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Research Article

The Difficulties of Prospective Elementary School Teachers in Item Problem Solving for Mathematics: Polya's Steps

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Abstract

Problem-solving in mathematics is one of the skills that have to be mastered by elementary school teacher candidates. This study aimed to analyze the difficulties of prospective elementary school teachers at the Universitas Muhammadiyah Malang (UMM) in item problem solving for mathematics. This research was a descriptive exploratory with a qualitative approach. The subjects were elementary school teacher education students at the UMM, who attended the Elementary School Mathematics Learning course II, totaling of 38 students. The instrument used was a mathematical problem based on HOTS, while the interview and observation referred to problem-solving strategies based on Polya's steps (ability to understand problems, ability to plan problems, ability to act based on a plan, and ability to re-check answers). Data analysis was performed by analyzing the written answer sheets of the subjects while coding and grouping the subject's learning styles. The data from the interview and observation were analyzed with content analysis. The results showed that students still experienced difficulties in all Polya's steps. The ability of problem-solving based on Polya's steps include understanding the problem, planning, and writing strategies, as well as carrying out activities according to plan. The results of the study stated that only 5.3% of students were in a good category. Students also have had difficulty in re-checking answers, because only 8% of students did the work correctly. It can be concluded that the ability of problem-solving in Mathematics based on Polya's steps was still relatively weak.

Keywords:

Polya's steps, prospective elementary school teachers, problem solving

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Introduction

Being a teacher is a profession that requires knowledge and skills in order to meet the requirements or demands of the students' needs (Liakopoulou, 2011; OECD, 2005, 2009). The task of students of the Education study program is to prepare themselves to become professional teachers in the future (Gomez, 1993; Osmanoglu, Isiksal, & Koc, 2015; Stacey Donaldson, 2010). They must know better and more about how to teach the appropriate subject, and must have knowledge and skills related to the teaching-learning process (DeJarnette, 2016; Ecevit, Yalaki, & Kingir, 2018; Kloser, Wilsey, Madkins, & Windschitl, 2019; Uyanik, 2016).

One of the skills that have to be acquired by students, especially those who currently act as prospective teachers is problem solving (Eichmann, Goldhammer, Greiff, Pucite, & Naumann, 2019; Foshay & Kirkley, 1998; Osmanoglu et al., 2015; Whimbey, Lochhead, & Narode, 2013; Widaninggar, Mardiyana, & Kurniawati, 2017). Problem-solving is a process of finding a solution to achieve certain goals (Eichmann et al., 2019; Khoiriyah & Husamah, 2018). Problem-solving is a planned process that needs to be carried out in order to obtain a distinct solution of a problem, both for routine and non-routine problems (Dostál, 2015; Goldhammer et al., 2014). Problem-solving skills train students to figure out solutions of a particular problem-based issue in learning mathematics and finding appropriate solutions (Billstein, Libeskind, & Lott, 2016; Ersoy & Bal-Incebacak, 2017; Esan, 2015). It is a complex process, containing affective and behavioral processes, and is based on cognitive processes that are the result of finding a way out of difficulties and strategies to deal with obstacles (Clark, Cuthbert, Lewis-Fernández, Narrow, & Reed, 2017; Gaudiano, 2008).

Systematically, the importance of problem-solving can be seen from the three values that are functional, logical, and aesthetic. Functionally, problem-solving is crucial because, through problem-solving, mathematics and science as essential disciplines can be developed. With a focus on problem-solving as a tool in solving problems, this ability can be adapted to various contexts and daily problems. Aside from being a tool to increase knowledge and help understand everyday problems, problem-solving is also a way of thinking. The latter perspective, problem-solving helps us improve logical reasoning ability. Finally, problem-solving also has an aesthetic value. This approach can also challenge the mind and provide gradual of puzzles for students so that it can increase curiosity, motivation and persistence always to be involved in mathematics (Abramovich, Grinshpan, & Milligan, 2019; Belland, Kim, & Hannafin, 2013; Lindholm, 2018; Oyama, Manalo, & Nakatani, 2018). The benefits of providing problem-solving habit are the continuous development of students' cognitive abilities; their creativity is being honed as well. Besides, their ability to understand mathematical applications which are mostly smart problem solving is well-exercised, resulting in an increased motivation to further learn mathematics (Argarini, 2018).

There are ten problem-solving strategies, namely (1)act it out, (2) draw pictures or diagrams, (3) look for patterns, (4) make tables, (4) calculate all possibilities systematically, (5) guess and check, (6) work backwards, (7) identify information that is not needed, (8) write open sentences, and (9) use more simple examples (Yayuk, Ekowati, Suwandayani, & Ulum, 2018). Prospective teachers should already have the ability to use problem-solving strategies to solve the problems or challenges they face. Problem-solving ability is a form that can be learned. Accordingly, the main objective of the education program is to ensure that students can solve the problems they face in real life. In this context, prospective teachers should be trained in order to have adequate problem-solving skills (Yenice, Ozden, & Evren, 2012). Generally, in real-life condition, the ability mentioned above is still weak. Most teachers use different strategies for solving these problems (Avcu & Avcu, 2010; Bulut & Karamık, 2015).

Mathematical problem solving has long been considered an important part of mathematics and mathematics learning. In this connection, several experts have contributed to efforts to promote mathematical problem solving throughout the world (P. Liljedahl, Santos-Trigo, Malaspina, & Bruder, 2016). Regina Bruder provides a heuristic approach and outlook for problem solving (Reuter, Schnotz, & Rasch, 2015). This heuristic notion is included in Peter Liljedahl's summary, which looks specifically at the development of heuristics and leads to higher and creative aspects of problem solving (Peter Liljedahl & Sriraman, 2006). Then followed by Luz Manuel Santos Trigo who introduced the problem solving in and with digital technology (Santos Trigo, 2011). Their views and approaches refer to the critical way in the works of George Polya. There are four steps to problem-solving, namely getting to know the problem, forming a solution plan, carrying out the solution plan, and looking back or reflective act (Polya, 1981, 1988). A student is said to be able to understand a problem if he/she can express information on the problem well and not just answer questions (Gulacar, Bowman, & Feakes, 2013). The information is related to things that are known about the matters that are asked. Students can be considered to have understood the problem if they were able to reveal the data that is known and the data requested related to the problem at hand. the ability to uncover data and provide data involves the higher-order thinking skills (Herranen & Aksela, 2019; Hu, Chiu, & Chiou, 2019; Ichsan et al., 2019; Jacques, Cian, Herro, & Quigley, 2019; Ramdiah, Abidinsyah, Royani, & Husamah, 2019; Ramdiah, Abidinsyah, & Mayasari, 2018).

Based on the results of observations and initial discussions with students, it was revealed that concepts and materials related to problem-solving had never been obtained at the previous educational level. The content from the problem solving is one approach that teaches students to learn to solve problems actively, both mentally and physically. This is supported by the opinion of experts that teaching knowledge is not merely a matter of telling (Loughran, 2013; Schmidt, Wagener, Smeets, Keemink, & van der Molen, 2015; Worden, 2015). Learning is not an automatic consequence of pouring information into the minds of students (Başkale, Bahar, Başer, & Ari, 2009; Borg & Drange, 2019; Knight & Cooper, 2019). Learning requires mental involvement and work of the students themselves. Explanation and demonstration alone will not produce long-lasting learning outcomes, because the learning which can produce long-lasting outcomes is only can be done through active learning (Brame, 2016; Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2019; De Sousa, Richter, & Nel, 2017; Serdyukov, 2017) and also with and learning by emphasizing the phenomenon of daily problems (Muhlisin, Susilo, Amin, & Rohman, 2018).

Several things can project active learning. First, students must do many and various kinds of tasks. Second, they need to maximize the use of the brain to study ideas, solve problems, and apply what they learn. Third, active learning must be agile, fun, passionate, and full of passion. Fourth, students can even often leave their seats, with the concept of moving about and thinking aloud (Silberman, 1996).

Several previous research results claim that the ability to do problem-solving matters at the student level is still said to be weak. Hapizah (2017) shows that the problem-solving ability of students is still considered inadequate, especially the ability to review. Kania's research (2019) that was conducted in one of the provinces in Indonesia asserts that many students had difficulty in developing mathematical problem-solving abilities. Furthermore, Irwanto, Saputro, Rohaeti, and Prodjosantoso (2018) see that students taught by using a traditional approach experienced difficulty in connecting the concept and applying their knowledge to problem-solving situations.

Considering the urgency of the role of problem-solving in the field of mathematics study (in this case in Elementary School Teacher Education Study Program of Universitas Muhammadiyah Malang-Indonesia and observing the difficulties of students, it is necessary to make an urgent effort to see the condition and profile of problem-solving skills of students in the mathematics study program. Analyzing student difficulties during the problem-solving process is very important as the basis for choosing strategies or teaching materials suitable for the problem-solving skill. The results of Kaya, Izgiol, and Kesan (2014) research showed that there was a significant difference in their problem-solving skills and impulsive approach to problem-solving according to grades.

One factor that enhances learning is learning strategies or models (Hudha, Amin, Sumitro, & Akbar, 2018; Husamah, Fatmawati, & Setyawan, 2018; Muhlisin, 2019; Muhlisin, Susilo, Amin, & Rohman, 2016). According to Bal (2015), it is suggested that importance be given to classroom activities that positively affect the beliefs of primary school teacher candidates concerning problem-solving and learning mathematics. Mehmood (2014) emphasizes that Problem Solving Method was recommended for the teaching of Mathematics at Elementary level. The skill is also suggested to be taught in the teacher training program for better absorbance.

Problem of Study

Problem-solving approach, especially in learning mathematics, has several stages. Polya (1981, 1988) leads us to think in series as an effort to reduce difficulties when the problem-solving process occurs (Billstein et al., 2016; Dewi, Suarjana, & Sumantri, 2014; Kaya et al., 2014; Komariah, 2011; Mehmood, 2014; Rudtin, 2013; Sam & Qohar, 2016; Umar, 2016). Students' understanding of problem-solving facilitates them to teach how to think through HOTS, if they later become teachers. Information about students' abilities in problem-solving, including the difficulties they face, needs to be assessed thoroughly so that it becomes the basis for taking further solutions. If these conditions are not detected, it will be difficult for students to optimize their potential, both during the educational process and when the application of knowledge in professional work dues (Patnani, 2013). In this connection, the purpose of this study is to analyze the difficulties of prospective elementary school teachers studying in Mathematics study program at the Universitas Muhammadiyah Malang in solving problems based on Polya's steps.

Method

Research Design

This type of research is descriptive exploratory with a qualitative approach. In order know how active students learn (active learning) in mathematics, researchers conducted a careful and in-depth examination (exploration) of what was done, written and spoken by students while following the mathematics learning process.

Partcipants

The subjects in this study were The Elementary School Teacher Education students of Faculty of Teacher Training and Education at the Universitas Muhammadiyah Malang, Malang City, East Java Province, Indonesia, who took the Elementary School Mathematics Learning course II in the even semester of the academic year 2018/2019, totaling 38 people.

Instrument and Procedures

The main instrument in qualitative research was the researchers themselves, while the supporting instruments were mathematical problems based on HOTS. In order to get information about the active learning of the research subjects, activities were carried out to explore individual minds through the method of think-aloud and task analysis (Calder & Carlson, 2004; Someren, Barnard, & Sandberg, 1994). The data were collected through participants' written answers documents, observations, and semi-structured interviews with representatives of groups selected randomly based on their respective learning styles. All of the instruments were used to identify the problem-solving strategies (Polya, 1981, 1988), namely by understanding the problem, planning, implementing, and re-checking tasks.

Data Analysis

Data analysis was performed by analyzing the subject's written answer sheets by coding and grouping the subject's learning styles. While the data from interviews and observations were analyzed with content analysis which consisted of three activities that co-occurred, namely: data reduction, data presentation, and concluding (Miles, Huberman, & Saldana, 2014). These three data analysis activities were not hierarchical but were interwoven activities that interact with each other from before, during, and after data collection.

Results

The following data related to the results of the description of students' abilities in Problem Solving skill. The number of subjects displayed was as many as 38 of 6th-semester students who were randomly selected and were studying the Elementary School Mathematics Learning course II.

In order to see the students' ability to solve problems, the order was given by citing Polya's steps, they are:

Ability to Understand Problems

The problem given was "In the box below, there are numbers, from 1 to 9 that can be placed inside each box, so that the sum of three numbers in each row, each column and each diagonal is the same. Put the correct numbers!" As for the boxes of numbers were seen in Figure 1.

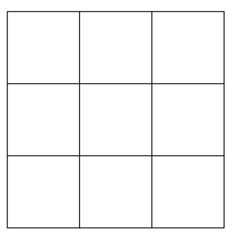

Figure 1.
The Blank Boxes of Numbers

The results of respondents' answers were: 26 students did not start by writing down what was known from the questions, two students wrote answers "a. There are numbers 1 to 9 that will be placed in the box; b. Three numbers in each row, column, and diagonal have the same number, while ten students gave answers that were known to only have numbers 1 to 9 which would be placed in a box, as in Table 1.

Based on the answers given, it can be seen that students' understanding of writing questions from what is known has not been fully categorized ‘good' (Error writing information on known things). This was indicated by, from the total of 38 students, only two students gave detailed and complete answers (5.3%), while the other ten students (26.3) still wrote down some of the known; even 26 students (68.4%) did not answer. This was reinforced from the results of the interview that students were not accustomed to working according to the sequence of steps. Students like to directly work from what was asked, even though they did not yet understand the essence of the problem.

Table 1.

The Data on Students' Ability to Write What is Known from the Problem

No	Ability to write what is known from the problem	Total of Students	Percentage (%)
1	Giving a detailed and complete answer	2	5.3
2	Giving an incomplete answer	10	26.3
3	No answer	26	68.4
Total		**38**	**100**

Ability to Plan Problems

The ability to write a plan that will be used to solve problems is related to the ability to choose a problem-solving strategy. Data as in Table 2 shows that two students (5.3%) wrote the answer "using a trial and error strategy by putting numbers 1 to 9. Only one student was answering that the strategy chosen by him was to draw the boxes, while 35 students did not write any answer.

Based on the written answers, it can be said that students had not been fully able to write down strategies that were supposed to be used to solve problems. Some tried to give answers, which were indicated by the incomplete elements written down as answers.

The inability to write down types of problem-solving strategies is strengthened from the results of interviews. Eventually, students were not accustomed to providing strategies for their answers; they just learned these types of problem-solving strategies in college. In the previous level, students were not familiar with this strategy at all.

Table 2.

The Data on Students' Ability to Plan Problems

No	Ability to Plan Problems	Total of Students	Percentage (%)
1	Able to select a strategy	2	5.3
2	Able to select a strategy but incomplete	1	2.6
3	No answer	35	92.1
	Total	**38**	**100**

Ability to Act Based on a Plan

In the following completion stage, students wrote their answers as in Figure 2 and 3.

1	**6**	**8**
5	**7**	**3**
9	**2**	**4**

Figure 2.
Answer 1

5	**3**	**7**
1	**8**	**6**
9	**4**	**2**

Figure 3.
Answer 2

The answer in Figure 2 projected that the number in columns and rows had fulfilled the requirements, which was 15, but the diagonals were not 15, but 12 (1 + 7 + 4) and 24 (9 + 7 + 8). Therefore, it was said that the students' answer was not correct. Based on the answers written by the students in Figure 3, in the column, row, and one of the diagonals, the total number was 15, but one column was still wrong because $9 + 8 + 7 \neq 15$, but 24.

Ability to Re-check Answers

In this step, students were to re-check their answers and to observe problem-solving variations. The data on students' ability to re-check their answers were presented in Table 3.

Table 3.
The Data on the Ability to Re-check Answers

No	Ability	Total of Students	Percentage (%)
1	Re-check and provide a correct answer	3	8
2	No re-check	35	92
	Total	38	100

Based on the data on Table 3 on the ability to re-check answers, only 8% of students work correctly. The description was 1) In row: 2 + 7 + 6 = 15 (correct); 9 + 5 + 1 = 15 (correct); and 4 + 3 + 8 = 15 (correct). 2. In column: 2 + 9 + 4 = 15 (correct); 7 + 5 + 3 = 15 (correct); and 6 + 1 + 8 = 15 (correct). 3. Diagonally: 2 + 5 + 8 = 15 (correct) and 4 + 5 + 6 = 15 (correct).

Based on this re-checking, students were increasingly convinced by the answers that have been written in the boxes that they were all correct. Their answers have fulfilled all the requirements in diagonal, row, and column, as in Figure 4.

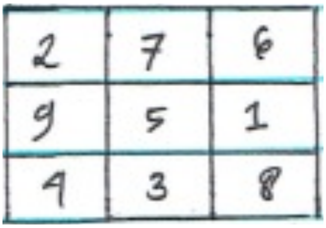

Figure 4.
The Correct Answer

Table 3 also displayed that there were 92% of students who still had not re-checked correctly; even they did not do this process. The answers of most students (whose answers were wrong) were exemplified in Figure 5.

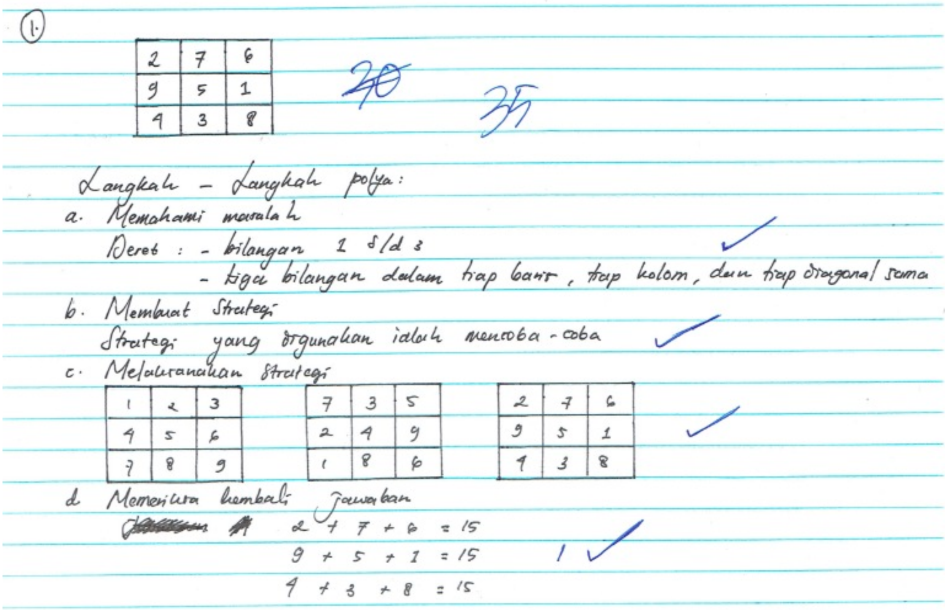

Figure 5.
An Example of Mostly Appeared Answers from Students (the Wrong Answer)

Discussion

The findings in Table 1 were in line with previous researches underpinning that many students do not understand the purpose of the mathematic problem being asked. Mathematic problems should not be able to be done directly without a deep understanding. Students must first understand "what is known" and "not known" from the problem and what is asked by the problem. In this case, the role of the lecturer is to help students express how the process runs in their minds when solving problems, for example, by asking students to tell the steps in their minds (Hapizah, 2017; Rudtin, 2013; Sam & Qohar, 2016). Students need to tell the steps that are in their minds, so they can acknowledge weaknesses in working on math problems. Weaknesses of students in working on math problems can be used as a source of learning information and understanding for lecturers. So, lecturers can design learning following the student's thinking process (Widaninggar et al., 2017). Students can also use this pattern when they become teachers later.

The findings in Table 2 strengthened by the results of the interviews showed that learning activities that have been performed by students tended not to encourage them to plan problems while finding a problem-solving strategy. In fact, according to Hadi and Radiyatul (2014), the more varied their learning experience, there is a tendency for students to be more creative in preparing a problem-solving plan followed by the problem-solving stage according to the plan deemed most appropriate. The ability to complete this second phase is heavily dependent on students' experience in solving problems.

Something will remain a problem if it is merely a challenge that cannot be solved by routine procedures known to students. Therefore, a problem may be a problem for a student, but it becomes a standard item for other students because those students have already known the procedure to solve it or has already solved a similar problem (Mahardhikawati, Mardiyana, & Setiawan, 2017).

To develop students' abilities in problem-solving, aspects of carrying out planning are determinant (Rudtin, 2013). What is applied depends on what has been planned before and also includes the following: deciphering the information provided in mathematical form and implementing the strategy during the process and the calculation that takes place. In general, at this stage, students need to maintain the chosen plan. If such a plan cannot be implemented, then students can choose other methods or plans (Cahyani & Setyawati, 2016).

The ability to analyze information used to solve problems is related to several other abilities, including identifying information, explaining the interrelationships of patterns and manipulating objects (Allen & Kelly, 2015). Students must be able to find the interrelationships between the existing information on the problem so that the plan of problem-solving can be executed (Mahardhikawati et al., 2017). Following Figure 2 and Figure 3, the student's answers were still wrong. This should be suspected because the previous stages (planning aspect) were not carried out correctly. According to Saputri (2019), aspects of planning in solving problems indeed become a pivotal part. If students plan before solving problems, students will be better able to organize problem-solving. Such a student will already know what steps he must carry out for the next stage, which is to execute the plan. However, most students only memorize and know the material, so they do not understand the essence of the problem.

One of the goals of learning mathematics is that students can solve problems. The problems raised are not just limited to routine problems but can be non-routine problems. The problem is a challenge for students to solve. Non-routine problems become difficult to solve because they cannot be solved using general mathematical concepts and principles. In solving those problems, an appropriate strategy is needed by combining all mathematical concepts and principles mastered by students (Argarini, 2018).

The ability of students to solve a problem could be seen from the ability to conduct a re-checking stage. Re-checking is a crucial step in solving problems. The ability to review suggests that students understand and can solve problems. In reality, based on Table 3, students often have problems with re-checking results. This finding is in line with previous research, affirming that the most significant difficulty of students is in the fourth step, which is to re-examine the results (Rustina & Heryani, 2017).

This is in line with the findings of Netriwati (2016), where students with a low level of mathematical knowledge are less likely to understand the mathematical problem. Although they are able to write down what they know and ask about the problem, they are not able to explain what has been done on the worksheet. They are only able to answer one problem correctly but cannot explain it. They also cannot plan well and are less able to use all the elements known to solve problems. Also, they are less able to carry out the problem-solving procedure. They are not able to explain the calculation process that has been made and have not been able to mention and write down how to re-check the answers that have been obtained in the given problem. They solved the problem heuristically by working on trial and error without paying attention to the stages in Polya's theory. Students with this category are generally less able to convey ideas and less able to communicate well according to what they have done and are not able to explain the results of the work they get.

This need has to be considered seriously by the lecturers and officials of the Elementary School Teacher Education Study Program because these students will later become teachers in primary schools (Tarusu, 2018). According to Anugrahana (2016), Elementary School Teacher Education Study Program must prepare prospective teachers who have several applied essential competencies. The basic competencies possessed by future teachers can be in the form of pedagogic, personality, social, and professional competencies. One of their tasks, is to prepare students to have the ability to solve problems as a provision in living life in order to become a fully human being. Therefore, lecturers should start paying attention to improving students' mathematical problem-solving abilities because it is one of the process skills that elementary school students need to have.

Conclusion

An analysis of the difficulties of prospective elementary school teacher candidates has been carried out in mathematical problem solving based on Polya's steps. The results showed that students still experienced difficulties in all Polya's stages. The ability to solve problems based on Polya's steps covers the act to understand the problem, plan, and write strategies, as well as carry out activities according to planning. The research proved that only 2 or 5.3% of students were in the 'good' category. Students also have difficulty in re-checking answers, because only 8% of students did the work correctly. It can be concluded that the ability of mathematical problem-solving skills based on Polya's steps is still relatively weak.

Such condition has to be immediately noted by the lecturers and managers of the Elementary School Teacher Education Study Program at the Universitas Muhammadiyah Malang-Indonesia. These students will later become teachers who serve in various regions in Indonesia. On a global scale, lecturers should carry out learning based on improving students' mathematical problem-solving abilities. Improving problem-solving abilities will be appropriate if done through active, creative, and innovative learning to be able to develop students' mathematical problem-solving abilities. Classroom action research, quasi-experiment, research and development based on mathematical problem solving really need to be done in the future, can be carried out by various researchers around the world especially developing countries, related to the thinking skills development of the elementary school teacher candidates.

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