Teachers’ reflections on students’ mathematical problem solving in junior high school

Y Harisman 1,2, Y S Kusumah 1 and K Kusnandi 1
1Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
2STKIP PGRI Sumatera Barat, Jl. Gunung Pangilun Padang Utara Kota Padang Sumatera Barat 25000, Indonesia

E-mail: yulyantiharisman_math@student.upi.edu

Abstract. Reflection will help teachers improve their learning that has been done, especially in the problem-solving process. Therefore, this research was designed to answer the question of how to picture teacher reflection in mathematical problem solving learning process. This study adopted qualitative research with grounded theory and systematic design. Three teachers from three junior high schools with different clusters were selected as research subjects. Teaching and learning process were documented during three meetings. The selected subject was geometry because it requires a pattern of thinking in applying concepts and skills in solving problems. The learning video was analysed to create open questions that could explore how teachers reflect on the learning process they have conducted. The teachers and the researcher watched the video to reflect the teaching and learning process. The teachers were given several questions displayed in the video. The study revealed three categories of teacher resulted in their reflections process. The teacher categories are excellent, very good, and good. These categories of reflection can be a reference for teachers in studies that have a reflection phase such as lesson study and classroom action research.

1. Introduction
Teacher reflection is how a teacher reviews the learning process that has been conducted. The reflection will help them to fix any mistake they have made in order to avoid the same mistake to occur again in the next learning process. Expert researchers on teacher reflection in mathematics such as Muir and Beswick's [1] have categorized three levels of teacher reflection on mathematics learning process. The category was obtained based on the case studies of several school teachers. The measurement of the reflection levels was accomplished by interviewing research subjects after observing their learning process videos. The reflection levels achieved by Muir and Beswick are presented in Table 1. Muir and Beswick's research was followed by Geiger [2]. The research conducted by Geiger [2] developed by adding dimension aspect, that is: aspect of self, practice, and students. The reviewed reflection level from Geiger's reflection response object technical is explained in Table 2.
Table 1. Teacher’s reflection levels

| Level 1: Technical Reflection | A teacher describes general accounts of classroom practice, often with a focus on technical aspects, with no consideration of the value of the experiences. For example: The lesson went well. I did not ask enough questions. The students could all do the task. |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level 2: Deliberate Reflection | A teacher identifies ‘critical incidents’ and offers a rationale or explanation for the action or behavior. For example: Johnny was really off task today. I think the question was too hard for him; the way he was working out the area showed me he was confusing it with perimeter. I wanted them to use the concrete materials. |
| Level 3: Critical Reflection | The teachers move beyond identifying ‘critical incidents’ and providing explanations to considering others’ perspectives and offering alternatives. For example: I should not have put Jack on the spot by asking him to explain what a square number was. He was obviously uncomfortable. Perhaps I could incorporate a ‘think-pair-share’ strategy whereby the students could talk with each other before sharing more publicly. |

Table 2. Levels of reflection against object of reflective response

| Reflection Levels | Object of reflective response |
|-------------------|-------------------------------|
| **Technical**     |                                |
| Self              | Teaching activity is described during a teaching event. The description is factual rather than personally insightful. |
| Practice          | Critical incidents are related to teaching practice, and a rationale or explanation for the practice is articulated. |
| Students          | Students’ responses to teaching activity are described in terms of technical aspects. The focus is on consequences or outcomes of teaching practice. |
| **Deliberate**    |                                |
| Self              | The purpose of an activity is clearly articulated, and a judgment is made about the success or otherwise of a teaching practice. When unsuccessful, an alternative practice or activity is suggested. |
| Practice          | Students’ responses to teaching activity are noted, and a rationale or explanation for the response or behavior is constructed. |
| Students          |                                |
| **Critical**      |                                |
| Self              | The purpose of an activity is clearly articulated, and a judgment is made about the success or otherwise of a teaching practice. When unsuccessful, an alternative practice or activity is suggested. |
| Practice          | Students’ responses to teaching activity are noted, and a rationale or explanation for the response or behaviour is constructed. Potential improvements to the activity are related to an anticipated student response. |
However, the measurement of those levels was held in general teaching and learning mathematics. There is still not much research that highlights how teachers reflect on the learning process of problem-solving. Therefore, this research paper will answer a question of how the relationship of the category of teacher reflection on the problem-solving learning process is.

2. Method
This research is a preliminary analysis of the development research. The product of this research is the theory about category of teacher reflection in problem-solving. The method used is a qualitative approach and the research design is grounded theory. According to Creswell [3], the grounded theory design is a systematic qualitative procedure that is used to bring up a general explanation of researchers based on the views of the participants, explaining the process, act, or the interaction among participants. The type of grounded theory research design used in this research is a systematic design, which is widely used in the field of educational research. The design is composed of basic-obedient research, detailed, and predictable compared to the initial concept of grounded theory designs. Three secondary schools (Junior High School) in Bandung in Indonesia with a different cluster (level) were selected as the site of the research.

Table 3. Reflection techniques

| Reflection Techniques                      | Purposes                                                                 |
|-------------------------------------------|--------------------------------------------------------------------------|
| Pre-Review of Reflection (prior to reflection): Making reflection questions | In order to understand the depth of teachers-done reflection through playing learning videos done by teachers. |
| Viewing of video footage (Watching recorded video together with teachers) | In order to enable teachers to take a role as an observer, not a member. |
| Professional Conversation                 | In order to observe further aspects of teaching behaviour through discussion. |
| Comparison of two students’ mathematical behaviours (Highlighting some students intentionally on learning videos) | In order to encourage teachers to do critical reflection towards mathematical behaviours of students individually. |

Professional Reading

In order to understand if teachers are able to recognize students’ strength and weakness on mathematical problem-solving

A cluster is a group of schools based on the school rankings. According to information obtained from the Department of Education in Bandung, there were three clusters for Junior High Schools in Bandung. The clusters were A, B, and C. The purpose of selecting a school with various levels is an effort to avoid the problems of reliability and validity that may exist on a small sample Patton [4]. A voluntary teacher (volunteer) at eighth grade of each school served as the subject of the observation in the learning process of mathematical problem-solving. What was needed in order to obtain the category of teachers in the learning process can respectively be seen in Table 3 of reflection technique, and reflection analysis can be seen in Table 4.

Table 4. Analysis of Teachers’ Reflection Data

| Data gathering | Used instruments | Analyzed unit                                                                 | Data interpretation |
|----------------|------------------|-------------------------------------------------------------------------------|---------------------|
| Transcript of teachers’ interview | Semi-structured questions corresponding to teachers’ reflection technique | Object of reflection response: Mathematical problem-solving learning process (understanding problems, planning strategies, implementing strategies and verifying solutions). Level of reflection: 1. Technical; 2. Deliberate; 3. Critical | Qualitative interpretation |
3. Result and Discussion

Based on the results of interview transcripts analysis, as well as analysis of learning videos conducted by the three teachers, the theory of teacher reflection categories on the learning process of problem-solving was obtained and presented in Table 5.

| Table 5. Categories of teacher reflection on the learning process of problem solving |
|-----------------------------------------------|
| Aspect                                           | Aspect description                                           | Good                                                                 | Very Good                                                                 | Excellent                                                                 |
| Teacher's reflection on the learning process of mathematical problem solving | Reflecting on how to provide understanding to understand problems in the learning process of mathematical problem solving | Able to reflect on the process of how to provide understanding to understand problems in the learning process of problem-solving, but cannot provide an alternative how to overcome them | Able to reflect on the process of how to provide understanding to understand problems in the learning process of problem-solving, but cannot provide an alternative how to overcome them | Able to reflect on the process of how to provide understanding to understand problems in the learning process of problem-solving, but cannot provide an alternative how to overcome them |
| Teacher's reflection on the selection of strategies in the learning process on mathematical problem solving | Reflecting the process of selecting strategies in learning about mathematical problem solving is limited to revealing the facts that occur in the classroom | Able to reflect on the strategy selection process in learning about mathematical problem solving, but cannot give an alternative how to overcome it | Able to reflect on the strategy selection process in learning about mathematical problem solving, and provide an alternative how to overcome it | |
| Teacher's reflection on the use of strategies in the learning process on mathematical problem solving | Reflecting on the use of strategies in learning about mathematical problem solving is limited to revealing the facts that occur in the classroom | Able to reflect the process of using strategies in learning about mathematical problem solving, but cannot provide an alternative how to overcome them | Able to reflect on the use of strategies in learning about mathematical problem solving, and provide an alternative how to overcome them | |
| Teacher's reflection on the verification of solutions in the learning process on mathematical problem solving | Reflecting the process of verifying solutions in learning about mathematical problem solving is limited to revealing facts that occurred in the classroom | Able to reflect the process of verifying solutions in learning about mathematical problem solving, but cannot provide an alternative how to overcome them | Able to reflect the process of verifying solutions in learning about mathematical problem solving, and providing an alternative how to overcome them | |
| Reflection of teachers on students in the learning process on mathematical problem solving | Reflecting student behavior during the learning process on mathematical problem solving is limited to revealing the facts that occur in the classroom | Able to reflect student behavior during the learning process on mathematical problem solving, but cannot provide an alternative how to overcome it | Able to reflect on student behavior during the learning process on mathematical problem solving, and provide an alternative how to overcome it | |
The subject selected in this research is the process of geometry. Based on Rusyida’ research [5], it is clear that students’ mathematical problem solving ability in geometry is still low. The students have difficulties to solve a problem measuring problem-solving ability in all of the indicators in geometry. It may be because the teacher does not reflect on the learning process. This research provides information on how the categories of teachers’ reflection on their learning process. Many studies have looked at how the teacher reflects on their learning process such as the study done by Wice [6]. Wice’s research emphasizes the importance of evaluation after learning. The same argument is also expressed by Gore [7] in his research entitled “Reflecting on Reflective Teaching”. There has been no research focusing on reflection of teachers on the learning process of mathematical problem-solving. One form of illustration of how to obtain teacher reflection category on the process of understanding the problem is described as follows.

3.1 T-1 teacher’s (teacher who comes from school one) beliefs about mathematical problem solving learning

The process undertaken to observe the teacher’s reflection category on how to provide an understanding to understand the problem in the mathematical problem-solving process done to teacher T-1 (teacher from school one) was by showing the learning video about the mathematical problem solving that has been done. The subject observed in the video was the problem-solving process of how to find the cube nets. Video was served with an initial duration starting from 00.02- 01.15 (Pre-Review Reflection). Several reflection questions have been made regarding the process of providing an understanding of the problem-solving process (Pre-Review Reflection). In that duration, the teacher T-1 gave an understanding of what the cube nets are.

The researcher along with the teacher T-1 observed the video recording. This was done to provide teacher T-1 in taking the role of an observer, not as a participant. The video shows the T-1 teacher did not do the process of providing an understanding of finding the shape of the cube nets but directly planned the chosen strategy to find the cube nets.

The researcher then asked questions and conducted discussions related to the learning video to see teacher T-1’s reflection category on how to provide an understanding that students are able to understand the problem in the learning process of professional problem solving (Professional Conversation). Based on the answers given, the teacher T-1 can be categorized as an excellent teacher in reflecting the process of providing understanding in solving mathematical problems. This can be seen from the following interview footage.

**Interviewer** : At the beginning of the lesson teacher do not give the process of understanding to find the shape of the cube nets; is it not required by the students?
**Teacher (T-1)** : Oh yes it seems I forgot to inform students
**Interviewer** : If necessary, according to you what is the easiest way for students to explain how to find the cube nets?
**Teacher (T-1)** : It can be conveyed in various ways, can be by drawing a series of adjoining rectangles, which, if assembled again, will form a cube build. The next way can be by giving the intact cube then opened, it will form a flat wake with the condition that no side is loose, side by side and not overlapping, well that's called the cube nets. It is a universal definition and agreement.

**Interviewer** : Is it necessary to involve students in explaining how to understand the problem?
**Teacher (T-1)** : Yes, teacher should possibly ask students to bring various cube-shaped spaces from their houses or pastry boxes and others or handed them over to students, so that they can construct their own what is meant by the cube nets

Based on the results of the interview, T-1 teacher has been able to reflect on the process of how to provide an understanding to understand the problem in the learning process of problem solving. The teacher has also provided an alternative way of providing an understanding of what is meant by the
cube nets and how to understand it such as depicting a rectangle on the board and removing the intact cube in order to be opened and form a flat wake.

3.2 T-2 teacher’s (teacher who comes from school two) reflections about mathematical problem solving learning

Furthermore, the same process is also conducted to see the reflection of teacher T-2 (teacher coming from school two). Based on the answers given, the Teacher T-2 can be categorized as an excellent teacher in reflecting the process of providing understanding in solving mathematical problems. This can be seen from the following interview footage:

Interviewer: Based on the video presentation the process of providing an understanding of finding the shape of the cube nets committed by Mother, it is to draw a series of squares on the board and explains if the squares are folded and form a cube build, it is a web of cubes and vice versa.

Is that easy for students to understand?

Teachers (T-2): Before going there, I want to reveal in advance that the lesson that started just before the media is not ready, it should be ready and the tools and materials have been distributed to each student, then students should be given instructions through LKS or LJK in order to not spend time.

It is easy because so far children have understood it from a series of rectangles to form cube nets. But maybe the way that you did was less interesting for students; maybe most children also do not feel interesting to pay attention to it. It is seen from the video, there is still a child who tells the story with his friend.

Interviewer: If so, do you have any alternative to explain how to give an understanding of what a cube’s web is?

Teachers (T-2): It would be easier to understand if students bring their own concrete objects in the shape of a cube later like a cake box that can be removed from its sides. Later students take off their sides. In order for students to understand what the cube nets are with any real or concrete objects it might be easier. Next, ask the students to release the cake box to form a flat wake, and then say to this child is the cube nets, ‘why would it form a cube when we assemble?’. Only the constraints later in the cake box have a few more sides to stick it, do not let the child affected by it, later thought the child is part of the cube nets. We emphasize to the students that it does not include or ask the students to remove the more sides first

Interviewer: Is it necessary to involve students in explaining how to understand the problem

Teachers (T-2): Yes that is, you should not explain it in the same direction. Students are asked to bring themselves wake-up cube-shaped space, so they can automatically understand what the cube nets with activities they do.

Based on the results of interviews, teacher T-2 have been able to reflect on the process of how to provide understanding to understand the problem in the learning process about problem solving and provide an alternative how to overcome them. Teacher T-2 revealed that the process of giving comprehension was not interesting for students. The video shows that there are still students who talked with friends during the class.

Furthermore, teacher T-2 has also provided an alternative way of providing understanding to be more interesting for students by asking the students to bring themselves concrete objects in the form of a cube like a box of cakes where the sides can be removed. Then, students were asked to remove the sides, so that students easily understood what the cube nets are.
3.3 T-3 teacher’s (teacher who comes from school three) reflections about mathematical problem solving learning

In the next fact, based on the answers given, the teacher T-3 (teacher who comes from school three) can be categorized as a good teacher in reflecting the process of providing understanding in solving mathematical problems. This can be seen from the following interview footage:

Interviewer: The process of providing an understanding of what the cube's nets are performed by a teacher is by using the power point media. While the media is shown, it is seen that all of cube sides are open. Then Mother gives an explanation when all the sides open and form a flat cube, then that's called the cube nets. Is that easy for students to understand?

Teachers (T-3) : According to my vision, it has been easy and effective, but sometimes there are pupils who do not like the power point, so there is still my handwriting on the board. On the board, I explain the other again, not about what the webs are. For example in the power point, there are nets and I asked this child what is it? the answer of the son is square, how many? There are 6 (six) square children, children's answer. I made it a bridge to find the surface area of the cube. It is also explained that the webs will form a cube, but that is just a short, which they need to understand is the surface area of the cube.

Interviewer : Do you have any alternative to explain how to find the cube nets?

Teachers (T-3) : No, this is an effective way. This is related to the concept. This concept should be quickly understood and the application will be used later to find the surface area formula.

Interviewer : Is it necessary to involve students in explaining how to understand the problem?

Teachers (T-3) : Yes, but they make it at home only. I ask them to make cube nets at home. In this section, it does not have to be long time because the ultimate goal is the surface area of the cube, so this is just a bridge only. Teacher likes to ask the child how many square, there are 6 (six), it will be associated with surface area of a cube, later.

Based on the results of the interview, the T-3 teacher was only able to reflect on the process of how to provide understanding to understand the problem in the process of learning about solving the problem that is only limited to reveal the facts that occurred in the class, and did not provide an alternative strategy in understanding the problem. Teacher T-3 revealed that the process of providing comprehension that had been done was effective for students and the time is convenient.

Furthermore, teacher T-3 did not provide insights on alternative ways of giving comprehension to be more interesting for students, for example by asking students to bring their own concrete objects in the form of a cube like a box of cakes that can be removed from the sides.

The same process was also performed on every process of learning made by the mentioned teacher in every learning process on students who attended the learning process. The results of the analysis of each interview process, which were coded, resulted category in Table 5.

Based on the categories of reflection, there are different gradations of each teacher. In order to reflect on the learning process in problem solving teachers can use these categories as standardization. The process of reflection is related to the professionalism of teachers in teaching according to Donald [8] and Danielson[9]’s opinion that a professional teacher must reflect on his or her actions. Lin [10] also conducted a study in professional development where teachers reflect on themselves with peers. Zeichner [11] has used his years of experience to reflect on the world's teacher learning process. According to Calderhead [12], teachers should be aware that the role of reflection is very important in learning.

4. Conclusion

Teacher reflection on the learning of mathematics in general is also the same as the reflection of teachers on the learning process of problem solving. The study revealed three categories of teacher resulted in their reflections process after they finished teaching and learning process. The resulted category consists of excellent, very good, and good teacher. An excellent teacher in doing reflections
on the learning process of problem solving is a teacher who can anticipate and give solutions for better learning of Polya’s stages. A very good teacher in doing reflections on the learning process of problem solving is a teacher who notices her/his mistake but cannot give solutions for better learning of Polya’s stages. A good teacher in doing reflections on the learning process of problem solving is a teacher who only focuses in revealing the facts that occur in the classroom of Polya’s stages. This category of reflection can be a reference for teachers in studies that have a reflection phase, for example, lesson study or classroom action research. Furthermore, when the teacher misses their mistake in learning, the teacher can improve for the next learning process.

References
[1] Muir T and Beswick K 2007 Teacher Education and Development Special Issue 8 74
[2] Geiger V, Muir T and Lamb J 2015 J Math Teacher Educ 47 4
[3] Creswell J W 2015 Penelitian Kualitatif dan Desain Riset (Yogyakarta: Pustaka Pelajar)
[4] Patton M 1990 Qualitative Evaluation and Research Methods (2nd ed.) (Newbury Park, CA: Sage Publication)
[5] Rusyda N A, Kusnandi K and Suhendra S 2017 Journal of Physics: Conference Series 895 012081
[6] Wice, Viky L, Spiegel, Amy N and Bruning, Roger H 1999 Journal of Teacher Education 50 1
[7] Gore J M 1987 Journal of Teacher Education 38 2
[8] Schon D A 1987 Educating the Reflective Practitioner. Toward a New Design for Teaching and Learning in the Professions. The Jossey-Bass Higher Education Series (Francisco: Jossey-Bass Publishers)
[9] Danielson and Lana M 2009 Fostering Reflection (Alexandria: Educational leadership)
[10] Lin H S, Hong Z R, Yang K K and Lee S T 2013 International Journal of Science Education 35 18
[11] Zeichner K 2008 Educ. Soc journal 29 103
[12] Calderhead J 1989 Teaching and Teacher Education Journal 5 43