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Brain-based learning model to explore students' procedural fluency ability in learning quadrilateral 2D shapes

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ABSTRACT This study aims to determine the completion of student learning in procedural fluency through the Brain-Based Learning model, along with their procedural fluency in flexibility, efficiency and accuracy in quadrilateral 2D shapes. It employed a sequential explanatory research design. The research subjects were 7th graders (VII B) at SMP Negeri 2 Sokaraja, the academic year 2019/2020. The data collection technique was a procedural fluency test for students on quadrilateral 2D shapes, and the data analysis technique was the z-test. Results showed that students' procedural fluency through BBL achieved learning mastery. In terms of flexibility, students were able to solve procedural fluency test questions in two ways. Students could perform each step of the method in terms of efficiency, and in terms of accuracy, it was shown that results were repeated consistently. These findings implied that procedural fluency through BBL, along with students' flexibility, efficiency, and accuracy, belong to the fairly fluent category.

1. INTRODUCTION

Mathematics is a basic science indispensable for the development of other sciences. It is used in everyday life to deal with various problems, ranging from simple to complex problems. Rosmaiyadi (2017) specifically states that Mathematics is a scientific discipline with distinctive characteristics relating to abstract ideas or concepts arranged hierarchically.

Mathematics learning includes efforts to facilitate, encourage, and support students. Bahr (2007) denotes seven ability criteria, which must be mastered by students during the Mathematics learning process, namely: a) problem solving, b) communicating, c) reasoning, d) modelling, e) connecting, f) conceptualizing, and g) procedural.

Among those criteria, procedural fluency is one of the critical abilities. Kilpatrick, Swafford, and Findell (2001) reveal that procedural fluency has an important influence on students' mathematical abilities in schools. Without sufficient procedural fluency, students likely face difficulty in deepening their understanding or solving mathematical problems. The National Council of Teachers Mathematical (2014) states that procedural fluency ideally comes after students' first mastering conceptual understanding, strategic reasoning, and problem-solving.

2. METHOD

This study employed pre-experimental research design. It applied treatment to research subjects without a control group, in which the research process focuses on the impact of changes following the treatment of the observed research subjects. The independent variable is the Brain Based Learning (BBL) model, and the dependent variable is students' procedural fluency.

The data collection technique involved procedural fluency test in the form of a description. In so doing, all related Mathematics learning materials were delivered. The instrument used in this study was a procedural fluency test in the form of a description. The procedural fluency test is scored based on the indicators. The test scoring guidelines are presented as table 2.

The analysis process was performed by testing the proportion difference test on a single sample using the z-test. According to Sundayana (2016), "the z-test can be used to test hypotheses in a one-treatment study that uses a percentage". Data analysis for students' procedural fluency through BBL model, namely data reduction, includes correcting the results of student work, and categorizing procedural fluency into four categories (fluent, fair, poor, and not fluent).

3. RESULTS AND DISCUSSION

Results of the procedural fluency using BBL model showed that the highest score was 16 and the lowest score was 10. The maximum score was 16, which means that out of 31 students, some were able to obtain the maximum learning completeness criteria. Students' scores were hence converted to a scale of 100 to observe see the completeness of their learning. Criteria of students' learning completeness

TABLE 1. Scoring Rubrics for the Test of Students' Procedural Fluency

Aspects/ Indicators	Student response	Score
Applying procedures accurately, efficiently, and flexibly	There is no answer, or the answer does not match the question, or there is no correct answer	0
	The procedures used are mostly incorrect, and there are incorrect calculations	1
	Most of the procedures used are correct, but there are erroneous calculations	2
	The procedure used is almost complete, but there are a few errors	3
	The procedures used and the calculations are complete and correct	4
Applying procedures to different problems and contexts	There is no answer, or the answer does not match the question, or there is no correct answer	0
	The procedures used are mostly incorrect, and there are incorrect calculations	1
	Most of the procedures used are correct, but there are erroneous calculations	2
	The procedure used is almost complete, but there are a few errors	3
	The procedures used and the calculations are complete and correct	4

TABLE 2. Scoring Rubrics for the Test of Students' Procedural Fluency

Aspects/Indicators	Student response	Score
Build or modify procedures from other procedures	There is no answer, or the answer does not match the question, or there is no correct answer	0
	The procedures used are mostly incorrect, and there are incorrect calculations	1
	Most of the procedures used are correct, but there are erroneous calculations	2
	The procedure used is almost complete, but there are a few errors	3
	The procedures used and the calculations are complete and correct	4
Knowing which procedure is more appropriate to use in solving a problem.	There is no answer, or the answer does not match the question, or there is no correct answer	0
	The procedures used are mostly incorrect, and there are incorrect calculations	1
	Most of the procedures used are correct, but there are erroneous calculations	2
	The procedure used is almost complete, but there are a few errors	3
	The procedures used and the calculations are complete and correct	4

should be >70% following the Minimum Completeness Criteria. In this study, it is equivalent to 11.2.

It can be seen from the table that the highest score was 100 by S-13 and S-22, while the lowest score was 62.5 (< KKM of 70%) by S-23. Thus, 28 students achieved above KKM, and only 3 students achieved below KKM. The average score of all students was 81.85. It can be said that students' overall score was above the KKM value of 70%. The frequency of students' procedural fluency test scores less than KKM are 3 persons (9,68%), and more than KKM are 28 persons (90,32%) (Table 2 and Table 3)

It can be seen from the table that the frequency of 28 students, who scored above KKM, was 90.32%. Meanwhile, the students scored below KKM were 3 students, as equivalent to 9.68%. Analysis of student achievement on each indicator is presented in the following Table 3.

Table 3 shows that the results of the first indicator test were 3.42, which was on average with the indicator achievement of 85.5%. Results of the second indicator test averaged 3.1 with the achievement of the indicator 77.5%. Furthermore, results of the third indicator averaged 3.52 with an indicator achievement of 88%. Last, results of the fourth indicator averaged 3.06 with the achievement of the indicator 76.5%.

Students' procedural fluency using the BBL method was categorized to observe their achievement in learning quadrilateral 2D shapes. The categorization is presented at Figure 1.

TABLE 3. Analysis of the Achievement of Each Indicator of Students' Procedural Fluency Test Results Using the BBL Model

Indicator	Test	
	$\bar{X}$	%
Applying procedures accurately, efficiently and flexibly.	3.42	85.50
Applying procedures to different problems and contexts.	3.10	77.50
Building or modifying procedures from other procedures.	3.52	88.00
Understanding which procedure is more appropriate to use in solving a problem.	3.06	76.50

The figure above shows that that 19.36% of students included in "very good"; 41.94% of students included in "good"; 29.03% of students included in "fair"; and 9.67% of student included in "poor".

Assessment of student skills is carried out by looking at their ability in solving questions in the LKPD and individual assignments. The indicators measured in this study were in accordance with procedural fluency indicators, consisting of four categories.

Results of the calculation showed that Z_count=2,5 > Z_table=1,65. (H_1 was accepted). This finding implies that students' procedural fluency through BBL model achieved

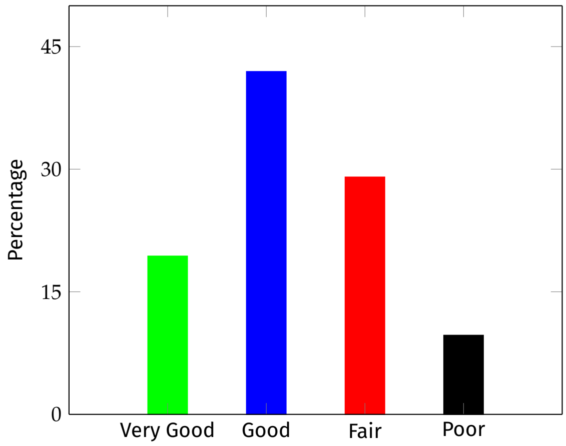

FIGURE 1. Categorization of procedural fluency test results using brain based learning (BBL) Model.

complete learning The following graph categorizes procedural fluency into four, namely, fluent, fair, poor, not fluent.

The general results of this present study show that students' procedural fluency learning quadrilateral 2D shapes included in the "fair" category, which students mostly fulfilled two aspects of each question. Furthermore, not all students were able to solve procedural fluency test questions with flexibility, efficiency, and accuracy as classified in the fluent category. It can be said that only a few students were fluent and procedurally fluent in each question. There were students worked fluently on Question 2 on the indicators of applying procedures in different contexts and problems. However, there were students who could not work fluently in their procedural fluency, on Question 1, 3 and 4. This finding implied students' less skill in developing procedures for the problems of these questions.

The learning model used in this study was a group discussion method adapted to the BBL model, which demands group learning activities (Jensen, 2011). In group discussion, students are required to participate actively during learning. Students' active participation can be in the form of group discussions with other students, or actively asking questions related to the learning materials, and communicating the results of the discussions. These made it easier for students to understand the learning material, as stated by Nurmalasari, Kade and Kamaluddin (2013) that "students are more active because they have a pivotal role in the teaching and learning process; it is expected that students will find it easier to understand the concepts". Therefore, learning where students are the center is better for the development of students' abilities, including their procedural fluency.

At the beginning of learning using the BBL model, students faced difficulties when working on the learning materials because they were not used to work in groups. Another obstacle was students' difficulties when working on LKPD about procedural fluency questions. This was because students were neither used to work on questions in the form of applying procedures in different contexts and problems; nor solving procedural problems flexibly, accurately, and efficiently. This newly introduced BBL model might confuse students, which made them ask the teachers and friends continuously, causing noise and disturbing focus.

However, the implementation of BBL model potentially explored students' procedural fluency. One of the causes were that learning through BBL model employes teaching materials that are closely related to daily problems, which attract stduents' interest. Jensen (2011) states that BBL model encompasses learning topics related to the contextual and real-world basis. The learning materials are easier to understand, and the learning objectives are more achievable.

Another aspect of procedural fluency is efficiency. Students' responses in this study showed that they were mostly able to solve procedural fluency test questions using the correct, and able to streamline every step of the method. It means that students did not stop at the steps of the method, instead attempted to complete procedural fluency test questions until obtaining the final result. This finding supports Bahr and Garcia (2010), who states that students who met the efficiency aspect would not likely stop at many steps, and did not lose direction in logical strategies. Among the problems were the completion step that is too long, despite that the solution can be shortened to be more efficient in calculations. Consequently, students became too focused on the concepts in solving procedural fluency test questions, leading to complicated calculation process that resulting on wrong final answers.

4. CONCLUSION

Students' procedural fluency through BBL model achieved complete learning. In terms of flexibility, students were able to solve procedural fluency test questions in two ways: the way they understand or have learned, and using other ways to make sure that their answer is correct. In the aspect of efficiency, students were able to solve procedural fluency test questions using the correct concept, in which they were able to streamline every step of the method. Last, the accuracy was shown through students' ability to carry out the calculation process carefully. The results obtained from solving the procedural fluency were correct, and the students rechecked the calculations to ensure their final answer. In conclusion, students' procedural fluency through the BBL model was fairly fluent in terms of flexibility, efficiency and accuracy.

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