**The Contextual and Scientific Approaches in Mathematics Learning: a comparison of its effectiveness in terms of the Mathematical Literacy**

**D B Widjajanti 1), N Maryani2)**

***1,2) Yogyakarta State University, Yogyakarta, Indonesia***

**Corresponding author:** [**djamilah\_bw@uny.ac.id**](mailto:djamilah_bw@uny.ac.id)

**Abstract.** Comparing Contextual and Scientific approaches in mathematics learning in terms of student literacy skills is essential for mathematics teachers. It is with this purpose that this research. We chose Solid Geometry for junior high school students for this research material. We randomly took two classes of the nine classes, grade 8 in MTsN 1 Boyolali, Central Java, Indonesia, to become the research sample. The instrument for measuring students' mathematical literacy skills is in the form of essay questions. The instrument is valid and reliable. The comparison of the two learning approaches uses an average score of mathematical literacy. The study results using a significance level of α = 5% concluded that the mean scores of mathematical literacy skills between the two classes were not significantly different.

1. Introduction

Students' mathematical literacy skills are still in the spotlight. Students have learned a lot of mathematical concepts, principles, and algorithms at school. There are countless numbers of mathematical concepts, principles, and algorithms that have been studied by students, as long as they go to school. However, students' mathematical literacy skills, especially for Indonesian students, are still considered a concern [1].

Mathematical literacy is students' ability to be able to use mathematics in various contexts of everyday life [2]. This ability includes the ability to formulate, use, and interpret mathematics in multiple contexts [3]. Included in math-literacy is a person's ability to reason mathematically and use mathematical concepts, procedures, facts, and tools to explain and predict phenomena. Ojose [4] states that math-literacy is the knowledge to apply basic mathematics to everyday living.

According to the PISA framework [5], mathematical literacy domains include content, context, and process. The three of them are related. Content includes (1) Change and relationships; (2) Space and Shape); (3) Quantity; and (4) Uncertainty and data. Regarding context, PISA classifies it into personal, occupational, societal, and scientific contexts. As for the process, PISA classifies it into Formulate (formulating a situation mathematically); Employ (using mathematical concepts, facts, procedures, and reasoning), and Interpret (interpreting, applying, and evaluating results/solutions).

 Mathematics teachers have chosen various methods/approaches/strategies for learning mathematics to develop students' mathematical literacy skills. Some of the approaches chosen by mathematics teachers are the Contextual and Scientific Approach. Many mathematics teachers use both of these approaches because of the potential to improve student achievement in mathematics. Several research results conclude the effectiveness of both in terms of student achievement [6 - 8].

Mathematics teachers use Contextual Teaching and Learning (CTL) as a learning approach to motivate students to connect subject matter with phenomena and contextual problems in the real world [9]. Learning to use CTL allows students to understand the mathematical concepts they are learning and relate them to their previous learning experiences. In this way, students can find ideas and relationships between these concepts.

The teachers can implement CTL in the classroom using the steps known in the acronym REACT, namely: (1) Relating; (2) Experiencing; (3) Applying; (4) Cooperating; and (5) Transferring [10]. Relating is learning in the context of real-life experiences or previous knowledge. Experiencing is a learning strategy through exploration, discovery, and creation. A variety of classroom experiences can include manipulative use, problem-solving activities, and practical work in laboratories. Applying is learning to use the concepts that have been understood to practice solving real and relevant problems. Cooperating is learning in a group to sharing ideas, responding, and communicating between students. Meanwhile, transferring is learning by using previous knowledge for new contexts. Learning using CTL includes constructivist learning.

Similar to CTL, the Scientific Approach also refers to constructivist learning theory. A scientific approach is a learning approach that adopts the scientific method. At the simplest level, the scientific method consists of observing, explaining, and testing steps [11]. The purpose of learning activities that use scientific methods is to help students understand the methods scientists use to solve problems.

The teachers recognize the steps of the scientific approach with the abbreviation 5-M (in Indonesian), namely: (1) observing; (2) questioning; (3) gathering information; (4) reasoning; and (5) communicating [12]. In the first step, namely observing, the teacher presents something that must be attended by students. In mathematics learning, the teacher can give pictures, a list of examples of a concept, or videos that contain mathematics problems. In the second step, namely questioning, the teacher allows all students to ask questions after observing what the teacher says. In the third step, gathering information, students seek information from learning resources shown by the teacher to understand concepts or solve problems. In the fourth step, reasoning, students individually or discuss in groups, learn to solve the teacher's questions. In the final step, communicating, students present their learning results, orally or through writing.

In more detail, we describe the relationship between the steps in CTL and the Scientific Approach with mathematical literacy skills as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CTL** |  | **Math Literacy** |  | **Scientific** |
| Relating |  | Formulate |  | Observing |
| Experiencing |  |  |  | Questioning |
| Applying |  | Employ |  | Gathering Information |
| Cooperating |  |  |  | Reasoning |
| Transferring |  | Interpret |  | Communicating |

**Figure 1.** The relationship between learning steps and mathematical literacy skills

Considering the steps in these two learning approaches, theoretically, CTL can further improve students' mathematical literacy skills compared to scientific learning. In CTL, almost all steps can improve students' ability to choose/use the right formula. Whereas in the scientific approach, almost all steps have the potential to develop students' abilities in formulating mathematical models in solving problems.

There have been several research results related to each approach's effectiveness. But no one has yet compared the effectiveness of the two in terms of junior high school students' mathematical literacy abilities, especially for the topic of Solid Geometry. Knowing the effectiveness of both will help mathematics teachers in schools in designing effective learning to develop mathematical literacy skills. It is for this reason that researchers conducted experimental research to answer the hypothesis whether CTL is more effective than the Scientific Approach when viewed from the average score of junior high school students' mathematical literacy skills on the topic of Solid Geometry.

1. Methods

This type of research is experimental. The factor in this study is a learning approach consisting of contextual and scientific approaches. We determined students' mathematical literacy skills as an observed response. The research conducted at MTs N 1 Boyolali, Central Java, Indonesia, took place in March 2020. The implementation of learning to try out the two approaches lasted five meetings. Each meeting lasts 80 minutes. The teacher who teaches both classes is the same. The research schedule is as follows.

**Table 1.** Research Schedule

|  |  |  |  |
| --- | --- | --- | --- |
| Meeting number | Date and Time | | Activities and materials |
| CTL | Scientific |
| 1 | Thursday, March 5, 2020 | Saturday, March 7, 2020 | Cubes |
| 2 | Tuesday, Marc 10, 2020 | Thursday, March 12, 2020 | Blocks |
| 3 | Thursday, March 12, 2020 | Saturday, March 14, 2020 | Prisms |
| 4 | Tuesday, Marc 17, 2020 | Thursday, March 19, 2020 | Pyramids |
| 5 | Thursday, March 19, 2020 | Saturday, March 21, 2020 | A combination of cubes, blocks, prisms, and pyramids |
| 6 | Thursday, March 24, 2020 | Saturday, March 28, 2020 | Test |

This study's population was all 8th-grade students of MTs Negeri 1 Boyolali in the 2019/2020 school year. We randomly chose two classes as a sample of the nine existing grade 8 classes. At random, we made one class, the first experiment class (called the Contextual class). We make the other class the second experiment class (which is called Scientific Class). The contextual class consists of 37 students, while the scientific class consists of 36 students. The two classes are equivalent, judging from the results of their average initial ability test on Solid Geometry.

This study uses an instrument in the form of mathematical literacy questions. The essay question consists of 4 question numbers. The question is classified as valid and reliable, with a Cronbach's Alfa reliability coefficient of 0.78.

We have developed Lesson Plans and Student Worksheets for the Solid Geometry topic. This learning tool has been declared valid by Geometry experts. Lesson Plants for Scientific Learning contains Core Competencies, Basic Competencies and Competency Achievement Indicators, Objectives, Materials, Methods, Media, and Learning Activities. Learning activities include an introduction, core, and conclusion. The core activities consist of observing, questioning, gathering information, reasoning/associating, and communicating. Lesson Plants for CTL are different from lesson plants for Scientific Learning, only in the core activity section. The rest is the same. The core activities include Relating, Experiencing, Applying, Cooperating, and Transferring activities.

The student worksheet for Scientific Learning contains sections: 'let's observe,' 'what your question?', 'let's find out,' 'let's analyze,' and 'let's share.' Meanwhile, the Student worksheet for CTL contains the sections 'did you know,' 'pay attention to this problem,' 'questions to practice,' 'solve,' and 'let's work on these other problems.'

To test whether the Contextual Approach is more effective than the Scientific Approach in terms of the average score of students' mathematical literacy skills, we used an independent sample t-test with a significance level of α = 5%. Previously, the normality assumption test resulted in the conclusion that the data came from a normally distributed population.

1. Result and discussion

The learning implementation in both classes went according to plan. The treatment for each class took place in 5 sessions. After learning the Solid Geometry topic, we gave mathematical literacy test questions.

The data description from the Contextual Class and the Scientific Class shows that the mean and standard deviation of the mathematical literacy scores of students of both classes are relatively equal, as illustrated in Table 2 below.

Table 2. Statistics for the Mathematical Literacy Skills Score

|  |  |  |
| --- | --- | --- |
| Statistics | Contextual Class  (n = 37) | Scientific Class  (n = 36) |
| Mean | 77.78 | 75.88 |
| Std. Deviation | 7.54 | 6.28 |
| Minimum\*) | 62.5 | 62.5 |
| Maximum\*) | 87.5 | 87.5 |

\*) possible scores 0 - 100

The hypothesis testing results about the similarity of the mean score of students who learn using a contextual and scientific approach using α = 5% conclude that the mean of both can be considered the same (sig (2-tailed) = 0.242). Thus, we concluded that the two approaches' effectiveness was not significantly different in terms of the average score of mathematical literacy skills of junior high school students on the topic of Solid Geometry.

These results differ from our' hypotheses. Theoretically, the Contextual Approach has more potential to develop students' mathematical literacy skills than the Scientific Approach. The allegation was due to the Contextual Approach's first step, namely relating, which allows students to learn mathematics in a real-life context and links to previous experiences that students have had. According to Stoehr, K et al. [13], learning mathematics in a real-world context is more comfortable for students to understand.

It seems that the steps in the scientific approach are also effective in developing students' mathematical literacy skills. This effectiveness is likely supported by the selection of what the teacher provides for students to observe. Thus, if the teacher wants to develop students' mathematical literacy skills, it is better to choose math problems that exist in everyday life for students to observe.

Another possibility that makes the results of these two treatments not significantly different is the underlying learning theory. Both learning approaches (Scientific and CTL) use the basis of Constructivism Learning Theory. According to Taber [14], using constructivism in learning means giving students space and time to construct their knowledge through activities designed by the teacher. In this research, both of these learning approaches in their implementation provide enough space for students to build their knowledge. In scientific learning, especially in the gathering information and reasoning/associating steps. Whereas in Contextual Teaching-Learning, especially in the experiencing and applying steps.

Although this study concludes that the effectiveness of the two learning approaches is not significantly different, however, the results per indicator are not entirely the same. The following table 3 shows the achievements per indicator.

Table 3. Percentage of Achievement of Each Indicator

|  |  |  |  |
| --- | --- | --- | --- |
| **Indicator** | **Description** | **Contextual Class (%)** | **Scientific Class (%)** |
| Formulate | Create a mathematical model | 88.29 | 97.30 |
| Employ | Determine the solution using the correct formula | 74.19 | 65.27 |
| Interpret | Interpret mathematical solutions into the context of the problem by providing the right reasons | 77.48 | 77.00 |

The percentage of achievement of the first indicator, namely "formulate" in the Scientific class, outperformed the Contextual level. However, for the second indicator, namely "employ," the result is the opposite. Even the percentage of achievement of this second indicator, which is only 65%, is the lowest achievement in the two classes' three indicators. The results in Table 3 are under our hypothesis, as illustrated in Figure 1. The strength of CTL is in developing students' abilities in selecting/using appropriate formulas. While the advantages of the Scientific Approach are in developing students' abilities in developing mathematical models. For the CTL and Scientific approach, things that need additional attention from the teacher are students' skills in using mathematical concepts, facts, procedures, and reasoning to solve problems.

To get an overview of how students work on the teacher's mathematical literacy questions, in the following, we show one example of the questions and some of the students' answers.

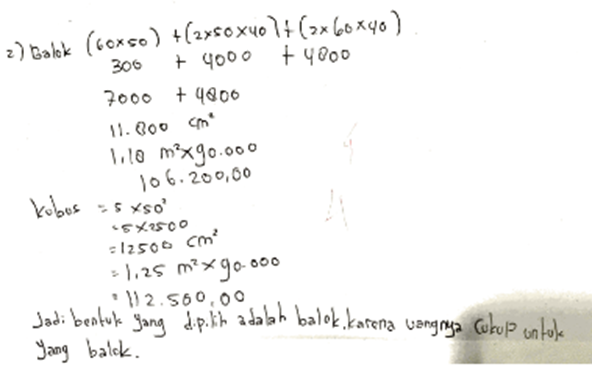
*Two students, Elsa and Izza, get a group assignment by the teacher to create one aquarium without a roof for Biology subjects made of glass. The teacher provides two aquarium options, namely the aquarium in the form of blocks with a size of 60 x 50 cm x 40 cm and a cube aquarium with a side of 50 cm. They both have an opinion different. Elsa chose a cube-shaped aquarium, while Izza wants a block aquarium. If the teacher gives the amount of money IDR 110,000.00 and the price of glass are IDR 90,000.00 per m2. Which form should students choose with the available cash? Give the reason!*

Figure 2 shows an example of a student's incorrect answer. This student did not carefully read the information on the question that the aquarium was without a roof. He is also wrong in doing multiplication. Then, he didn’t give a reason.



**Figure 2.** Examples of student incorrect answers

Slightly better than the student's error, as in Figure 2, in Figure 3, the student's mistake is wrong in multiplying 60 by 50. From this answer, we can also know that this student is incomplete without giving an "=" sign at every line change. Also, there is no description of "glass price" when students click the building's surface area and the price of glass per square meter. Incompleteness like this does not only exist in one or two students' answers, but there are several. Therefore, mathematics teachers need to teach students to get used to writing complete solutions with correct signs and information.



**Figure 3.** Examples of student incorrect answers

The mistakes made by students in the two classes were relatively similar. In general, students are not careful in reading the information, use formulas incorrectly, are not thorough and detailed in doing calculations, and do not give reasons. Such mistakes need the attention of the math teacher.

1. Conclusion

Although explicitly the steps of learning mathematics with the CTL and Scientific approaches are different, the results of this study conclude that the effectiveness of both in terms of the average mathematical literacy skills is not significantly different. These results differ from our hypothesis, which initially considered the CTL approach to be superior to Scientific. Our further research concludes that, in principle, these steps of the two learning approaches are equally useful for developing the math literacy skills of grade 8 students at MTs N 1 Boyolali, Central Java, Indonesia, on the topic of Solid Geometry. Although the two classes' average mathematical literacy skills are not significantly different, each learning approach has its advantages. The strength of CTL is in developing students' abilities in selecting/using appropriate formulas. In comparison, the Scientific Approach edges are in developing students' abilities in developing mathematical models.

References

[1] Stacey K 2011 The PISA view of mathematical literacy in Indonesia *J. Math. Educ.* **2** 95–126

[2] OECD 2009 PISA 2009 Assessment Framework. Key competencies in reading, mathematics and science *Assessment* **20** 528–33

[3] OECD 2017 PISA 2015 Mathematics Framework 65–80

[4] Ojose B 2011 Mathematics Literacy: Are We Able to Put the Mathematics We Learn into Everyday Use? *J. Math. Educ.* **4** 89–100

[5] OECD 2012 PISA 2012 Assessment and Analytical Framework 27–37

[6] Saragih D I and Surya E 2017 Analysis the Effectiveness of Mathematics Learning Using Contextual Learning Model *IJSBAR* **34** 135–143

[7] Susanti U and Wutsqa D U 2020 Keefektifan pendekatan contextual teaching learning dan problem solving ditinjau dari prestasi dan kepercayaan diri siswa *JRPM* **7** 97–107

[8] Amiyani R and Widjajanti J B 2019 Self-confidence and mathematics achievement using guided discovery learning in scientific approach *J. Phys. Conf. Ser.* **1157**

[9] Suhendar U and Widjajanti D B 2016 Komparasi Keefektifan Saintifik dan PMRI Ditinjau dari Prestasi, Minat, dan Percaya Diri Siswa Kelas VII *PYTHAGORAS J. Pendidik. Mat.* **11** 91–101

[10] Crawford M L 2001 Teaching Contextually *CORD* 3-14

[11] Carey S S 2004 A Beginner’s Guide to Scientific Method WARDSWORTH CENGAGE Learning

[12] Kurniasih I and Sani B 2014 Implementasi Kurikulum 2013 Konsep dan Penerapan *Kementrian Pendidikan dan Kebudayaan* 1–162

[13] Stoehr, K., Turner, E., & Sugimoto, A. 2015 One teacher’s understandings and practices for real-world connections in mathematics. *Proceedings of the 37th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* 1150 –1153

[14] Taber, K. S. 2019 Constructivism in Education: Interpretations and Criticisms from Science Education. *In Information Resources Management Association (Ed.*), Early Childhood Development: Concepts, Methodologies, Tools, and Applications 312-342