Developing Mathematical Problem Posing Ability of Prospective Mathematics Teachers for Enhancing their Professionalism

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Abstract. Problem posing as one of the mathematical competencies is required by young generations to face complex problems in the era of the Industrial Revolution 4.0. Prospective mathematics teachers, who will become a teacher have to teach their students (as a member of young generations) problem-posing skills. However, not all prospective mathematics teachers are good at these skills. The purpose of this study is to find out how problem posing can enhance prospective mathematics teachers' professionalism and how to develop their mathematical problem posing ability. The method used is descriptive qualitative. There are literature reviews on 20 journals from the past 10 years that support and related to this study. The results show that developing mathematical problem posing ability can support and enhance prospective mathematics teachers' professionalism in order to face education in the era of the Industrial Revolution 4.0.

Keywords: Mathematical Problem Posing, Prospective Mathematics Teachers

1 Introduction

The advanced technological development in the era of Industrial Revolution 4.0 requires people to have a lot of skills including skills in creativity, innovation, critical thinking, problem-solving, communication, and collaboration. These skills are also in line with the Singaporean strategy in facing technological change, which covers analytical and evaluative capacities, complex problem solving, and effective collaboration capabilities [1].

The above-mentioned problem solving is not sufficient to solve problems; it needs also problem posing as its main step. It is stated in [2] that "Without posed problems, there are no problems to solve". "Problem posing is the natural capacity of the human mind, essential for surviving". Referring to the meaning of the words, problem-posing can be interpreted as an ability to raise problems.

According to [3], problem-posing has several meanings, namely, reformulation of the questions that have been given with some changes to make it easier for students to understand, formulation of questions related to the requirements on the questions that have been solved in order to find alternative solutions, and making questions from a given situation. On the other hand, problem-posing known as activities to formulate problems. Problem posing requires students to formulate questions or reformulate them based on the given information and related problems.

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Prospective mathematics teachers, who will become a teacher have to teach their students (as a member of young generations) problem-posing skills. They must have good mathematical problem posing skills to be able to teach well. But in reality, there are still many prospective mathematics teachers who have poor problem-posing skills. As revealed in [4] states the problem-posing ability of prospective mathematics teachers is still low.

Prospective mathematics teachers still have difficulties in mathematical problem posing. As stated in [5], the reason is prospective teachers remain dependent on the course books during their education and they do not face problem-solving studies. Besides, researchers in [6] also determined that prospective mathematics teachers posed verbal word problems. They could not fulfill the expectations of mathematical thinking and reasoning. Furthermore, they indicated that prospective teachers had misconceptions about problem concept and they got confused between the concepts of problem and exercise. They also expressed that prospective classroom teachers and mathematics teachers could not manage to go beyond mathematical problems given in textbooks. In their studies, they concluded that prospective teachers had difficulties in organizing the problems, understanding the features of problems and had common mistakes.

To overcome the difficulties and low problem-posing skills, prospective mathematics teachers should learn and develop these skills. As well as stated in [7] that teachers have an essential role in the implementation of problem-posing into the curriculum. They have to develop skills in problem posing and must be able to create tasks including situations that are suitable for students to engage in problem posing.

In this study, we will find out how to develop mathematical problem posing ability for prospective mathematics teachers according to explanation and guidance forward in some journals. We will explain how mathematical problem posing can enhance their professionalism in the era of the Industrial Revolution 4.0.

2 Research Method

The method applied in this research is descriptive qualitative. According to [8], qualitative research is used in natural object conditions, the researchers act as the key instruments, data collection is done purposively, data merging techniques are done by the triangulation, data analysis is inductive or qualitative, and the results of research emphasize more on meaning than generalization. Triangulation is a data collection technique that combines various data collection techniques (literature reviews and interviews) and existing data sources. When the triangulation is employed, the process of data collection and testing its credibility is done simultaneously. Additionally, the descriptive method is a method that aims to describe a research object that is examined through the sample or data that has been collected and make conclusions that are generally accepted [9].

The data collection in this study was purposive. There are literature reviews on 20 journals from the past 10 years that support this study. The selected data will be divided into several categories. Firstly, education challenges in the era of the Industrial Revolution 4.0 and what should the prospective mathematics teachers have to face it. Secondly, mathematical problems posing and why the prospective mathematics teacher should be good in those skills. Thirdly, strategies for developing mathematical problem posing skills.

In addition, this study is enriched by interviews with two prospective mathematics teachers about the importance of having mathematical problems posing skills in the era of the Industrial Revolution 4.0. This will add to the reference and diversity of research results.

In the interview, we asked some questions that will lead us to the information we need, such as: What do you think is the challenge of being a mathematics teacher nowadays? What have you prepared besides going to school and studying the science of mathematics? Do you know mathematical problem posing skills? Do you think mathematical problem posing is very important for a prospective mathematics teacher in this era?

After the data collection stages are completed, the data will be analyzed deeply using inductive analysis to get the representative results. Therefore, this descriptive qualitative method is expected to be a suitable method for this study because it can clearly describe the purpose of this study.

3 Findings and Comments

3.1 Educational Challenges and What Should Prospectives Mathematics Teachers Prepare to Face It.

In this study, we found many research articles are related to educational challenges in the era of Industrial Revolution 4.0, all of them stating that in this era we will face rapid change in the technological and digital tools. The work that is usually done by humans is replaced by the existence of computers and telecommunications that can expand the work and tasks of humans [10]. A lot of jobs and works will be limited and might become different from the previous era. Some works will fully disappear for humans because it can be replaced by machines and technology. For example, the human cashier in Indonesia's highway has been replaced by the tap card machine to make it more efficient. Not only with humans, but also we will compete with Artificial Intelligence (AI), robots, machines, and so many technological tools. In this era, lifelong learning becomes a necessity for humans to compete with machines [11].

In fact, the Industrial Revolution 4.0 required the ability to use a digital device and another technological tool. No exception in the field of education. We can found so many software applications and sources to get knowledge, even we can learn by ourselves in our home. If we cannot use it, we will be left behind. But it doesn't mean students or even the teachers are aware of global issues, learning and innovation skills, or how to solve their problems in life. Only those with the knowledge and skills in dealing with continuous changes and adapting oneself to new situations will be successful [12].

A prospective mathematics teacher should be aware of this education challenge. Their role in transferring knowledge might be replaced by online sources or software applications. Sink or swim, a prospective mathematics teacher should learn how to use it so they can still provide their students through it. They should take the advantages, but it is not enough just to have the knowledge in today's era.

Rapid changes in technology also bring complex problems, and peoples need skills to solve it. We found in [13] that the PISA result of American students is lower than the average, the benchmark assessment in reading, mathematics, and science for the developed countries of the world. These assessments measure the applied skills of critical thinking and problem-solving. It is contrary to the needs of this era. We have to provide students to have analytical thinking, critical thinking, creative thinking, and problem-solving skills is necessary, so they can survive in this era. The participants in the interview also stated the biggest challenge was educating and preparing students to face problems in their lives by increasing their thinking skills. The knowledge students get from learning is one of their footholds in adapting. But education must

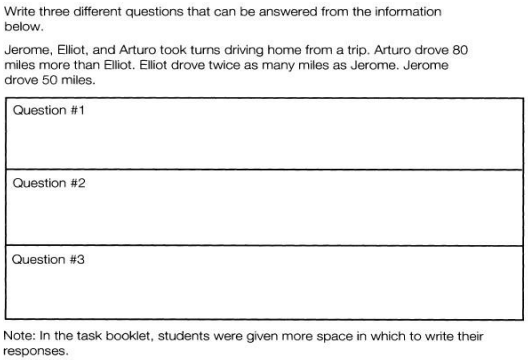
facilitate the development of students from various aspects and skills, including problem-posing skills.

We found in [14] three recommendations for teachers. First, disciplinary knowledge and domain knowledge are as important as ever and will continue to be so well into the foreseeable future. Educational systems remain fundamentally based on disciplinary knowledge and, as such, require teachers to be adequately trained and proficient in the disciplines. Second, knowing the technology is important, but knowing when and why to use is more important. Third, as a result of the increased opportunity for interaction across countries and around the world, teachers need to know how to foster cultural competence, emotional awareness, and leadership skills to facilitate not just interactions, but meaningful interactions and relationships. In line with the statements above, interview results show that participants argue they need to prepare themselves with knowledge to teach, psychological knowledge of students, and knowledge about the world nowadays. They have to be convinced that education must be in accordance with the times, and now is the age of the industrial revolution.

3.2 Mathematical Problem Posing and Why Prospective Mathematics Teachers Should Have It

Without a problem-posing, there will be no problem-solving. The result in [15] provided a theoretical argument that the quality of the problems subjects pose might serve as an index of how well they can solve the problem. Several researchers have conducted empirical studies examining potential connections between problem-posing and problem-solving. In other literature, problem-posing abilities are reported to be an important aspect or indicator of creativity in mathematics [16]. From that statement, it is obvious that problem-posing is one of the important skills in education, mathematics and also in life. Problem posing is required in all the steps of problem-solving.

It was described in [3] that problem posing as it is referring to both the generation of new problems and the reformulation of given problems, posing can occur before, during or after the solution of a problem. For the example, problem-posing task for middle school students that we found in [17] is going to be shown in **Figure 1**.


Write three different questions that can be answered from the information below.

Jerome, Elliot, and Arturo took turns driving home from a trip. Arturo drove 80 miles more than Elliot. Elliot drove twice as many miles as Jerome. Jerome drove 50 miles.

Question #1

Question #2

Question #3

Note: In the task booklet, students were given more space in which to write their responses.

Fig. 1. Problem-posing task [17]

When students are posing problems, they will respond differently to each task. The data coding scheme summary for the student response from [17] is shown in **Figure 2**:

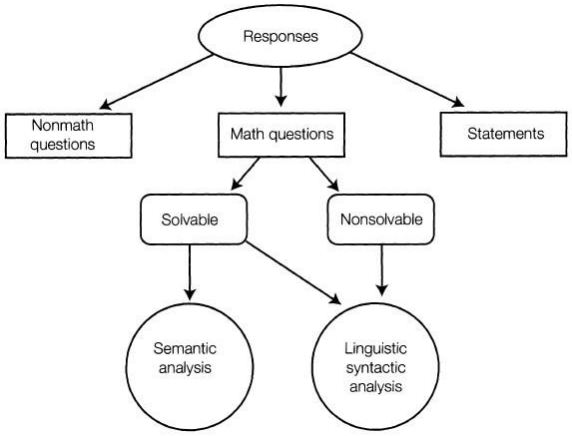


Fig. 2. Summary of multiple-step data coding scheme [17]

Students' problem-posing responses were first categorized as mathematical questions, nonmathematical questions, or statements. Those responses are given in the form of mathematical questions when taken together with the information given in the task core, which can be considered to constitute a mathematical problem. Thus, it is possible to consider student-generated questions to be problems and to analyze them as such. The next step involved categorizing the mathematical problems as solvable or not solvable. Problems were considered to be not solvable if they lacked sufficient information or if they posed a goal that was incompatible with the given information. For example, the response, "Did Arturo drive faster than Jerome?" was considered to represent a problem that was not solvable because information regarding relative driving speeds or times was neither given in the task nor supplied by the student. An example of an "impossible" problem-one in which the goal is incompatible with the conditions-is the response, "How many miles more did Jerome drive than Elliot?". The last step in the coding process involved examining the complexity of the posed problems. One type of complexity was related to the linguistic or syntactic structures embedded in the posed problems [17].

Furthermore, to generate new problems can use some strategies depend on the most suitable conditions (mathematics content, student levels, learning outcomes and mathematical thinking types) [18]. Problem posing is classified as 1) Free problem-posing situations, where students asked to make simple or difficult problems according to daily life, construct problems for mathematical competition. It is more useful to relate real-life situations into mathematics content being taught. 2) Semi-structured problem-posing situations: Students are given an open situation and are invited to explore it using knowledge, skills, concepts and relationships from their previous mathematical experiences and it takes the following forms: Open-ended problems (i.e. mathematical investigation), problem similar to given problems, problems with similar situations, problems related to specific theorems, problems derived from given pictures, word problems. This strategy was developed with student-teachers as the following: A semi-structured situations from daily life was presented to all students [19]. Students were asked to

complete the situations using their perspective to be able to pose problems from that formed situation. Students can generate problems by omitting the questions from given situations. 3) Structured problem-posing situations: Any mathematical problem consists of known data (given) and unknown (required). The teacher can simply change the known and pose a new problem, or keep the data and change the required problems. This reformulation approach appears to be the most effective method for introducing structured problem posing activities in mathematics classrooms.

One simple example of problem posing is, when we have a problem, we automatically ask ourselves, what kind of problem is this? Is it a small or big problem? Does this include a complicated problem or not? These questions are problem posing before we enter the problem solving steps. Even in the problem solving step, we have to divide the problem into subproblems that can lead us to the settlement process to reduce the burden of problem complexity, we describe it into smaller sub-problems. When the problem is over, we do a problem posing once again, is our problem solving appropriate? Is the way we do it in the most effective way? These problem posing questions are also part of the process of critical thinking and reflective thinking. Mathematical problem posing is a comprehensive ability that covers a variety of other mathematical thinking abilities. If this simple example is an application in everyday life, then problems in mathematics that are solved through mathematical abilities problem posing ability is an exercise to deal with problems in everyday life.

In accordance with some experiences, to make a good assessment tool the teacher also did problem posing. To deal with and solve problems in class, the teacher must pose problems before they can solve them. For this reason, prospective mathematics teachers must prepare themselves and develop mathematical problem posing abilities.

However, the results of the interview contradict this requirement. Participants know and understand problem solving, but still do not know and understand problem posing. After explaining the problem posing and the urgency of these skills, participants realized that they need to have a good mathematical problem posing. Participants realized that as prospective mathematics teachers, they had to learn more so they could provide students with a variety of skills. They realize the challenges of education in the present and learn that they must improve their mathematical problem posing abilities.

3.3 How to develop Mathematical Problem Posing

Referring to the urgency in improving mathematical problem posing skills for prospective mathematics teachers, we will discuss the difficulties and obstacles that will be faced in problem posing, as well as the solutions offered to reduce these obstacles. From eight journals, some of the obstacles to the lack of mathematical problem posing abilities are: Little experience in problem posing make the problem they posed rarely polished and often include imperfections in wording or logic [5,20]. Prospective mathematics teachers can do problem posing but still inexperienced [17]. Problems posed by the participants were not logical, did not have a solution, or incomplete due to differences in terms of experience [21]. Lack of explanations and instructions make problem posing method intention hard to understand [22]. When posing problems, too depend on textbook participants failed to come up with the required mathematical thinking and reasoning skills. Still, many participants did not use creativity when posing problems [23]. Lack of knowing cognitive level, curriculum knowledge, and posing studies [5].

Some strategies that can be done to reduce the obstacles and improve the mathematical problem posing ability are as follows:

1. Giving prospective mathematics teachers more chances to experience problem posing. Integrating problem-posing activities into the curriculum and classroom practice in parallel with problem-solving, so young teachers acquire problem-posing skills and confidence in problem posing themselves to the point where they would capable and willing to help their students to pose problem [20].
2. Problem posing requires planning, skills, and personal strength, so it should be given serious consideration in preparing lesson activities [21].
3. Using strategies of posing mathematical problems from given textbook problems and posing mathematical problems from semi-structured situations [19].
4. Improve instruction to inform the intentions and consider a method to support problem posing tasks [22].
5. Provide problem posing activities would make prospective teachers more active and think more analytically. The lack of problem posing can affect academic success in a negative way [23,24].
6. RME strategies can improve the problem posing ability for the material area and volume of the rotating object [4].
7. "Formulate share listen and create" strategies can improve problem posing ability [25]
8. Provide problem posing activities and 'what if not? strategies in solid geometry, considered can be applied to other discussions [24].
9. Fostering learners' problem posing by reproducing the examples became a learning support [26].
10. Emphasize problem solving and problem posing studies, in-depth analysis of the curriculum, special teaching methods in detail and resorting to the resources during problem posing process [5].

4 Conclusion

From some explanations and journal reviews, prospective mathematics teachers need to develop mathematical problem posing. The most widely proposed way is to practice and continue to apply problem posing. In addition, based on the above-mentioned journals, it is necessary to have expert guidance in making questions or doing problem posing for prospective mathematics teachers, so that the questions can be in accordance with the content and context. Problem posing should be engaged in the curriculum of prospective mathematics teachers. By developing mathematical problem posing skills, prospective mathematics teachers have to equip themselves to enhance their professionalism in Industrial Revolution 4.0 era.

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