Developing Mathematical Resilience of Prospective Math Teachers

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Abstract. Prospective math teachers need to develop positive adaptive attitudes toward mathematics that will enable them to continue learning despite having to deal with obstacles and difficulties. This research focuses on the resilience improvement of the prospective math teachers after being treated using problem-based learning based on their basic knowledge on mathematics and their overall knowledge on math. This research used only one group for pre-test and post-test. The result of this research shows that there is improvement on prospective teachers’ resilience after they were given treatment using problem-based learning. One of the factors causing the resilience improvement of the prospective math teachers is the instructions on students’ work sheet. In the instructions, students were asked to write difficulties in solving math problems as well as write down the solution they take to overcome them. This research can be used as a reference for other researchers who want to do the same research related on students’ resiliency on math and or math lecturers to improve the resilience of prospective teachers to be resilient teachers on math in the future.

1. Introduction
Probability theory is one of the subjects that must be understood by the prospective teachers of mathematics because it becomes the basis of the next course and become one of the topics in senior high school. Learning the probability theory and mathematics is not easy though mathematics plays an important role in the advancement of technology and science [1]. Unfortunately, the experience of having difficulties in learning math often faced by students. This condition increases anxiety and is contrary to mathematical resilience. Many factors appeared as the causes of students’ anxiety. Asking students to perform tasks that require high-speed memory achievement, requiring learners to memorize the formula without understanding, difficult individual exams, lack of vocabulary to describe difficulties, lack of opportunities to practice and learn in various contexts are the factors.

Mathematics is also considered difficult to master; therefore students need to develop positive adaptive attitudes toward mathematics that will enable them to continue learning. A positive adaptive attitude to mathematics is called mathematical resilience [2]. Characteristics of mathematical resilience include perseverance when faced with mathematical difficulties, working in tandem with peers, possessing the language skills necessary to express mathematical understanding and having a mathematical learning growth theory [3]. Resilience describes a set of qualities that drive the successful process of adaptation and transformation despite the risks and hardships. Being a resilient mathematician describes a learner who has “a set of qualities that drive successful adaptation and transformation despite the risks and difficulties” that they may encounter in solving problems in math classes [4].

Based on preliminary studies, generally the students’ mathematical resilience is still relatively low; most students in self-control and facing problems in math learning are still relatively weak. Some students when they are faced with difficulties in solving mathematical problems in probability theory are not encouraged to ask their peers or teachers concerned, but they commonly avoid the difficult tasks. In the end, many students just copy the work of their friend. Students are afraid of asking questions and answering questions delivered by their lectures. This condition occurred due to their lack of confidence.
can be said that problem solving ability and students' mathematical resilience in learning probability theory is still weak.

Students who have good mathematical resiliency of course have the characteristics/ criteria that can be observed. [6] states that learners with good mathematical resilience have the following characteristics: not only have the skills they need to examine the desired questions but also the skills needed to function mathematically in the outside world, have a willingness to develop math skills, reflective And attentive to learning mathematics. Think hard / earnest, discuss with others, be able to read/ see mathematical ideas, and not despair to make progress with his seemingly difficult and problematic ideas. [8] students with good mathematical resilience have growth beliefs related to their abilities; They do not think of mathematics as an outcome that others know but he does not; Even when they are in trouble he remains convinced that he will be able to overcome those difficulties and succeed; They are aware of the resources that can help it and be confident in its existence and usefulness; They maintain the belief of their ability to overcome the obstacles of mathematics; Develop new skills if needed and cooperate with others if needed.

Research on resilience such as [9], [12] the success of Resilience in education is influenced from students' self and student environment which makes it possible to reduce student's success to resilient. [1] Which states Resilience in solving problems in learning mathematics in japan that play an important role in technological progress and Science. [12],[14] argue that students can be directed to see capabilities that can be developed from time to time with good effort and strategy, the help of others and make it more resilient if they find a way to learn diligently. [13] Suggests that economically disadvantaged Students have higher levels of resilience than other students in addition to school and student environment factors.

However, there has not been deep research related to math teacher candidates’ resiliencies. Prospective teachers are the people chosen for the future of the nation. Prospective math teachers should be able to give examples to their students how to survive the difficulties and limitations in learning mathematics. Therefore this paper studied about the increasing resilience of prospective teachers in the probability theory course.

2. Experimental Method

This research is one group pre-test and post-test. The subjects of this research are 183 prospective math teachers of Universitas PGRI Semarang coming from various regions in central java province-Indonesia. The data taken are the initial and final questionnaires about mathematical resilience in the opportunity theory course with problem-based learning. The data for this research were analyzed based on the overall factor and the early mathematical ability of the prospective math teachers.

3. Result and Discussion

During the learning process, researchers used worksheets that were given to students with special work instructions to train the mathematical resilience of prospective teachers as figure 1. it is shown that: starting points (b) prospective teachers are trained to recognize the difficulties that occur in themselves in mathematical learning and solve mathematical problems, this is in accordance with the results of research from [8] At point c. Student prospective teachers are invited to realize mistakes in thinking and trying to solve mathematical problems as well as discussing with his friends followed by correcting the mistake that was so right that is accompanied by explanation of reason justification reason. This is in accordance with the results of research from [7] and [8].

At points d. Student prospective teachers are invited and familiarized to find as many references as possible in learning and solve problems both offline and online reference. Here, student prospective teachers are also taught to search for reliable sources from online references. This is in accordance with the results of the study [9]. In addition to the commands on the worksheet, of course, learning settings should also guide the prospective math teacher students to become a resilient. Here is a partial excerpt of the learning scenario in the probability theory course using problem based learning.
**Figure 1.** Special work instructions on worksheet

The Figure 2 is possessed by the lecturer. One of the lecturers help students to convince themselves that the problem they faced now is the same problem they will face when they teach students in the high school in the near future. This is similar to the resilience theory proposed by [5]. In point 2) students are invited to identify mistakes that have been done in trying to solve the problem. Here students will learn that the mistakes made in learning mathematics is not an obstacle to stay away from mathematics but it must be a stepping stone to achieve success in learning math even though the current passes through several obstacles. This is similar to the resilience theory proposed by [2] and [6].

**Figure 2.** Part of lesson plan

From the statistical results obtained that mathematical resilience of prospective math teachers increased after getting problem based learning on the probability theory course. By using the N-gain test which is seen based on student's early mathematical ability factor and overall appears in Table 1. It is shows that overall there is an increase in mathematical resilience of prospective teachers who is equal to 0.12. However, when viewed from the KAM factor, it is precisely for students who have early mathematical ability is having a great pen reply than the others that is equal to 0.13. The results of statistical calculations are similar to those of research [6]. The learning outcomes use problem-based learning which is also in the form of a mathematician candidate in which the development of mathematical resilience can be influenced and supported by coaching. Fostering a mathematical resiliency must of course pay attention to several factors that can influence it. In general, [10] describes three factors that influence resilience: individual, family and community factors. This is reinforced also by [11] which states that cognitive skills have an important effect on the level of individual resilience. Minimum average intelligence is required for the growth of resilience in the individual because the resilience is closely
related to the ability to understand and convey something through the appropriate language, reading ability, and non-verbal communication. Resilience also relates to the ability to unleash the mind from trauma by using fantasy and expectations grown in the individual.

Table 1. Details of N-gain seen from KAM and overall factors

| Questionnaire early | Questionnaire final | N-gain |
|---------------------|---------------------|--------|
| high                | 47.92               | 0.12   |
| medium              | 49.07               | 0.13   |
| low                 | 44.35               | 0.11   |
| totality            | 47.05               | 0.12   |

From the above results, we can say that one way to improve the resilience of mathematics teacher candidates is to use problem-based learning where special care is given to support improvement. Those can be done by convincing ourselves that we are capable of understanding concepts and solving mathematical problems, learning from the mistakes made in group work to convince yourself that surviving and learning from mistakes can make us successful, allowing students to experiment and try new ideas in solving problems/understand/find mathematical concepts, training students to recognize their own mistakes in problem solving and ask to provide a reason for the justification they have done, familiarizing students to think hard, talk to others, read about mathematical ideas and reflect on the information obtained, so they will be able to make progress, and leading to trustworthy offline and online references.

3.1 Teaching applications

In this research, one of the topics discussed is Bayes’ Theorem (two events),

\[
P(A | B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A)P(B | A)}{P(A)P(B | A) + P(A^c)P(B | A^c)}
\]

Figure 3 can illustrate two events A and B,

![Figure 3. Derivation of Bayes theorem (two events)](image)

We want to know \( P(A | B) = \frac{P(B \cap A)}{P(B)} \)

Since \( P(B \cap A) = P(A)P(B | A) \),

and \( P(B) = P(B \cap A) + P(B \cap A^c) = P(A)P(B | A) + P(A^c)P(B | A^c) \),

thus, \( P(A | B) = \frac{P(B \cap A)}{P(B) + P(B \cap A^c)} = \frac{P(A)P(B | A)}{P(A)P(B | A) + P(A^c)P(B | A^c)} \)
4. Conclusion

The conclusion of this research is that problem-based learning on probability theory courses can improve student resilience of mathematics prospective although it is low. In addition, students with mathematical abilities are increasing resilience higher when compared with other mathematical ability groups. Supporting students’ in having more confidence in learning more about mathematic, having them in discussion and working in peer and practicing a lot can be triggers for students to achieve their best level in math.

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