Prospective teachers' mathematical resilience after participating in Problem-based Learning

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Abstract. The main goal of this study is to improve mathematical resilience of prospective math teachers through the implementation of Problem-based Learning. This study is a quasi-experimental using non-random of pretest and posttest control design. 57 prospective math teachers from Universitas PGRI Semarang are taken as the sample of this study. The data needed to achieve the goal of this study are taken from documentation, observation, interviews, students’ worksheets, and pre and post responses. The results of the analysis show that mathematical resilience in prior knowledge category of high, medium and low of the students who experienced study using Problem-based Learning and overall is improved. This students’ mathematical resilience improvement belongs to low category. This study can be taken as consideration for another researchers for doing further research which is in the same vein as this study.

1. Introduction
Mathematics is hard; it needs plenty of practices. But is mathematics that hard to learn so that it makes students vulnerable? There are so many factors causing students vulnerable in mathematics: low positive attitude, environment support, and even teacher factors are among those contribute to achievement. By strengthening positive-adaptive attitude in mathematics, students can preserve their eagerness in learning. This kind of attitude known as mathematical resilience [1]. This is dealing with mathematical problem-solving skill, working in team,possessing mathematical language, and mastering theories about mathematical learning growth [2]. Regardless of risks and obstacles that might occur, resilience effects to successful adaptation and transformation process. Being resilient means students are able to encounter any kinds of obstacles they face in math classes [3].

Mathematical resilience is needed to develop students’ competence in math and to function them mathematically [4]. By that reason, development of positive-adaptive attitude of the students is needed to keep them steady in learning math. Conventional learning brings negative effects to students in learning math [5,6]. Students need to be ready and steady to overcome that negative situation. The ability to cope and to solve any kinds of academic difficulties (including anxiety) is called resilience. In Japan, mathematical resilience is applied for advancing technology and science [7]. In another words, resilience is a person’s strength to cope and overcome difficult situations that may bring damaging effects to their surrounding [8]. In addition, [8] Waxman, et.al stated that resilience is important because it deals with one’s ability to face and overcome problems and it is strengthened by life's difficulties. In line with [8], Waxman, et al (2003) in Goodall [9] mentioned that resilience
allows one to deal with difficult situations that negatively affect them and cause them to surrender. It enables them to find and use their abilities to adapt.

In particular, mathematical resilience is a combinations of some students’ mathematical approaches resulting students’ confidence and success for the things they have done [10]. Lee and Wilder stated that mathematical resilience [11] is an attitude toward mathematics that allows students to continue learning mathematics despite experiencing difficulties and deterioration in learning mathematics. Ashcraft [6] mentioned that mathematical resilience consent students to get solution to any kinds of problem and anxiety in learning mathematics. The anxiety itself is a form of pressure or anxious that damage the students’ achievement in mathematics [12]. Lee and Grupte defined resilience as an ability to survive during hard times of learning mathematics and find its solution by themselves. Mathematical resilience helps students to deal with difficult situations during math learning time. [13] stated that grouping and discussing can trigger student resilience. Wilder and Lee stated that if any students deal with mathematics by trying to solve the problems, coping the obstacles and misunderstanding and working with mathematical ideas, for those reasons they need mathematical resilience [14].

The students who master mathematical resilience well, have some characteristics. Wilder and Lee [14] mentioned that those characteristics cover: skill full ability to mathematically function both in and out of school, skill full ability to develop their mathematical competence, reflective, and concentrate more on mathematical learning. Moreover, [15] stated that students who have good mathematical resilience are: adaptive, solutive, challenge full, creative, and curious about learning experience, have good self-control, have good self-esteem, have high social network and humble. [9] Goddall and wilder put an extra features to students who have good mathematical resilience. Those include ultimate confident, problem solver, and well-managed.

Students experience mathematical resilience, and it can be obtained. In accordance to this statement, [15-19] uttered that coaching can be a solution for mathematical resilience problems. Some factors are interfenced in the coaching itself.

Mathematical problem solving and mathematical resilience are related. The relationship between those two can be figure out in Benard [3] which informs three points: questions help students in developing resilience, teachers are students’ biggest motivation to solve the difficulties, students-teacher discussion for sharing thought. Students often experience frustration; it is necessary to give them time to contemplate their frustrations then give them motivation so that the level of resilience can be increased. In line with what has been found by [20] informed that students’ resilience can be formed by providing students more time to resolve their stress and tension.

Problem based learning (PBL) is applied in learning from elementary school to university level and it gives positive impact on learning outcomes. In his research, El Sayed [21] stated that problem-based learning class has higher mathematical problem solving than the conventional one. [22] Heman mentioned that students’ mathematical disposition ability increases when they get PBL in class. [23] Mackinley and Barney stated that PBL can improve students’ activity in classroom learning. While [24] uttered that PBL is an approach taught to students to get critical thinking and dispositions enhancement. [25] added that PBL facilitates students in their critical thinking improvement and generic skill development through active participation in learning process. Furthermore, [26] added that 80 out of 100 percents of learning goals can be achieved through PBL. The PBL approach affects on students’ capability in thinking critically [27]. Applying the PBL approach in the class can improve the goals and students’ retention [28]. It is appropriate to apply PBL in the class to develop prospective math teachers’ competence in learning [29].

Based on the background of the study above, this study aims at finding out the way to increase mathematical resilience of the prospective math teachers taught using PBL seen from the point of view of prior knowledge mathematical abilities (PKMA) factor.
2. Methods
This study used pre and post responses design. The samples of this study were 57 prospective math teachers from different regions in Central Java. Those were the students of Universitas PGRI Semarang. The initial and final questionnaires were the main data used in this study. Then, those were analyzed in accordance with the overall factor and the basic knowledge of the prospective math teachers.

3. Results and Discussion
3.1. Descriptive Data Analysis of Increasing Student Mathematical Resilience
Data analysis for increasing mathematical resilience was obtained from the results of pretest and posttest which included mean, standard deviation and N-gain based on PKMA categories and learning models. Recapitulation of data on increasing mathematical resilience is presented in the following Table 1. Based on Table 1 shows that the average increase in mathematical mathematical resilience of students with high category PKMA who get PBL is higher than students who get Conventional Learning (CL). Average gain category normalized PBL and CL models included in the low category. Furthermore, the average increase in mathematical resilience of students with PKMA in the medium category who received the PBL model was lower than the students who received CL, and the group improvement category which was seen from the average gain for PBL and CL classes was in the low category. The mean increase in the ability of mathematical resilience of students with low category PKMA who get PBL is higher than students who get CL, and the group improvement category which is seen from the average gain for PBL and CL classes is in the low category. In total based on Table 1 shows that the average increase in mathematical resilience of students who get PBL model is higher than students who get CL, the group increase category which is seen from the average gain for PBL and CL classes is included in the low category.

Table 1. Descriptive data recapitulation of student mathematical resilience

| Class             | Category | N | Gain average | N-gain Std. dev. | N-gain average |
|-------------------|----------|---|--------------|------------------|----------------|
| Problem Based     | High     | 5 | 25.356       | 0.148            | 0.234          |
|                   | Medium   | 19| 12.105       | 0.088            | 0.148          |
|                   | Low      | 4 | 15.404       | 0.076            | 0.120          |
|                   | Overall  | 28| 14.942       | 0.106            | 0.137          |
| Conventional      | High     | 5 | 8.038        | 0.072            | 0.076          |
| Learning          | Medium   | 20| 12.391       | 0.118            | 0.112          |
|                   | Low      | 4 | 14.409       | 0.115            | 0.135          |
|                   | Overall  | 29| 11.919       | 0.109            | 0.109          |

Description:
N: Number of Students

3.2. Inferential Analysis of Data on Increasing Student Mathematical Resilience
From table 2 it can be seen that the negative ranks are 18 which means there are 18 N-gains on CL which are better than PBL and positive ranks are 10 which means there are 10 N-gains on PBL that are better than CL. Then, the Asymp value. Sig. (2-tailed) 0.066> 0.05 which causes H0 to be accepted. In other words, the students who were taught using PBL has the same mean enhancement of mathematical resilience as those who were taught using CL.
Table 2. Mean difference test for increasing mathematical resilience learning

| Resilience Test | Wilcoxon | Learning Type | Testing Rules |
|-----------------|----------|---------------|---------------|
| Enhancement     | Negative Ranks | 18 | PBL | |
|                 | Positive Ranks  | 10 | CL  | H₀ Accepted |
|                 | Asymp. Sig. (2-tailed) | 0.066 | |

3.2.1. Test of Average Difference in Increasing Student Mathematical Resilience Based on Learning Type and PKMA Category. Based on table 3 shows that there is no difference in average increase in students’ mathematical resilience for PBL and CL for all PKMA categories and overall. Furthermore, in table 4 section the category being seen negative ranks is 12 which means there are 12 N-gains on PBL which are better than CL and positive ranks are 7 which is there are 7 N-gains on CL which are better than PBL. Furthermore, in the overall PKMA, there is a negative ranks of 18 which means that there are 18 N-gains on PBL which are better than CL and positive ranks are 10 which have 10 N-gains on CL which are better than PBL.

Table 3. Test of differences in average improvement of mathematical resilience based on PKMA category of high, medium, low, overall and learning models

| PKMA Category | t-Test: Two-Sample Assuming Equal Variances | Learning Type | Testing Rules |
|---------------|--------------------------------------------|---------------|---------------|
| High          | t Stat 2.148                               | 8             | H₀ Accepted   |
|               | df                                          |               |               |
|               | Sig. (2-tailed) 0.064                      |               |               |
| Low           | t Stat -0.228                              | 6             | H₀ Accepted   |
|               | df                                          |               |               |
|               | Sig. (2-tailed) 0.413                      |               |               |
| PKMA Category | Wilcoxon                                   |               |               |
| Medium        | Negative Ranks 12                          | 7             | H₀ Accepted   |
|               | Positive Ranks 7                           |               |               |
|               | Asymp. Sig. (2-tailed) 0.286               | 18            |               |
| Overall       | Positive Ranks 10                          | 10            | H₀ Accepted   |
|               | Asymp. Sig. (2-tailed) 0.066               |               |               |

3.2.2. Interaction between Learning Models and PKMA on Increasing Student Mathematical Resilience. Inferential analysis to determine the interaction between learning models (PBL and CL) and PKMA (high, medium, and low) on improving students' mathematical resilience is done using two-way ANOVA. One of the basic assumptions that must be met in using the two-way ANOVA test is that the data must be normally distributed. The data on students' mathematical resilience for PKMA is medium and overall categories that get PBL and CL are not normally distributed, so the two-way ANOVA test cannot be used. Thus, the analysis of the interaction effect on this data is carried out descriptively from the resulting graph.

Graphs of interaction between learning models (PBL and CL) and PKMA in the high, medium, and low categories of students' mathematical KPM is shown in Figure 1 can be concluded that: (1) The average line graph of the increase in mathematical resilience of students who get PBL is above the average line graph of mathematical resilience improvement that gets CL. This indicates that PBL has a greater influence on improving students' mathematical KPM compared to CL models for each level of PKMA category; (2) In the PBL and CL groups, the PKMA category is higher and lower than the medium PKMA, this indicates that high and low PKMA has a greater influence on improving students' mathematical resilience than moderate PKMA; (3) In the PBL group, it can be seen that the lowest
PKMA category is the highest compared to the others, this indicates that low PKMA has the most different effects than the other PKMA categories. On the other hand, in the CL category it is seen that the highest PKMA category is the highest compared to the others, this indicates that high PKMA has the most flawed influence than other PKMA categories; (4) Based on the distance of the graph, it appears that for each category of PKMA it tends to be the same and not until the intersection occurs. Thus, it can be concluded that there is no interaction between the model (PBL and CL) and the PKMA category on the improvement of students' mathematical resilience.

![Figure 1. Graph of interaction between PBL, CL and PKMA on increasing mathematical resilience](image)

**Teaching application**
In this research, one of the problems used in learning:

![Figure 2. Snippet of student work for mathematical critical thinking ability](image)

In this learning, the paper sheet is given in lectures, the lecturer is a facilitator, while students are active independently or in groups in reviewing the material and solving the problems raised. Examples of assignments contained in the paper sheet at the next meeting to discuss material problems that require previous supporting concepts such as in Figure 2.
Completion of the problems presented by the scholarship shown in Figure 2 is complete along with assistance in solving the problem by summarizing what is known starting from the numbers 0 to 9 and writing down the number of vowels and consonants. In the completion presented students have written down how to obtain the number of items intended by the calculation of the multiplication rules and have concluded the answer. However, students have not explained the reason for the answer and the acquisition of the calculation.

In training students' resilience, students write down the difficulties in the discussion process and the processors are still confused in determining odd or even slots, then the calculation process is still in doubt about permutation or combination. Meanwhile, in dealing with these difficulties, students discuss with other members in the group, find references in the printed book and browse on the internet.

The students also wrote the error of the idea when discussing, thinking that if the even slot had been used for 1 hour then the attack could not be used in odd slots. Then the references used by students in discussing these problems are introductory books and http://www.google.co.id/amp/s/aimprof0.

On the settlement of these problems by other groups, there were those who were not careful in solving them, namely calculating the probability of the event, even though they did not raise the probability. In addition, students have not given the right reasons according to mathematical concepts that are in accordance with the answers written in solving the mathematical problems above. Difficulties of students like this are because student students have not been able to provide reasons in the process towards conclusions.

In problem-based learning many students experience difficulties at the beginning, because they are not accustomed to being presented with problems at the beginning of learning which in fact students in this study are 2nd semester students. However, problem-based learning is learning that can change the way students view mathematics especially the probability theory own. This is consistent with [30] Problems are used because they can trigger space between old ways and new ways of knowing how problems can help to integrate knowledge, personal development and professional action. The following is a PBL overview in the class shown in the interview snippet with one of the following students:
Figure 4. Snippet of interview about problem-based learning

The fragments of the interviewer’s results with M_{4a-1} on Figure 5 show that problem-based learning makes students more enthusiastic and optimistic in facing problems, both mathematical problems and problems in daily life and optimistic in solving them.

4. Conclusion

The students with high PKMA category in PBL class got higher average score in mathematical resilience improvement than the students with high PKMA category in CL class. But, both PBL and CL N-gain are considered low. The students with medium PKMA category in PBL class got lower average score in mathematical resilience improvement than the students with medium PKMA category in CL class. But, both PBL and CL N-gain are considered low. The students with low PKMA category in PBL class got higher average score in mathematical resilience improvement than the students with low PKMA category in CL class. But, both PBL and CL N-gain are considered low. The students in PBL class got higher average score in mathematical resilience improvement than the students in CL class. But, both PBL and CL N-gain are considered low. And the last, that there is no interaction between the model (PBL and CL) and the PKMA category on the improvement of students’ mathematical resilience.

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