Development novice teachers' higher-order thinking skills through online problem-based learning platform: A mixed methods experimental research

Pongwat Fongkanta, Fisik Sean Buakanok*
Rajabhat University, Thailand
*Corresponding Author: nellitawati@fip.unp.ac.id

ABSTRACT

One key competency in teaching profession is the ability to think at a higher level. Therefore, it is important to understand how to develop and refine effective training approaches for novice teachers. This study examined the novice teachers' higher-order thinking skills development through online problem-based learning platform and analyzed the level of novice teachers' higher-order thinking skills. The research involved 57 novice teachers participating in the research for learning development courses. The mixed method experimental design was employed in this study. Data were collected by using multiple choice tests and self-report reflective thinking forms. Descriptive statistics were used to analyze novice teachers' HOTS. The t-test was conducted to evaluate mean differences among the novice teachers' HOTS. Content analysis was used to code and categorize themes and pattern of HOTS perception. Results revealed that novice teachers have shown improvement in higher-order thinking skills include the problem solving, critical thinking, creative thinking sub-skills through online problem-based learning approach. Their proficiency in HOTS significantly increased, $t(57) = 17.72$, $p < .001$, with a high portion achieving advanced levels. Furthermore, they gained the positive perspective in employing online PBL for HOTS development.

Keywords: novice teacher, HOTS, Online PBL platform, Mixed methods experimental research

INTRODUCTION

The 21st century has seen changes in and an impact on the educational process due to the rapid growth of information technology and communication. The educational management model needs to be improved to meet the shifting demands of the 21st century. Also, education plays a vital role in human capital formation in that national development (World Bank, 2018). One of the key principles of educational change movements is the belief that teacher professional development is essential for educational development especially in school context (Ajani, 2022). Furthermore, the needs of teacher competency propose in classroom that higher-order thinking skills (HOTS) are essential for effective learning and teaching of teacher and promote the professional teachers (Retnawati et al., 2018).

Professional teachers required professional knowledge in teaching include HOTS and be able to use them during the teaching-learning processes (OECD, 2019). HOTS include in core knowledge of subject area and teaching and competencies in classroom management dimension and necessary for investigation, creative problem-solving, and decision-making (Davis & Rimm, 1994; Higuchi & Donald, 2002). Bloom's taxonomy categorizes thinking skills, placing higher-order thinking like analysis, evaluation, synthesis and creativity above memorization and basic comprehension (Robert & McGuinnes, 2014; Leighton, 2011; Armstrong, 2010; Krathwohl,

2002). Moreover, alternative assessment to measure HOTS is to integrate problem-solving tests, critical thinking, and creative thinking (Rofiah et. al, 2013; Marzano, 1993). Furthermore, Marshall and Horton (2011) presented HOTS components were included logical thinking, critical thinking, and reasoning skills. The partly of novice teachers focus on learning management with memorized approach that less need critical thinking, synthesis thinking, and problem solving to do tasks (Onsuk et al., 2023) and less classroom management skills (Sadik & Akbulut, 2015). This problem could affect to the thinking skill in their students. However, novice teachers, those having less than five years of teaching experience, could bring new energy and ideas to classroom that could improve the learning environment of students (OECD, 2019), especially, when they gain the design learning of professional development.

In the design of learning strategies and innovation, it is crucial to focus on facilitate learners' knowledge construction and reflection rather than remembering principles (Allas et al, 2020; Herrington et al., 2014; Saito & Miwa, 2007). The Problem-Based Learning (PBL) approach is an instructional approach designed to enhance students acquire knowledge and allows students to apply their knowledge to solve problems, fostering independent and higher-level thinking. Integrating Problem-Based Learning (PBL) into a research course involves structuring the course around real-world research problems that students must investigate and solve (Silva et.at, 2018). Yao (2012) emphasized that one of the recommendations of the National Research Council's study (NRCS) on facilitating HOTS among students is that teachers must create learning environment where students are at comfortable expressing their thoughts, creativity, and personal meaning. So, teacher would construct learning such that they may train to be coaches and encourage students' problem-based learning. Implementing PBL in an online environment presents unique opportunities and challenges. It can effectively develop higher-order thinking abilities when properly executed with combined various teaching strategies, and materials (Shanti et al., 2022). The online platform can enhance collaboration, access to resources, and the integration of various technologies to solve problems (Tasman, 2020).

Various research has looked at teachers' competency to design the evaluation of HOTS and lesson plan (Suwarma & Apriyani, 2022; Widana, 2017; Tasman, 2020) and develop the HOTS for teacher students in which learning onsite context (Meesanga & Kaosamlee, 2020; Rahmawati et al., 2019; Thongpanit, 2019). On the other hand, little is known about how particularly development an efficiency learning process for novice teachers who should have enhanced the higher-order thinking skills that can benefit novice teachers directly. Furthermore, little is applied the online problem-based learning platform into classroom session. Hence, the purpose of this study is to examine the novice teachers' higher-order thinking skills through online problem-based learning platform and to analyze the level of teachers' higher-order thinking skills.

METHOD

This study was carried out by using the mixed method experimental research design consisting of pre-post testing and in-depth interviewing. The research variable was problem-based learning approach and higher-order thinking skills. The population is novice teacher who enrolled the research for learning development courses. A total of 57 samples were selected for this study by using cluster random sampling.

To capture valuable insight from novice teacher participants, a pre-post testing by 4 options multiple choices test that measure three component of HOTS skills as problem-solving skill, critical thinking, and creative thinking with the total score was 30. The HOTS test was constructed using a test specification by adapting Bransford's IDEAL problem-solving test (Bransford & Stein,1984) and Critical Thinking Assessment Test, CAT (Stein et al, 2006) (Table 1.). Participants were also asking to self- report on reflective thinking form in higher-order thinking skills perceptions and perspective. The reliability of HOTS test was established using Cronbach's alpha measurement to demonstrate internal consistency that was 0.75. A Cronbach's alpha coefficient higher than 0.70 that was considered acceptable for a reliable scale.

Table 1. Test specification of HOTS test

Component of HOTS skills	Sub-skills
Problem-solving	1. Identify the problem
	2. Define the problem
	3. Examine the options
	4. Act on a plan
	5. Look at the consequences
Critical thinking	1. Analysis
	2. Interpretation
	3. Inference
	4. Evaluation
Creative thinking	1. Identify alternative
	2. Identify new information, Explain how new

The procedure of this study is that researcher developed a learning activity based on problem- based learning to be applied in research for learning development courses. The activities for problem-based learning were created to intervene in this study. The procedures were starting by asking participants to report the higher-order thinking skills previously. Then, problem-based learning interventions was applied in online platform. The proposed PBL process involves four stages. The first consist of the exploring and analyzing problem that occurred in school. The second stage, create educational innovation and design to propose solution and share in reflecting room. The third stage, research and manipulate to classroom solving-problem. The fourth stage, present the finding and do reflection (Wood, 2006; Savery, 2006). These approaches conduct in the online platform during the intervening session, the qualitative data of the higher-order thinking skills by using the reflective form repeated two times. The activities and process were completed via the online learning platform Google classroom, which allows all participants to access course materials, and assignments through their own account. The procedure of this study showed on figure 1.
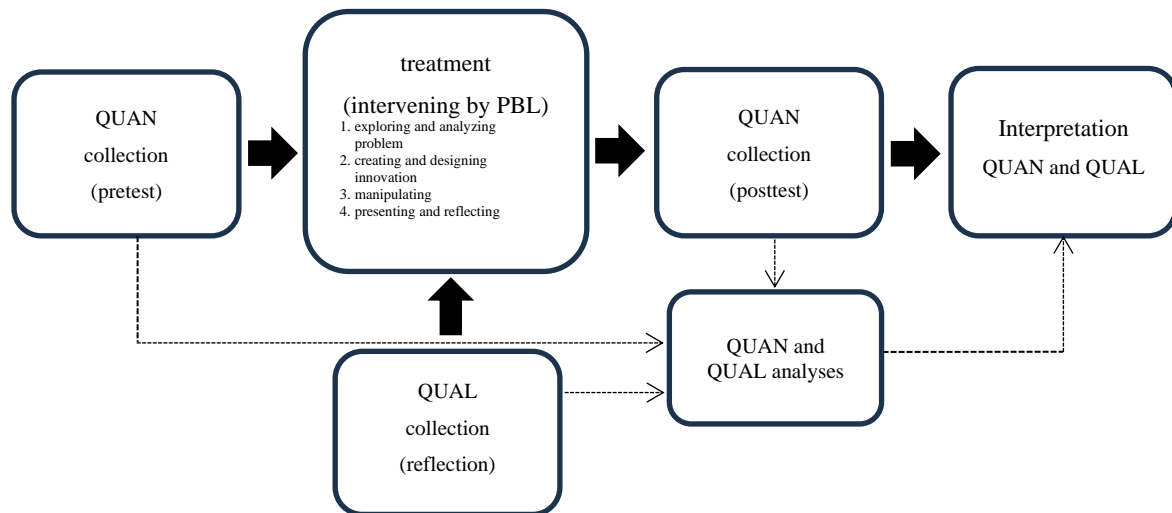

Figure 1. Embedded design mixed-methods research (Creswell and Clark, 2011) and Problem-based learning approach (Wood, 2006)

The data analysis, descriptive statistics were used to report the result and determine differences in higher-order thinking skills. Also, the criteria of interpretation the level of higher-order thinking skills was used group-referenced assessments, high level refer to score higher than $\bar{X} + 1SD$, moderate level refer to score between $\bar{X} - 1SD$ to $\bar{X} + 1SD$, and low level refer to score less than $\bar{X} - 1SD$ (Gravetter & Wallnau, 2016). The t-test was conducted to evaluate mean differences of pretest and posttest score among the novice teachers' higher-order thinking skills.

The content analysis was used to code and categorize themes and pattern. Furthermore, both quantitative and qualitative data was used to interpret for answering the research objectives.

FINDINGS AND DISCUSSION

Findings

As can be seen in Table 2, the developing result of novice teachers' higher-order thinking skills and analyzing category of novice teachers' skills disclosed the difference of novice teachers' skill scores by repeated measured two times. A pairwise comparisons of novice teachers' higher-order thinking using t-test revealed that the novice teachers' higher-order thinking skills posttest scores (M= 23.04, SD= 2.96) were significantly greater than the novice teachers' higher-order thinking skills pretest scores (M= 15.44, SD=2.38), $t(57)$ = 17.72, $p < .001$. The three components of HOTS results show the number of high skill group different among three components. The novice teachers' problem solving skills posttest scores (M= 8.23, SD= 1.29) were significantly greater than the novice teachers' problem-solving skills pretest scores (M= 5.79, SD=1.43), $t(56)$ = 9.16, $p < .001$. The novice teachers' critical thinking skills posttest scores (M= 8.02, SD=1.29) were significantly greater than the novice teachers' critical thinking skills pretest scores (M= 5.49, SD=1.27), $t(56)$ = 11.97, $p < .001$. Moreover, the novice teachers' creative thinking skills posttest scores (M= 6.79, SD=1.52) were significantly greater than the novice teachers' creative thinking skills pretest scores (M= 4.16, SD=1.37), $t(56)$ = 10.64, $p < .001$.

Table 2. The pretest-posttest score of novice teachers' higher-order thinking skills and comparing mean analysis

Skills	Pretest				Posttest				Mean Difference	t
	Min	Max	M	SD	Min	Max	M	SD		
Problem solving	2	8	5.79	1.43	5	10	8.23	1.29	+2.44	9.16*
Critical thinking	3	8	5.49	1.27	5	10	8.02	1.29	+2.53	11.97*
Creative thinking	2	7	4.16	1.37	3	9	6.79	1.52	+2.63	10.64*
Higher-order thinking	**11**	**22**	**15.44**	**2.38**	**16**	**28**	**23.04**	**2.96**	**+7.60**	**17.72***

* $p < .05$

The result representing the overall mean of novice teachers' higher-order thinking skills was 23.04. It is a moderate level that mean score of the posttest over the 60 percent, criterion, of the total score. The three components of HOTS results show the number of high skill group different among three components. The highest number of novice teachers' skills was problem-solving skills, whereas creative thinking skills was lower than critical thinking and problem-solving skill. Most novice teachers have had moderate skills for each HOTS. The number of novice teachers who have high skills in problem solving and critical thinking were more than the number of novice teacher who have low skills. In contrast, the number of novice teachers who have high skills in creative thinking was less than the number of novice teacher who have low skills. The category of novice teachers' skills was classified in Table 3.

Table 3. Percentage of student skill category

HOTS components	High	Moderate	Low
Problem solving	16	72	12
Critical thinking	14	74	12
Creative thinking	12	65	23
Higher-order thinking	**17**	**58**	**25**

The thematic content analysis of HOTS perceptions and perspective were coded and categorize themes. Data were quantified by counting and converting into percentage. The results revealed that the highest percentage of novice teachers' perceptions of HOTS, at 31.58% gained, was attributed to their ability to design solutions and generate ideas for problem-solving. For the critical thinking component, the novice teachers' perceptions in interpretating the result and inference were highest gain at 22.81%. Moreover, the highest gain in the able to apply in another context section was 19.30 % for creative thinking component. Furthermore, the perspective of HOTS was described concisely in each component (Table 4.).

Table 4. Result of thematic content analysis with percentage and perspective of HOTS

HOTS components	HOTS perceptions			Perspective
	1st reflection (%)	2nd reflection (%)	Gain (%)	
Problem-solving				Most novice teachers reflected that the problem solving made they feel exhausted. However, some novice teachers said it more useful to deal with classroom problem and more challenge for us.
1. Able to define the classroom problem.	52.63	82.46	+29.82	
2. Capacity to design the solution, idea to solve problem.	36.84	68.42	+31.58	
3. Examine the options and act on a project protocol.	43.86	71.93	+28.07	
4. Predictions about what consequences will find.	52.63	75.44	+22.81	
Critical thinking				Most novice teachers reflected that they don't like statistics section and find it difficult to interpret data to answer research questions.
1. Analyzing data from data collection.	52.63	66.67	+14.04	
2. Interpretating the result and Inference.	47.37	70.18	+22.81	
3. Able to assess the credible of the result.	40.35	52.63	+12.28	
Creative thinking				Most novice teachers reflected that the creative thinking was more useful to expand the idea for creative new solutions.
1. Able to apply in another context.	45.61	64.91	+19.30	
2. Identify alternative and propose the new solution.	49.12	59.65	+10.53	

The narrative response of the novice teacher about the HOTS perceptions through problem-based learning using online platforms according to the quantitative result were presented. The posttest problem-solving skill score was 8.23 and the HOTS perceptions was highly expanding, +22.81% - +31.38%, that the posttest and the second reflection got higher score than the pretest score and the first reflection. This result showed the apparently student improvement. There was the case that selected quotes related to the identified themes.

"Working under a real problem that founded in classroom with my team seem more effective on online platform" (Participant #3)

"Each case gave me an opportunity to understand more about that problem topic and how to select a feasible educational innovation to solve problem" (Participant #12)

The critical thinking sub-skills, the posttest score was 8.02 and the HOTS perceptions was highly expanding, +12.28 - +22.81, that the posttest score and the second reflection got higher than the pretest score and the first reflection. This result revealed the obviously student improvement. There was the case that selected quotes related to the identified themes.

"Got knowledge about data analysis and knew on how to analyze data but feel difficulty in using statistics program for reaching the result and interpreting result on my research". (Participant #1)

"Instead of just understanding how to analyze data I was able to judge the correcting of the result" (Participant #23)

The creative thinking sub-skills, the posttest score was 6.79 and the HOTS perceptions was moderately expanding, +10.53 - +19.30, that the posttest score and the second reflection got higher than the pretest score and the first reflection. This result revealed the obviously student improvement. There was the case that selected quotes related to the identified themes.

"I could add my innovative ideas with an alternative solution in the future research project. I also propose the suggestion on how to apply the educational innovation to other school" (Participant #15)

"Having agreements and disagreements about the recommendation for the future research on discussion online board. But we get consensus about the recommendation. We spend quietly more time in a single topic" (Participant #32)

Discussion

Higher-order thinking skills was moderate level at 23.04 in novice teacher. They received the PBL process involves the exploring and analyzing problem, create educational innovation and design to propose solution, research and manipulate to classroom, present the finding and reflection using online platform. The finding showed the effective of PBL to develop the novice teacher HOTS. The PBL approach allows students to apply their knowledge and experience to solve problems, fostering independent, and higher-level thinking. It can provide opportunities for working in groups and finding and evaluating research materials (Duch et al, 2001). By emphasizing problem-solving and evaluation, Problem-Based Learning (PBL) fosters the development of HOTS, thereby enhancing learners' capacities for critical and creative thinking. Therefore, the integration of PBL into teaching practices in online platform can effectively enhance students' higher-order thinking skills.

Moreover, according to Marshall and Horton (2011) presented the two processes for developing HOTS among students. First, to establish an environment for students to explore more about the complex problems by posing essential open-ended questions. Second, giving opportunities for all novice teacher to think about their own thinking based through group activities during online class. The process emphasized to do on clearly identify and examine the problem include the create innovation with the critical thinking skill for particularly problem. Moreover, Actions follow the plan after clearly identify the problem and innovation were a process to foster students' HOTS (Tam, 2018). The analysis of the learning experience activities and generalizing and formulating rules regarding alternative approaches that were promote learners' HOTS particularly in the areas of reasoning, problem-solving, analysis, assessment, invention, and making decision and judgment (Handayani et al., 2023).

The PBL process manipulate on the online platform that integrated an ICT to promote novice teacher skills. Especially, online discussion forums were an implement forums or discussion boards where learner can post questions, share ideas, and discuss solutions. According to Ganapathy et, al. (2017) founded that teacher facilitated the learning process with the integration of ICT as a supplementary tool in promoting higher order thinking skills. Furthermore, a computer-based design allowing students to think and solve problems with their peers include the step of problem representation, search for solutions and implement solutions by using the features of multimedia. It also enables students to engage with and immediately documents their thoughts using their critical thinking and creative thinking during the problem-solving process .

CONCLUSION

Based on the findings and discussions highlighted, researcher can derive the following conclusions. The novice teachers have been improved in higher-order thinking skills include the

problem solving, critical thinking, creative thinking sub-skills by using online problem-based learning approach. Their HOTS reached to high level with high proportion and revealed the positive perspective in PBL using online for HOTS development. For further research, should be includes an addition of a controlled group in the study to enhance the effectiveness of the online problem-based learning approach. Furthermore, to confirm the reliability and extend the applicability of the study's outcomes, it is recommended to conduct further replication research.

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