

Forms (together with the post-test) for the target respondents in this study. The open questions were related to the student's perception towards remote learning PBL (pre-, during, and post-). Data gathered in this study used a thematic analysis approach based on six steps introduced by Braun and Clarke [32] as following figure.

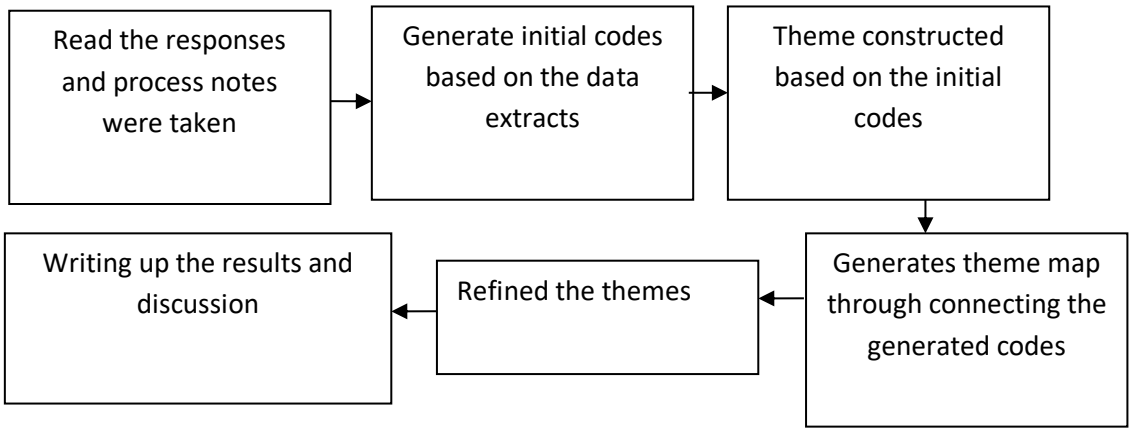

Fig. 2. Thematic analysis steps

The target respondents were undergraduate students from the Public Management Program at UUM, who enrolled in the three credit hours course taught by the lecturer for semester A192. There was a total of 34 students involved as respondents in this study. This study employed a single module to examine the student's experience in remote learning PBL and its impact on improving their critical thinking and problem-solving skills. There was only one problem scenario for the students as the central component of the module in this study. The research was conducted for three remote learning meetings. To make the subject matter and PBL more relevant, the modules designed in this research were based on the topics outlined in the course syllabus. The lecturer designed ill-structured problems using real-world scenarios from news, government reports or other related reports that showed the problem related to the subject matter. In the module, ill-structured problems were provided in the first meeting; students formed groups of four to five and were requested to solve the PBL module in the second meeting; and students wrote their reflections in the third meeting. In essence, the following Table 1 illustrates the implementation process of Remote Learning PBL module instructions.

During the pandemic time, the first session was conducted using Webex for the virtual meeting between lecturer and students. According to the remote learning PBL module design, warm-up activities were needed when the students were new to both PBL and remote learning. Hence, the first meeting emphasized module introduction and the related warm-up activity. At the beginning of the meeting, students were requested to complete the questionnaire that assessed their pre-critical thinking and problem-solving skills in Google Forms. After all, had submitted the questionnaire, students were asked to download and read the learning materials uploaded to the UUM-OL platform by the lecturer. The learning materials included YouTube videos on ways to solve ill-structured problems.

Table 1
Remote Learning PBL Module Instructions

Duration	Instructions
First Meeting	• Students need to answer the questionnaire that assesses their pre-critical thinking and problem-solving skills in Google Forms. • The lecturer provided a video of the designed open-ended real-life problem and related learning materials to students via UUM-OL. Students are required to watch the video and read the related materials, then prepare questions to be asked in the next meeting.
Second Meeting	• The lecturer served as the facilitator to guide the discussion and provide guidelines and feedback. • Students formed groups of four to five and worked in groups to produce their findings and solutions to solve the given problem. • Students were given the opportunity to ask questions during the meeting and try to work out the problem in their respective groups. • Students completed the PBL task.
Third Meeting	• Students presented their findings. • Students were asked spontaneously by the lecturer in the Webex meeting about their learning outcome evaluation and suggestions for future learning. • Students need to answer the questionnaire that assesses their post-critical thinking and problem-solving skills and provide their reflections on the learning by answering the open questions given by the lecturer in Google Forms.

In the second meeting, students were first split into a group of four to five. Then, the lecturer presented the guidelines on the PBL module and explained to students the steps to solve the ill-structured problem. On the other hand, students could ask questions to clarify the context during the meeting. Thereafter, in groups, they were requested by the lecturer to solve the assigned problem and present their findings in the next meeting.

In the third meeting, groups presented final findings and solutions to the class via Webex. During this meeting, the lecturer engaged in collective reflections with the entire class on the final meeting of the module. Also, students were requested to complete and submit the Google Forms that included (a) post-critical thinking and problem-solving skills assessment questionnaire and (b) reflections on the learning by answering the open questions given by the lecturer.

4. Results, Findings and Discussion

There was a total of 34 returned responses from the students. Before the research instruments were used to test the hypothesis, it was tested on validity and reliability. The instruments were validated using content validity, and the reliability of the instruments was calculated using Cronbach's Alpha. The validation results for both problem-solving and critical thinking variables indicated the items' designs were valid by two subject matter experts. The Cronbach's Alpha test showed that the items of problem-solving skills have a reliability coefficient of 0.852, whereas critical thinking items were 0.794. These results indicated that the instruments for both variables were valid and reliable.

Descriptive analysis indicated that critical thinking skills possessed greater variance and standard deviation compared to problem-solving skills. Intensively, pre-test critical thinking recorded an 11.08 variance and 3.33 standard deviation, while post-test critical thinking recorded a 10.27 variance and 3.20 standard deviation. On the other hand, pre-test problem-solving recorded a 3.34 variance and 1.83 standard deviations, while post-test problem-solving recorded a 3.35 variance and 1.83 standard deviations.

Before running paired sample T-Test, the basic assumptions of the paired sample T-Test were tested, and the subjects were assumed to be approximately normal. The normality was conducted using skewness and kurtosis values. In this study, a specific statistical test such as a Shapiro-Wilks test

was not used because the statistical test was less useful in small samples [33]. Based on the SPSS output, the skewness and the kurtosis value for pre- and post-critical thinking and problem-solving skills were within the range of ±2. In other words, they were considered acceptable to prove the normal distribution [34].

The research objectives of this study were to test the effects of remote learning PBL in improving students' critical thinking and problem-solving skills. The hypotheses were tested using a paired sample T-Test to determine the presence or absence of the differences in students' critical thinking and problem-solving skills before and after the remote learning PBL module. Table 2 illustrates the results of the study.

Table 2
Paired Sample T-Test Results

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Problem-Solving Skills	Pre-test	11.588	34	1.828	0.313
	Post-test	12.471	34	1.930	0.331
Critical Thinking Skills	Pre-test	23.882	34	3.328	0.571
	Post-test	25.088	34	3.204	0.549
Paired Samples Correlations					
			N	Correlation	Sig.
Problem-Solving Skills			34	0.467	0.005
Critical Thinking Skills			34	0.572	0.000
Paired Samples T-Test					
	Std. Deviation	Std. Error Mean	t	df	Sig.
Problem -Solving Skills	1.887	0.324	-2.726	33	0.010
Critical Thinking Skills	3.022	0.518	-2.326	33	0.026

The statistical result showed there was a significant difference in the scores of pre-test-problem solving skills (M=11.588, SD=1.828) and post-test-problem solving skills (M=12.471, SD=1.930) with $t(33)=-2.726$, $p<0.01$. As a result, H1 was accepted and indicated there was a difference in students' problem-solving skills between pre-remote learning PBL and post-remote learning PBL. On the other hand, there was a significant difference in the scores of pre-test critical thinking skills (M=23.882, SD=3.328) and post-test critical thinking skills (M=25.088, SD=3.204) with $t(33)=-2.326$, $p<0.05$. The result showed that there was a difference in students' critical thinking skills between pre-remote learning PBL and post-remote learning PBL, and H2 was accepted.

Based on the mean value of critical thinking and problem-solving skills shown in Table 2, it indicated that the change was the increase of the scores for both critical thinking and problem-solving skills after implementing the remote learning PBL module. Moreover, the negative t-value indicated that the post-test scores for problem-solving skills and critical thinking skills are greater compared to pre-test scores. Particularly, the t-value was calculated as (M1 (pre-test) - M2 (post-test) /standard deviation), thus, the negative value was obtained when the M2 value was greater than the M1 value. As a result, it could be concluded that the hypothesis testing results were parallel to past studies that

indicated that remote learning PBL helped to improve students' problem-solving skills and critical thinking skills [25-29].

The Cohen test is used to determine the magnitude of the difference between two groups by calculating the mean difference between the groups and dividing the result by the pooled standard deviation and the effect size formula is Cohen's d = (M2 - M1)／SD pooled. Based on the calculation, the effect size of the pre- and post- problem-solving skills test was 0.469, whereas the effect size for the pre- and post- critical thinking skills test was 0.369. According to Cohen [35], an effect size greater than 0.2 and less than 0.5 was considered a small effect. In other words, it could be concluded that there was a small change in problem-solving skills and critical thinking skills after implementing the remote learning PBL module.

The third objective of the research was to assess the impact of remote learning PBL based on the qualitative assessment of an open question. Based on the thematic analysis for the collected feedback from the pre-session of remote learning PBL, the first theme was 19 respondents stated that they had no ideas about PBL. Intensively, respondents stated that they did not have knowledge of the steps, approaches or methods used to solve the given ill-structured problems. These responses suggested that the students did not have exposure to the PBL learning method before, and it followed that they were unclear on the remote learning PBL module.

In addition, respondent number 30 stated that they could not catch up on the module and respondent number 33 responded that the noise from the environment interrupted his attention in the session. During remote learning, communication barriers such as physical noise tend to interrupt the decoded messages, and this affects the effectiveness of learning. Likewise, Berge [36] indicated that communication barriers were the challenges in remote learning. This barrier included technical, psychological, social, contextual, and cultural challenges in remote education teaching and learning. The lecturer in remote learning is required to realize these challenges and try to find solutions to reduce communication barriers that occur in remote learning environments.

The second theme was no confidence in delivering the ideas. There were four respondents grouped in this theme. Basically, they felt not confident to do the problem-based analysis, not confident in the proposed ideas, and felt that the proposed solutions might not be accepted for the final decision. Apart from the negative feedback, there was some positive feedback from respondents.

The third theme was ready to be engaged positively in remote learning PBL. Seven respondents were grouped under this theme. Although they were not exposed to PBL lessons before, they mentioned that they tried to understand the given topic. On the other hand, there were five respondents seeking PBL as an interesting learning mechanism, and they felt excited to participate in remote learning PBL. Integration of technology such as interactive videos attracted the interest of students to engage in active learning.

Based on the thematic analysis for the collected feedback from during-session of remote learning PBL, students gradually made clear on PBL learning mechanism and learned to draw connections among the ideas to general solutions. The first theme was that PBL helped students to trigger higher thinking levels and promoted greater problem-solving skills. Basically, there were seven respondents who stated that they had learned the problem-solving steps and were able to implement the steps in the problem-solving process. Based on Bloom's taxonomy, PBL helped to trigger higher thinking levels, and this was true in this study. The feedback from the respondents implied that they have learned to find suitable information that is relevant to the topic and able to use the information and draw connections among the ideas to generate possible solutions.

The new idea generations were, in fact, spurred through ideas sharing in a group, and these differing opinions led to the exposure of different problem-solving ways. For instance, respondent

number 2 was able to see things differently, respondent number 19 listed the problem and solutions, respondent number 8 related the problem with learning objectives and respondent number 1 was able to use the information to draw a connection to the problem and the topic of study. In addition, during the problem-solving process, respondents learned to evaluate the solutions and were able to justify the stand or decisions to select a suitable solution. Respondent number 2 and 27 stated that they were able to select a suitable solution for the problem and respondent number 21 indicated that he was able to think rationally to select the best solution.

Interestingly, the thematic analysis results showed that discussions with group members and the lecturer played an important role in problem-solving. There were seven respondents' feedback grouped in this theme. Discussion with group members spurred the brainstorming process and aided in generating possible solutions. In addition, idea sharing in a group promoted active learning and created curiosity and fun in the problem-solving process. The lecturer facilitated the problem-solving process and reinforced the understanding of students regarding the problem-solving steps. Moreover, the lecturer shared extra information regarding the topic and facilitated students to think from different perspectives.

During the implementation of the problem-solving session, there were two respondents who reported that they faced difficulty understanding the topic and were confused about the steps to solve the problem. The result suggested a hazard in conducting remote learning PBL where the challenges of the lecturer to guide the students' understanding of PBL. Cheaney and Ingebritsen [26] stated that remote learning was more difficult to conduct because the lecturer did not have face-to-face contact with the students and students were searching to develop their answers largely on their own. This resulted in some of the student's finding difficulty in the learning module and they were struggling in the remote learning environment that they were not familiar with.

Finally, the thematic analysis under post-session of remote learning PBL indicated that most of the students improved in their understanding, critical thinking skills and problem-solving skills. There was a total of 20 respondents who indicated that PBL helped to improve their understanding, critical thinking skills and problem-solving skills. Specifically, there were ten respondents highlighted that they had achieved a basic understanding of problem-solving steps, or human resource-related knowledge based on the learning topic. Ten respondents reported that they achieved greater critical thinking. Intensively, PBL improved student's ability to summarize and identify the problem, determine the good or bad of the proposed solutions, and find the best solution for the problem. Moreover, the experience in PBL also helped the students to improve their knowledge and application skills in other related aspects. For instance, respondent number 22 indicated that she implemented problem-solving skills in other related disciplines such as marketing problems in an organization, and respondent number 5 indicated that she applied problem-solving steps in other individual assignments. On the other hand, the result showed that students had more confidence in handling remote learning sessions. This suggested that the students' acceptance of remote learning PBL hinged on the understanding of the method.

5. Conclusions

Problem-based learning helps students to learn through the experience of solving problems. This enhances students' thinking and problem-solving skills by constructing the problem scenario and resembling the situations that are connected to the learning objectives. The current study found that PBL can be implemented in a remote learning environment and the hypothesis testing results indicated that remote learning PBL improved students' critical thinking and problem-solving skills, albeit the effect size was not that ample. The results proved that PBL enhances the subsequent

retrieval and reinforces the understanding of students on the subject matter, and hence, triggers them to higher thinking levels in Bloom's Taxonomy. Moreover, PBL in remote learning settings motivates the students' active learning and participation in the learning process.

PBL in a remote learning setting still has great challenges compared to face-to-face PBL [26]. Although students' reactions to the remote learning PBL are positive, some reservations occurred especially about the environmental disruptions and the challenges such as difficulties in catching up with the course syllabus. Therefore, lecturers need to look at their students' feedback from time to time to improve the learning mechanism and to create a better learning environment. For instance, lecturers need to take active steps to minimize distractions in remote learning PBL and assist students in managing additional cognitive demands imposed by remote learning platforms. Since the PBL in remote learning creates positive impacts on students' thinking and problem-solving skills, future studies should take a step further to impose remote learning PBL in other courses rather than the selected course in this study and implement several PBL modules in order to maximize the impact on students' overall learning.

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