

Research Article

Deductive Reasoning and Mathematical Resilience in Complex Analysis

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Abstract.

The pre-research data of mathematics prospective teachers in one of the universities in Bandung showed that the deductive reasoning ability in complex analysis was still not at good level. Beside the cognitive aspect, the affective aspect could be considered too in doing learning process, such as mathematical resilience. This study aims to analyze and identify the correlation between deductive reasoning and mathematical resilience in complex analysis. The research was conducted in one of the mathematics education departments of a university in Bandung. Correlation was the method used in this study. Mathematics prospective teachers were the sample of this research. This study concluded that mathematical deductive reasoning of prospective teachers was on a moderate level, the mathematical resilience of prospective teachers was on the positive category, and there was a significant correlation between deductive reasoning and the mathematical resilience of prospective teachers on a moderate level.

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Published: 26 April 2024

Publishing services provided by Knowledge E

Keywords: deduktif reasoning, matchemathical resilience, complex analysis

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Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

Mathematics learning is facing some difficulties, which one of it is the effort to improve mathematical ability. Difficulties in understanding and mastering mathematics are not without any cause. Mathematics is a field of study that needs logic and systematic way of thinking, fortitude and precision with conscious effort [1]. Reasoning ability is a process to get logical conclusion based on facts and relevant sources [2, 3]. Mathematical reasoning is a mathematical thinking process to attain mathematical conclusion based on fact, data, concept, and method that relevant to each other. Reasoning ability is classified into two aspects, which are deductive and inductive reasoning. Deductive reasoning is an ability to conclude a conclusion based on definition or agreed rules, and the rightness value tend to be absolute [4, 5].

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Complex analysis is one of the courses that needs a good deductive reasoning ability to begin with. Complex number is the core of this course discussion, which consisted of two parts: real and imaginary number. The proficiency of cognitive, psychomotor, and intelligence is needed in this course [6]. The study [7] stated that there are still a lot of students that face difficulties and show dislike toward mathematics learning. As example, some students are anxious and avoid doing some activities that need mathematical reasoning. The research that has been done by [8, 9] found that students' deductive reasoning ability is still on low level. In the other studies conducted by [6, 10] the students' ability in Complex Analysis is shown to be in a not good level.

The pre-research that has been conducted by author through a three questions item of mathematical deductive reasoning test that being held in a university in Bandung shown that only 18.75% of prospective mathematics teachers that has good grades, while 81.25% of them do not have good grades. The effort to improve deductive reasoning, aside from affected by external factors, like teacher or learning method, the student should notice the internal factors that affected himself/herself, such as positiveness toward mathematics. In order to cope with anxiety, fear, and difficulties to face obstacles, the attitude of being diligent, persistent, confident, and adaptive through challenges is needed, which namely resilience. Mathematical resilience is a positive attitude in learning mathematics that took form in confidence, diligence in facing difficulties, desire to get into discussion, reflecting, and analyzing [7, 11]. A person with high level of mathematical resilience will have adaptive attitude, resolve problem logically and flexibly, are curious and learning from experience, self-control, consciousness of self-sentiment, have a strong social connection and easy to offer some helps [12]. Hence, the obstacles in learning mathematics could be overcome through mathematical resilience.

There is some research about the usefulness of mathematical resilience. The research by [13–15] stated that mathematical resilience is affecting mathematical learning output. Research of [16] found that students with high level of mathematical resilience are able fulfill the five aspects of mathematical literacy ability. The findings from [17] shown that students that have good mathematical resilience will also have good problem-solving ability. The study from [18] said that there is a positive connection between mathematical resilience and academic proficiency. In this study, the researcher examined the connection deductive reasoning and mathematical with assumption that these abilities have to be improved so students could solve the problems that was stated in the result of Complex Analysis pre-research. The research about deductive reasoning and mathematical resilience in Complex Analysis is also act as the novelty.

Hence, based on the explanation that has been explained, the aim of this study is to identify deductive reasoning, mathematical resilience ability, and the connection between the two variables in Complex Analysis of prospective mathematics teachers. It is expected with the finding of positive connection between mathematical resilience and deductive reasoning could help the teacher in using effective learning method and approach to improve students' mathematical ability, specifically to improve the mathematical deductive reasoning ability in Complex Analysis course.

2. RESEARCH METHOD

Correlation is the research method that used in this study [19]. The research was conducted in mathematics education study program in one of university in Bandung on the academic year of 2020/2021. Prospective mathematics teachers who took Complex Analysis Course are the population of this research. Hence, one class with 21 prospective mathematics teachers is chosen as the research subject. Test and questionnaire are the data collecting technique that used in this study.

Test is used in order to collect the data of deductive reasoning and questionnaire is used to collect mathematical resilience data. The deductive reasoning test instrument is consisted of 6 item questions that corresponded to the deductive reasoning indicators based on [2]. The test instrument is tested through validity, reliability, differentiating power, and difficulty level test before given to the research subjects. The result shown that only 1 item questions that would not be used since it has low validity bad differentiating power, and the difficulty level is categorized as very hard.

Mathematical resilience questionnaire contains 37 statement items (20 positive statements and 17 negative statements), that arranged based on mathematical resilience in [2]. To check its feasibility, the questionnaire is validated by judgment expert from 2 experts that stated this questionnaire non-test instrument is feasible to be used. This research aims to identify deductive reasoning ability, prospective mathematics teachers' mathematical resilience, and correlation between deductive reasoning and mathematical resilience. Mathematical deductive reasoning is identified through the mean data of test, which the level will be categorized. Prospective mathematics teachers' mathematical resilience will be identified through non-test analysis of the questionnaire that took form in Likert scale. Its mean will be calculated and will be categorized. The identification of deductive reasoning and mathematical connection in Complex Analysis course will be done through product moment correlation test, which will be assisted by Jamovi 1.6.23. The data will be tested its normality test and linearity test between

deductive reasoning (Y) and mathematical resilience (X). The calculated score from the test then interpreted through correlation level category.

3. RESULT AND DISCUSSION

3.1. Prospective mathematics teachers' Mathematical Deductive Reasoning in Complex Analysis Course

The test conducted in this study obtained the data of mathematical deductive reasoning that has been adjusted for each question to be corresponded with mathematical deductive reasoning indicator.

Question 1:

Prove:

1. $\sin(2z) = 2 \sin z \cos z$
2. $\cos(2z) = \cos^2 z - \sin^2 z$
3. Use the complex function definition to denoted $\sin\left(\frac{\pi}{2}\right)$ in the form of $x + iy$

In this question, prospective mathematics teachers are instructed to do proving of complex trigonometric function. Figure 1. will show one of prospective mathematics teacher's answer for question 1.

The image shows a handwritten mathematical proof on lined paper. It starts with '1. Buktikan' (1. Prove). The first line is 'a. $\sin(2z) = 2 \sin(z) \cos(z)$ '. The second line is ' $\sin(2z) = \frac{e^{i(2z)} - e^{-i2z}}{2i}$ '. To the right, there is a boxed note: 'note: $\sin(A) = \frac{e^{iA} - e^{-iA}}{2i}$ ' and ' $\cos(A) = \frac{e^{iA} + e^{-iA}}{2}$ '. The third line shows the derivation: ' $2 \sin(z) \cos(z) = 2 \left(\frac{e^{iz} - e^{-iz}}{2i} \right) \left(\frac{e^{iz} + e^{-iz}}{2} \right)$ '. The fourth line simplifies this to ' $= \frac{e^{i2z} - e^{-i2z}}{2i}$ '. The fifth line concludes with 'karena $\sin(2z) = 2 \sin(z) \cos(z) = \frac{e^{i2z} - e^{-i2z}}{2i}$ '. The final line says 'maka $\sin(2z) = 2 \sin(z) \cos(z)$ Terbukti' (Therefore, it is proven).

Figure 1: One of prospective mathematics teacher's answer of no 1a.

Figure 1 shown that the prospective mathematics teacher is seen to be doing proving based on trigonometric complex function.

Question 2:

If $z = x + iy$,

show that:

$$e^{iz} = \frac{1 + 2 \sin x (i \cos x - \sin x)}{e^{2y}} \quad (1)$$

In this question, prospective mathematics teachers are instructed to do logical reasoning to show a complex function equation based on the given information.

2. Jika $z = x + iy$, tunjukkan bahwa

$$e^{iz} = \frac{1 + 2 \sin x (i \cos x - \sin x)}{e^{2y}}$$

$$e^{iz} = e^{i2(x+iy)}$$

$$= e^{i2x - 2y}$$

$$= \frac{e^{i2x}}{e^{2y}} = \frac{1 + \sin(2x)i - 2\sin^2 x}{e^{2y}}$$

$$= \frac{1 + 2i \sin x \cos x - 2\sin x \sin x}{e^{2y}}$$

$$= \frac{1 + 2 \sin x (i \cos x - \sin x)}{e^{2y}} \quad (\text{Benar})$$

Figure 2: One of prospective mathematics teacher's answer of no 2.

Figure 2 shown that the prospective mathematics teacher is trying to show a complex function equation by using the definition of exponent complex function.

Question 3:

By using complex function derivative definition, determine

$$f'(z) \text{ of } f(z) = ze^{iz} \quad (2)$$

In this question, prospective mathematics teachers are instructed to use formula or certain rules to do calculation, which is doing differentiation by using the definition of complex function derivative.

Figure 3 shown that the prospective mathematics teacher is trying to use the definition of derivative to differentiate the given complex function.

Figure 4 shown that there are 4.76% of prospective mathematics teachers that lies on very good category, 4.76% of prospective mathematics teachers on good category, 33.33% of students on moderate category, 52.38% of prospective mathematics teachers on not good category, and 4.76% of prospective mathematics teachers on not very good category. Descriptive statistic test is done to get more data about prospective mathematics teachers' deductive reasoning ability.

3. Dengan menggunakan definisi turunan fungsi kompleks, tentukan $f'(z)$ dari $f(z) = ze^{iz}$

Jawab

Diketahui : $f(z) = ze^{iz}$
 dan turunan fungsi kompleks didefinisikan dengan :

$$f'(z) = \lim_{\Delta z \rightarrow 0} \frac{f(z+\Delta z) - f(z)}{\Delta z}$$

sehingga

$$f'(z) = \lim_{\Delta z \rightarrow 0} \frac{(z+\Delta z)e^{i(z+\Delta z)} - (ze^{iz})}{\Delta z}$$

$$= \lim_{\Delta z \rightarrow 0} \frac{(z+\Delta z)e^{iz} + e^{i\Delta z} - ze^{iz}}{\Delta z}$$

$$= \lim_{\Delta z \rightarrow 0} \frac{ze^{iz} + ze^{i\Delta z} + \Delta ze^{iz} + \Delta ze^{i\Delta z} - ze^{iz}}{\Delta z}$$

$$= \lim_{\Delta z \rightarrow 0} \frac{ze^{i\Delta z} + \Delta ze^{iz} + \Delta ze^{i\Delta z}}{\Delta z}$$

$$= \lim_{\Delta z \rightarrow 0} \frac{ze^{i\Delta z}}{\Delta z} + \lim_{\Delta z \rightarrow 0} e^{iz} + \lim_{\Delta z \rightarrow 0} e^{i\Delta z}$$

$$= e^{iz} (1+z)$$

dengan definisi turunan fungsi kompleks diperoleh turunan dari $f(z) = ze^{iz}$ adalah $f'(z) = e^{iz} (1+z)$ //

Figure 3: One of prospective mathematics teacher's answer of no 3.

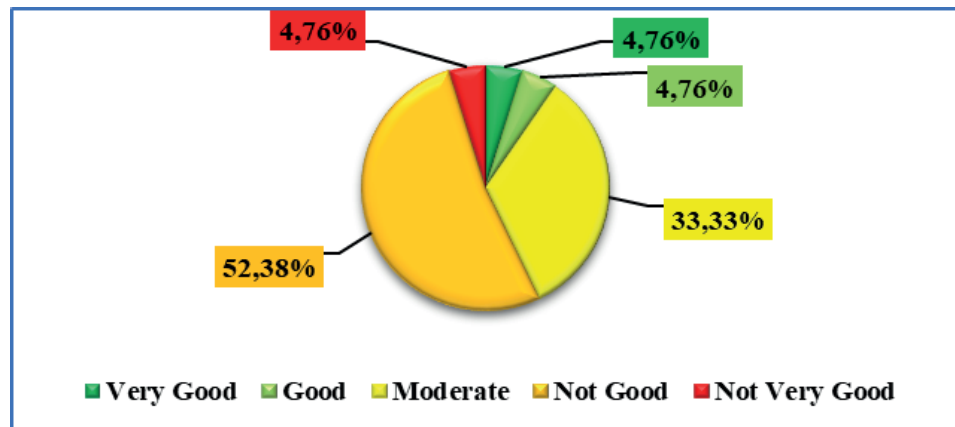


Figure 4: The Data of deductive reasoning ability in percentage.

TABLE 1: Descriptive data of deductive reasoning ability.

Minimum Score	Maximum Score	Mean
15	85	42.86

Table 1 shown that the minimum score is about 15, maximum score is at 85, dan the mean of the test is 42.86. Hence, it is known that deductive reasoning ability of students in Complex Analysis course is on moderate category (42.86).

3.2. Prospective mathematics teachers' Mathematical Resilience in Complex Analysis Course

The questionnaire in this test resulted the data of prospective mathematics teachers' mathematical resilience in the form of likert scale, which will be analyzed through the mean score so categorizing could be done.

TABLE 2: Students' mathematical resilience distribution.

Indicator	Item Mean	Total Mean
1	2.73	2.72
2	2.88	
3	2.33	
4	2.93	
5	2.73	
6	2.71	

Table 2. shown the mean of prospective mathematics teachers' mathematical resilience distribution. The indicator of 1, 2, 4, 5, and 6 is on positive category, while indicator 3 is on negative category. Since the total mean score is obtained, it could be interpreted that the students' mathematical resilience in Complex Analysis course is on positive category (2.72).

3.3. Correlation Analysis of Deductive Reasoning and Mathematical Resilience

3.4. In Complex Analysis Course

Normality test is done first to check whether the data in this research is normally distributed or not. The data normality test is done through Shapiro Wilk test, which assisted by Jamovi 1.6.23.

TABLE 3: Normality test.

	Descriptives	
	PD	RM
Shapiro-Wilk W	0.933	0.943
Shapiro-Wilk p	0.161	0.250

By looking at Table 3 it is known that the Shapiro-Wilk p score of deductive reasoning (PD) data is 0.161 and the score of mathematical resilience (RM) data is 0.250. With the significance of 5%, the data could be mentioned as normally distributed data

so the parametric test in this study could be executed. The analysis of the connection between deductive reasoning ability and mathematical resilience is done through product moment correlation test, which assisted by Jamovi 1.6.23. The linearity test of deductive reasoning ability (Y) and mathematical resilience (X) is done before continuing to test the correlation.

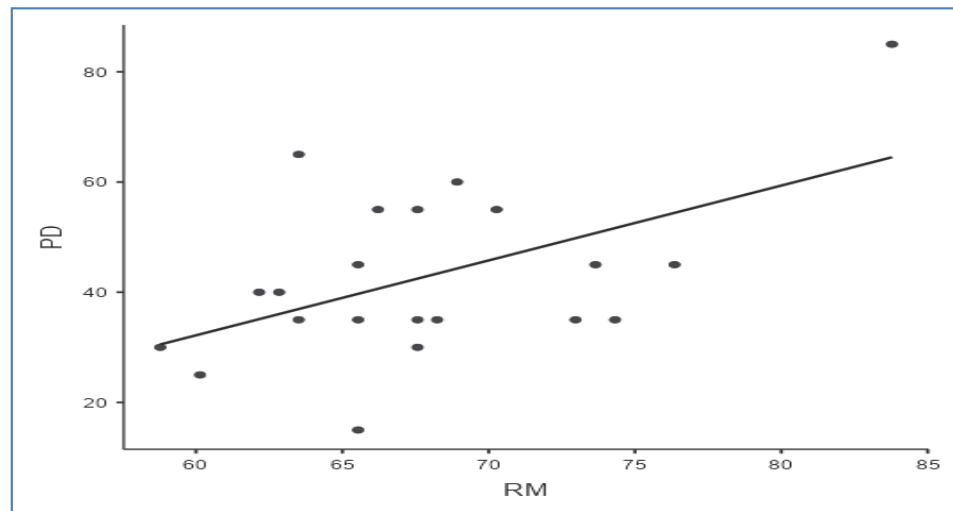


Figure 5: Linearity test.

Figure 5. shown the result of linearity test which could be stated that deductive reasoning ability (PD) and mathematical resilience have linear correlation that indicated by a linear line that transversed from left-bottom to right-top which also indicates that there is a positive correlation between the two variables.

TABLE 4: Product moment correlation test.

Correlation Matrix			
		PD	RM
RM	Pearson's r	0.514 *	—
	p-value	0.017	—

Note. * p < .05, ** p < .01, *** p < .001

Table 4. shown the result of product moment correlation test. It can be stated that there is a connection between deductive reasoning ability (PD) and mathematical resilience (RM) in Complex Analysis course with the score of 0.514, which can be interpreted as moderate level. This finding is corresponded with the study that shown there is a significant and positive correlation between mathematical resilience and students' academic ability [18]. The research [17] obtained the similar result which can be interpreted that there is a significant correlation between problem solving ability and mathematical resilience.

4. CONCLUSION

This study shown that prospective mathematics teachers' deductive reasoning ability in Complex Analysis is categorized on moderate level (42.86), prospective mathematics teachers' mathematical resilience in Complex Analysis is on positive category (2.72), and the correlation between deductive reasoning and mathematical resilience in Complex Analysis is categorized as positive and on moderate level (0.514). By knowing the existence of correlation between deductive reasoning and mathematical resilience, teachers are expected to be able to implement learning process that could improve the aspects of cognitive and affective.

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