Reasoning and Problem Solving Geometry of Primary School Teacher Education Student’s Through Polya Stage: Carrying out the Plan

**Abstract**. Someone is said to reason if they do a logical thinking process to get a conclusion or judgment in solving a problem. The purpose of this study is to obtain a picture of student reasoning at carrying out the plan in solving geometry problems. This research is a descriptive exploratory study with a qualitative approach. Methods of collecting data through problem-solving tasks, interviews, and documentation. The subject of this study was a male student at UHO Primary School who had a mathematical ability level in the medium category. The data obtained were analyzed qualitatively through five steps, namely 1) data classification; 2) data reduction 3) data presentation; 4) interpretation of data, and 5) concluding. The results of this study indicate that 1) the subject has carried out problem-solving according to the plan and its logical arguments; 2) the subject uses the concepts and principles that will be used in solving problems and their logical arguments; 3) the subject computes (calculations) correctly and logically; 4) the subject makes a conclusion from the calculation correctly and logically; 5) the subject uses the interpretation of the results of calculations correctly and logically.

1. Introduction

The process of thinking is an important factor for creating situations that encourage students to think. Thinking is an active intellectual process and skilled conceptualization, applying, analyzing, synthesizing, and/or evaluating information that is collected or produced by observation, experience, reflection, reasoning, or communication, as a guide for being confident in taking action [1]. In the level of mathematics learning, a situation must be created that provides opportunities for students to develop all potential thinking and reasoning. The reasoning is another term in reasoning which means using reason (logical thinking). Reasoning is selective thinking that contains controlled meaning [2]. Reasoning is a process to achieve goals in thought [3].

Reasoning comes from the basic words of reason which means activities for logical thinking or ability/range of thinking [4]. The reasoning is the process of concluding principles and from the evidence [5]. In reasoning, someone moves from what is already known to a new conclusion or evaluates the conclusions that have been proposed. To develop reasoning skills for students, lecturers must design reason-based questions that can help students think and justify their answers. Other strategies can create a conducive environment in the classroom, which can help students express themselves without hesitation. The students' initial knowledge is very helpful to support the reasons. Guidance and interaction between lecturers and peers also enable students' reasoning abilities.

The ability of people to reason logically (or lack thereof) is considered a fairly important issue in the past because the use of the deduction paradigm becomes established [6]. Reasoning includes the ability to (1) determine scientific questions (2) plan ways to answer questions (3) analyze data, and (4) interpret results [7]. Reasoning can be developed through mathematics learning. Mathematical reasoning is an ability to understand mathematical ideas in depth, observe data and investigate ideas implicitly, compile estimates, analogize and generalize, and reason logically [8]. Measuring indicators of students who have reasoning can be done through analysis (Analyze), generalize (Generalize), and synthesis (Synthesize) with correct, flawed, and poor reasoned categories [9].

There are three major reasons for geometry taught in schools and universities, namely (1) expanding spatial awareness, (2) developing reasoning skills and (3) stimulating, challenging and informing students [10]. Completing geometry questions requires reasoning and analysis to find certain patterns and formulas. The form of the question is one of the basics in determining the types of problems in geometry. Polya (1973) classified two types of problems, namely problems to find (problem to find) and problems to prove (problem to prove) [11]. Student reasoning in solving geometric problems referred to in this study is a description of what is thought about the process of thinking or mental activity of students about concluding information on geometric objects.

1. Experimental Method

This research is a descriptive exploratory study with a qualitative approach. The purpose of this study is to explore how the reasoning and solving of students' problems in primary school teacher education is based on the stages of the policy at the planning stage of the plan. The implementation procedure in this study is divided into three stages, namely: (1) preparation, (2) implementation phase, and (3) data analysis stage. The subjects of this study were two students consisting of a woman has labeled Subject-1 and a man has labeled Subject-2 selected based on the results of a gender test analysis. The instrument used in this study is divided into two main instruments and supporting instruments. The main instrument in this research is the researcher, while the supporting instruments include tests of mathematical abilities, problem-solving assignments, gender questionnaires, record aids, and interview guidelines that are declared valid by expert validators. Supporting instruments are used to obtain exposure to reasoning profile data and student problem-solving.

The data obtained will be analyzed qualitatively. Data analysis process refers to a qualitative data analysis model consisting of three steps which include (1) condensation of data (2) data presentation; and (3) concluding [12]. By making a few modifications, the steps carried out in this study include: (1) categorization/classification of data, (2) data reduction, (3) data presentation, (4) data interpretation/interpretation, and (5) conclusions

1. Result and Discussion

*3.1 Exposure of Subject-1 reasoning data in solving geometry problems at the carrying out the plan*

Subject-1 interview data based on the answers to geometry problem-solving tests 1 and 2 are presented in the following Table 1:

**Table 1**. Results of interview Subject-1 using TPMG 1 and TPMG 2

| TPMG 1 Interview Results | TPMG 2 Interview Results |
| --- | --- |
| 1) Subject-1 solves the TPMG 1 problem, by writing down what is known and what is asked. The solution uses four steps, namely sketching the beam calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SFT3101). | 1) Subject-1 solves TPMG 1 problems by writing down what is known and what is asked. The solution uses four steps, namely sketching the beam calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SFT3201). |
| 2) (Subject-1 gives the reason for step 1 (L01) sketching that to better understand where the image I made is complete with predetermined sizes (SFT3104). | 2) (Subject-1 gives the reason for step 1 (L01) sketching that to better understand where the image I made is complete with predetermined sizes (SFT3204). |
| 3) (Subject-1 gives the reason for step 2 (L02) which is looking for the volume of the beam by multiplying p x l x t from the respective size (22 cm x 33 cm x 44 cm) and the result is 31,944 cm3 (SFT3106). | 3) (Subject-1 gives the reason for step 2 (L02) which is looking for the volume of the beam by multiplying p x l x t from the size of each (22 cm x 33 cm x 44 cm) and the result is 31,944 cm3  (SFT3206). |
| 4) (Subject-1) gives the reason for step 3 (L03) which is to calculate the volume of water before it freezes. To get the volume of water before it freezes using the volume value of the beam divided by the value of 10% the volume of water before freezing (0,1) which is 29,040 (SFT3107) (SFT3110). | 4) (Subject-1) gives the reason for step 3 (L03) which is to calculate the volume of water before it freezes. To get the volume of water before it freezes using the volume value of the beam divided by the value of 10% the volume of water before freezing (0,1) which is 29,040 (SFT3207) (SFT3210). |
| 5) (Subject-1 gives the reason for step 4 (L04) which is to write t ’that is the depth of water (which was asked about the problem) (SFT3111), the result is 40 cm (SFT3112). | 5) (Subject-1 gives the reason for step 4 (L04) which is to write t ’that is the depth of water (which was asked about the problem) (SFT3111), the result is 40 cm (SFT3212). |

From the data obtained at the stage of data collection in the form of TPMG 1 interview results

The subject works on TPMG 1 (SFT3101). From this data, it can be seen that subject-1 carries out problem-solving following the plan in solving problems with logical arguments.

Subject-1 solved the TPMG 1 problem, writing down what was known and what was asked. The solution uses four steps, namely sketching the beam calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SFT3101). From this data, it can be concluded that Subject-1 performs problem-solving according to the plan along with its logical arguments (Cr 1).

Subject-1 gave the reason for step 1 to sketch that to better understand where the image I made was complete with the predetermined sizes (SFT3104). Subject-1 gives the reason for step 2 which is looking for the volume of the beam by multiplying p x l x t from the size of each (22 cm x 33 cm x 44 cm) and the result is 31,944 cm3 (SFT3106). Subject-1 gives the reason for step 3 which is to calculate the volume of water before it freezes. To get the volume of water before it freezes using the volume value of the beam divided by the value of 10% the volume of water before freezing (0,1) 29,040 (SFT3107) (SFT3110). From this data, it can be concluded that Subject-1 uses concepts and principles in solving problems correctly along with logical arguments (Cr 2).

Subject-1 gives the reason for step 4 which is to write “*t”* that is the depth of water (which was asked for the problem) (SFT3111), the result is 40 cm (SFT3112). From this data, it can be concluded that Subject -1 computes (calculates) correctly and logically (Cr 3).

Subject-1 concludes that the depth of water must be filled so that the volume and place when it freezes is equal to 40 cm (SFT3113). From this data, it can be concluded that Subject-1 concludes from calculations correctly and logically (CR 4).

*Subject-1 confirms that the water depth of 40 cm is logical because of its addition of 10% (SFT3114). From this data, it can be concluded that Subject-1 uses the interpretation of the results of mathematical calculations on problem-solving (Cr 5).*

*From these data, Subject-1 can be carrying out the plan made in solving problems and logical arguments. Subject-1 fulfills five categories of reasoning, thus it can be concluded that Subject -1 uses reasoning very logically in solving geometric problems at the stage of making plans.*

*3.2 Exposure to Subject-2 reasoning data in solving geometric problems at the carrying out the plan*

Data from interview subject-2 based on the answers to the geometric problem-solving tests 1 and 2 are presented in the following Table 2:

**Table 2.** Results of interview Subject-2 using TPMG 1 and TPMG 2

| TPMG 1 Interview Results | TPMG 2 Interview Results |
| --- | --- |
| 1. Subject-2 solves TPMG 1, by writing what is known, and what is asked. On completion, use four steps, namely sketching, calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SMT3101). Subject-2 reveals if the unit is not the same, then first equate it (SMT3102). Subject-2 says P = Length, l = width, t = height (SMT3103). Subject-2 said it was permissible because from any side it could be set as a base (SMT3104). | 1. Subject-2 solves TPMG 1, by writing what is known, and what is asked. On completion, use four steps, namely sketching, calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SMT3201). Subject-2 reveals if the unit is not the same, then first equate it (SMT3202). Subject-2 says p = Length, l = width, t = height (SMT3203). Subject-2 said it was permissible because from any side it could be set as a base (SMT3204). |
| 1. Subject-2 gives a reason for step 1 (L01) that makes an image as an illustration so that it is easy to answer problems and easily understand them (SMT3105). | 1. Subject-2 gives a reason for step 1 (L01) that makes an image as an illustration so that it is easy to answer the problem and easy to understand (SMT3205). |
| 1. Subject-2 gives a reason for step 2 (L02) that p, l, can be exchanged, because the problem is not determined by size, so p can be l, and l can be p (SMT3106). Subject-2 gives a reason for step 2 (L02) that the result is obtained because it enters the numbers in the formula namely p x l x t, so it is 22 cm x 33 cm x 44 cm and the result is 31,944 cm3 (SMT3107). | 1. Subject-2 gives a reason for step 2 (L02) that p, l, can be exchanged, because the problem is not determined by size, so p can be l, and l can be p (SMT3206). Subject-2 gives a reason for step 2 (L02) that the result is obtained because it enters the numbers in the formula namely p x l x t, so it is 32 cm x 43 cm x 54 cm and the result is 74.304S cm3 (SMT3207). |
| 1. Subject-2 gives the reason for step 3 (L03) we will look for the volume of water before it freezes, on the problem it says when it freezes the volume of water increases by 10%. And before the volume of water before freezing has not been obtained, that is what we are looking for first the volume of water before it freezes, that is by using a beam volume value with 10% volume of water when frozen (0.1) (SMT3108). Subject-2 replied that 0.1 was a result of 10% () (SMT3109). Subject-2 says that it is the associative nature of mathematics, which I derived from the previous formula, the result of which is (1 + 0.1 = 1.1) (SMT3110). Subject-2 replied that the results were 31,944 with 1.1 so the results were 29,040 (SMT3111). | 1. Subject-2 gives a reason for step 3 (L03) we will look for the volume of water before it freezes, on the problem it says when it freezes the volume of water increases by 10%. And before the volume of water before freezing has not been obtained, that is what we are looking for first the volume of water before it freezes, namely by using a beam volume value with 10% volume of water when frozen (0.1) (SMT3208). Subject-2 replied that 0.1 was a result of 10% () (SMT3109). Subject-2 says that it is an associative mathematical property, which I derived from the previous formula, the result of which is (1 + 0.1 = 1.1) (SMT3210). Subject-2 answers that the result is 74,304 with 1.1 so the result is 67,549.09 (SMT3211). |
| 1. Subject-2 gives a reason for step 4 (L04) that t ’is the depth of water (which was asked about the problem) (SMT3112). Subject-2 said the results from the result of the division of V water before freezing with (p x l) became 29,040 cm3 divided by 72.6 cm2 and the results were 40 cm (SMT3113). Subject-2 says that the depth of water that must be filled so that the volume and place when it freezes is equal to 40 cm (SMT3114). | 1. Subject-2 gives a reason for step 4 (L04) that t ’is the depth of water (which was asked about the problem) (SMT3112). Subject-2 says the result is the result of the division of V water before freezing with (p x l) to 67,549.09 cm3 divided by 1376 cm2 and the result is 49.09 cm (SMT3213). Subject-2 says that the depth of water that must be filled so that the volume and place when it freezes is equal to 49.09 cm (SMT3214). |

From the data obtained at the data collection stage in the form of TPMG 1 interview results that Subject-2 solves TPMG 1, by writing what is known, and what is asked. On completion, use four steps, namely sketching, calculating the volume of the beam, calculating the volume of water before freezing and calculating the water depth (SMT3101). From this data, it can be concluded that Subject-2 performs problem-solving according to the plan along with its logical arguments (Cr 1).

Subject-2 reveals if the unit is not the same, then first equate it (SMT3102). Subject-2 says P = Length, l = width, t = height (SMT3103). Subject-2 said it was permissible because from any side it could be set as a base (SMT3104). Subject-2 gave a reason for step 1 (L01) that made the image as an illustration so that it was easy to answer the problem and easily understand it (SMT3105). Subject-2 gives a reason for step 2 (L02) that p, l, can be exchanged, because the problem is not determined by size, so p can be l, and l can be p (SMT3106). Subject-2 gives a reason for step 2 (L02) that the result is obtained because it enters the numbers in the formula, namely p x l x t, so it is 22 cm x 33 cm x 44 cm and the result is 31,944 cm3 (SMT3107). Subject-2 gives a reason for step 3 (L03). We will look for the volume of water before it freezes, the problem is said when it freezes the volume of water increases by 10%. And before the volume of water before freezing has not been obtained, that is what we are looking for first the volume of water before it freezes, that is by using a beam volume value with 10% volume of water when frozen (0.1) (SMT3108). Subject-2 replied that 0.1 was a result of 10% () (SMT3109). Subject-2 says that it is the associative nature of mathematics, which I derived from the previous formula, the result of which is (1 + 0.1 = 1.1) (SMT3110). From this data, it can be concluded that Subject-2 uses concepts and principles in solving problems correctly along with logical arguments (Cr 2).

Subject-2 replied that the results were 31,944 with 1.1 so the results were 29,040 (SMT3111). From this data, it can be concluded that Subject-2 gives a logical reason because the problem is determined that the volume of water increases by 10% when it freezes so that the volume of the beam obtained is multiplied by 10% and the results for him are correct (Cr 4). Subject-2 gives the reason for step 4 (L04) that “*t”* was the depth of water (which was asked about the problem) (SMT3112). From the results of the distribution of V water before freezing with (p x l), it becomes 29,040 cm3 divided by 72.6 cm2 and the result is 40 cm (SMT3112). 5) Subject-2 gives a reason for step 4 (L04) that t ’is the depth of water (which was asked about the problem) (SMT3112). Subject-2 said the results from the result of the division of V water before freezing with (p x l) became 29,040 cm3 divided by 72.6 cm2 and the results were 40 cm (SMT3113). From this data, it can be concluded that Subject-2 is computational (calculation) correctly and logically (Cr 3).

Subject-2 says that the depth of water must be filled so that the volume and place when it freezes is equal to 40 cm (SMT3114). From this data, it can be concluded that Subject-2 makes conclusions from calculations correctly and logically (Cr 4).

Subject-2 gives the reason that the result is 40 cm and that logically means the addition is 10% (Cr 5).

*From these data, Subject-2 can be carrying out the plans made in solving problems and logical arguments. Subject-2 fulfills five categories of reasoning, thus it can be concluded that Subject -2 uses very logical reasoning at the carrying out the plan*.

1. Conclusion

This study shows that the profile of reasoning in solving geometry problems at the carrying out the plan, both Subject-1 and Subject-2 can: a) carry out problem-solving in accordance with the plan with logical arguments; b) use concepts and principles in solving problems correctly along with logical arguments; c) computation (calculation) correctly and logically; d) make conclusions from calculations correctly and logically; e) interpret the results of mathematical calculations to solve problems correctly and logically.

Acknowledgments

The author would like to thank the Ministry of Research, Technology and Higher Education in supporting and funding this research.

References

1. Snyder, L.G. and Snyder, M.J., 2008. Teaching critical thinking and problem solving skills. *The Journal of Research in Business Education*, *50*(2), p.90.
2. Sarsani, M.R., 2008. A Study of the Reasoning Abilities of Ninth Standard Students with Respect to Their Gender and Type of the Institution. *Journal on Educational Psychology*, *1*(3), pp.44-54.
3. Hardin, G., 1968. The Tragedy of the Commons. *Science,* p.162. Avaliable in http://www.sciencemag.org/cgi/content/full/162/3859/1243
4. Peter, S & Yani S., (2008). *Kamus Bahasa Indonesia Kontemporer*. *Jakarta: Balai Pustaka*
5. Stenberg, R.J., 2008. Psikologi Kognitif (Edisi IV). *Diterjemahkan Yudi Santoso.* Yogyakarta: Pustaka Pelajar.
6. Holyoak, K.J. and Morrison, R.G. eds., 2005. *The Cambridge handbook of thinking and reasoning* (Vol. 137). Cambridge: Cambridge University Press.
7. Weld, J., Stier, M. and McNew-Birren, J., 2011. The development of a novel measure of scientific reasoning growth among college freshmen: the constructive inquiry science reasoning skills test. *Journal of College Science Teaching*, *40*(4), p.101.
8. Gunhan, B.C., 2014. A case study on the investigation of reasoning skills in geometry. *South African Journal of Education*, *34*(2).
9. Rohana., 2015. The Enhancement of Students Teacher Mathematical Reasoning Ability Through Reflective Learning. *Journal of Education and Practice*, *6*(20).
10. French, D., 2004. *Teaching and learning geometry*. A&C Black.
11. Polya, G., 2004. *How to solve it: A new aspect of mathematical method* (No. 246). Princeton university press.
12. Miles, M.B., Huberman, A.M. and Saldaña, J., 2014. *Qualitative data analysis: A methods sourcebook. 3rd*.