Design of assessment based on guided discovery to improve the quality of teachers' professionalism of mathematics

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Abstract. This research aims to improve the quality of teachers' professionalism in designing assessments based on guided discovery. Guided discovery is a good learning method in encouraging students to discover mathematical concepts themselves. However, the problem that occurs is teachers tend to apply traditional methods, do not recognize guided discovery methods and do not know how to design assessments based on guided discovery. Therefore, this research fills the gap of the problem by compiling a design of assessment based on the guided discovery. The research subjects were mathematics teachers and students in Probolinggo. The method in this research was conducted in 6 stages, namely: initial investigation, design, construction, validation, evaluation and revision, and implementation stages. Data analysis consisted of data reducting, displaying data, making a conclusion. The results of this research are five aspects of assessment, namely aspects reflecting previously idea; experiments openly; experiments independently; find solutions convergently; implement discovery *into the problem-solving process*. The percentage of validity from experts on the five aspects of this assessment system was 81.25% with criteria of "valid" whereas; the percentage of validity from practitioners is 90.62% with criteria of "valid". The researcher recommends that improving the quality of teachers' professionalism should be focused on the design of assessment based on guided discovery.

1. Introduction

The improvement of the quality of education is very important for students to build and develop their knowledge on an ongoing basis for future practice [1]. The improvement of the quality of education has been developed rapidly to develop learning in early pre-school children [2]. The quality of higher education is also a target in many universities to increase student satisfaction with the development of knowledge [3]. This condition shows that the quality of education has always been a major concern for every level of education for the development of preschoolers through college.

Improving the quality of education is also based on qualified and professional educators. [4] argues that teachers or professional educators are one of the main factors that determine quality improvement in the education process. This is also consistent with the opinion of [5], namely the experience of the

professionalism of teachers meeting the accreditation requirements of school education. Professionalism of a teacher is not only seen from the side of teaching, educating, or guiding students in learning in the classroom, However, teachers are required to develop their abilities and competencies from within themselves by making publications, enhancing innovative works and especially determining the right assessment in the development of a better learning process [6], [7]. [8] recognizes that assessment literacy is very important for teachers to find out information about student learning needs related to the effectiveness of the teaching process in the classroom, where assessment in education is very influential on professional teachers. Therefore, teachers need to be educated at the professional level to make good assessments in the learning process.

However, the problem that occurs is teachers do not want to change their mindset, they still apply the traditional method, and the assessment is limited to a piece of paper & pencil without observing the student learning process. Research of [9] shows that assessments for learning processes and data-based decision making about students' independent learning behavior have not been integrated into teaching practices by class teachers. In addition, teachers and students have difficulty interacting in the learning process. This condition is not much different from the conditions of student learning in class III of public elementary school at Kebon Kulon Probolinggo, namely, teachers are unable to think of innovative ideas in teaching, teaching methods are still monotonous (traditional methods), learning is passive with students just sitting & listening, and learning does not encourage students to think or do something new or innovative. In addition, assessments from students are only in the form of assessments in midterm and midterms and do not look at the learning process that is passed by students. This shows that the level of professionalism of teachers needs to be improved and further developed.

In improving good learning, researchers propose guided discovery-based methods to be applied in learning in class III of public elementary school at Kebon Kulon V Probolinggo. The selection of this method aims to guide students to discover their own mathematical concepts [10]. In addition, [11] states that guided discovery can develop the level of activeness, creativity and interpersonal skills of students. In addition, research conducted by [12] states that the application of the guided discovery method can develop and enhance students' understanding and problem-solving skills because students themselves discover mathematical concepts.

The application of guided discovery in Mathematics learning can work well if it is supported by several supporting aspects. The supporting aspects impact maximizing student learning. [13] states that assessments that can maximize student learning are assessments of learning that place students at the center of learning. In the use of the guided discovery method, students as learning centers express their perceptions and discover mathematical concepts independently. Student perception is an assessment of learning that is positively related to students' deep learning [14]. But in reality, the teacher's view of assessment in the learning process is still less. For example, the assessment of teachers at the public elementary school of Kebon Kulon on student learning outcomes is only focused on passive learning and teachers prioritize the outcome rather than the process of discovering and expressing mathematical concepts independently. This is shown from the interview with the teacher.

Researcher	: What method do you usually use at learning in the class, Sir?
Teacher	: The method applied in class is the discussion method. I give formulas to students and students apply the formulas in the form of exercises. However, students have difficulty applying the formula and the exercise. For example, I give a formula of the square area and then students cannot immediately understand. they require repeated exercise. This exercise can be of various problems regarding the application of the square area.
Researcher	: Researcher: where do the sources for the exercises (question problem) come from?
Teacher	: The exercises are taken from various references. I take from books, sometimes I take from browsing on Google

Researcher	: Do you know this guided discovery method, sir?
Teacher	: I don't know. I also have never applied it, because students have difficulty implementing new methods. So, students are better informed immediately for the formulas. students also need to be given exclusive guidance in completing exercises related to the implementation of the circumference of a square.
Researcher	: What is your assessment of the result of student' learning?
Teacher	: For the assessment of the results of students' learning, I only use scores of the final exam.

Based on interviews with the teacher, the teacher seemed to be unfamiliar with the guided discovery method and only focused on learning that required drill practice, lecture, and only focused on the midterm or final exam. This shows that the teacher does not pay attention to the student's learning process, but only on the final results. According to [15], learning is a process of behavior change that is based on student learning processes not just on the final outcome. Therefore, this study wants to inform the teacher about the appropriate assessment design in guided discovery-based learning that can increase the activeness, creativity, and understanding of students with their findings independently. Thus, the teacher is expected to be able to utilize this grading system to change student grades quantitatively into descriptive which explains every process or effort made by students heterogeneously in learning mathematics in class.

2. Methodology

This research is qualitative research with a descriptive approach because this research produces an assessment design consisting of five aspects that describe the process of learning mathematics based on guided discovery accompanied by indicators and scores of each indicator. This assessment design changes the grades that describe each process or effort made by students in learning mathematics into student grades quantitatively. The subjects of this study were the teachers and students of public elementary school at Kebon Kulon V Probolinggo. The selection of subjects is based on the problems found during observation and the teacher is a practitioner in the school who has a role in determining assessment in classroom learning. Data analysis was performed in three stages, namely reducing data outside the research context, presenting data, and drawing conclusions. The stages of data analysis in this methodology are shown in Figure 1.

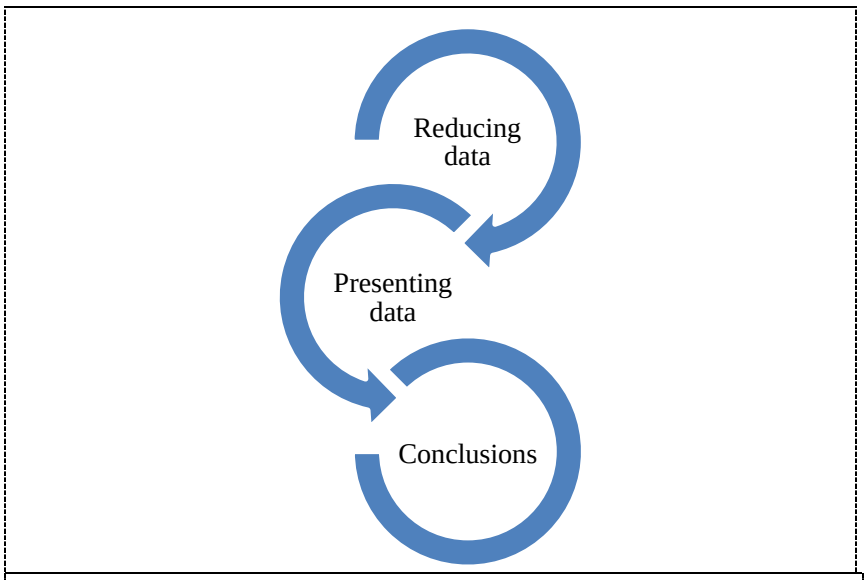

Figure 1. Stages of data analysis (Adapted by Creswell [16])

The procedure for designing assessment based on guided discovery is adapted from Plomp's model which includes five stages [17]. The five stages are the initial investigation stage; design stage; construction stages; evaluation & revision stages, and implementation stages. Stages of the procedure in this methodology are shown in Figure 2.

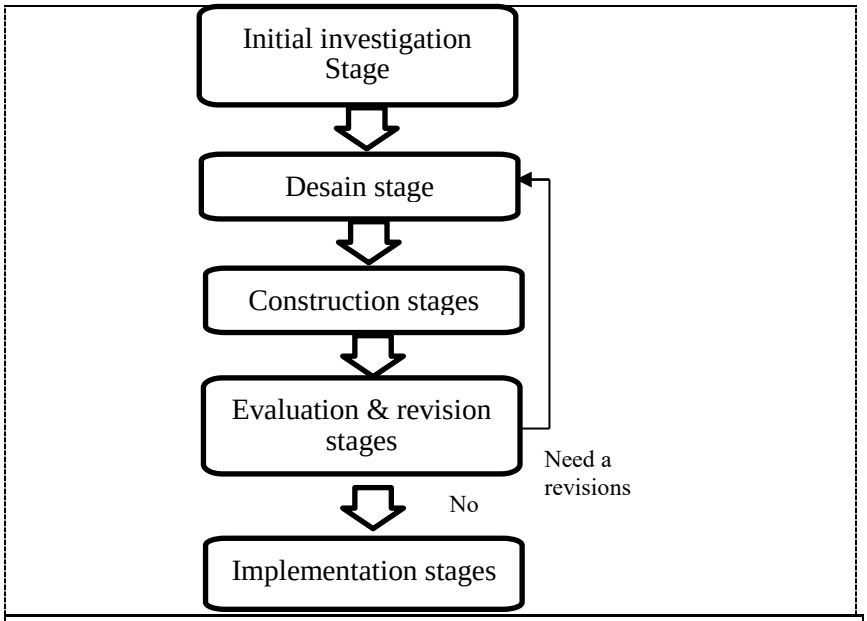

Figure 2. Stages of the procedure for designing assessment (Adapted by Plomp[17])

2.1. Initial investigation

This stage consists of several activities, namely the researcher looks at the teaching or learning in the classroom by the teacher, sees the problems that arise, the difficulties of students and teachers related to classroom assessment. This activity is intended to recognize the assessment problems found in class.

2.2. Desain stage

This stage was concerned with determining the material, determining SK and KD in accordance with the topic of the material that is a problem in class, preparing learning tools, and designing the assessment. This research focused on classroom assessment. The assessment system is based on the guided discovery stage by [18], namely the introduction & review stage, the open stage, the convergent stage, and the closing stage. This assessment design was also supplemented by the implementation of experiments in the guided discovery stage. At this stage, the assessment design based on guided discovery was concerned with important points that can illustrate the evaluation of each major activity in guided discovery learning followed by the conduct of experiments.

2.3. Construction stages

This stage is the application or preparation of guided discovery assessment instruments. Based on the main points of the assessment design that illustrates the guided discovery learning process of the design stage, the researcher completes or adds indicators that represent the conditions of each student heterogeneously. The design of this scoring system includes indicators which are also accompanied by quantitative scores in the range of 0-4.

2.4. Evaluation & revision stages

The evaluation phase in this research is to carry out the validation process by experts. The validation process was carried out by four experts, namely two practitioners at the school and two PGSD lecturers from Panca Marga University Probolinggo. The validators evaluate the design or assessment rubric based on guided discovery. Validation data analysis includes four choices: strongly disagree, disagree, agree, and strongly agree.

The validation results are then analyzed using the following formula.

$$R_i = \frac{\sum_{j=1}^{n} V_{ji}}{n} \quad \text{..... (1)}$$

Where: Ri = Average of the validation results for the validators for each component

Vji = The jth validator value of the i-th component

n = Number of validators

The evaluation percentage for each indicator is based on the formula:

$$\mathrm{P_i} = \frac{\mathrm{R_i}}{\mathrm{k}} \quad \text{..... (2)}$$

Where: Pi = Percentage of validation results for each component

Ri = The average of the validation results for all validators in each component

k = Highest scale

Percentages for evaluation of each aspect and overall components are adjusted according to the formula:

$$\mathrm{J_i} = \frac{\sum_{i=0}^{n} \mathrm{P_i}}{\mathrm{l}} \quad \text{..... (3)}$$

Where: Ji = Percentage of results of validation for all components

Pi = Percentage of validation results for each component

l = number of components

The criteria for evaluation of the whole validation results are shown in the following table.

Table 1. Criteria for evaluation of overall validation results

Percentage	Criteria of Validity	Information
$85 \leq P \leq 100$	Very Valid	No revision
$70 \leq P < 85$	Valid	No revision
$55 \leq P < 70$	Valid Enough	Needs revision

$40 \leq P < 55$	Less Valid	Needs revision
$0 \leq P < 40$	Invalid	Needs revision

(Source: Hobri [19])

If the results of the evaluation from the validator are in the criteria of "valid", then the product does not need to be revised. If the results of the evaluation are in the criteria of "sufficiently valid", then the product needs to be revised for some aspects that need to be to be revised. Whereas, if the results of the evaluation are in the criteria of "invalid", the researcher must revise the total of the product. The results of the validation test of this research design are in the criteria of "valid". Therefore, the assessment design does not need to be revised and this assessment design can be continued to the implementation phase.

2.5. Implementation stages

After the learning instrument and the assessment design are validated and also revised, the researcher implements the instrument and assessment design to students of class III of public elementary school at Kebon Kulon V Probolinggo. The process of implementing the instrument and assessment design was conducted twice, namely for students in small groups and students in large groups. The number of students in small groups was five students, while the number of students in large groups was 25 students. The results of repair from the implementation of the instrument and assessment design for students in small groups are reapplied to students in large groups. The results of the implementation of the instrument and assessment design for students in large groups are better and more practical than students in small groups. This is also supported by the results of the students' questionnaire. Based on the results of validation by practitioners & experts, and the implementation of the instrument & assessment design for students in small groups and in large groups, the instrument and assessment design can be said to be valid and practical to be implemented at students of elementary school.

3. Results

The results of this study focus on the design of assessment based on guided discovery. The design of assessment based on guided discovery is seen from the implementation of guided discovery in the class. There are five characteristics of the process of problem-solving by students in applying guided discovery learning. These five characteristics are represented by five students.

Subject 1 (S1)

When S1 solved the problem about plane figure, He reflect on the previously idea by writing down the results of their reflections on the worksheet correctly and correctly. S1 listen and conducting of the teacher's instructions to conduct experiments properly and correctly. S1 make a correctly square (2 cm x 2 cm) through a square unit (1 cm x 1 cm). S1 conduct experiments independently by making more than six new plane figures that different sizes (it's not included plane figures obtained from openly experimenting).

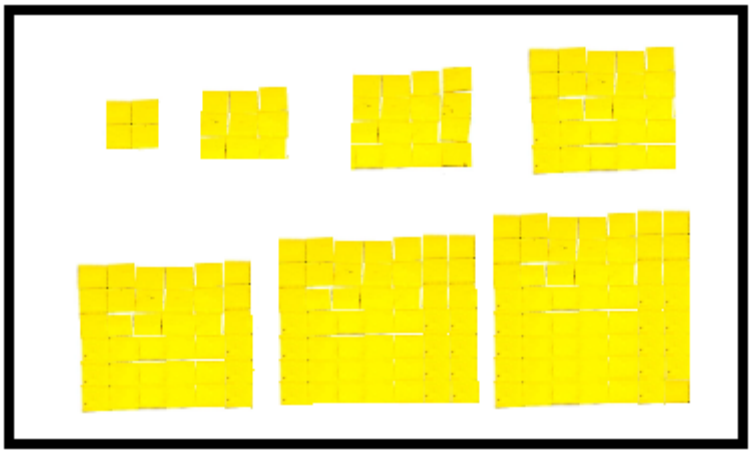

Figure 3. Student Work Results: S1 make more than six new plane figures that different sizes

S1 observe, compare, and write the results of their observations appropriately on the worksheet; and then S1 find independently the formula for the square circumference. S1 find a formula of square circumference, namely "4 x sides". S1 can determine the exact problem-solving strategy obtained from their findings to be applied to a problem so that a good and correct solution is obtained.

Subject 2

In solving the problems, S2 reflects on the previously idea, but some of the results of reflections written by students are true and some of the results of other reflections are wrong. S2 make a square (2 cm x 2 cm), but there is a slight measurement error through a less precise ruler. S2 conduct experiments independently by making five to six new plane figures that different sizes. S2 observe, compare, and write the results of their observations appropriately on the worksheet; but they found the pattern of the formula of plane figure circumference with the intervention of the teacher. S2 can determine the exact problem-solving strategy obtained from their findings to be applied to a problem, but there are some calculation errors because students are not careful in calculating or operating the numbers on the problem.

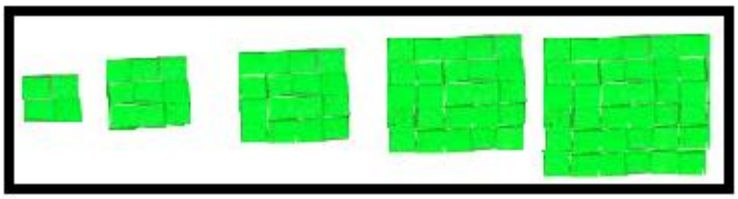

Figure 4. Student Work Results: S2 Make Five to Six New Plane Figures

Subject 3

In solving the problems, S3 reflect on the previously idea and only write down some of their reflections correctly. S3 listens to the teacher's instructions but they does an experiment that is not in accordance with the teacher's instructions. S3 make a square (3 cm x 3 cm). S3 conduct experiments independently by making three to four new plane figures that different sizes. S3 observe, compare, and write the results of their observations appropriately on the worksheet; but they is still not quite right in finding the formula of the plane figure circumference. S3 only write the correct problem-solving strategies to apply to a problem, but they do not continue the procedure of problem-solving.

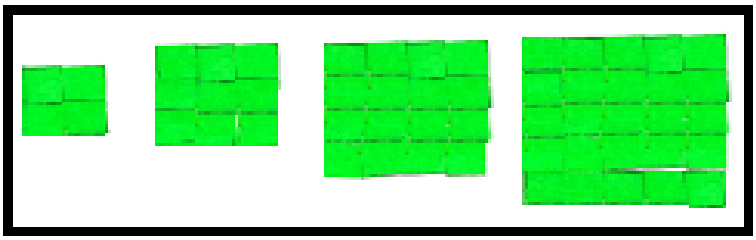

Figure 5. Student Work Results: S3 Make Three to Four New Plane Figures

Subject 4

In solving the problems, S4 Students reflect on the previously idea and only write down some of the results of their reflection but are wrong. Students does not listen and students do not experiments that have been instructed by the teacher or do experiments outside the mathematical context to be discussed. For example, students make other plane figures, namely rectangle (2 cm x 1 cm), etc. Students conduct experiments independently by making one to two new plane figures that different sizes. Students observe, compare and write the results of their experiments, but there are measurement errors in their observations; so students cannot find the pattern of the formula of plane figure circumference. Students incorrectly determine problem solving strategies to be applied to a problem, so they can't find a solution to solve the problem.

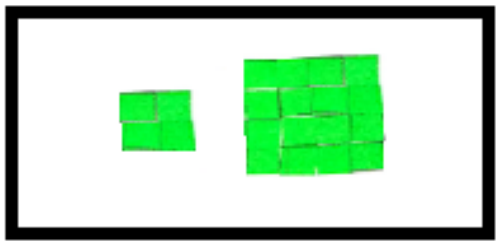

Figure 6. Student Work Results: S4 Make One to Two New Plane Figures

Subject 5

S5 do not reflect on the prerequisite material or do not write the reflection results on the worksheet. S5 do not conduct experiments openly. S5 do not do experiments or students do not make a new plane figures. S5 did not write their observations and they did not find the formula of the plane figure circumference. Threfore, S5 do not complete the problem solving process at all.

Based on the problem-solving process conducted by the five students, the results of this study focus on design of assessment based on guided discovery that includes five aspects, namely reflecting on previously idea, conducting experiments openly, conducting experiments independently, finding solutions convergently, implementing the result of discovery into the process of problem-solving. Five aspects of this assessment design were analyzed through the validation test by experts and practitioners and these five aspects were declared valid. Based on the results of the analysis of the validation test, the percentage of validity from the experts regarding the five aspects of this assessment design is 81.25% (criteria of valid). While the percentage of validity from practitioners regarding the five aspects of assessment design is 90.62% (criteria of valid). Therefore five aspects of this assessment design are valid for use in the implementation of learning based on guided discovery. These five aspects will be explained to discussion section.

4. Discussion

Based on the results above, design of assessment based on guided discovery includes five aspects, namely reflecting on previously idea, conducting experiments openly, conducting experiments independently, finding solutions convergently, implementing the result of discovery into the process of problem-solving. These five aspects are discussed by considering several references, as follows.

4.1. Reflecting on previously Idea

Reflection on previously idea is one of the main things that students need to do in learning new things or forming new knowledge. In this study, students will learn the formula of the square circumference, so students must be able to reflect the previously idea related to the properties of a square shape. This is consistent with the opinion of [20], that is the process of reflection on previous experiences is the first step to building new knowledge. In this study, students' knowledge experience about the properties of square shapes can help them in finding the circumference of a square. This is consistent with the opinion of [21],[22],[23]; that is the formation of new knowledge is based on previous knowledge that has been possessed by someone. Because of the importance of the aspect of "reflecting on previously idea" in forming or discovering new concepts, the researcher makes the assessment indicators that describe the process of students' reflection in mathematics learning based on guided discovery, namely in Table 2.

Table 2. Assessment indicators on the aspect of “Reflecting Previously Idea”

Information	Score
Students reflect on the previously idea by writing down the results of their reflections on the worksheet correctly and correctly	4
Students reflect on the previously idea, but some of the results of reflections written by students are true and some of the results of other reflections are wrong	3
Students reflect on the previously idea and only write down some of their reflections correctly	2
Students reflect on the previously idea and only write down some of the results of their reflection but are wrong	1
Students do not reflect on the prerequisite material or do not write the reflection results on the worksheet	0

4.2. Conducting experiments openly

Conducting experiments openly is an activity of students in conducting experiments with the help of instructions from the teacher, so students are not difficult to do experiments. This is consistent with the opinion of [24], that is the teacher needs to help students at the beginning of the experiment so that the experiment is not difficult to conduct by students. In this study, students are guided by the teacher to make a square (2 cm x 2 cm) through square units (1 cm x 1 cm). In addition, students are asked to calculate, observe and compare the sum of the lengths of the sides on the two of square shapes (square units measuring 1 cm x 1 cm and new squares measuring 2 cm x 2 cm). This is suitable in the statement of [25], namely the implementation of experiments gives students the opportunity to experience themselves, follow a sequence of processes, observe and compare a particular object. In this case, students actively conduct experiments and learn to identify, observe and compare problems through this experiment activity. The indicators in the design of assessment in general that describe the process of conduct to experiments openly on heterogeneous students in mathematics learning based on guided discovery are shown in Table 3.

Tabel 3. Assessment indicators on the aspect of "Conducting Experiments Openly"

Information	Score
Students listen and conducting of the teacher's instructions to conduct experiments properly and correctly. For example, student make a correctly square (2 cm x 2 cm) through a square unit (1 cm x 1 cm).	4
Students listen and do the teacher's instructions to experiment but the results of the experiment are less precise or inaccurate. For example, student make a square (2 cm x 2 cm), but there is a slight measurement error through a less precise ruler.	3
The student listens to the teacher's instructions but they does an experiment that is not in accordance with the teacher's instructions. For example, students make a square (3 cm x 3 cm)	2
Students d not listen and students do not experiments that have been instructed by the teacher or do experiments outside the mathematical context to be discussed. For example, students make other plane figures, namely rectangle (2 cm x 1 cm), etc.	1
Students do not conduct experiments openly	0

4.3. Conducting experiments independently

The implementation of experiment independently is an experiment conducted by students themselves which are based on the side of creativity of students, this experiment without the help of the teacher. Therefore, the learning is not centered on the teacher, but the learning only focused on students' activities. Based on previous experiments, students conduct experiments independently by creating a variety of new squares that different sizes creatively. This is in accordance with the statement of [26], namely experiments conducted by students based on previous experiences can be expanded and adapted to find the shape of a new plane figure creatively . This is supported by the statement of [6], namely the implementation of experiments can provide many opportunities for students to discover independently a new concept to be learned. The Indicators in the design of assessment that describe the process of conducting experiments independently of students are shown in Table 4.

Table 4. Assessment indicators on the aspect of "Conducting Experiments Independently"

Information	Score
Students conduct experiments independently by making more than six new plane figures that different sizes (it's not included plane figures obtained from openly experimenting).	4
Students conduct experiments independently by making five to six new plane figures that different sizes	3
Students conduct experiments independently by making three to four new plane figures that different sizes	2
Students conduct experiments independently by making one to two new plane figures that different sizes	1
Students do not do experiments or students do not make a new plane figures	0

4.4. Finding solutions convergently

The discovery of problem solutions in this study means students find their own patterns for the concept of a square circumference formula. The discovery of this formula is also accompanied by the teacher. In this study, students are asked to observe, compare, and write the results of their observations into students' worksheets; and then students are asked to draw conclusions and find a

formula of square circumference, namely "4 x sides". In this study, students can to compare, assess, and translate assessment results on student worksheets (LKS); and then students arrange to deduce and find the pattern of the circumference of a square, which is 4 x sides. This is in accordance with the opinion of [18], namely the discovery of patterns requires a process of mentoring or guidance from the teacher. Therefore, students need to discuss and compare the details of the results of experiments that needed to find a mathematical concept. The Indicators in the design of assessment that describe the process of "finding solutions convergently from students" are shown in Table 5.

Table 5. Assessment indicators on the aspect of "Finding Solutions Convergently"

Information	Score
Students observe, compare, and write the results of their observations appropriately on the worksheet; and then studnts find independently the formula for the plane figure circumference. For example, students find a formula of square circumference, namely "4 x sides"	4
Students observe, compare, and write the results of their observations appropriately on the worksheet; but they found the pattern of the formula of plane figure circumference with the intervention of the teacher	3
Students observe, compare, and write the results of their observations appropriately on the worksheet; but they is still not quite right in finding the formula of the plane figure circumference	2
Students observe, compare and write the results of their experiments, but there are measurement errors in their observations; so students cannot find the pattern of the formula of plane figure circumference	1
Students did not write their observations and they did not find the formula of the plane figure circumference	0

4.5. Implementing the result of discovery into the process of problem-solving

Implementing the results of findings into the process of problem-solving in the study, means students have understood the use of the findings obtained to be applied in various problem-solving forms. This aspect is the end result that the most important in the assessment process because teachers/educators can see the student's ability to apply his findings and solve the problem related to their findings. The Indicators in the design of assessment that describe the process of "Implementation process of student findings in the form of problem solving" are shown in Table 6.

Table 6. Assessment indicators on the aspect of "Implementing the result of discovery into the process of problem-solving"

Information	Score
Students can determine the exact problem-solving strategy obtained from their findings to be applied to a problem so that a good and correct solution is obtained	4
Students can determine the exact problem-solving strategy obtained from their findings to be applied to a problem, but there are some calculation errors because students are not careful in calculating or operating the numbers on the problem	3
Students only write the correct problem-solving strategies to apply to a problem, but they do not continue the procedure of problem-solving	2
Students incorrectly determine problem solving strategies to be applied to a problem, so they can't find a solution to solve the problem	1
Students do not complete the problem solving process at all	0

5. Conclusion

The results of this study are the assessment design of the guided discovery based learning process in the form of five aspects of assessment, namely: (1) *reflecting on the previously idea*: this aspect includes the assessment of student activities in reflecting and remembering previously idea that is very much needed by students in learning new things or forming new knowledge; (2) *conducting experiments openly*: this aspect includes the assessment of students' activities in conducting experiments openly with the help of instructions from the teacher as the beginning of forming new understanding for students through an experiment; (3) *conducting experiments independently*: this aspect includes the assessment of student activities in the process of experiments conducted by students themselves based on the creativity of students without the help of teachers, so learning is not centered on the teacher but only focused on student activities; (4) *finding solutions convergently*: this aspect includes the assessment of students' activities in the process of discovering their own patterns from the circumference formula or flat area; (5) *implementing the result of discovery into the process of problem-solving*: this aspect is the final result that most determines the assessment process, because teachers / educators can see the ability of students to apply their findings and solve problems related to their findings. The percentage of validity from the experts regarding the five aspects of this assessment design is 81.25% (criteria of valid). While the percentage of validity from practitioners regarding the five aspects of assessment design is 90.62% (criteria of valid). Therefore, the five aspects of this assessment design are valid for use in the implementation of learning based on guided discovery. These assessment designs aim to improve the quality of teachers' professionalism in designing assessments based on guided discovery for other topics in classroom learning.

Acknowlegment

The authors are very grateful to the Universitas Panca Marga Probolinggo, because we have the support of motivation to complete this research.

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