# 11th Grade Students' Self-Beliefs in a Mathematics Problem-Based Learning (PBL) Classroom

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This study aimed to investigate self-beliefs of 11th grade students in a mathematics PBL classroom ($n$ = 47). The data were collected over a period of five weeks during the second semester of the 2018 academic year using students' self-construal questionnaires, students' self-efficacy questionnaires, students' observation forms, students' reflection forms, the teacher's notes, and students' interview forms. Descriptive statistics (percentage, mean, and standard deviation) and descriptive analysis were used to analyse the data. It was found that students in a PBL classroom showed positive self-beliefs in the dimensions of self-construal and self-efficacy.

The Programme for International Student Assessment (PISA) is an international assessment which aims to evaluate education systems by testing students' skills and knowledge as well as how effectively they can apply what they learn in school to real-life situations. There are three core subjects including reading, science and mathematics. Moreover, students are tested in an innovative skill as a collaborative problem solving in 2015. Collaborative problem solving prefers to students working through a problem or issue through shared skills, understanding and effort to achieve a solution. It has been suggested that collaboration skills can be taught and practiced in science, reading and mathematics. In doing so, students can work and present in groups as well as help each other to learn the subject matter (The Organisation for Economic Co-operation and Development [OECD], 2018)

Using group work in the classroom may impact academic goals and achievement. Group work influences may either facilitate or discourage student performance depending on how they engage with their group (Abrami, Lou, Chambers, Poulsen & Spence, 2000). Moreover, self-beliefs are involved in how students engage in group work in the classroom (Hanham & McCormick, 2018). Hanham and McCormick (2008, 2009) studied two dimensions of self-beliefs including self-construal and self-efficacy. They found that these two dimensions of self-beliefs impact students' attitudes toward cooperation and are also related to group level characteristics.

Self-construal connects to how an individual relates to groups (Täuber & Sassenberg, 2012). Furthermore, a previous study found that successful communication depends on each student's self-construal (Haberstroh, Oyserman, Schwarz & Li-Jun, 2002). Markus and Kitayama (2010) defined self-construal as a human being who is either separated from or related to a group. Two kinds of self-construal are independent self-construal, where individuals are separated and distinct from others, and interdependent self-construal, which means individuals are related and connected with others. Each person may show both independent and interdependent self-construal in varying degrees (Cross, & Markus, 1991). This study defined independent self-construal as students' expressions that they can realise their abilities and opinions by themselves. Interdependent self-construal was defined as students' expressions that they realised their abilities and opinions from peers.

Self-efficacy also relates to group work behaviours (Johnson, Johnson, & Holubec, 1994). Students who have high self-efficacy for group work may engage in group work, seek out group work activities, and learn through group processes (Hanham & McCormick, 2018). Moreover, self-efficacy also has a positive impact on academic outcomes and

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learning (Bandura, 1997; Pintrich & Schunk, 2002). Hanham and McCormick (2018) defined self-efficacy for group work as referring to individuals' beliefs concerning their capabilities to engage in group work, such as building and sharing ideas, resolving conflicts, and coordinating the activities of the group. This study focused on 3 sub-dimensions of self-efficacy comprising 1) building and sharing ideas such as explaining personal ideas and building on other' ideas, 2) resolving conflicts such as by accepting others' viewpoints, and 3) coordinating activities such as organising group work.

Previous research suggests that students who participate in a PBL environment develop their competences individually and in groups (Pedersen, 2013). It has been suggested that, when students develop their competences individually and in groups, it is related to independent and interdependent self-construal. Moreover, students have opportunities to practice applying their content knowledge and skills in a PBL environment while they are working on problems. Thus, we can see self-efficacy improvement because PBL helps students to develop competencies including the ability to deal with problems, reason critically and creatively, and collaborate productively in groups or teams (Demirören, Turan & Öztuna, 2016; Dunlap, 2005; Mataka & Kowalske, 2015).

Problem-based learning (PBL) is an instructional approach wherein students are required to solve real-world problems (Barrows, 1996; Belt, 2002; Hmelo-Silver, 2004). The problems will be instruments for learning that are embedded in solving those problems. Also, the students usually work in groups to solve problems (Ram, 1999). Research concerning PBL's effects showed that students acquire not only content and knowledge, but also in-depth understanding (Dods, 1997; Juakwon & Katwibun, 2017). When students work individually and in groups, they have different types of beliefs (Hanham & McCormick, 2018). Therefore, this study was focused on exploring 11$^{th}$ grade students' self-beliefs in a PBL mathematics classroom. The PBL learning processes from Othman, Salleh, and Sulaiman's (2013) study were adapted. They proposed five steps in the PBL process, including (1) an introduction to the problem, (2) self-directed learning, (3) group meeting, (4) presentation and discussion, and (5) exercises.

## Method

In this mixed-method research, the aim was to investigate students' self-beliefs in a mathematics PBL classroom. The participants comprised 47 11$^{th}$ grade students from a high school in Chiang Mai, Thailand. The research instruments were:

1) Ten PBL lesson plans: One of the researchers taught the PBL lesson plans for five weeks in the second semester of academic year 2018. Each lesson took 100 minutes. The second researcher acted as the supervisor/adviser (Corresponding author).
2) Students' self-construal questionnaire, an 8-item self-reporting instrument measured on using a 7-point Likert scale adapted from Hanham and McCormick (2018)
3) Students' self-efficacy questionnaire, an 8-item self-reporting instrument using an 11-point Likert scale adapted from Hanham and McCormick (2018)
4) Students' self-efficacy observation forms used for writing down students' expressions concerning building and sharing ideas, resolving conflicts, and coordinating activities by research assistants
5) Students' self-construal reflection forms used for getting information from students
6) Students' interview forms used for getting in-depth information
7) The teachers' notes used for getting more information

The participants took the students' self-construal questionnaire (Cronbach's alpha coefficient, $r = 0.79$) and students' self-efficacy questionnaire (Cronbach's alpha coefficient,

r = 0.75) (Pre-test) before the lessons started in their free time for 10-15 minutes. In the classroom, data were collected by one of the researchers who taught the ten lesson plans. Two research assistants observed the students in the classroom by using the students' self-efficacy observation forms. In the meantime, other sources of data included the students' reflection forms and teachers' notes (video recordings were used to provide backup data). At the end of all lessons, students' self-construal questionnaire (Cronbach's alpha coefficient, r = 0.80) and students' self-efficacy questionnaire (Cronbach's alpha coefficient, r = 0.73) were used to verify the students' self-beliefs in terms of self-construal and self-efficacy (Post-test). Moreover, six students with mixed mathematical abilities (two high, two average, and two low level) were chosen for interviewing at the end of all the lessons in order to get in-depth information about students' self-construal and self-efficacy. The collected data were analysed using both quantitative and qualitative methods. The data from students' self-beliefs for self-construal and self-efficacy were analysed using descriptive statistics, including percentage, mean, and standard deviation. The data from students' reflection, interview forms, students' self-efficacy observation forms and the teachers' notes were analysed using descriptive analysis.

## Results

This study employed a mixed-method design using multiple data sources, as described above, to investigate 11$^{th}$ grade students' self-beliefs in a mathematics PBL context. The findings in this study are first reported with students' self-construal questionnaire and students' self-efficacy questionnaire. Subsequently, information about students' self-beliefs in terms of self-construal and self-efficacy is aligned with the five steps of PBL classroom. Finally, interviews concerning student' self-beliefs are described.

*Part 1: The mean scores of students' self-construal and self-efficacy questionnaire*

Regarding the students' self-construal questionnaire and students' self-efficacy questionnaire, the students' mean scores were increased from pre-test to post-test (see Table 1 and Table 2).

Table 1
*Means and standard deviations of scores on students' self-construal questionnaire (n = 47)*

| Self-Construal | Pre - test | | Post - test | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Independent | 3.86 | 1.77 | 4.02 | 1.02 |
| Interdependent | 5.02 | 1.43 | 5.44 | 1.13 |
| Overall | 4.44 | 1.6 | 4.53 | 1.08 |

Table 2
*Means and standard deviations of scores on students' self-efficacy questionnaire (n = 47)*

| Self-Efficacy | Pre - test | | Post - test | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Building and sharing ideas | 7.49 | 2.28 | 7.75 | 2.16 |
| Resolving conflicts | 7.52 | 2.18 | 7.88 | 2.27 |
| Coordinating activities | 7.45 | 1.93 | 7.75 | 1.93 |
| Overall | 7.47 | 2.13 | 7.79 | 2.12 |

*Part 2: Students' self-beliefs in the PBL classroom*

Below, the researchers describe the findings regarding the students' self-beliefs aligned with the five steps of the PBL process based on students' self-construal reflection forms, students' self-efficacy observation forms, and the teachers' notes. It was found that self-construal, both independent and interdependent, appeared in all steps of the PBL process, though some students' appearance was not obvious. Moreover, self-efficacy was observed in 3 sub-dimensions including building and sharing ideas, resolving conflicts, and coordinating activities, which happens in Steps 3 and 4 of the PBL process.

Step 1: Introduction to the Problem

In this step, the teacher introduced the real-world problem to the class. The students preferred to learn using a problem situation that certainly happens because it is more interesting. The teacher also let the students share their opinions with their peers. It was found that some students (approximately 20%) confidently shared their opinions and ideas with the entire class about the problem situation. For example, when the teacher asked for the opinion of the whole class, these students normally responded to the questions (independent self-construal). Many students (approximately 70%) paid attention to their peers' answers without verbalisation. For example, they listened to others who talked or shared their experience related to the problem situation provided by the teacher (interdependent self-construal).

Step 2: Self-directed learning

In this step, the students began to solve the problems by themselves. They attempted to do their work individually. Some students (approximately 20%) preferred to do their work by themselves without asking their peers (independent self-construal), as shown in Figure 1. On the other hand, many students (approximately 75%) tried to do their individual work by themselves at the beginning, but then rechecked the solutions with their peers after finishing with their work (interdependent self-construal), as shown in Figure 2.

*Figure 1.* Students' independent self-construal in Step 2: Self-directed learning.

*Figure 2.* Students' interdependent self-construal in Step 2: Self-directed learning.

Step 3: Group meeting

In this step, students were divided into 3-4 students per group to work in group meetings. The students worked together with their peers to find solutions as a group. Then, the students wrote down their ideas on worksheets and prepared for the presentation. The information below was identified. Some students (approximately 25%) distinguished ideas from their group members and presented their ideas to the group (independent self-construal). Many students (approximately 75%) monitored their peers, who offered ideas to solve the problems (interdependent self-construal).

Many students (approximately 70%) could clearly explain their ideas to the group. They provided reasoning and clarification for their positions. However, some students (approximately 25%) built on other group members' ideas. They extended other group members' propositions to make them clearer. Many students (approximately 60%) asked other group members for ideas. They offered new ideas and asked for supporting reasons for those ideas (sharing and building ideas). Many students (approximately 80%) accepted other group members' viewpoints, while some students (approximately 60%) encouraged other group members to express their viewpoints. They talked about their ideas or their opinions first. Afterwards, they asked for other group members' viewpoints (resolving conflicts). Many students (approximately 80%) could coordinate the activities of the group. They talked about the problem and the ideas to solve the problems with other group members. They listened to other group members. However, many students (approximately 75%) played an effective role in running the group. They did their group work for which they were assigned. In addition, some students (approximately 50%) made valuable contributions to their group work. They made a good group final product and prepared to present in the next step (coordinating activities), as shown in Figure 3.

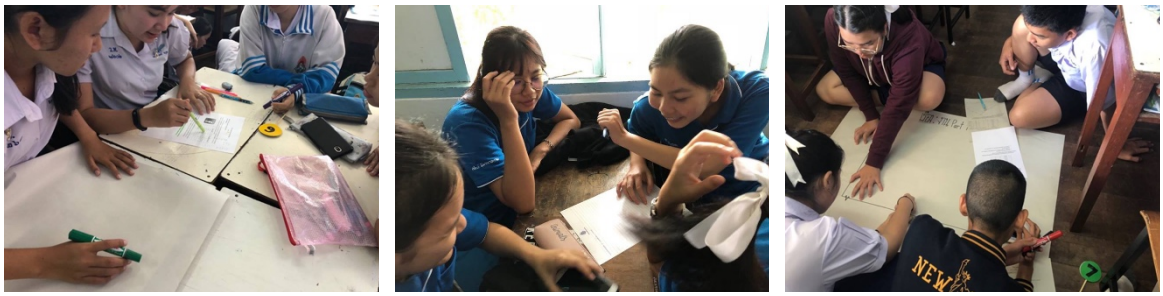

*Figure 3.* Students' self-efficacy in Step 3: Group meeting.

Step 4: Presentation and discussion

In this step, the teacher asked for volunteers to present their group work. Then, a discussion with the whole class brought the students to the conclusion of the topic being studied. The information below was identified. After the presentation, some students (approximately 10%) normally asked questions and shared their dissimilar ideas or opinions with the whole class (independent self-construal). However, many students (approximately 80%) monitored their peers' presentation. For instance, when peers presented to the classroom about how to solve the problems, students attentively listened and discussed with their peers sitting next to them (interdependent self-construal).

Some students who presented their group work to the classroom (approximately 20%) could clearly explain their ideas for solving the problems to the whole class (sharing and building idea). Many students (approximately 80%) paid attention to the presentation and wrote down comments before asking the presenters questions (coordinating activities). After each group presentation, some presenters (approximately 20%) asked their classmates' opinions about their group work. If their peers found a mistake in their work, these students were willing to accept it with reasoning (resolving conflicts). Moreover, some students (approximately 20%) expanded on their peers' ideas to solve the problem rationally (sharing and building ideas). The students exchanged their ideas and opinions until agreeing on the best solutions (resolving conflicts) (see Figure 4).

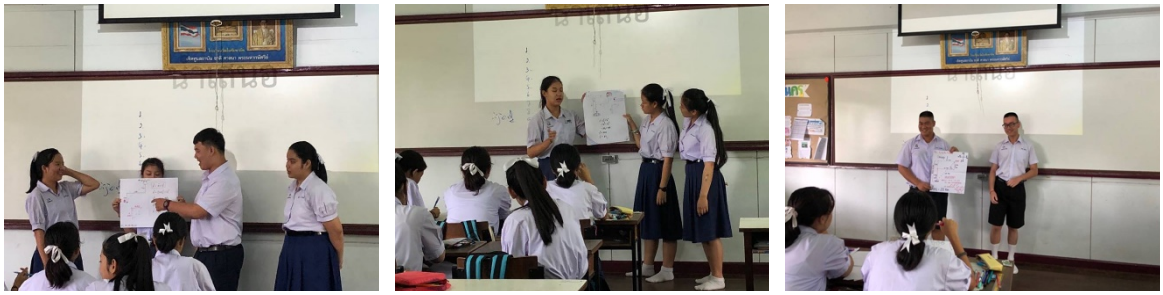

*Figure 4.* Students' self-construal and self-efficacy in Step 4: Presentation and discussion.

Step 5: Exercises

In this step, the teacher promoted students' learning by allowing them to do exercises. It was found that students engaged to complete the exercises. Some students (approximately 40%) preferred to do their work by themselves without asking their peers for help (independent self-construal), as shown in Figure 5. On the other hand, roughly half the students (approximately 50%) tried to do their individual work by themselves at the beginning, but asked for help from their peers afterwards. When they finished their work, they rechecked the answers with their peers (interdependent self-construal), as shown in Figure 6.

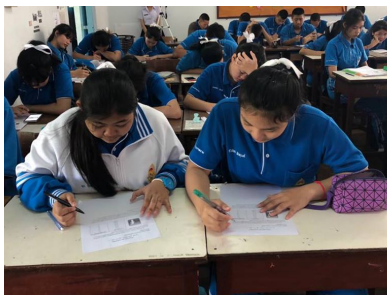

*Figure 5*. Students' independent self-construal in Step 2: Self-directed learning.

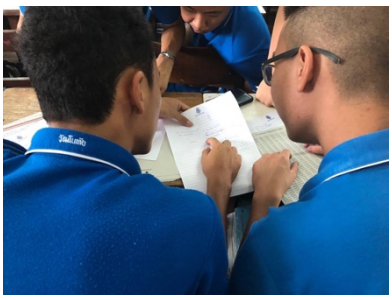

*Figure 6.* Students' interdependent self-construal in Step 2: Self-directed learning.

*Part 3: Description of data collected from students' interviews*

From the interview data of 6 selected students with mixed mathematics ability (two high, two average, and two low), the researchers found that students at high and average levels showed both independent and interdependent self-construal, while students at a low level only showed interdependent self-construal. In addition, students at high and average levels showed self-efficacy for sharing and building ideas, resolving conflicts, and coordinating activities, while students at a low level showed self-efficacy only for sharing and building ideas and coordinating activities, as seen in Table 3.

Table 3
*Comparing the characteristics of Self-Beliefs based on Students' Interviews*

| Mathematics Achievement Level | Self-Beliefs |
|---|---|
| High | 1. Self-Construal: The students prefer to think in different ways to solve problems (independent). They learn variously from their peers when they work in groups and conduct discussions (interdependent).<br>2. Self-Efficacy: The students frequently share their ideas with other group members or the whole class. They often build on other group members' ideas to make their own work better (sharing and building ideas). They sometimes ask for other group members' viewpoints when they work with a group. If their peers find a mistake in their work, they accept it with reasoning (resolving conflicts). However, they are quite confident that they usually make good group work (coordinating activities). |
| Average | 1. Self-Construal: The students prefer to think in different ways to solve problems (independent). They think opinions from their classmates can help them to understand how to solve problems better (interdependent).<br>2. Self-Efficacy: The students usually explain their ideas to other group members when they come up with new ideas. They are going to tell other group members (sharing and building ideas). They usually ask for other group members' viewpoints. If their peers, especially the high-level students, find a mistake in their work, they accept it with reasoning (resolving conflicts). However, they think that they normally do good group work for their part (coordinating activities). |
| Low | 1. Self-Construal: Students at this level do not show any expressions in terms of independent self-construal. The students think their group is helpful. For example, they can share knowledge and skills when they work with their group members (interdependent).<br>2. Self-Efficacy: The students rarely explain their ideas to the group (sharing and building ideas). However, they think that they do good group work for their part (coordinating activities). |

## Conclusion

This research investigated students' self-beliefs, including self-construal and self-efficacy, in a mathematics problem-based learning classroom. The results showed that the students obtained positive independent and interdependent self-construal. In addition, overall self-efficacy in 3 sub-dimensions showed positive behaviours. The results from students' self-construal questionnaires and self-efficacy questionnaires showed that the mean scores for both increased from Pre-test to Post-test. The results revealed that the students' self-beliefs, including self-construal and self-efficacy in all steps of the PBL process, were found to be positive. Based on the results from the interviews, students at a high level showed both independent and interdependent construal. On the other hand, students at a low level showed only interdependent construal. However, students at a high level showed all sub-dimensions of self-efficacy, while students at a low level showed 2 in

3 sub-dimensions of self-efficacy, namely sharing and building ideas and coordinating activities.

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