Effect of Project-Based Learning Towards Collaboration among Students in the Design and Technology Subject

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Abstract

Teaching Design and Technology that focuses only on the end product had led to students less exposure to collaboration skills in their learning. Therefore, a study that determines the teaching method in applying collaboration skills among students and its effect is required. The two teaching methods used were the 'doing a project' method for the control group and project-based learning for the treatment group. A quasi-experimental study was carried out with a nonequivalent control group. Two groups were selected from two different daily schools consisting of 34 students for the control group and 32 students for the treatment group. A pre-test, followed by an intervention for 7 weeks was carried out. After the intervention, a post-test was carried out for both groups. A questionnaire regarding collaboration skills was used in both tests. The data obtained were analyzed descriptively and by inference. The pre-test showed that there was no significant difference in the level of collaboration of both groups. However, the results of the post-test showed that the level of collaboration in the treatment group is significantly higher than in the control group. Thus, the study showed that collaboration can be applied and cultivated among students by using project-based learning. This can be achieved by structured discussion from explicit planning, and student-centered learning activities with teaching and learning aids that support the execution of students' project work.

Keywords: technical and vocational education and training (TVET), learning by doing a project, teaching methods, student-centered learning, quasi- experimental research design

1. Introduction

The Design and Technology (D&T) provides students the opportunity to increase knowledge and understanding of designing and technology as well develop skills through making functional products. Design and Technology subject is widely offered in the national curricula of countries including the United States, England, Canada, China, India, Singapore, Malaysia, France, Finland, Ireland, New Zealand, and South Africa. In Malaysia, the subject offers at level two of primary, lower-middle, and high school education levels, where students are exposed early to skills in design, improvement, and building functional products. Development of the design process is one of the things in technical and vocational for industrial improvement and economic growth. Thus, skills acquired through content knowledge alone are less relevant compared to the combination of content knowledge and 21st century skills that are increasingly needed by the industry (OECD, 2018; WEF, 2018). Design and Technology is one of the literacy subjects in TVET that requires students to generate ideas to produce creative and innovative products as well as to develop students' generic skills (Australian Curriculum, Assessment, and Reporting Authority, 2021; Malaysian Curriculum Development Division, 2016; Department of Education UK, 2013). D&T is geared toward the production of products starting from the student's initial idea to product marketing. Students are also exposed to the need to seek information, relate their understanding to activities of daily living, and stimulate the generation of ideas for product design and problem-solving through collaboration.

1.1 Doing A Project or Project-Based Learning

In Malaysia, many of D&T learning standard emphasize with a project. Larmer et. al., (2015) stated doing a project

refers to designing a project as an add-on to the traditional instruction to meet the requirements of the curriculum teacher. Teachers who carry out the method of doing a project tend to teach by giving detailed content of the lesson. As a result, students can answer questions based on what has been taught by memorizing the content. Unfortunately, the process of doing a project does not have a significant impact on other generic skills in meaningful ways because they are based only on the understanding and knowledge learned (Bender, 2012). Students' learning is more focused on specific disciplines outlined in the curriculum without diversifying into various disciplines. Students are also not involved in self-directed learning or student-center learning. This method is often used in Mathematics subjects where continuous drills will help students to become proficient in answering questions (Ellis & Berry, 2005).

Meanwhile, project-based learning (PBL) is a teaching method acquire knowledge and skills by students working over a period of time to investigate and answer questions, problems, or challenges. Students will also produce the final product as an output to the problems identified through meaningful activities throughout the learning process and the teacher as a facilitator in ensuring the learning objectives are achieved. Through PBL, students use products designed and built based on technology and real life as a tool for them to implement a meaningful learning process to acquire knowledge and skills. Meanwhile, the end product describes the extent to which students can apply the knowledge and skills acquired by the application of values in learning.

PBL Gold Standard model focuses on the needs in project development (Larmer et al., 2015). There are three parts in PBL Gold Standard which include 1) student learning goals 2) elements in project design and 3) project-based teaching practices. These three parts are the main pillars that can help teachers, schools, and organizations to measure, calibrate and improve the practices that have been implemented in T&L. The student learning goals of knowledge, understanding, and skills are the core of the PBL Gold Standard for project design and teaching practice. During the implementation of PBL, students are expected to be able to acquire skills needed in project construction such as collaboration skills, problem-solving, critical thinking, and self-management.

There are seven important elements in designing a project namely challenging problem or question. sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and public product. Furthermore, there are seven practices suggested for teachers in implementing PBL consists of design and plan, align to standards, build the culture, manage activities, scaffold student learning, assess student learning, and engage and coach.

1.2 Collaborative Skills in Student Learning

A good social environment can help create interaction in student learning. Dewey (1910) and Vygotsky (1978) have shared similar ideas regarding the importance of the social environment in the development of learning and its relationship to the daily activities performed by students. Thus, collaborative activities in learning provide opportunities for students to interact in acquiring knowledge and skills together. Collaboration requires the involvement of two or more individuals who interact dynamically, are interdependent, and are adaptive working to achieve shared goals (Saari & Rashid, 2013). Collaboration can be implemented with a willingness to compromise with a sense of responsibility in achieving common goals (WEF, 2015).

The success of collaborative activities requires individuals to master collaborative skills which are supported by several psychometric factors that have been identified in various studies. Scholars who define and develop collaboration models such as Johnson and Johnson (2017) provide almost identical general concepts among each other in terms of achieving common goals, task-related process skills, collaborative behaviors, conflict resolution as well as guidance and support among members of the group. In general, collaboration involves communication, openness in listening, giving, receiving, and sharing opinions or information, making negotiations, processing information, coordinating activities together, and helping each other to achieve common goals.

According to Johnson and Johnson (2017), there are five elements in collaboration skills which are 1) positive interdependence among group members, 2) individual and group accountability, 3) promotive interaction within the group, 4) social skills within the group, and 5) group processing. In the implementation of collaborative activities, members engage directly with all members in the group socially and cognitively to acquire knowledge, understanding, problem-solving, and decision making. Through the process, members will share benefits over their interdependence with each other.

Collaborative learning is based on social dependence theory (Johnson & Johnson, 2005). The social system in the group is seen as the interdependence between the members in the group interacting so that the changes that occur in the members will be able to change the other members to achieve the same goal. Positive dependence is a positive behavior with the belief by each member to give and obtain shared benefits in achieving goals within the group through the understanding of members in the group. Thus, positive dependence provides an experience to work

together towards gaining understanding and benefits to achieve common goals without the existence of competition and effort from only one party.

To maintain the element of positive interdependence among members in a group, each member needs to have a sense of responsibility towards the group. According to Johnson and Johnson (2017), group accountability borne by members have a positive relationship with motivation as they can generate quality discussions and outcomes. Thus, accountability can prevent the occurrence of social problems in the group such as social loafing, free riders, and conflict in the group because each member feels the need for them to strive to achieve shared goals. In addition, research on student accountability in groups can help the students to achieve competence in communication (Astuti & Lammers, 2017). Although a study by Dingel et al. (2013) found that free riders did not affect the academic achievement of group members, however, their presence can cause group members to feel uncomfortable and would interfere with the quality and outcome of collaboration. This is also stated by Johnson and Johnson (2017) which is associated with the factor of the total number of members in the group that is the more members in the group then the tendency for each member to have a sense of responsibility towards the group is less than if in a small group.

Collaboration requires students to have social skills to carry out activities in groups. Past studies have shown that there is a positive relationship between social skills factors on the effectiveness of group work to obtain learning and achieve shared goals (Dingel et al., 2013). Therefore, social skills in students are needed to implement collaboration so that team members can carry out their functions effectively and avoid conflicts between members in the group that lead to withdrawal due to misunderstanding and mistrust of group members.

Despite this, previous studies have found that there are still several students in groups who do not understand each other and refuse to engage in collaborative activities (Leng, 2018) and socialize during group activities (Pang et al., 2018). Thus, according to Johnson and Johnson (2017), promotive interaction elements in collaborative activities should be emphasized through continuous discussion, providing encouragement and support to members, appreciating the efforts given by members, and willingness to exchange ideas, opinions, and information. Thus, promotive interactions within the group will not only be able to benefit cognitive understanding and problem-solving but also have a social impact on group members by providing commitment and support to enhance and maintain positive relationships within the group.

In performing tasks by exploring knowledge and experience collaboratively, individuals will be faced with challenges that require them to go through the process of problem-solving, decision making and ultimately achieving goals together in a group. Therefore, individuals need to be able to identify the challenges and problems faced and respond to resolve them accordingly. According to Johnson and Johnson (2017), the process of conducting collaborative activities requires members to perform reflection, monitoring, evaluation, and decision making in determining what needs to be implemented in the group. The inefficiency of the group in taking and discussing the opinions of each member leads to unsuccessful collaboration (Le et al., 2018).

Monitoring and obtaining feedback from each member also help in the process of collaborative activities. This can be done by reviewing and evaluating the results of the group work based on the planning that has been agreed upon in the group. Thus, according to studies from Lam (2019) and Tibi (2015), collaboration skills can be improved through structured assignments and discussions to ensure all members achieve their goals. The results of this study support Johnson & Johnson (2005) where an increase in efficiency in problem-solving and decision making, motivation towards tasks, and a reduction in social loafing can be obtained through planned processing in collaborative activities. Structured assignments and discussions in learning can also help teachers to monitor, review and evaluate students' work. Therefore, teachers need to have an understanding of planning and implementing appropriate teaching methods to optimize student outcomes in acquiring the necessary knowledge and skills. Thus, a study was conducted to determine the students' collaboration skills in designing products using the PBL method for D&T subjects.

2. Method

The research design for this study is quasi-experimental. This design allows the researcher to conduct studies to identify cause and effect inferences for which pure experimental design cannot be carried out (Shadish, Cook & Campbell, 2002) and had been done widely in determining the effectiveness of teaching methods, modules, or programs in a variety of real situations.

2.1 Participants

The researcher selected two groups in the study which were categorized as the control group and the treatment group. The control group did not receive any treatment and would act as a benchmark to make comparisons of the variables

while the treatment group would receive treatment during the intervention period. A pre-post-test procedure was performed on two selected study groups to see the cause and effect obtained from the interventions conducted. This is based on quasi-experimental design criteria which require two or more randomly selected groups with the aim of testing hypotheses against a given treatment (Creswell & Creswell, 2018).

The intervention period was conducted simultaneously for both groups for seven weeks. During this intervention period, teachers in the treatment group used a daily lesson plan as well as materials provided by the researcher according to the guidelines regarding the PBL method by Larmer et.al., (2015). However, for the control group, the teacher will use the daily lesson plan prepared by himself without guidance on PBL by the researcher.

The study was conducted in two daily schools which offer D&T subjects. Researchers have selected schools in the same zone to ensure the dissemination of information related to D&T subjects given to teachers is consistent to avoid discrepancies in information related to the implementation of teaching D&T. Both schools were selected based on equivalence in terms of the number of students in the class, the number of T&L hours by week and the performance of academic achievement for three consecutive years. There are four classes in both schools that offer the subject, and the selection of classes is based on the criteria of teachers who teach D&T subjects.

Researchers used purposive sampling in the selection of control groups and treatment groups. According to Shadish et. al., (2002), purposive sampling in quasi-experiments is practical to use in describing the effects of treatment in studies on selected groups. However, generalizations of the results from the study focused only on the groups that had been identified.

This study is using a questionnaire for respondents. Part A refers to collaboration skills in conducting learning activities while part B is a demographic that consists of background information of respondents. Demographic items were placed at the end of the instrument to avoid influencing respondents 'answers regarding collaboration skills. The instrument was used in pre-test and post-tests which were distributed in the same week for the control and treatment groups. The content of the instrument used was adopted and adapted from the Collaboration Skill Questionnaire by Tibi (2015) based on the definition of effective collaboration in groups by Johnson and Johnson (2005). There are 25 items represented by six Likert scales in this instrument which include five components required in collaboration skills which are 1) positive interdependence among group members, 2) individual and group accountability, 3) promotive interaction within the group, 4) social skills within the group, and 5) group processing.

In the previous study, the Collaboration Questionnaire obtained a Cronbach's alpha value of 0.88 for all elements. All items in the instrument had content validation by the original researcher. However, the researcher then validated the content in terms of language translation and the suitability of the items according to the context of the study and the selected group of respondents. The researcher made modifications to the instrument in terms of terminology and sentence structure to be suitable for use in D&T subjects. This is necessary to ensure that the items provided accurately measure the variables studied and facilitate the respondents to understand and answer the questionnaire. Three experts in the Technical and Vocational Education and Basic Education field identified and evaluated the instruments that had been translated and modified. Modifications by the researcher in terms of sentence structure, terminology as well as the number of items in the instrument were done again after reviewing by experts. Findings for Cronbach's alpha values were in the range of .715 and .787 for each item in the questionnaire. Therefore, this instrument is considered to have acceptable reliability for use in the study.

2.2 Interventions

This study uses the PBL teaching method for the treatment group and the doing a project teaching method for the control group. For the control group, the teacher conducted each T&L session according to his daily lesson plan by explaining the content of the lesson with the help of PowerPoint slides and textbooks. The teacher also uses existing materials such as a set of traffic lights as a teaching aid when explaining the functions of electronic components. In the final two T&L sessions, students implemented the electronic design project in groups using a set of traffic lights by limiting only to changes in programming for the lighting time and color of the LED lights. The teacher uses workbooks as reinforcement exercises for students after the T&L session.

In contrast to the treatment group, the teacher applied collaboration skills through activities and learning materials provided by the researcher. The researcher designed PBL instruction using a daily lesson plan that is crafted in line with the seven key elements in the PBL Gold Standard Model for product design and seven project-based teaching practices. Learning activities, teaching aids, and learning aids are prepared with the aim that students can implement learning activities collaboratively. The process of review, evaluation, and validation by experts in the Technical and

Vocational Education field was carried out on the daily lesson plans, teaching aids, and learning aids before the intervention began. Corrections and improvements were made several times until approved by the appointed panel of evaluators.

The intervention program began by performing pre-tests for both groups in the first week. This test was implemented to obtain the level of collaboration skills of students before treatment was given to the treatment group. Students were distributed with pre-test papers by the teachers. The teacher informed the students to answer honestly, no discussion of answers is allowed and whatever results are obtained in the pre-test will not affect their performance marks in the examination. All answers were answered in the test papers given. The teacher recollects all the test papers upon completion of the given time. No test papers are allowed to be taken away to avoid threats to the validity of the data in the future. All test papers were submitted to the researcher for data analysis.

The entire T&L conducted throughout the intervention for both groups was subjected to the learning standard in the Standard Document for Curriculum and Assessment for the topic of Electronic Design. For the control group, the teacher implemented the project after teaching the whole content of the lesson on the topic. Meanwhile, the teacher in the treatment group implemented the teaching by making the project a tool for the development of student learning. T&L session is conducted for 60 minutes per session according to the time allocation in the schedule set by the school. There were 14 T&L sessions throughout the intervention period.

The treatment group performed collaborative activities according to the steps in designing the project, which are 1) project launch for the first and second T&L session; 2) project support and management in the third to 11th T&L session, and 3) evaluation and display student work in the 12th and 14th T&L session. Students are required to conduct discussions, practical work, and product testing in the group through working together and groups' agreement in achieving learning objectives. During the T&L activities, students were given guidance by the teacher in carrying out collaborative activities with the guidelines stated in the project journal and activity sheet. Despite this, students are given the freedom to express creativity and explore knowledge in producing projects in groups. At the end of the T&L session, students fill in the learning reflection chart and state their findings. Students also need to fill in the feedback regarding collaboration activities at each session for teacher monitoring. At the same time, the teacher distributes group worksheets in which students have to complete exercises given in groups after the T&L session.

At the end of the intervention program, post-tests were conducted to assess the level of collaboration skills of the students after the completion of learning the topic. This test is intended to compare the findings with pre-tests that have been conducted previously. The teacher recollects all the test papers upon completion of the given time period to answer. All test papers were submitted to the researcher for data analysis.

3. Results

Overall, collaboration skills for the control group were at a moderate level for both tests, pre-test (M = 4.33, SP = .42) and post-test (M = 4.32, SP = .38). Findings showed that there was a decrease of 0.05 and 0.06 for the mean score value of the positive dependence element between group members and processing of collaborative activities in the group except for the social skills element in the group increased by 0.73 and promotive interaction in the group increased by 0.61 (Table 1). The individual accountability element in the group did not show any changes.

However, different findings were obtained in the treatment group where there was an increase of 0.75 in the overall mean score value between pre-test (M = 4.31, SP = .42) and post-test (M = 5.06, SP = .40). The level of collaboration skills for the treatment group was found to increase from a moderate level on the pre-test to a high level on the post-test. The five elements in collaboration skills show an increase in mean score values that were in the range of 0.61-0.87 between the two tests (Table 1).

The overall data for collaboration skills are normally distributed. Independent t-test analysis for the pre-test showed no significant difference (p > .05) where t (64) = .231, p = .818) was obtained between the mean score values for the control group (M = 4.33, SP = .42) and treatment group (M = 4.32, SP = .38) (Table 2). This shows that in general, the level of collaboration skills for respondents for both groups before the intervention program was implemented was equivalent.

Table 1. Mean Scores of Collaboration Skill Levels by Component for the Control and Treatment Groups

Components	Control Group				Treatment Group			
	Pre-test		Post-test		Pre-test		Post-test	
	Min	SP	Min	SP	Min	SP	Min	SP
Positive interdependence among group members	4.21	.68	4.16	.59	4.26	.61	5.10	.61
Individual accountability within the group	4.32	.61	4.32	.47	4.19	.52	5.06	.51
Promotive interaction within the group	4.41	.62	4.45	.54	4.28	.63	4.89	.60
Social skills within the group	4.44	.52	4.45	.44	4.44	.60	5.17	.52
Group processing	4.29	.66	4.23	.62	4.37	.52	5.09	.51

Meanwhile, independent t-test analysis for post-test found a significant difference (p <.05) where t (62) = 7.622, p = .001 between the mean score values for the control group (M = 4.31, SP = .42) and treatment group (M = 5.06, SP = .40) (Table 2). These findings indicate that the intervention program conducted on the treatment group affected the level of collaboration skills of the respondents compared to the control group who used the method of 'doing a project'.

Table 2. Differences in the Level of Collaboration Skills in Pre-Test and Post-Test between the Control Group and the Treatment Group

Test	Group	M	SP	t	df	p
Pre	Control	4.33	.42	.231	64	.818
	Treatment	4.32	.38			
Post	Control	4.31	.42	7.622	62	.001
	Treatment	5.06	.40			

Table 3 is a paired sample t-test analysis conducted on the data for the pre-test and post-test for the control group. The results of the analysis found no significant difference (p> .05) where t (32) = .184, p = .855 between pre-test (M = 4.33, SP = .42) and post-test (M = 4.32, SP = .38) for the control group (Table 3). These findings indicate that the learning method used in the control group did not significantly change the level of collaboration skills of the respondents.

Findings from the analysis of differences in the level of collaboration skills in pre-test and post-test for the treatment group showed that there was a significant difference (p <.05) where the value of t (31) = 7.555, p = .001 between pre-test (M = 4.31, SP = .42) and post-test (M = 5.06, SP = .40) (Table 3). These findings indicate that the learning methods conducted in the intervention program by the treatment group had a significant effect on the level of collaboration skills of the respondents compared to the learning methods conducted previously.

Table 3. Differences in the Level of Collaboration Skills in Pre-Test and Post-Test for the Control Group and Treatment Group

Group	Test	M	SP	t	df	p
Control				.184	32	.855
	Pre	4.33	.42			
	Post	4.32	.38			
Treatment				7.555	31	.001
	Pre	4.31	.42			
	Post	5.06	.40			

4. Discussion

In this study, collaboration skills refer to the behavior of students to work together in a group and function well throughout the activities carried out to achieve shared goals and can function well throughout the learning activities.

The findings of the study showed that the level of collaboration skills for the group of students who conducted PBL was at a moderate level before the intervention and increased to a high level after the intervention was conducted. The increase in the level of collaboration skills in the group of students who practice the PBL method is influenced by all elements of collaboration skills namely 1) positive interdependence among group members, 2) individual and group accountability, 3) promotive interaction within the group, 4) social skills within the group, and 5) group processing.

At the beginning of the intervention, the overall mean score for the level of collaboration skills between two groups of students did not have a significant difference. These findings indicate that both groups of students have equivalent levels of collaboration skills in implementing project design in the previous. Before the intervention was implemented, teachers for both groups of students conducted T&L based on the Standard Document for Curriculum and Assessment and made the end product from the project as a basis for assessment in the classroom. Among the five elements in collaboration skills, it was found that positive interdependence between group members, social skills in the group, and processing of collaborative activities in the group obtained the closest mean scores for both groups. These findings indicate that the learning processes and methods, the discussion approach used in the project design as well as the students 'social skills are equivalent for both groups.

However, when the intervention was implemented, the implementation of the project for the two groups of students was differentiated by the way the project process was done, either through the PBL method based on learning through experience or remaining on the existing method of doing a project. The findings of the study showed that there were significant differences between the group of students who carried out the PBL method and the group of students who carried out the 'doing a project' method. These findings show that the teaching method implemented on the group of students who run the PBL method has a positive effect on the level of collaboration skills of students compared to the group of students who run the 'doing a project' method. The differences between these two methods can be seen in the purpose for which the project is made and how the project implementation process is done.

In this study, the elements of positive dependence between group members, processing of collaborative activities in the group, and individual accountability in the group showed the highest differences in the group of students conducting PBL compared to other elements for both groups after the intervention was conducted. Based on the theory of social dependence (Johnson & Johnson, 2017), interdependence among group members will be able to change individuals and other members towards something in achieving the same goal. This is because relationships between peers can influence student learning (Cockerill et al., 2018). This was found to occur in groups of students who run the PBL method where group members gain an understanding to determine project goals and show efforts to achieve them together without the existence of competition and efforts from a few members only. Elements of student choice and voice, making reviews, and inquiry in PBL also help in building students 'trust and dependence on other members of the group for information and ideas to be shared. Group members solve problems and make decisions together. Rashid et. al. (2009) stated students need to be teaching how to develop self-reliance and focus on work activities that are important to them. Therefore, teachers need to find the way to show direction for students to learn which workplace options can provide fulfillment and satisfaction so student can seek ways to qualify for opportunities. This is because students are given the right to express their opinions and ideas supported by the necessary information.

Nonetheless, previous studies have noted that there is a tendency for students to depend solely on other members which will pose problems such as free riders or passive members (Dingel et al., 2013; Pang et al., 2018). This situation may arise due to students not being prepared, not understanding the purpose of the discussion activity being conducted, or negative attitude factors. Students are also not able to be fully involved because they may not be aware of the need for them to share information in carrying out project work. This also happened during the intervention carried out in the PBL group where there were still students who stated in their learning reflections that there were friends who did not give cooperation, ideas, or opinions in implementing the project. Accordingly, at the beginning of the intervention, the teacher who conducts the PBL method needs to explain to the students about the role and responsibilities of each member of his group and its impact on their project outcomes. This initial explanation is important to ensure that students understand the importance of engaging in groups. Teachers are supposed to be facilitators during the lesson (Larmer et. al., 2015). According to Saari and Rashid (2013), creativity flourish among trainee who attached with the multinational companies of the National Dual Training System program since the companies equipped with proper classroom, have a train coaches, systematic curriculum for their trainees. Through a structured discussion and pleasant environment, each member of the group is asked to voice ideas, opinions, and information on the problems or questions raised. This also helps to avoid problems during the implementation of project work such as the existence of free riders, social loafing, passive members, or conflicts that can be reduced or

eliminated. Therefore, learning activities need to be well planned by teachers taking into account the need for each student to be involved and implement them in the allocated time.

Monitoring and review of group work should also be done by group members and teachers regularly. This is to avoid obstacles in conducting collaboration caused by the inefficiency of members in carrying out collaboration activities (Le et. Al, 2018). Teachers need to plan and implement activities and use learning aids that can be a guide for students to implement discussions and group work. In this study, ideas, opinions, and information obtained from each group member are recorded and discussed together in making choices, solving problems, or making decisions. In addition, group members also determine the rubric to be used in evaluating the work. This makes students more motivated to ensure that the end product reaches the level that has been determined in the early stages of the project and to promote a sense of ownership among members of the group. Thus, group members will be aware of engaging in the group activities. According to Johnson and Johnson (2017), group members who are aware of their responsibilities have a positive relationship to motivation in generating quality discussions and outcomes. Ebenehi et al. (2016) suggested friends have a duty to ensure that their colleagues are groomed with intellectual, social, skills, through daily interctive engagements among them.

Both teaching methods show an increase in the mean score of the promotive interaction element in the group after the intervention was implemented. These findings indicate that both teaching methods have a positive effect on promoting interaction between group members. As both groups did project activities in groups, therefore both groups were found to carry out project-related discussions. However, through the PBL method, structured discussion activities are planned and implemented with the guidance of teachers through manuals or clear guidelines such as project journals to implement discussion activities. This is also stated in a study by Lam (2019), Mendo-Lazaro (2018), and Tibi (2015) who found that structured discussion can help students to interact positively in an orderly and effective manner regarding assignments, expressions of ideas, and opinions to obtain an agreement in groups. A conducive environment for the discussion process is created during the discussion such as by taking turns in interacting, encouraging members to voice opinions and ask questions as well as taking notes, and appreciating members for their contributions. Thus, students who carry out collaborative activities should be given ample time in carrying out activities to share information, ideas, and opinions to explore and solve problems with project assignments.

5. Conclusion

Overall, this study shows that the PBL method for D&T subjects has an impact on students' collaboration skills. These findings support Vygotsky's (1978) theory of social development in which student learning can be enhanced through continuous interaction under the guidance of teachers and peers. In this study, PBL is done through group activities with an emphasis on structured discussion to gain the necessary knowledge, experience, and skills.

Structured discussions can guide students toward effective interaction and ensure that group members are focused as well as able to achieve shared goals (Lam, 2019; Mendo-Lazaro, 2018; and Tibi, 2015). For creating meaningful discussion, a teacher can make use of braintstorm or small group technique such as with help of advanced questions worksheet to each student. Prior to the discussion session, each student should be prepared to participate actively during the session. Teachers play a role in explaining the direction setting and project design process at the beginning of the PBL is carried out (Larmer et. al., 2015). This can help students with their responsibility to contribute to their groups. Rashid et al., (2009) and Mansor and Rashid (2013) suggested that students need to be taught how to develop self-reliance and focus on work activities that are important to them so can provide fulfillment and satisfaction in the future. Throughout the project implementation process in PBL, students identify their involvement in the group as well as build trust and dependence on group members to jointly perform tasks in the group. The learning activities and learning aids used need to have guidelines for conducting discussion sessions. Therefore, further study to formulate guideline for creating meaningful leaning activities and experiences should be conduct. Also, a study to complement discussion sessions that currently utilized such as brainstorm or small group technique. Furthermore, an in-depth study of the teachers is expected to discover problems that may arise in applying collaboration skills among students in identifying the effectiveness of the PBL method on collaboration skills for D&T subjects.

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