The Effects of Problem-Based and Collaborative Learning on Students' Higher-Order Thinking Skills

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Abstract

The Standard Secondary School Curriculum introduced in 2017 places a greater emphasis in Additional Mathematics on applying the elements of higher-order thinking skills (HOTS). However, students showed poor performance in the application of HOTS in solving Additional Mathematics problems. Therefore, this study examined the effects of Problem-Based Learning (PBL) and Collaborative Learning (CL) with the help of Geometer's Sketchpad on the four levels of HOTS of Form Four students namely Applying, Analysing, Evaluating and Creating. A PBL-CL module was developed as a guide for teachers to foster HOTS among students. A HOTS test was developed to assess the level of HOTS of students. This study used a quasi-experimental pre-test and post-test control group research design involving 270 Form Four students in Sabah, Malaysia. The assessment of HOTS involved three intervention groups namely PBL-CL, PBL and Conventional Learning (Conv) group. Statistical analysis employing MANCOVA, ANCOVA, and Effect Size techniques were conducted. The results showed that the PBL-CL group produced a significantly higher post-test mean scores compared to the PBL and Conv groups in all four levels of HOTS. This shows that the PBL-CL method has a positive effect in helping the development of HOTS. Therefore, Additional Mathematics teachers are strongly recommended to integrate PBL-CL in their TL practice to increase the level of HOTS among students.

Keywords: *collaborative learning, form four students, higher-order thinking skills, problem-based learning.*

I. INTRODUCTION

Mathematics is one of the most important fields in the development of human capital in the 21st century. In line with that, the transition in mathematics education from emphasizing cognitive algorithm skills to higher-order thinking skills (HOTS) has an impact on the implementation of Mathematics teaching and learning[1]. Therefore, at the school level in particular, the introduction of HOTS in the subject of Additional Mathematics as an elective subject is seen to help realize this aspiration. Compared to Mathematics, Additional Mathematics places a greater emphasis on mathematical applications and real-world problem-solving which is closely related to solving non-routine problems. This coincides with the change of the Malaysian Integrated Secondary School Curriculum to the Standard Secondary School Curriculum which has been implemented since 2017 so that students not only to improve students' knowledge, skills and interests but also to apply elements of HOTS in the curriculum[2]. However, the results of the Additional Mathematics subject in the Malaysian Certificate of Education (MCE) since HOTS was introduced by the Ministry of Education are of great concern to all parties, especially in the state of Sabah. It was found that 46.67% of students have poor application skills while 37.36% have poor analytical skills[3]. In addition, the weak categories of evaluating and creating skills showed 52.49% and 39.48% respectively. In conclusion, there are more than 40% of students out of all MCE candidates who are still weak in answering HOTS questions.

Several approaches such as problem-based learning (PBL), collaborative learning and the use of technology in teaching should be highlighted to overcome this problem. PBL is an authentic (real) problem-learning approach so that students can organize their knowledge, develop high skills and inquiry and increase their self-confidence[4]. PBL is designed to provide students with real-life situations to solve real-world problems through a series of activities and investigations based on the theories, concepts and principles they learn, as well as helping students build their thinking needed to succeed[5]. Through this method, relevant and meaningful real-world problems are presented to students. Students actively work in groups to solve problems, communicate, and argue for the best solution and the instructor only plays a role in facilitating student knowledge-building activities[6].

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A collaborative learning approach is also seen as one of the ways to deal with this problem. However, [7] stated that the main problems in the implementation of teaching at the secondary school level are collaborative learning that is practised less effectively, the lack of students' HOTS skills and less satisfactory academic performance. According to[8], collaborative learning methods are difficult and rarely implemented because teachers think that collaborative learning methods are a waste of time. Teachers take the easy way out by telling students the answers without explanation to save time and be able to finish the syllabus quickly. As a result, collaborative learning methods that can train students about HOTs are neglected. In conclusion, the success of improving students' HOTS depends on the teacher's role in planning and preparing group learning activities that involve all students[9].

Based on the problems above, this study was conducted by focusing on learning strategies in the classroom. One of the alternatives to existing learning strategies is a collaborative problem-based solution method. Past studies show that problem-based solution methods are needed by students to train critical thinking to create skills that help in understanding concepts in depth[10]. In addition, [11] stated that the interaction between students which is the main feature of collaborative learning can improve student performance and student interest. However, research on the use of collaborative problem-based solution methods is less conducted at the secondary school level. Thus, the researcher sees a need to develop a learning module using elements of problem-based solution methods and collaborative learning with the help of technology such as Geometer's Sketch Pad (GSP) to encourage active learning in the classroom. According to [12], students' enjoyment while learning Mathematics by exploring using GSP shows that students must know how to use technology. Therefore, a suitable module guided by technology such as GSP needs to be produced to encourage students to think of problem-based solutions in a collaborative approach to improve students' HOTS and collaborative skills.

II. LITERATURE REVIEW

Problem-Based Learning

In general, problem-based learning known as PBL is defined as a teaching and learning method where students are involved in solving real-world problems and with sufficient knowledge to solve problems. [13] stated that PBL learning has the following cognitive effects on student learning, namely, activation of existing knowledge, elaboration of existing knowledge through small group discussions, restructuring of knowledge to suit the problem presented, learning according to context and the emergence of a desire to know. Therefore, [13] introduced seven steps of the PBL model which are 1) Clarifying of terms and concepts that are not easy to understand, 2) Defining the problem, 3) Problem analysis, 4) Draw a systematic inventory of the explanations deduced from step 3, 5) Formulate learning objectives, 6) Gather additional information outside the group, and 7) Synthesize newly acquired information.

In Malaysian schools context, PBL is designed to prepare students to learn in real-life situations to solve real-world problems through a series of activities and investigations based on the theories, concepts, and principles learned, helping students develop their thinking and communication skills needed to succeed[5]. Unstructured problems in PBL can improve students' cognitive processes accompanied by good studies[14]. In mathematics education in particular, several studies show that students have a positive effect on their achievement scores in learning Mathematical thinking skills through PBL[15].

Geometer's Sketch Pad

Geometer's Sketch Pad (GSP) is one of the dynamic geometry software systems for creating, exploring, and analysing various mathematical concepts in algebra, geometry, trigonometry, calculus and other fields. GSP is also a dynamic geometry software that allows teachers and students to build and change geometric objects or object components, by dragging different objects onto the computer screen. According to [16], GSP is an interactive tool that encourages a discovery process where students first describe and analyse problems and then draw conclusions. GSP allows students to work through many examples and allows them to discover patterns by constructing their own sketches[17]. The study by [18] showed that there was a significant difference between the mean evaluation of secondary students' interest in teaching geometry using GSP software compared to students who were taught without GSP. According to [19], the use of technology increases students' enjoyment and interest. Therefore the use of technology can be one of the steps taken to increase secondary school students' interest and achievement in geometry.

Higher-order Thinking Skills (HOTS)

HOTS is the main component of creative and critical thinking ability and is the highest level of cognitive process[20]. In Bloom's Taxonomy, thinking levels can be classified according to six levels of cognitive thinking, where the three lowest levels are Knowledge, Understanding, and Application, while the three highest levels are Analysis, Synthesis and Evaluation. Following the formation of 21st-century learning in all schools in Malaysia, the revised edition of Bloom's Taxonomy was introduced in

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2001. This revised edition of [21] has updated the six levels of Bloom's thinking into verbs and also divided the top four levels into the high-order thinking skills group (HOTS) and the two lowest levels into the low-level thinking skills group (LOTS). The HOTS assessed in Form Four Additional Mathematics is based on the top four levels of the revised edition of Bloom's taxonomy, which are Apply, Analyse, Evaluate and Create [2]. In a previous study, [22] identified several problems faced by teachers in the implementation of Mathematics teaching through the integration of HOTS. Students' basic knowledge, students' difficulties in understanding high-order questions and teachers' difficulties in constructing high- order questions are problems identified by teachers. Findings about teacher problems in the context of students' basic knowledge are in line with the study by [23] who stated that teachers believe that students need to first know all the facts and concepts of a subject before they can be encouraged to think. This is because students find it difficult to understand high-level questions even after being given prompt questions and only some students can continue learning while others encounter a dead end. In addition, the lack of modules or other reference materials that characterize HOTS makes it the main constraint of learning HOTS in the classroom[22].

Collaborative Learning

Collaborative Learning (CL) is a technique designed to make learning a fun and active process. It is also called cooperative learning or small group learning. According to [24], collaborative learning is a teaching method where students at various performance levels work together in small groups towards a common academic goal. Collaborative skills have been further defined as learning that occurs as a result of interactions between peers involved in completing tasks together. The focus is on what students can do to initiate and manage their learning through collaboration with others [25] (Ingleton et al., 2000). [26]'s study found that most students claimed to gain academic benefits such as better understanding and performance. In addition, students were also seen to acquire generic skills through improved communication and problem-solving skills.

Research Aim and Objectives

This study was carried out to determine the effects of problem-based learning and collaborative learning (PBL-CL) with the help of Geometer's Sketch Pad on the higher-order thinking skills of Form Four students. Specifically, the objective of this study was to determine the effects of problem-based learning and collaborative learning on the four levels of HOTS of Form Four students, namely Applying, Analysing, Evaluating and Creating.

III. RESEARCH METHODOLOGY

Design

The research employed a quasi-experimental pre-test and post-test control group design to examine the effects of three different TL methods on Form Four students' higher-order thinking skills. The implementation of TL groups was divided into three types, namely PBL-CL, PBL and Conventional Learning (Conv) methods. In the PBL-CL method, a module developed by the researcher was used as a teaching module. In the PBL-CL module, students were exposed to GSP-assisted problem-based learning that uses collaborative learning techniques. The collaborative learning techniques used were Think Aloud Pair Problem Solving, Send A Problem, Structured Problem Solving and Group Investigation. Meanwhile, Form Four students in the PBL group were exposed to problem-based learning with the help of GSP without using collaborative learning techniques. The students in PBL group are also given the same assignments as the PBL-CL and Conv groups but the group activities are more teacher-centered. As for the Conv method, students follow the conventional teaching and learning process with the help of GSP but without module, where almost all learning activities are fully controlled and guided by the teacher. All students were given the intervention in the same week but with different TL methods for eight weeks between November - December 2021.

Population and Sample

The research population consisted of 487 Form Four students in Lahad Datu district[3]. In this research, students from five out of 10 national secondary schools in the Lahad Datu district were ramdomly selected as sample to sit for the pre-test. The HOTS Test was used as an instrument to determine the research sample. Next, the HOTS Pre-Test and CS Pre-Test were administered to Form Four students for the five schools involved. From the test scores, students from three schools with the same or almost the same score values were selected as a sample in this research. The selected schools were then randomly divided into three groups, namely the PBL-CL, PBL and Conv group. In addition, the selection of three schools was also assessed from the aspect of the number of students taking the subject of Additional Mathematics at the school. Each selected school had a minimum of 90 students as research subjects. This means, three schools provided 270 students as research subjects. Next, each selected school was divided into three classes consisting of 90 students, with each group having 30

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students. According to Chua (2008), the Multivariate Analysis of Variance is robust against violations of normality when the sample size is or greater than 30. The teaching methods namely the PBL-CL method (n = 30), the PBL method (n = 30) and the Conv method (n = 30) was implemented in each selected school.

Higher-Order Thinking Skills Test (HOTS-T)

The HOTS-T instrument [28] was used to measure higher-order thinking skills. The HOTS-T instrument developed by the researcher was guided by the top four levels in Revised Bloom's Taxonomy by [21], namely Applying, Analysing, Evaluating and Creating. All items were developed based on the Additional Mathematics Curriculum and Assessment Standard Document concerning the topics found in the Form Four Additional Mathematics textbook. Each HOTS level has two subjective type items with different question forms. In total, eight items were constructed representing all levels of HOTS: 1) Applying (2 items) 2) Analyse (2 items) 3) Assess (2 items), and 4) Creating (2 items)

The scoring criteria for the HOTS refer to the analytical scoring rubric that has been modified in assessing students' HOTS issued by [29]. It is based on the total marks obtained from two items according to the HOTS construct, where each item contains a total of four marks, which makes each level contain a total of eight marks. The following rubric details the student's achievement level based on the cognitive assessment of the student's HOTS level: 1) 1 - 2 marks: Inability to solve problems accurately; 2) 3 – 4 marks: Lack of ability to solve problems accurately; 3) 5 – 5 marks: Able to solve problems accurately; and 1) 7 – 8 marks: Very capable of solving problems accurately.

The validity of the HOTS-T instrument was analysed based on item fit analysis using Rasch Measurement Model. Three criteria were used to assess the appropriateness of items according to [30] and [31] namely: 1) Outfit Mean Square Values (MNSQ) – the value must be between 0.50 and 1.50; 2) Outfit Z-Standardized Values (ZSTD) – the value must be between -2.00 and 2.00; and 3) Point Measure Correlation (PTMEA-CORR) – the value must be between 0.40 and 0.85. If the item meets one of the three criteria, the item should be retained [32]. Findings from the assessment of item fit in Rasch analysis show that all items in the HOTS-T instrument meet all the criteria for Outfit MNSQ, Outfit ZSTD and PT-MEASURE CORR. Thus, all items are retained. Meanwhile, the reliability of the HOTS-T instrument which was also assessed using Rasch analysis reported good index values for item reliability (r = .98) and person reliability (r = .91).

Data Analysis

The data were analysed using inferential analysis to meet the objectives of the research. A multivariate analysis of variance (MANOVA) was used to examine whether there was a statistically significant difference between the mean scores of Form Four students in the Pre- HOTS-T test according to the construct. Multivariate Analysis of Covariance (MANCOVA) was used to evaluate the effect of three different teaching and learning groups on students' higher-order thinking skills and collaborative skills. Four covariates were identified namely pre-applying, pre-analysing, pre-evaluating, and pre-creating. This covariate served as a control variable for teaching and learning groups, which served to adjust for possible differences between groups. If the overall MANCOVA results were statistically significant, then a series of Univariate Analysis of Covariance (ANCOVA) was performed to determine the significant effect of teaching and learning groups on each dependent variable.
The next step of statistical analysis is if the ANCOVA results are statistically significantly different in the three teaching and learning groups, a post-hoc comparison technique is performed to determine which group is significantly different compared to the other group for each dependent variable. The level of significance was set at $p < .05$, which means that the researcher determined that there is a difference between the intervention groups. The preliminary analysis was carried out by the researcher where the prerequisite assumptions of the MANOVA/MANCOVA, namely the identification of outliers, normal distribution, equality of covariance, linearity of variables, multicollinearity, and homogeneity of variance must be met before assessing multivariate statistical findings [34]. All prerequisite assumptions of MANOVA/MANCOVA had been met except the assumption of equality of covariance where the assumption of equality of matrices in this research had been violated in the HOTS-T pre-test [Box's M = 125.551, $F(20, 255895.975) = 6.142$, $p < .01$], and the HOTS-T post-test [Box's M = 207.763, $F(20, 255895.975) = 0.164$, $p < .01$]. According to [48], violations of the covariance equality of group members are common and easily overcome by using Pillai's Trace. In addition, the effect size (ES) was also used to measure the strength of the effect and provide important information in statistical analysis based on the value suggested by [39].

IV. RESULT

Table 1 shows the comparison of pre-test and post-test mean scores for the four levels of high-order thinking skills, namely Applying, Analysing, Evaluating and Creating. Overall, there was an increase in the mean score at the post-test for each HOTS construct in each TL method.

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Table 1
Descriptive Statistics for the Higher-Order Thinking Skills Test in the Pre-test and Post-test

Construct	TL method	*N*	Pre-test		Post-test	
			M	*SD*	*M*	*SD*
Applying	PBL-CL	90	4.12	1.279	6.49	1.343
	PBL	90	4.22	1.695	4.79	1.764
	TR	90	4.06	1.692	4.22	1.701
Analysing	PBL-CL	90	4.07	1.512	5.96	1.398
	PBL	90	4.12	1.585	4.49	1.782
	TR	90	3.88	1.621	4.21	1.532
Evaluating	PBL-CL	90	3.73	1.766	5.86	1.678
	PBL	90	3.69	1.771	4.10	1.601
	TR	90	3.50	1.711	3.64	1.801
Creating	PBL-CL	90	3.33	1.722	4.89	1.394
	PBL	90	3.37	1.940	3.54	1.657
	TR	90	3.14	1.726	3.87	1.745

Through MANCOVA analysis, the results of Pillai's multivariate test (Table 2) show that overall there is a significant effect of the independent variable (teaching method) on the dependent variable [$F(8, 522) = 29.458$, $p < .05$]. While the findings also show that there is no effect between the covariate that is Pre-Test on the dependent variable Pre-Applying [$F(4,260) = 4.140$, $p > .05$], Pre-Analysing [$F(4, 260) = 6.282$, $p > .05$], Pre-Evaluating [$F(4, 260) = 4.103$, $p > .05$] and Pre-Creating [$F(4, 260) = 9.598$, $p > .05$]. The teaching method is a factor in achieving HOTS (Applying, Analysing, Evaluating and Creating) by controlling pre-test for each construct of HOTS.

Further, the researcher conducted an ANCOVA test to identify whether there is an effect of the independent variable (teaching method) on the dependent variable which is the construct of Applying, Analysing, Evaluating and Creating. ANCOVA analysis shows that there is a significant effect of the teaching method on the construct of Applying [$F(2, 266) = 81.780$, $p < .05$, $\eta^2 = .311$], Analysing [$F(2, 266) = 90.185$, $p < .05$, $\eta^2 = .383$], Evaluating [$F(2, 266) = 104.291$, $p < .05$, $\eta^2 = .440$], and Creating [$F(2, 266) = 65.025$, $p < .05$, $\eta^2 = .246$]. A high relationship was found between the teaching method and the dependent variable showing that 31.1%, 38.3%, 44.0% and 24.6% of the variance obtained in Post-Applying, Post-Analysing, Post-Evaluating, and Post-Creating respectively were contributed by the teaching method.

Post-Hoc analysis was also performed to determine the effect of the independent variable on the dependent variable. Table 4 shows the pairwise comparison test results and effect sizes for the effect of teaching methods on the Applying, Analysing, Evaluating and Creating constructs. Pairwise comparison shows that the PBL-CL method is significantly higher than the PBL method for all constructs in high-otfer thinking skills ($p < .05$). Meanwhile, the pair comparison also shows that the PBL-CL method is significantly higher than the Conv method for all constructs ($p < .05$). The same finding is also seen in the pair comparison between the PBL and Conv method where the PBL method is significantly higher than the Conv method in all constructs ($p < .05$) except for the Analysing construct. For effect size analysis, students who followed the PBL-CL method showed a large effect size compared to the PBL method for each construct namely Applying ($d = 1.084$), Analysing ($d = 0.918$), Evaluating ($d = 1.073$) and Creating ($d = 0.882$). Statistically, it can be concluded that the PBL-CL method is effective in improving the four levels of high-order thinking skills.

Table 2
Summary of MANCOVA and ANCOVA Results for the TL Methods and the Covariates

Effect	MANCOVA			ANCOVA			
	Pillai's Trace ***F***	***df***	***p***	***F***	***df***	***p***	**η²**
TL method	29.458	8, 522	*p* < .05	81.780	2, 266	< .05	.311
Pre-applying	4.140	4, 260	.487	90.076	1, 266	.086	.473
TL method	29.458	8, 522	*p* < .05	90.185	2, 266	< .05	.383
Pre-analysing	6.282	4, 260	.631	150.787	1, 266	.042	.550
TL method	29.458	8, 522	*p* < .05	104.291	2, 266	< .05	.440
Pre-evaluating	4.103	4, 260	.577	126.858	1, 266	.074	.609
TL method	29.458	8, 522	*p* < .05	65.025	2, 266	< .05	.246
Pre-creating	9.598	4, 260	.603	80.243	1, 266	.081	.543

Table 4
Pairwise Comparison Test Results and Effect Size for the Effect of the TL Methods on Higher-Order Thinking Skills

Construct	Pair Comparison	*MD*	*p*	ES	Interpretation
Applying	PBL-CL vs PBL	1.791	< .05	1.084	Big
	PBL-CL vs TR	2.206	< .05	1.481	Big
	PBL vs TR	.389	.416	.328	Small
Analysing	PBL-CL vs PBL	1.518	.062	.918	Big
	PBL-CL vs TR	1.570	< .05	1.193	Big
	PBL vs TR	.052	< .05	.169	Small
Evaluating	PBL-CL vs PBL	1.217	< .05	1.073	Big
	PBL-CL vs TR	1.508	< .05	1.275	Big
	PBL vs TR	.291	< .05	.270	Small
Creating	PBL-CL vs PBL	1.372	< .05	.882	Big
	PBL-CL vs TR	1.556	< .05	1.082	Big
	PBL vs TR	.185	< .05	.212	Small

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V. DISCUSSION

In principle, the PBL-CL, PBL and Conventional learning (Conv) method have an overall positive effect on the four levels of higher-order thinking skills for Form Four students, namely Applying, Analysing, Evaluating, and Creating. The results of the analysis also found that the mean scores of Form Four students who were taught through the PBL-CL method were significantly higher compared to their peers who were taught through the PBL and Conv method in all levels of higher-order thinking skills. Through PBL-CL method, students learn to do activities actively in a collaborative learning environment. To master the level of Applying in the topic of quadratic functions in particular, students need to master algebraic factoring, using the correct formula and the method of perfecting the square in solving non-routine problems [36]. Therefore, through the activities in PBL-CL Module, students write in their sentences about the process of the square completion method and apply in the various forms of graphs given. The activity is optimally implemented to encourage students of the PBL-CL group to think, communicate, and write. As a result, effective learning occurs as each group member helps each other and participate actively to criticize and complement each other in completing the given task [37].

In this research, four activities in the PBL-CL module require students' exploration outside the classroom to strengthen students' understanding of quadratic graphs in real life. Students are asked to take a parabola-shaped picture and enter it into the GSP software to investigate and analyse the characteristics of quadratic graphs learned previously. Indirectly, the use of this GSP medium can be a good link in understanding concepts related to real life in learning Mathematics by the visual learning style [38]. Because of that, analysing skills through exploration and investigation in the formation of mathematical concepts can increase the level of analysing of students [39]. Therefore, the formation of mathematical concepts linked to the students' experience based on the activities that happen around them needs to be given priority in the process of learning and teaching mathematics. In addition, the implications of the seven-step PBL Schmidt process approach applied in the PBL-CL module encourage students in PBL-CL group to explore non-routine problems given in a systematic and planned manner. This can help students identify and analyse the solution to the given problem and be able to confidently answer questions based on the given problem or situation. This is supported by [40] who stated that problem-based learning is a suitable approach to stimulate students' critical thinking in analysing information. As a result, the mean score of Form Four students who were taught through the PBL-CL method was significantly higher than the students who were taught through the PBL and Traditional method in the analysing level of thinking.

The students of the PBL-CL group share ideas in making conclusions and hypotheses through a systematic problem-based learning process. During the problem-solving process, students are more able to justify and share ideas systematically and more easily integrate the thoughts that occur to make evaluations and conclusions [41]. For example, the activity of solving problems in the evaluating level is done inductively such as identifying the shape and characteristics of graphs that are applied in real life. Next, students draw conclusions based on investigative methods by relating specific situations to make an assessment [42]. To achieve this objective, students make and prove conjectures, provide logical explanations, analyse, make judgments, and evaluate and justify the mathematical activities carried out. As a result, this process indirectly increases the thinking level of evaluating. In this research, the activities in the PBL-CL module also encourage productive interaction among Form Four students who have different knowledge backgrounds to improve the thinking level of evaluating. Intelligent and proactive students acting as experts explain solution methods by including clear and accurate mathematical concepts to be shared among group members in making conclusions and evaluations. Through positive interaction and effective communication among group members, students generate ideas and this social process affects their creativity, cognition, and potential [43].

The activity of the PBL-CL module encourages the students of the PBL-CL group to pitch their creative ideas in solving problems in the form of questions through group presentations. During the presentation session, the reciprocal process from the responses of other groups refreshes and further expands their ideas [44]. This causes students to always think about producing the best method to be highlighted among them and further fosters the thinking level of creativity among the students of the PBL-CL group. In addition, the PBL-CL method can provide a learning environment where real experience helps Form Four students to produce logical problem-solving methods because they think abstractly and have a clear understanding of concepts [45]. In the fourth activities of the PBL-CL module, for example, students carry out activities outside the classroom by exploring graph-shaped objects. Next, they investigate the shape of the graph in a creative way using GSP. Student in groups are given the freedom to choose their methods to determine the characteristics of their chosen graph with accurate mathematical justification to be presented in a later presentation. Indirectly, students also learned to produce quadratic graph sketches creatively in their minds and represented through the shape and characteristics in each graph. Furthermore, the mutual interaction of students with their environment and daily routine has a positive effect on developing their higher-level of thinking [46].

Compared to students who learnt via the Conv method, students carry out conventional and teacher-

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centred learning activities where all activities have been planned by the teacher. Tasks are completed individually with the help of GSP, however, no task specialization is given to each student. Students are also exposed to routine problem-solving. As a result, students in this group could not apply the formula well because peer guidance was limited. This is because group interaction in Traditional groups is not emphasized with positive interdependence, individual responsibility, dealing with positive interactions, and social skills in groups [47], as evidenced in the PBL-CL group.

VI. CONCLUSION

The research shows that the PBL-CL method is able to improve the four levels of higher-order thinking skills, namely Applying, Analysing, Evaluating, and Creating better than the PBL and Traditional learning methods. This shows that the integration of PBL and GSP-assisted collaborative learning into the TL process can make teaching more effective with non-routine investigation, exploration and problem-solving activities and presentations conducted in a collaborative learning manner. The PBL-CL method allows students learn to integrate PBL and collaborative learning with the help of GSP which has an impact on students' high-order thinking skills while solving non-routine problems.

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