# Investigation of 10th Grade Students' Agency and Authority in a Mathematics Problem-Based Learning Classroom

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This study aims to investigate 10th grade students' agency and authority in a mathematics problem-based learning (PBL) classroom. The participants were 40 Grade 10 students. The data were collected during January-February of 2019 from twelve PBL lesson plans, Agency and Authority Observation Forms, Teacher's Notes, Students' Reflections and Students' In-Depth Interview Forms. The Agency and Authority Observation Forms were adapted from Schoenfeld and Floden (2014). The researchers found that all of the students' agency and authority dimensions in all steps of the PBL process were observable. The overall level of each dimension was at a high level.

For two decades, mathematics reform efforts have been focused on increasing collaborative and student-centred environments, in which students have opportunities to share their ideas in a mathematics community, as well as analyse and evaluate the ideas with their peers (National Council of Teachers of Mathematics [NCTM], 2000). Much attention has been given to supporting teachers as they undergo the process of changing their roles, functions, and dispositions within the classroom (Ding, Li, Piccolo, & Kulm, 2007). An increasing number of researchers, both within mathematics education (Empson, 2002; Ernest, 2002; Valero, 2002) and beyond have argued for increased attention to student *agency* and *authority* as a way to promote students' equity, collaborative activities, and learning opportunities.

In an academic context, when considering various aspects of student collaboration, mathematics teachers must also consider the issue of agency and authority in the mathematics learning environment. Gresalfi, Martin, Hand, and Greeno (2008) described an individual's agency as the way in which he or she acts or refrains from action, and the way in which his or her action contributes to the joint action of the group in which he or she is participating. In a mathematics education context, Baldinger and Louie (2014) described that *agency* is an individual's willingness to engage in the discipline, which comes from their perception that she or he can make progress with challenging issues by working on them continually and can have trust in the conclusions that she or he draws.

Engle (2011) noted that learners have intellectual agency when they confidently share what they actually think about the problem in focus. Apart from that, the students should be encouraged to have agency along with authority. In an academic context, Amit and Fried (2005) defined authority as, "a relation that exists when one person (*or group of people*) tends to obey, act on, or accept without question the statements or commands of another person (*or group of people or entity capable of producing statements or commands*)" (p. 147). Schoenfeld (2013) said that the roots of *"authority"* reside in the word "*author*", and the idea is that students create, or author, mathematical ideas and their justifications (thus becoming authorities). At the same time, students are not free to invent without constraint; they make conjectures, but they are multiply accountable – to the discipline, to the teacher, and to the other students.

However, in the past, Thai students in formal education became accustomed to a passive learning environment, which provided fewer opportunities for setting goals, communicating with their teachers and peers, receiving feedback, and adapting their own knowledge during the learning process (Suanpang & Petocz, 2006). These days, many Thai

students are still accustomed to passive learning with less emphasis on being mathematics idea-creators and problem solvers or having discussion skills. Schoenfeld et al. (2014) explained that a teacher's main goal is to support all students, especially those who have not been successful with mathematics in the past, to develop a sense of mathematical agency and authority.

In collecting evidence of agency and authority, many researchers have proposed several dimensions of these two elements. Interestingly, Schoenfeld et al. (2014) offered the five dimensions of a mathematically powerful classroom, one of which is that the students' agency and authority should be promoted. There are four classroom contexts that promote agency and authority and can be flexibly applied in any classrooms, namely, (1) whole class activities: launch, teacher exposition, and whole class discussion, (2) small group work, (3) student presentations, and (4) individual work. Furthermore, Schoenfeld (2013) claimed that the discourse structures provided by the teacher can foster or inhibit agency and authority. In a student-centred environment, there are many activities that students can learn by themselves, such as individual work, small group work, presentations, discussions, and exercises. These activities correspond to the four classroom contexts that promote agency and authority. Thus, a student-centred approach should be considered.

In the 21st century, one of popular student-centred teaching methods is Problem-Based Learning (PBL). PBL is an active learning strategy that stimulates students to learn about a subject through real-world problems and promotes the development of mathematical thinking skills, problem-solving abilities, communication skills, and agency and authority (Hmelo-Silver, 2004; Siriwat & Katwibun, 2017). In addition, Othman, Salleh, and Sulaiman (2013) proposed the following five steps in the PBL processes: (1) an introduction to the problem, (2) self-directed learning, (3) group meeting, (4) presentation and discussion, and (5) exercises. Therefore, students can learn by working individually or in a small group to investigate, communicate, share their ideas, have discussions, and apply their essential skills to solving the problems. Thus, the PBL environment is claimed to support various students' characteristics and skills, including agency and authority.

Nowadays, many Thai mathematics classrooms are still teacher-centred classrooms where the students are restricted with regard to expressing their agency and authority. Moreover, Schoenfeld (2013) suggested that the students should have the opportunity to construct mathematical conjectures, explanations and arguments for the development of agency and authority. In this study, therefore, students' agency and authority were investigated in a mathematics PBL classroom. The PBL learning process was adapted from Othman et al. (2013), which consists of five stages.

## Method

This study adapted a mixed methods research design using both quantitative and qualitative data collection and analysis. Combining qualitative and quantitative methods is important since using a single method could be inadequate in social research, as the realities of life and experience are multidimensional. Using a variety of different data resources provides benefits in validating and crosschecking the results (Patton, 2002). The researchers aimed to investigate students' agency and authority in a mathematics PBL classroom. The participants were a total of 40 Grade 10 students (9 boys and 31 girls) from a high school in Chiang Mai Province, Thailand. The data were collected throughout eight weeks during January-February 2019. The following research instruments were included:

1) Twelve PBL lesson plans, which are on the topic of the fundamental counting principle and probability. One of the researchers taught the PBL lesson plans for eight

weeks in the second semester of academic year 2018, and each lesson took 100 minutes. The second researcher acted as the adviser (Corresponding author).

2) The Agency and Authority Observation Forms adapted from Schoenfeld et al. (2014), comprise a 3-level structured observation. The students' agency and authority were observed by two research assistants and the teacher using the Agency and Authority Observation Forms throughout the twelve PBL classes. In addition, the observers recorded the level and the details of the students' behaviours in the observation forms. Videos were also recorded as supporting data while the teacher and students were doing the classroom activities. If there were any disagreements among the observers, the information from the video was used to resolve the issue. After using the observation forms, the inter-rater reliability (IRR) was examined (Rater Agreement Index: RAI = 0.87 - 0.92). The indicators of agency and authority that were used for the observations are presented in the second part of the results.

3) Teacher's Notes were also recorded after each class by the teacher. The teacher recorded the students' learning behaviours, problems in the classroom, and suggestions for the classroom problems.

4) Students' Reflections: After each class, the students were assigned to write a reflective journal entry as their homework. Students reflected on their behaviours in the PBL classroom.

5) Students' In-Depth Interview Forms focused on the Agency and Authority dimensions, based on Schoenfeld et al. (2014). At the end of the PBL lessons, nine students were selected based on their mathematical abilities (three high, three average, and three low) by sorting their scores on the mathematics test in the previous semester and the suggestions of the students' adviser. The students were selected to be interviewed about their agency and authority in the PBL classroom for approximately 20 to 30 minutes. The teacher used some previously developed questions in the interviews, e.g., "In group meetings, what role did you play?" and "In whole class discussions, how did you participate? Please tell me in detail."

In the data analysis, the quantitative data that were collected from the Agency and Authority Observation Forms were analysed by using descriptive statistics. Furthermore, the qualitative data that were collected from the Agency and Authority Observation Forms, the Teacher's Notes, the Students' Reflections, and the Students' In-Depth Interview Forms were analysed by descriptive analysis. In addition, the researchers determined and modified the interpretive codes based on the definitions of agency and authority for the analysis of the qualitative data.

## Results

After using twelve PBL lesson plans, our findings are presented based on the Agency and Authority Observation Forms, Teacher's Notes, Students' Reflections and Students' In-Depth Interview Forms. Firstly, we have defined the terminology that was used in observing behaviours, as seen in Table 1.

Table 1
*Definitions of Agency and Authority*

| Definitions | Examples of Behaviours |
| --- | --- |
| *Agency* is the students' expressions of leadership in the classroom activities, or they are the leaders in carrying out various classroom activities confidently, or they express themselves as a part of their own learning activities. | The students confidently presented their ideas in solving problems to the class, or they volunteered to be a group leader, or they attempted to make mathematics conjectures or arguments during discussions. |

| *Authority* is the students' expressions of freedoms or opportunities to carry out learning activities, or they have important roles and duties in learning activities, or they receive trust from their teacher and peers in carrying out various classroom activities. | The students solved the problems independently, or they presented their work or freely discussed it with their peers, or they were assigned to present their ideas to the classroom by their teacher or peers. |

*Part 1 - Overall mean scores of the students' agency and authority*

The students' overall Agency and Authority scores were assessed by the Agency and Authority Observation Forms, which is a 3-level structured observation. The agency and authority scores varied from 1 (*low level: behaviours barely appear*), to 2 (*average level: behaviours do appear*), and 3 (*high level: behaviours appear obviously*). Focusing on the analysis of the students' agency and authority based on the observations in the PBL classroom, it was found that the mean scores of the students' agency and authority from the twelve PBL lessons had an increasing tendency, as shown in Figure 1.
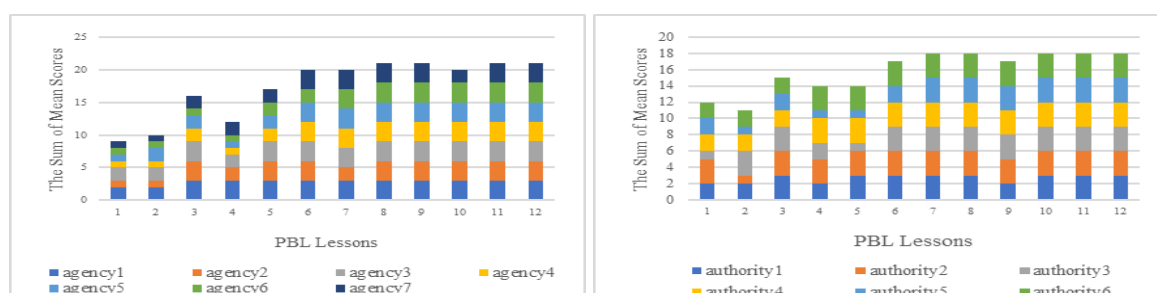


*Figure 1*. Students' overall agency mean scores (left side) and Students' overall authority mean scores (right side) from the Agency and Authority Observation Forms

*Part 2 - Characteristics of the students' agency and authority in the PBL classroom*

In this section, the percentages refer to the numbers of students' reactions resulting from all 12 lessons.

Step 1: Introduction to the problems

In the first step, the teacher presented real-world mathematical problems to the classroom and encouraged the students to participate in the problem presentations in order to make them feel that they are the owners of the problems. Data collected from the Teacher's Notes and Agency and Authority Observation Forms showed that most of the students (approximately 85%) were interested in the presented problem situations. For example, the students talked with the teacher and their peers about the problems that were presented *(authority)*, or they attempted to share their experiences involved with the problems *(agency)*. Many students (approximately 70%) participated in answering questions by raising their hand and standing up to speak *(agency)* as well as played a role as a predictor who conjectured about various possible strategies to solve the problems *(authority)*. Moreover, the occurrences of students' agency and authority in the first step of PBL are shown in Table 2.

Table 2
*The occurrences of students' agency and authority in the first step of PBL from the Agency and Authority Observation Forms*

| Indicators of Agency and Authority | Mean | SD | Level |
|---|---|---|---|
| Participating in the problem introductions *(agency)* | 2.83 | 0.39 | High |
| Playing significant roles while the teacher was introducing problems *(authority)* | 2.67 | 0.49 | High |

Interestingly, the data collected from the Students' Reflections showed that most of the students (approximately 80%) played significant roles, i.e., they shared their experience of solving the problems that are similar to the problem situations that the teacher presented, and explained their ideas, as shown in Figure 2.

| | *English version:* |
|---|---|
| ในก้าวนี้ เป็นช่วงที่หนูชอบมาก เพราะหนูได้นำเสนอไอเดียของหนูในการแก้ไขหรือปัญหาที่ครูกำหนด และหนูได้พยายามตอบคำถามครู และคุยกับเพื่อนเกี่ยวกับโจทย์ | I like this step very much because I can present my ideas about solving the problems to the classroom. Moreover, I attempt to answer the teacher's questions and talk to my peers about the problem situation. |

Figure 2. Student's Reflection on the first step of the PBL classroom: Introduction to the problem

Step 2: Self-directed learning

In this step, the students began to solve the problems by themselves. They attempted to do their work individually. Data collected from the Teacher's Notes showed that most of the students (approximately 95%) attempted to solve the problem situation individually. When they finished their work, they usually showed their work or ideas to their peers in order to compare ideas. Nevertheless, when students were uncertain; they usually asked for help from the teacher or their peers. In this step, the students worked individually at their desks; they did not have opportunities to clearly show agency and authority behaviours. In addition, data collected from the Students' Reflections also showed that the students attempted to work on their own before asking the teacher or their peers for help, as shown in Figure 3.

| | *English version:* |
|---|---|
| เมื่อ ครูกำหนดปัญหา และแจกใบกิจกรรมเดี่ยว ฉนจะทำด้วยตัวเองก่อน แล้วจึงไปเช็คคำตอบอีกที กับเพื่อนอีกครั้ง | When the teacher has assigned an individual worksheet, I will first attempt to solve the problems by myself. Then, I will check the answers with my peers. |

Figure 3. Student's Reflection on the second step of the PBL classroom: Self-directed learning

Step 3: Group meeting

In this step, the students were divided into small groups of 3 to 4 persons to solve the problem situations in group meetings. The students worked together with their peers to find the solutions as a group. While the students were solving their group problems, the teacher observed the performance of each group in order to investigate and check on their understanding as well as give them suggestions. Then, the students wrote down their solutions or ideas on the worksheets and prepared for the classroom presentations and discussion. Data collected from the Teacher's Notes and Agency and Authority Observation Forms showed that some students (approximately 60%) acted as their group leaders. For example, they led the group to brainstorm or discuss ideas *(agency)*, or they contributed to the group voluntarily *(authority)*. Moreover, many students (approximately 80%) attempted to share ideas in their group. For example, they attempted to convince their peers to agree with their methods *(authority)*, or they argued against the methods of their peers that they did not agree with *(authority)*. In addition, the occurrences of the students' agency and authority in the third step of PBL are shown in Table 3.

Table 3
*The occurrences of students' agency and authority in the third step of PBL from the Agency and Authority Observation Forms*

| Indicators of Agency and Authority | Mean | SD | Level |
|---|---|---|---|
| Students act as the group's leader *(agency)* | 2.50 | 0.80 | High |
| Students volunteer to do group activities *(agency)* | 2.75 | 0.45 | High |
| Students support or argue against other ideas in the group independently *(authority)* | 2.67 | 0.49 | High |
| Students contribute to the group's work independently *(authority)* | 2.58 | 0.79 | High |

Interestingly, the data collected from the Students' Reflections showed that the students played different roles in the classroom. For example, the students volunteered to be the group leaders *(agency)*. Moreover, the students brainstormed and discussed ideas in the group independently and also managed their roles within the group freely *(authority)*.

Step 4: Presentations and discussion

In this step, the teacher asked for volunteers to present their group work with approximately 3 - 4 groups based on the variety of the students' ideas or solutions. Therefore, the whole class discussion brought the students to the conclusion of the lessons. Data collected from the Teacher's Notes and Agency and Authority Observation Forms showed that many students (approximately 80%) paid attention to the presentations of their peers and recorded the important or extraordinary issues. Some students (approximately 60%) volunteered to present their group work *(agency)* by raising their hand or standing up to discuss it in the classroom confidently. Most of the students (approximately 80%) designed the structure of the presentation by themselves freely *(authority)*, such as introducing their own group in an interesting way or presenting mathematical symbols and terminology that their peers have never seen or used before. Many students (approximately 70%) also attempted to propose thought-provoking issues *(agency)* that could contribute to the classroom discussion from the presentation. Moreover, students discussed these issues with their peers independently *(authority)*. After the discussions, most of the students (approximately 85%) attempted to conclude the lesson independently by themselves *(authority)*. In the beginning of their conclusion, there were some students who acted as the leader of each group who began to summarise, and then the other students concluded with the teacher's suggestion if it was necessary, as shown in Figure 4.



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

Furthermore, the occurrences of the students' agency and authority in the fourth step of PBL are shown in Table 4.

Table 4

*The occurrences of the students' agency and authority in the fourth step of PBL from the Agency and Authority Observation Forms*

| Indicators of Agency and Authority | Mean | SD | Level |
|---|---|---|---|
| Students volunteer to present their group work *(agency)* | 2.33 | 0.89 | High |
| Students present their group work confidently *(agency)* | 2.42 | 0.79 | High |
| Students designed the structure of their presentation independently *(authority)* | 2.75 | 0.45 | High |
| Students ask questions or propose ideas that contribute to the classroom discussion *(agency)* | 2.17 | 0.94 | High |
| Students discuss and exchange ideas freely *(authority)* | 2.25 | 0.87 | High |
| Students conclude the lessons confidently *(agency)* | 2.33 | 0.78 | High |
| Students receive an opportunity from the teacher to conclude the lessons *(authority)* | 2.75 | 0.45 | High |

Step 5: Exercises

In this step, the students worked individually using concepts that they have learned in the classroom to solve exercise problems. Data collected from the Teacher's Notes showed

that when most of students (approximately 80%) finished their work, they usually showed their work or ideas to the teacher or their peers in order to compare their ideas. Nevertheless, when they were uncertain, they usually asked for help. Data collected from the Students' Reflections showed that the students attempted to work on their own before asking the teacher or their peers to help.

*Part 3 - Characteristics of the students' agency and authority from the Students' In-Depth Interviews*

From the interview data of nine selected students with mixed mathematics ability, the researchers found that the students express their behaviours in all classroom contexts. The students at a high level usually expressed their behaviours in a more diverse and complicated manner than the students at the average and low levels, as shown in Table 5.

Table 5
*Comparing the characteristics of the students' agency and authority from the Students' In-Depth Interviews*

| Level of students' mathematics ability | Expressions of students' agency and authority |
|---|---|
| High | Students are usually willing to participate in the whole class activities and do them confidently. In the individual work or exercises, they attempt to solve the problems by themselves before asking for help from others. They usually are the leader of the group. Sometimes, they are leaders of the classroom who have received trust from their peers to propose ideas or present their work. They often volunteer to be the first group to present their group work to the classroom. Moreover, they are also a person who conducts the classroom discussion, and they usually are the ones who proposed the conclusion of the lesson to the classroom. |
| Average | Students are sometimes willing to participate in the whole class activities. In the individual work or exercises, they solve the problems by asking for help from their teacher or capable peers. Sometimes, they were a leader of a group, but they do not get much trust from their peers in a group, especially in presenting their work to the classroom. They sometimes volunteer to present their group work to the classroom as the second or third group to do the presentation because they are not very confident with their work. Finally, in the whole class discussion, they are the only ones who supported the ideas that they agreed with. |
| Low | Students participate in the whole class activities when the teacher has asked for collaboration. In the individual work or exercises, they solved the problems with help from their teacher or capable peers. They rarely act as the leader of a group or volunteer to present their group work to the classroom. If they had to present their work, they could do it with help at a fair level. However, they attempt to do activities in their group such as writing the solutions for the worksheets, decorating their worksheets, etc. Finally, they usually ask about the thought-provoking issues in the classroom that brought everyone to the discussion. |

# Conclusion

This research investigated the students' agency and authority in a mathematics problem-based learning classroom. The findings revealed that the mean scores of students' agency and authority from twelve PBL lessons had an increasing tendency. Moreover, the students' agency and authority were described in the five steps of PBL. Data collected from the Agency and Authority Observation Forms showed that the students have expressed their agency and authority at a high level in all of the steps of PBL. In addition,

the data collected from the Teacher's Notes and Students' Reflections show that the students expressed their agency and authority, which are positive behaviours. According to the results from the interviews, the students at all levels of mathematics ability have expressed their agency and authority behaviours in all five steps of the PBL classroom contexts. However, the students at average and low levels usually expressed their behaviours in a less diverse and complicated manner than the students at a high level.

One limitation of this study is that the period of time in which the data collection was carried out to investigate the students' agency and authority was minimal. As a result, future research should be conducted over a longer period of time in order to obtain more detailed results. Therefore, the conducting of a longitudinal study of students' agency and authority in mathematics classrooms is recommended.

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