



Improvement of Mathematical Literacy with Differentiation Learning Model

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Abstract. Mathematics is not only a matter of students being able to count and be able to complete the tasks given by the teacher. Teachers must equip students to be able to use mathematics as a good tool for understanding, reasoning, communication, connection, and representation, to solve contextual problems that students will face in the future and are very closely related to life. In the 21st century, literacy skills are needed, one of which is mathematical literacy. In the initial test of quadratic functions related to the context of everyday life, the students have difficulty in formulating and consequently, solving the problems. Therefore, the teacher considers the use of differentiated learning by creating a visual model to solve quadratic function problems in the context of everyday life. This paper describes the approach to learning differentiation in mathematics learning to improve the mathematical literacy skills of grade 9 students on quadratic function problems. The research descriptive qualitative method. The data were collected from the implementation of learning and students' work. The activities were designed based on problem-solving steps to demonstrate mathematical literacy indicators, namely formulating problems, using mathematics, interpreting solutions, and evaluating solutions. In differentiated learning the teacher presents a contextual problem of quadratic functions and adds student practice activities and spreadsheets. The post-test results of 24 students showed that the differentiation learning approach could assist the students in solving contextual problems of quadratic functions.

Keywords: Differentiation · Mathematical Literacy

1 Introduction

Learning mathematics is one of the schools aims, among other things, so that students have confidence and competencies to use mathematics, as well as an appreciative attitude toward the role of mathematics, not only in daily life but also during the history of humankind [1]. The students' attitude in appreciating the use of mathematics can be identified from students who possess characteristics such as curiosity, attentiveness, and interest in studying mathematics, as well as tenacity and confidence in problem solving [2]. The success or failure of learning mathematics depends on the students' capacity and readiness to participate in learning activities, which is influenced by their attitudes to and interests in mathematics [3, 4].

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A meaningful and joyful experience in learning mathematics, especially the topic of quadratic function, will greatly affect the students' interest in learning. Students consider mathematics difficult, leading to lack of motivation and desire to learn. This condition causes unsatisfactory mathematics learning outcomes, which is evident in the scores and grades of daily test, assignment, and end-of-semester test.

In the school where this study was conducted, the daily test of quadratic function topic for the academic year 2021/2022 has a minimum completeness criterion of 66%, which is still far below the required completeness criterion of the study (75%). The reasons include (1) some students' perception that mathematics is an unexciting, difficult, and tedious subject; (2) the unfavorable mathematics learning process, because it is dominated by the lecture method; (3) the challenges faced by some teachers on teaching basic mathematics concepts to students and, (4) the lack of variation in the learning model used by the teacher. This situation causes students' understanding of concepts to be suboptimal which leads to low student achievement.

One of the models and approaches that can be implemented to improve the students' achievement is differentiated learning, which is according to Tomlinson [5], is an attempt to adjust the learning process in the classroom to fulfill the learning needs of each student. Differentiated learning takes into consideration the students' interest, learning profiles, and readiness to improve learning achievement. Learning differentiation can be achieved through differentiating content, process, product, and learning environment [6].

2 Methods

This research was conducted at SMP Negeri 1 Pagaden. The subjects in this study were grade 9 students in the 2021/2022 academic year. A group of 24 students, including 13 female students and 11 male students, with varying abilities participated in this study. This class has characteristics like other classes in general.

2.1 Research Approach and the Designed Learning Differentiation

The study is classified as a type of research known as classroom action research (CAR), with learning differentiation approach as the intervention. According to Arikunto [7], action research procedures occur in cycles. Figure 1 below illustrates the four stages of action research, which include Planning, Implementation, Observation, and Reflection.

Planning is an initial mechanism that focuses on preparing everything needed to implement the classroom action research, including the substance of the study, the research design, and the technical administration of its implementation. In general, the activities conducted in this preparatory stage include (1) research team coordination; (2) preparation of research designs, including the design of learning activities: preparing syllabus, making lesson plans, making teaching materials, making student worksheets; (3) the preparation of research instruments needed to evaluate the learning process and results includes making student questionnaires, making observation sheets, making assessment tools for aspects of knowledge, attitudes (observation and self-assessment) and skills, making project assignments, preparing equipment to document activities during the learning process takes place like a camera and coordinates

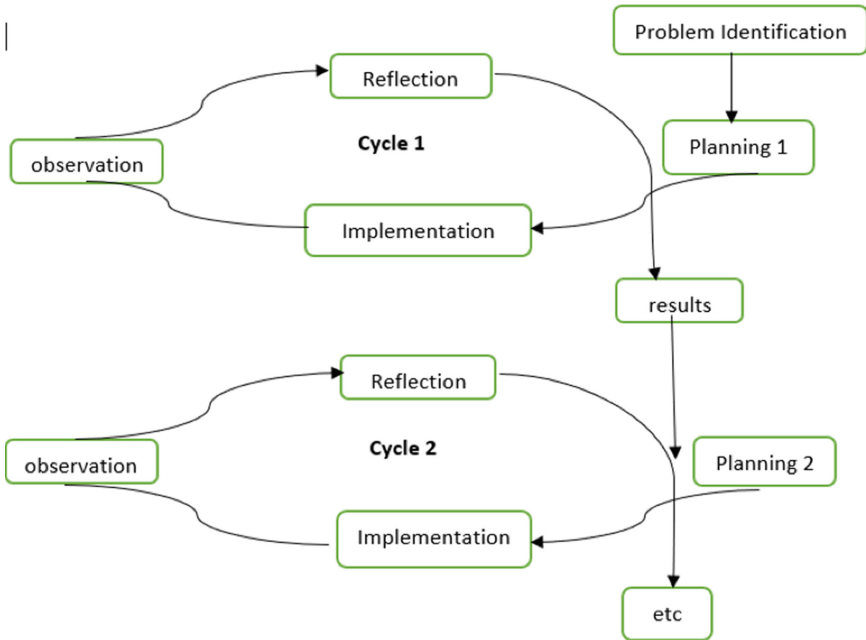


Fig. 1. The process of conducting classroom action research (CAR).

with colleagues to help observe learning activities; (4) identification of problems in the application of learning differentiation; and (5) finding alternatives and formulating problem-solving strategies.

The next stage is the implementation of the differentiation approach [8] and at the same time assessing the process of learning activities. This implementation stage includes (1) explaining the learning model and the learning objectives to the students; (2) implementation of learning with a differentiation approach; (3) assessment of learning both from the perspective of the process and learning outcomes; (4) mentoring students in completing assignments; and (5) presentations between groups. At this stage, various action plans in cycles 1 and 2 are implemented. Students are divided into 4 groups with a total of 4 students for each group.

(Ditasona, 2017) The designed differentiated learning consists of four meetings, which is explained as follows.

Meeting 1. The teacher explained the meaning of quadratic functions to students regarding factorization, the quadratic formula, axis of symmetry, and optimum values.

Meeting 2. The teacher discussed the graph of the quadratic function. Students constructed graphs using materials available at school such as checkered blackboards, ropes used for mattresses, safety pins, scissors, and tape to stick on the blackboard.

Meeting 3. The teacher explained the calculation of the quadratic function. Students and their groups (through class discussions facilitated by the teacher) designed activities with the theme of making sketches of graphics. In their groups, the students began to arrange schedules, take measurements of the vacant land next to the classroom. Students

determine the optimum point. Using a scale, students sketch the soil that has been measured. Students are given the freedom to sketch quadratic functions.

Meeting 4. During one week between meetings 3 and 4, students consulted the teacher on the implementation of the completion of project assignments (teacher supervision). The results of these sketches and reports will be presented in class. At the fourth meeting, students were given test to measure their learning achievement at the end of the cycle.

In addition to consulting with the teacher on project assignments, students also underwent observation during the teaching and learning process. Observation is carried out during the teaching and learning process by an observer or a math teacher. The observed students are grouped heterogeneously in achieving learning objectives in order to facilitate the process of completing project assignments in groups.

The observation stage provided valuable data that were analyzed to plan and adjust actions in the next cycle. This analysis was carried out during the reflection stage. Meanwhile, at the reflection stage of the second cycle, the results were analyzed and used to draw conclusions and determine suggestions.

2.2 Research Instruments

The research instruments used in this study include observation, questionnaires, interviews, and project assignments with a differentiation approach based on learning.

Project evaluation involves evaluating a task that needs to be accomplished within a specified timeframe, which typically entails investigating, planning, gathering, organizing, processing, and presenting data. Three key factors to take into account during project appraisal are (1) management ability, namely the students' ability to manage tasks such as selecting topics, gathering information, and time management; (2) relevance, namely ensuring the appropriateness of the project topic for the student's level of knowledge, understanding, and skills; and (3) authenticity, as in the project must be the student's own work with guidance and support from the teacher.

The observation was carried out by fellow teachers with the help of observation sheets. The observation sheets are organized to facilitate researchers in monitoring classroom actions, classroom situations, and student engagement during the learning process.

Questionnaires in this study were used to measure students' responses and attitudes after learning. The contents of this questionnaire are about students' opinions on the activities of the differentiated approach learning process, as well as teacher attitudes. From this questionnaire, we can find out about students' responses to learning activities as a whole. The interview conducted by the researcher was an open interview, the subject knew he was being interviewed and also knew what was meant by an interview. The purpose of this interview is to find out the views, attitudes, and motivations of students in learning the differentiation approach. The interview targets were three students who scored high, medium and low in the written test each cycle. Interviews were conducted outside of class hours after learning was completed.

As for the documentation, photos and videos are used to record student behavior during the learning process. Photo and video documentation were chosen with the aim of strengthening the results of the research and to explain the continuity of the research

from beginning to end, so that the research can be accounted for. Things to be documented are as follows: (1) when the teacher delivers material about quadratic functions using applications such as GeoGebra, Quizizz and Padlet, (2) student activities in the learning process, (3) student activities while working on project assignments, (4) student activities in discussion and presentation activities.

2.3 Data Analysis Technique

To analyze data from observation, observers and researchers discussed the results of observations at each meeting and analyzed them by looking at the suitability of the actions taken with the steps of implementing the differentiation approach learning, so the shortcomings made by the teacher will appear. If there are still weaknesses or actions that are not in accordance with the steps of implementing learning, it is necessary to plan new actions as an effort to improve the implementation of the next learning in the next cycle. The implementation of the action is said to be in accordance with the plan if the implementation of the action during the learning process takes place in accordance with the steps in the application of the differentiation approach learning.

To analyze the questionnaire data, the data is calculated by adding up all students who think according to the choices in the questionnaire compared to the number of existing questionnaires. The amount is converted to a percentage in the following way:

$$P = \frac{J}{N} \times 100\% \quad (1)$$

Information:

P = Percentage of respondents who answered according to their choice

J = Number of respondents who answered according to their choice

N = Number of student questionnaires

Koentjoroningrat [9] interprets the data using the following criteria (Table 1):

As for the students' mathematics learning outcomes, the analysis was carried out using the analysis of the achievement of learning process on the competence of attitudes, skills, and knowledge. For assessment of attitude, students are said to be successful in

Table 1. Interpretation of Questionnaire Results

Percentage	Interpretation
0	None
1 – 25	A fraction
26 – 49	Nearly half
50	Half
51 – 75	Most
76 – 99	In general
100	All

Table 2. Attitude Rating Range

Mode	Criteria
4	Very good
3	Good
2	Enough
1	Less

responding to mathematics learning if they reach the minimum criteria of B (Good) with an assessment range as shown in Table 2.

Knowledge assessment, in addition to knowing whether students have achieved teaching and learning activities is also to identify weaknesses and strengths of students' mastery of knowledge in the learning process (diagnostics). The results of the assessment are used to provide feedback to students and teachers to improve the quality of learning. The results of the knowledge assessment carried out during and after the learning process are expressed in the form of numbers with a range of 0–100. The analysis of the achievement of teaching and learning activities was carried out by comparing the percentage of the number of students who achieved teaching and learning activities at the basic value before the action was taken with the percentage of the number of students who achieved teaching and learning activities to the mathematics learning outcomes after the action was taken.

A skills assessment is conducted to evaluate how well students can utilize their knowledge in different contexts within a school setting, based on indicators of competence attainment, in order to perform specific tasks.

3 Result and Discussion

Research planning is carried out in the first week of August 2021 by compiling a lesson plan, preparing project assignments, preparing student worksheets, observation sheets, student questionnaires, assessment tools, and equipment to document activities during the learning process such as camera. The researcher also coordinated with colleagues to help observe CAR activities (Fig. 2).

Before entering Cycle 1, the activity begins with a pretest which was held on Wednesday, August 4, 2021 (Fig. 3). The first cycle was held on 9, 12, 16 and 19 August 2021. The first meeting was held on 9 August 2021, starting with a 10-min preliminary activity by giving apperception and motivation. In the preliminary activity students were asked to pray together, then the teacher checked the students' attendance. Teacher checked the students' preliminary knowledge on quadratic function. The teacher divided the students into four groups and asked them to appoint one person as group leader. Preliminary activity was closed with the teacher conveying the learning objectives.

In the core activity the teacher explained the meaning of the quadratic function on grid paper. Students asked questions to express their curiosity about the topic being studied. The teacher directed by giving guided questions. The teacher distributed the



Fig. 2. Coordination with the research team and preparing the students



Fig. 3. Pre-Test Activities

worksheets to students. The teacher asks the students to read the given challenges by paying attention to the limitations in the students' worksheet. Students find it difficult to find x_1 and x_2 . The teacher provided guidance, students must be able to imagine with the help of the content in the video shows in class (Fig. 4).

The second meeting was held on Thursday, August 12, 2021. The preliminary activity was the same as the first meeting, namely for 10 min the teacher gave apperception, motivation and conveyed learning objectives.



Fig. 4. Teaching and Learning Activities in Cycle I (Meeting 1)

In the core activity the teacher explained about finding the value of the axis of symmetry and the optimum values. The teacher introduced the students to existing applications in learning. Students in groups start to try the application to form the value of x_1 and value of x_2 . Children felt very happy to learn by using the media, given application and props. They enjoyed it so much that even during break time they did not want to leave class and continued to do the task. There were even groups that work by looking for sketches (Fig. 5).

The teacher gave the students the freedom to explore the given application by providing video tutorials. The test results in cycle 1 showed an increase in learning outcomes.



Fig. 5. Teaching and Learning Activities in Cycle I (Meeting 2)

The average score of the pre-intervention test was 69.06 with 68.75% completeness and after the first cycle of intervention the average learning outcomes test increased to 75.31. The achievement of learning outcomes in cycle 1 increased by 6.25 with 75% completeness. In cycle 1 there were four children whose scores are still below the minimum completeness criteria of 70. For children whose grades are below the required minimum, remedial teaching is held after school (Fig. 6).

The average of the first cycle of learning outcomes test was 75.21 and after the second cycle of intervention it increased to 81.25. Learning outcomes in cycle 2 increased by 5.94 with learning completeness of 87.5%. This finding is in line with a study by Ditasona [10], who found that students' mathematical reasoning ability increases with differentiated instruction.

In cycle 2 there are two children whose scores are still below the minimum completeness criteria of 70. For children whose grades are below the required minimum, remedial teaching is held after school. In cycle 2, the performance indicators have reached, namely 87.5% of students have scored above or equal to the KBM. Hence, the research was stopped and declared successful (Table 3).



Fig. 6. Student resume literacy that will be uploaded on the Gate Cita application

Table 3. The average Mathematics Learning Outcomes score and completeness percentage

	Pre Action	Cycle 1	Cycle 2
Average	69,06	75,31	81,25
Completeness	68,75%	75,00%	87,50%

September 2, 2021 was the end of cycle 2 activities, a test was carried out to see the completeness of learning results and filling out questionnaires.

4 Conclusion

Increasing mathematical literacy with the differentiation learning model can improve the learning outcomes of grade 9 students of SMP Negeri 1 Pagaden. From the results of the questionnaire, it can be seen that students' attitudes towards learning quadratic functions using the differentiation learning model are mostly good and very good. Learning outcomes based on aspects of knowledge increased. The average value of pre-intervention learning outcomes test is 69.06 with 68.75% achievement. In cycle 1, learning achievement has increased to 75% with an average learning outcome test of 75.31 and in cycle 2 learning achievement has increased again to 87.50% with an average learning outcome of 81.25. On the average skill competency, the project results have increased, namely in the first cycle 78.50 and in the second cycle 87.50.

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