10th Grade Students' Participation in a Mathematics Problem-Based Learning Classroom

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In this study, we investigated 10th grade students' (n = 46) participation in a mathematics problem-based learning classroom. The data were collected from 10 PBL lesson plans, students' participation observation forms, teacher's notes, students' reflections, students' participation self-surveys, and students' interview forms. The students' participation was described in six dimensions that were adapted from Abuid (2014). We found that the students performed in positive dimensions of students' participation at a very high level and students expressed in a negative dimension of students' participation at low level.

Introduction

Students' participation is considered to be a significant factor in learning (Sadker & Sadker, 1994). Much research has shown strong evidence for the importance of students' participation in classrooms (Petress, 2006). Participation can actively bring students into the learning process (Cohen, 1991). Liu, Yao, and Yao (2005) found that students who participate actively in their classrooms tend to have better academic achievement. In addition, there are various activities to support students' participation, such as questioning, discussion and explanation, that help the students to gain in-depth knowledge and understanding (Boyle & Nicol, 2003).

Many researchers provide different points of view of the definitions of students' participation. Vonderwell and Zachariah (2005) defined participation as a method where students engage and are active in learning. The definition from Selun and John (2008) showed that students' participation is a behaviour of students who act as active participants in their own learning. Therefore, this study defined students' participation as an expression of student behaviours in classroom that creates a learning experience.

In collecting evidence of students' participation, many researchers have proposed several dimensions of students' participation. Interestingly, Abuid (2014) identified eight dimensions of participation that can be flexibly applied in any classroom i.e., answering questions addressed to the class, answering questions addressed to the individual, volunteered participations, group discussion, e-learning forum, attendance and disruptive participation. In this study, the six students' participation dimensions including (1) answering questions addressed to the class, (2) answering questions addressed to the individual, (3) long in-class written answers, (4) volunteered participation, (5) group discussion, and (6) disruptive responses were adapted from Abuid (2014). In fact, Abuid's work (2014) has another two dimensions, including e-learning forum and attendance dimensions. However, in this study, the dimensions of students' participation in e-learning forum and through attendance were excluded in order to suit the context of the target classroom.

In the 21st century, learning approaches emphasize student-centred activities. This pedagogical approach for mathematics education shifts the educational paradigm away from traditional approaches (Schmude, Serow, & Tobias, 2011). The student-centred model moved attention from whole-class instruction to small-group work and individual inquiry, which brings about active learning and extends students' participation, motivation

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and achievement (Cannon & Newble, 2000). The study of McManus (2001) showed that passive learners did not receive the content of knowledge along with understanding. On the other hand, students who were expected to participate in active classrooms constructed and applied their new knowledge with understanding. Othman, Salleh, and Sulaiman (2013) recommended problem-based learning (PBL) as one of the most powerful student-centred approaches in the 21st century.

PBL is an instructional process where problems are used in the beginning of the instruction to introduce and provide the topics of learning (Chagas, Mourato, & Sousa, 2007). Students work in groups to solve a problem; the learning is enhanced by solving an ill-structured real-world situation. Then, students learn to assume a role as owner of the situation (Torp & Sage, 2002). Barrow (1996) identified the processes in a PBL classroom where learning occurred in small student groups while students learn together. Moreover, PBL motivates students to curtail disruptive behaviour and engages students to participate in learning (Achilles & Hoover, 1996). Therefore, the aim of this study was to investigate students' participation in a mathematics classroom using problem-based learning. The PBL can be defined by five steps of learning that are adapted from Othman, Salleh, and Sulaiman's study (2013): (1) introduction to the problem, (2) self-directed learning, (3) group meeting, (4) presentation and discussion, and (5) exercises.

Method

The study adopted a mixed research methodology using both quantitative and qualitative data collection. In order to validate and crosscheck the findings, we used different data sources (Patton, 1990). The research instruments included ten PBL lesson plans, students' participation observation forms, teacher's notes, and students' reflections, participation self-surveys, and interview forms. The participants were 46 tenth grade students from a high school in Chiang Mai Province, Thailand. The data were collected for four weeks from mid-December 2016 to mid-January 2017.

One of the researchers taught the students using the PBL lesson plans for 100 minutes per lesson. Additionally, in each lesson, the mentoring teacher used the students' participation observation form to collect the students' participation data. The teacher's notes, students' reflections and video tape recordings (to provide backup data) were used to reflect on teaching and students' participation. At the end of each week, students' participation self-surveys were used to evaluate the students' participation in all dimensions. At the end of the four-week PBL lesson plans, the teacher interviewed six students selected according to their mathematics abilities (two high, two average, and two low) in order to provide in-depth information.

In the data analysis, quantitative data that was collected from students' participation observation forms, students' reflections and students' participation self-surveys were analysed by using descriptive statistics including percentage, mean, and standard deviation. In addition, qualitative data that was collected from teacher's note, students' reflections and students' interview form were analysed by means of descriptive analysis.

Results

After using two PBL lesson plans with 46 tenth grade students, the results are reported in two parts. Part 1 describes data collected in the PBL classroom and Part 2 describes data collected from students' participation self-survey and students' interview.

Part 1 Description of Data Collected in the PBL Classroom

Step 1: Introduction to the problem. In this step, the teacher introduced real-world problems to the class. Data collected from teacher's notes and students' reflections showed that most of the students (80%) were interested in the topic that was introduced. Many students (70%) participated in answering questions. A few students (30%) shared their own ideas that were involved with the problem situation. Photographs of the students' participation in this step are shown in Figure 1.

Figure 1. Students' participation in the first step of PBL classroom: Introduction to the problem.

Interestingly, in the first step of the PBL lesson, students showed four out of six dimensions of students' participation (i.e., answering questions addressed to the class, answering questions addressed to the individual, volunteered participation, and disruptive responses). The researchers found that participation along the first two dimensions occurred very often. Meanwhile, the dimension of volunteered participation was at a high level, while the dimension of disruptive responses was at low level as seen in Table 1.

Table 1
The Occurrences of Students' Participation in the First Step of PBL From Students' Participation Observation Forms

Dimension	Mean	SD	Level
Answering questions addressed to the class	3.80	0.42	Very high
Answering questions addressed to the individual	3.60	0.52	Very high
Volunteered participation	2.90	0.88	High
Disruptive responses	1.80	0.63	Low

Step 2: Self-directed learning. In this step, students began to solve a problem by themselves. They attempted to do their individual work. Data collected from teacher's notes and students' reflections showed that most of the students (90%) attempted to write down their own ideas and tried to solve the problem. When the students were uncertain, they usually asked for help from the teacher or their peers. Photographs of the students' participation in this step are shown in Figure 2.

Figure 2. Students' participation in the second step of PBL classroom: Self-directed learning.

The second step of PBL lesson, the students were involved with two dimensions of participation (i.e., long in-class written answers and disruptive responses). We found that the first dimension was at a very high level and the other one was at low level as seen in Table 2.

Table 2
The Occurrences of Students' Participation in the Second Step of PBL From Students' Participation Observation Forms

Dimension	Mean	SD	Level
Long in-class written answers	3.80	0.42	Very high
Disruptive responses	2.10	0.74	Low

Step 3: Group meeting. In this step, students were divided into eight small groups of five to six students to participate in group meetings. The students worked together with their peers to find the solution as a group. Then, the students wrote down the ideas on worksheets and prepared for the presentation. Data collected from teacher's notes and students' reflections showed that many students (70%) were interested in sharing their own ideas. Furthermore, some students (60%) often wrote down new ideas to solve the problem before sharing again. The students asked for help from the teacher after they had discussed the problem in their group. In addition, the teacher asked some questions of particular students to help them and check their understanding. Many students (80%) participated in answering the questions. Photographs of the students' participation in this step are shown in Figure 3.

Figure 3. Students' participation in the third step of PBL classroom: Group meeting.

In the third step of the PBL lesson, the students were involved with five dimensions of participation (i.e., answering questions addressed to the individual, long in-class written answers, volunteered participation, group discussion, and disruptive responses). We found that the first four dimensions were at a very high level and the disruptive responses was at low level as seen in Table 3.

Table 3
The Occurrences of Students' Participation in the Third Step of PBL From Students' Participation Observation Forms

Dimension	Mean	SD	Level
Answering questions addressed to the individual	3.70	0.48	Very high
Long in-class written answers	3.80	0.42	Very high
Volunteered participation	3.30	0.67	Very high
Group discussion	3.60	0.52	Very high
Disruptive responses	2.10	0.74	Low

Step 4: Presentation and discussion. In this step, the teacher asked for volunteers to present their group work. Then, a whole class discussion brought the students to the conclusion of the topic being studied. Many students (80%) paid attention to the presentations of their peers. A few students (30%) wrote down ideas from the presenting groups. After that, the teacher asked some questions to clarify each idea. Many students (70%) answered the questions that were addressed to the class. In addition, many students (70%) who were called upon by the teacher always answered the questions. Some students (60%) volunteered to ask other groups and give some counterexamples. Photographs of the students' participation in this step are shown in Figure 4.

Figure 4. Students' participation in the fourth step of PBL classroom: Presentation and Discussion

Obviously, in the fourth step of PBL classroom, the students were involved with all six dimensions of participation i.e., answering questions addressed to the class, answering questions addressed to the individual, long in-class written answers, volunteered participation, group discussion, and disruptive responses. We found that four out of six dimensions (answering questions addressed to the class, answering questions addressed to the individual, volunteered participation, and group discussion) were at a very high level whereas another two dimensions (long in-class written answers and disruptive responses) were at a high level as seen in Table 4.

Table 4
The Occurrences of Students' Participation in the Fourth Step of PBL From Students' Participation Observation Forms

Dimension	Mean	SD	Level
Answering questions addressed to the class	3.50	0.53	Very high
Answering questions addressed to the individual	3.60	0.52	Very high
Long in-class written answers	3.00	0.82	High
Volunteered participation	3.50	0.71	Very high
Group discussion	3.30	0.67	Very high
Disruptive responses	2.60	0.52	High

Step 5: Exercises. In this step, the teacher promoted students' learning by allowing them to do exercises. Data collected from teacher's notes and students' reflections showed that many students (80%) attended to do the exercises. When the students didn't understand, they asked for help from their peers. Photographs of the students working during the exercise step are shown in Figure 5.

Figure 5. Students' participation in the fifth step of PBL classroom: Exercises

In the fifth step of the PBL approach, the students demonstrated two dimensions of students' participation (i.e., long in-class written answers and disruptive responses). The researcher found that the first dimension was at a very high level and the other one was at low level as seen in Table 5.

Table 5
The Occurrences of Students' Participation in the Fifth Step of PBL From Students' Participation Observation Forms

Dimensions	Mean	SD	Level
Long in-class written answers	3.60	0.52	Very high
Disruptive responses	1.80	0.92	Low

Part 2: Description of Data Collected from Students' Participation Self-Survey and Interview

The data were described by using means and the standard deviations of students' participation self-surveys based on six dimensions of students' participation adapted from Abuid (2014). The students usually participated in the dimensions of long in-class written answers, often participated in answering questions addressed to the class and group discussion dimensions, sometimes participated in the dimensions of answering questions addressed to the individual and volunteered participation, and seldom showed disruptive responses dimension in the PBL classroom as seen in Table 6.

Table 6
Means and Standard Deviations from Students' Participation Self-Surveys (n = 46)

Dimension	Mean	SD
1. Answering questions addressed to the class	3.50	0.81
2. Answering questions addressed to the individual	2.89	0.90
3. Long in-class written answers	4.67	0.60
4. Volunteered participation	2.91	0.99
5. Group discussion	3.54	1.13
6. Disruptive responses	1.86	0.53

From the interview data of six selected students with mixed mathematics ability (two high, two average, and two low), the researchers found that student's participation in five out of six dimensions (answering questions addressed to the class, answering questions addressed to the individual, long in-class written answers, volunteered participation and group discussion) were usually at a high level. Students at an average level usually

participated in three out of six dimensions (answering questions addressed to the class, long in-class written answers and group discussion). Students at a low level usually participated in three out of six dimensions (long in-class written answers, volunteered participation and group discussion), as seen in Table 7.

Table 7
Comparing Characteristics of Behavioural Participation from Students' Interviews

Level of students' achievement	Students' expression
High	Students usually answered whole class questions. They usually answered particular questions that were addressed to the individual. They usually answered questions and expressed their opinions by writing and drawing. They usually volunteered as the first speaker in group discussion to share their opinion and give examples. They usually concluded with various ways to solve a problem in group discussion. After presentations, the students occasionally gave a counterexample to the group. In addition, they sometimes expressed disruptive responses such as playing on mobile phones when they already finished their individual work.
Average	Students usually tried to answer when teacher addressed questions to the class. They sometimes participated in answering particular questions that were addressed to the individual. They usually tried to solve problem by themselves. Before starting discussion in a group, they wrote down their opinion. In addition, they did exercises by themselves. They sometimes volunteered to help their peers in the group meeting. They usually expressed their comprehension by discussing in a group and shared their own opinion with peers in the presentation and discussion step. Finally, they seldom expressed disruptive responses, such as falling sleep and playing mobile phones when their peers were giving a presentation.
Low	Students sometimes answered whole class questions. They seldom answered particular questions that were addressed to the individual. They usually participated in writing down their own answers. The students can answer easy exercise questions. They usually volunteered to prepare presentation tools. They seldom discussed in their groups. In addition, they usually disrupted peer learning while the teacher was giving a problem. The students talked about unrelated topics and used mobile phones when their peers were giving a presentation.

Discussion and Conclusion

This research investigated students' participation in a mathematics problem-based learning classroom. From the results in the classroom, students' participation was described in six dimensions (Abuid, 2014): (1) answering questions addressed to the class, (2) answering questions addressed to the individual, (3) long in-class written answers, (4) volunteered participation, (5) group discussion, and (6) disruptive responses. The overall level of the first five dimensions, which are positive behaviour, were at a very high level

and the other one, which is negative behaviour, was at a low level. These findings aligned with the results of Achilles and Hoover's study (1996) that showed PBL enhanced students' participation and decreased disruptive behaviour in classroom.

The results from students' participation self-survey showed that all students usually participated in the dimensions of long in-class written answers. According to the results from interviews, students at all levels of mathematics ability usually participated in the dimensions of long in-class written answers. In addition, students at average and low levels sometimes participated in the dimensions of answering questions addressed to the individual, and students at high and low levels seldom participated in the dimensions of disruptive responses. The results revealed that all positive dimensions of students' participation in all steps of the PBL process were observable. This may be caused by the processes of PBL classrooms that support students and give them a chance to participate in different kinds of activities such as individual work and group work (Torp & Sage, 2002).

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