Self-concept of pre-service mathematics teachers who gets a pedagogic approach suggested by APOS theory and direct learning as a comparison

M W Afgani¹,² *, D Suryadi² and J A Dahlan²

¹Department of Mathematics Education, State Islamic University of Raden Fatah, Jalan Prof. K. H. Zainal Abidin Fikri, KM. 3.5, Palembang 30126, Indonesia
²Department of Mathematics Education, Universitas Pendidikan Indonesia, Jalan Dr. SetiaBudhi No. 229, Bandung 40154, Indonesia

*afgani@student.upi.edu

Abstract. The aim of this study was to investigate the difference between pre-service mathematics teachers’ self-concept who gets a pedagogic approach suggested by APOS theory and direct learning in terms of students overall and their mathematical initial ability group. The pedagogic approach is Activity-Class Discussion-Exercise (ACE) teaching cyclic, whereas direct learning is a traditional approach. This study used a quasi-experiment method with post-test-only control design. The research subjects were 120 pre-service mathematics teachers from two universities in Palembang, Indonesia. They were divided into experiment and control class which 62 students were placed in a learning atmosphere that applied ACE teaching cyclic, whereas 58 of them were given direct learning. Instruments that used in this study were self-concept questionnaire, observation, and interview. Data analysis tests used in this study were t-test and Mann-Whitney U test. The results of data analysis descriptively showed that pre-service mathematics teachers self-concept in experiment and control class are categorized very positive in terms of students overall and their mathematical initial ability group. From inferential statistical analysis, the result showed that there is no significant difference between pre-service mathematics teachers’ self-concept who gets ACE teaching cyclic and direct learning in terms of overall and mathematics initial ability group. Based on the result, we concluded that ACE teaching cyclic and direct learning influent pre-service mathematics teachers’ self-concept very positively and there is no significant difference between two approaches in this study.

1. Introduction

Self-concept is one of internal factors relate to affective aspect which can influent individual’s academic. A main reason to investigate affective aspect in mathematics education, according to Reyes [1], is to find a way to help students learn mathematics deeply. Another reason is to achieve positive attitude toward mathematics, because it is also an important result for education, beside cognitive aspect. The decision about how deep a student understands mathematics in school can be effected by her/his affective characteristics. Oppenheimer [2] defined self-concept as individual characteristics derive from inside him/herself. The self also reflects the way of individual think about his/her potencies and future. Besides that, self-concept is a thought about an individual belief, view, and appraisal to him/herself [3]. Self-concept consists of the way of individual view her/himself as a person, individual feelings about...
her/himself, and an individual view becomes the human that s/he expects. Leonard and Supardi [4] also implied that self-concept is an individual positive respond to her/himself and her/his life. Self-concept is a factor formed through academic and non-academic experience that interacts with others.

Reyes [1] emphasized that academic self-concept is an individual perception about her/himself relate to performance in school. Singh [5] also had a similar view. He viewed that Self-concept also called self-construction, self-identity, or self-perspective that defined as a multidimensional concept leads to individual perception of “self” in relationship to some characteristics as academic or non-academic. The important role of students’ self-concepts, according to Tan and Yates [6], is the adaptation of an individual to the academic environment. The relationship between the two variables and their respective influences with each other cannot be ignored. Siagian [7] stated that the self-concept that exists in an individual is formed through a reciprocal process between him/herself and another individual. The individual will think positively about him/herself, if the people around him/her like him/her or think he/she has a role. For that, teachers need to create an atmosphere of learning that can optimize the self-concept of each student, so that it will affect their learning outcomes.

Teachers’ efforts to improve students' self-concept of mathematics have been done a lot by providing a diverse learning approach, but the results do not show any significant positive impact yet. The study results of Afgani, et al [8] revealed that some self-concept of pre-service mathematics teachers are still low. This indicates that the problem also occurs until the level of undergraduate students majoring in mathematics education. Self-concept that has not been optimal will affect the students’ academic ability, because there are several aspects in self-concept that is directly related to academic ability. Therefore, one of many solutions that can solve the problem is to provide a learning approach that can optimize the self-concept of the pre-service mathematics teachers so that it affects their mathematics understanding. This is because the prospective teacher will be transformed into a teacher where the self-concept that is formed during college in mathematics education will influence her/his mathematical understanding while teaching in school later. One of the pedagogical approaches that can be applied is ACE teaching cyclic based on APOS theory. This approach can develop hard skills such as mathematical understanding ability, as well as soft skill in the form of self-concept in learning mathematics, because according to Sumarmo [9], in general, all learning approaches can be implemented to develop various students’ mathematical hard skills and soft skills from elementary to university level.

ACE (Activity-Class discussion-Exercise) teaching cyclic based on APOS theory suggests three phases of activity, that are, activities in computer labs, classroom discussions, and exercises by completing tasks outside the classroom [10]. In computer labs, in this study, mathematics learning activities related to computer programming with Maple. The activity of writing computer syntax requires students to do it logically, thoroughly, and carefully. Students must be careful because the program used is Sensitive Case, this means the use of uppercase or lowercase letters affect the program output. Logical thinking is necessary in a mathematical understanding and will form rigorous students where it is a part of the personality in the self-concept aspect that needs to be trained. The activity phase after studying in the laboratory is discussion. In that phase, students are directed to group discussions where in the discussion process will train students to argue with each other to find the truth and solution of a problem. In group discussions, according to Byrd [11], high ability students can help provide explanations to other students whose underlying abilities on the given problem. The results of the group discussions were brought to class discussions. During classroom discussions, students are trained to share their knowledge and mathematics experiences with friends, and learn to appreciate differences of argument. Self-concept that can be formed from the discussion activity is the concern and tolerance of mutual respect. Unlike the case with the atmosphere of direct learning, the approach is a teacher-centered pedagogical approach, few activities involving students, and focused on obvious didactic communication in the form of delivering material they need to know and learn [12]. This means that direct learning does not require students to be actively involved in the learning process, while APOS learning facilitates various activities in students to construct mathematical knowledge.

Based on the background above, ACE teaching cyclic based on APOS theory can enable students to study mathematics with a variety of activities compared to direct learning which involves less student
activeness. The activities involve student self-concept. This shows that students' self-concept in learning mathematics can be developed through the application of ACE teaching cyclic based on APOS theory, but to what extent is the difference between the effects of the two approaches. That is the focus of this research. So, the research problems in this study was “is there a significant difference between pre-service mathematics teachers self-concept who gets ACE teaching cyclic and direct learning in terms of overall and mathematics initial ability group?”

2. Experiment method
This study used a quasi-experiment method with posttest-only control design. The research subjects were 120 pre-service mathematics teachers from two universities in Palembang, Indonesia. They were divided into experiment and control class which 62 students were placed in a learning atmosphere that applied ACE teaching cyclic as experiment class, whereas 58 of them were given direct learning as control class. In this study, the learning factors as independent variable, self-concept as dependent variable, and students’ mathematics initial ability as control variable. To know students’ mathematical initial ability group, we tested them with seven mathematics problems relate to calculus preliminary. The result showed that, in experiment class, there were 11 students with high ability, 45 students with average ability, and 6 students with low ability, whereas in control class, there were 11 students with high ability, 36 students with average ability, and 11 students with low ability. Instruments that used to investigate pre-service mathematics teachers’ self-concept in this study were self-concept questionnaire that was developed by Afgani, et al. [8], observation, and interview. Data analysis tests used in this study were t-test and Mann Whitney U test to investigate the differences between the two data sets which t test for normal distributed data, whereas Mann-Whitney U for non-normal distributed data.

3. Results and discussion
In this study, the data of pre-service mathematics teachers’ self-concept was analyzed after they were given ACE teaching cyclic based on APOS theory and Direct Learning (DL). First, we analyzed descriptively the mean scores of student self-concepts in the experiment and control classes in terms of overall and Mathematical Initial Ability (MIA) groups. Second, the further analysis of the data used inferential statistical test. Descriptive statistical results of student self-concept data showed that the average scores of student self-concept in the classroom that ACE teaching cyclic apply in terms of overall (82.757) and MIA group (High = 83.929, Average = 82.526, Low = 82.341) are smaller than the class applied by direct learning (Overall = 83.928, Average = 84.711), except for students with high (83.279) and low (81.980) MIA group. Nevertheless, on a scale of 0-100, the average self-concept score of pre-service mathematics teachers after being treated indicates the level of their self-concept in both classes as a whole or group of MIA included in very positive category. To obtain a better analysis, the students' self-concept data is further analyzed through a test of differences between the experiment class and the controls viewed in overall and each MIA group.

The difference test of self-concept between pre-service mathematics teachers who experience ACE teaching cyclic based on APOS theory and direct learning on each MIA group use the t-test, whereas the data in terms of students overall use Mann Whitney U test, because the data is not normally distributed. The results of the difference test of pre-service mathematics teachers’ self-concepts are summarized in table 1.
Table 1. Difference test results of self-concept between pre-service mathematics teachers in experiment and control class.

| MIA Group | Learning Factor | n   | Sig.  | H₀  |
|-----------|----------------|-----|-------|-----|
| High      | ACE            | 11  | 0.803 | Accepted |
|           | DL             | 11  |       |      |
| Average   | ACE            | 45  | 0.076 | Accepted |
|           | DL             | 36  |       |      |
| Low       | ACE            | 6   | 0.932 | Accepted |
|           | DL             | 11  |       |      |
| Overall   | ACE            | 62  | 0.172 | Accepted |
|           | DL             | 58  |       |      |

From Table 1, the result of the difference test of students’ self-concept between the experiment and control classes shows the sig. values are greater than p-value = 0.05 which means H₀ accepted. This can be concluded that there was no significant difference of self-concept between students that is applied ACE teaching cyclic based on APOS theory and direct learning in terms of students overall and group of MIA.

ACE teaching cyclic is developed based on APOS theory which the theory is a part of constructivism view. So, we compared the result of this study with the result of previous studies which used constructivism view as the philosophy in learning process, compared it with traditional approach which equivalent with direct learning in this study. The studies were reported by Kim [13] and Yanti [14]. They reported that there is no significant difference between students’ self-concept who get a pedagogic approach based on constructivism view and traditional approach. It means that the result of this study supported their result. We also found a study that investigates a pedagogic approach based on APOS theory, but dependent variable of the study was not self-concept, but relates it. The study reported by Lestari [15]. She reported that there is no significant difference between students’ learning motivation that gets M-APOS and conventional model. Her result study was relevant and corresponded with this study. It means that the result of this study also supported her result.

In this study, the aspects of self-concept that we observed to pre-service mathematics teachers include individual concern, social identity, individual personality, view of the future, the influence of others who become role models, the influence of the environment inside or outside the classroom, and view of the mathematics. In view of every aspect of self-concept observed in this study showed that pre-service mathematics teachers in the experiment and control classes have very positive self-concept after they were given treatment. This means they had very positive beliefs, views, thoughts, and appraisal as pre-service mathematics teachers. From the aspect of individual concern, students in both classes had a very high concern. One of those concerns is that they were happy to help when their friends are having difficulty in calculus task either during classroom discussions, as well as on outside class tasks. From the aspect of social identity, students in both classes felt very proud to be pre-service mathematics teachers. In view of the aspect of personality, students in both classes appraisal themselves to have a good personality as pre-service mathematics teacher. This aspect is directly related to academic ability. The results of Bjurberg and Ekman [16]’s study showed that a persistent personality, disciplined, orderly, open with criticism, and likes what is learned positively correlates with academic achievement. From the results of the investigation, we observed that they feel they have done their utmost to demonstrate the ability of mathematical understanding, although the facts showed the results are not as expected. Interviews with some students revealed that their efforts to succeed have not been optimal. This is because the time they provided to study calculus outside the classroom is not maximized, they solved on similar problems with the examples, and they easily give up when they met difficult questions. This means they were confident to solve mathematics problem, if the problem is as simple and exemplified. Besides that, especially for pre-service mathematics teachers in experiment class, they
rarely used Maple as a learning tool, they only used the exemplified syntax, and they did not explore Maple any further. The results of the interviews show that they were less persistent in learning calculus.

Viewed from the aspect of the view of the future, pre-service mathematics teachers in both classes had a very positive appraisal of their future. One form of appraisal is that they felt confident that they will be good math teachers. From the aspect of the influence of others who become role models, they felt there are some people around them that give a very positive influence in forming their self-concept. One of them is a teacher. This finding is consistent with the results of Bashir, et. al. [17]’s study which revealed that the majority of respondents in their study chose teachers as their role models. Viewed from the aspect of the influence of interaction with the environment in the classroom, students in the experiment class felt their self-concept was positively formed, while the students in the control class felt very positive. One form of interaction influence is the influence of the given learning factor. Differences in the assessment from two classes due to ACE teaching cyclic based on APOS theory is a new treatment for students in the experiment class, whereas direct learning is the treatment that is commonly accepted by students in the control class. Viewed from the aspect of the influence of interaction with the environment outside the classroom, students in both classes felt the interaction outside the classroom gives a very positive influence on their self-concept. One form of that influence is group learning activities in doing tasks in campus environment. They felt the campus environment is an ideal place to learn together rather than study at home alone. The results of interviews from some students revealed that it is because they felt need a friend while study. According to them, study in group can exchange information, can directly ask and search for answers together, reducing doubts on the answer to the task. This finding is appropriate with the results of Burke’s [18] observation. According to Bentley and Warwick [19], study in group disadvantages includes unequal contributions among group members and dependence on others. Their results also occurred in this study. Findings from observations during group or class discussions showed that some students feel less confident in their own answers. This is evident from some of them confirming answers to other friends. They confirmed by asking, what about your answer? Or what do you get?. The last aspect is the view of mathematics. They realized that calculus is needed for them.

From the results of the discussion above, the cause of there was no significant self-concept differences between pre-service mathematics teachers who gets ACE teaching cyclic based on APOS theory and direct learning in terms of overall and group of MIA due to many aspects that influence their self-concept, although from the aspect of personality seems to lead to negative self-concept, because the others aspect also contribute to the formation of their self-concepts, so it makes their self-concept into a very positive category.

4. Conclusion

From this study, we have succeeded to investigate the difference between pre-service mathematics teachers’ self-concept who gets a pedagogic approach suggested by APOS theory and direct learning in terms of students overall and their mathematical initial ability group. We concluded that ACE teaching cyclic and direct learning influent pre-service mathematics teachers’ self-concept very positively and there is no significant difference between two approaches in this study, because there were many aspects that influence their self-concept. So that, we recommended for further study to investigate what aspects of self-concept directly influence students' academic ability in mathematics.
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