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# The Efforts to Improve Mathematics Learning Outcomes in Sequences and Series Materials Using a Problem Based Learning Model with a Differentiated Strategy

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**Abstract:** The failure to integrate differentiated learning in the classroom is the driving force behind this research. Mapping students' learning needs is the first step in implementing individualized instruction in the classroom. Learning readiness, student interests, and learning profiles are three views on differentiated learning that can be used to map out students' requirements. The purpose of this study is to enhance student learning experiences and results. Two devices are used for data collection: learning achievement exams and student activity observation sheets. Both descriptive statistical analysis and descriptive analysis were used to analyse the data. The average class score was 74 in the first cycle and improved to 84.4 in the second. Every student was able to meet the 75-point Minimum Completeness Criteria (KKM) set by the school. It is possible to enhance student learning activities and outcomes by combining differentiated learning with the Problem Based Learning model, according to the study's findings. In addition to offering a learning environment that puts students' needs first, problem-based learning activities also benefit formative and summative learning through the third step of differentiation.

**Keywords:** Differentiate Learning, Learning Outcomes, Problem Based Learning

## A. Introduction

The goal of education, according to Ki Hajar Dewantara, is to prepare kids for the highest levels of safety and enjoyment as individuals and as members of society. Because every child has the same rights, the learning intended by Ki Hajar Dewantara requires teachers to appreciate and accept the differences that exist in each child. Children of the same age aren't all the same in terms of their height, hobbies, temperament, or likes and dislikes. While sharing many traits, children also differ widely from one another because they are all human. Therefore, liberating education, one of which is through differentiated learning, is very important.

Differentiated learning refers to a teaching approach where educators employ many

strategies to cater to the individual needs of every student (Purnawanto, 2023). These needs can come from the knowledge they currently have, the learning styles they prefer, and their understanding of the subject. Differentiated learning is student-centered learning, where teachers value and accommodate differences that exist in students. Students and teachers will evaluate every learning activity that has been carried out, in order for pupils to enjoy and be actively involved in the process. Differentiated learning activities are not only carried out individually, but are flexible, meaning that learning activities can be carried out in large groups, small groups, or individuals, depending on the conditions and interests of students who are carrying out learning activities.

Based on a literature study conducted by Wahyuni (2022) several data were obtained, namely: 1) Differentiated techniques can be used with a variety of learning paradigms, including Problem Based Learning, Project Based Learning, and Blended Learning's Station Rotation.; 2) Differentiated approaches can enhance the learning results of students; 3) Because differentiated techniques can address students' learning needs in terms of their interests, learning profiles, learning styles, and readiness for learning, they can be used in science education. This has a lot in common with Ki Hajar Dewantara's prescribed educational objectives. The same thing was also expressed by Hirza et al. (2022), that improving student learning activities and outcomes in mathematics in grade VIII at SMP Negeri X can be achieved through the use of dependent learning in conjunction with the Problem Based Learning approach. Through differentiated learning, children will grow and develop according to their respective identities, so that their safety and happiness can be achieved.

Mathematics is a science or knowledge that humans urgently need to live and underlie today's technological advances. Mathematics is even referred to as the root of science which can be seen from how important mathematics is as the basis of science, (Rachmantika, 2019). Learning mathematics is essential since it relates to students' conceptual knowledge. With the correct comprehension, these pupils will eventually contribute to the advancement of mathematics and its practical applications. In line with this, according to Komala & Afrida (2020), Problems in daily life can be solved using mathematics. However, the fact is that there are still many students who think mathematics is difficult because previously students already had fear, could not learn and accept material happily, (Manik et al., 2022). Students' fear of mathematics is also in line with the results of PISA Indonesia. PISA (International Student Assessment Program) is one of the many programs that can be used as a reference to assess the quality of education in Indonesia. The program is conducted by the Organization for Economic Co-Operation and Development (OECD) and is an international survey intended to measure the basic literacy level of 15-year-old students in subjects such as reading, mathematics, and science. The results of PISA in 2022 show that Indonesia is ranked 68th with a score of 379 in mathematics, 398 in science, and 371 in reading. In particular, for mathematics, Indonesia was ranked 70 out of 81 countries participating

in PISA, (PISA 2022 Results Factsheets Indonesia PUBE, 2023). This fact certainly shows the quality of education in Indonesia today.

The mathematics learning process at each level of education is considered successful if the learning objectives, namely making students have the knowledge and skills to solve problems faced by society in the future, have been achieved by Decision of the Head of the Education Standards, Curriculum and Assessment Agency of the Ministry of Education, Culture, Research and Technology No.033/H/KR/2022, The goal of mathematics education is to prepare students to be able to : 1) comprehend and apply facts, concepts, principles, operations, and mathematical relationships as well as mathematical comprehension and procedural skills flexibly, precisely, effectively, and properly in solving mathematical issues; 2) utilizing mathematical manipulations to make generalizations, assembling data, or elucidating mathematical concepts and assertions (mathematical reasoning and proof), as well as applying reasoning based on patterns and properties; 3) solving problems involving the comprehension of issues, creation of mathematical models, solving of models, or interpretation of results (mathematical problem solving); 4) Clarifying a situation or problem through the use of symbols, tables, diagrams, or other media; also presenting a situation using mathematical symbols or models (mathematical communication and representation); 5) connect mathematical learning resources in the form of facts, ideas, rules, operations, and mathematical relationships inside a subject area, within subjects areas, between scientific domains, and with real-world situations (mathematical connections), and 6. possess a mindset that recognizes the value of mathematics in everyday life, which includes a curiosity, focus, and enthusiasm for learning the subject as well as a mindset of inventiveness, endurance, independence, toughness, tenacity, and self-assurance in problem-solving (mathematical disposition). The learning materials in Mathematics Subjects at each level of education are packaged through the study fields of Number, Algebra, Measurement, Geometry, Data and Opportunity Analysis, and Calculus (as an option for grades XI and XII). One of the materials contained in the geometric element is sequences and series.

According to Hasanah et al. (2020) the challenges that pupils face when acquiring geometric series and sequences: 1) formulating inquiries about ratios, initial terms, and the number of tribes; 2) gathering data, specifically the inadequate utilization of textbooks and the internet; 3) associating or reasoning, that is, figuring out how many terms to employ and how to calculate the formula for sequences and series to solve issues; and 4) communicating, namely reading mathematical sentences, multiplication and roots. This shows that students still have difficulty solving math problems in sequences and series content. Each student has a uniqueness with their own learning style, educators certainly cannot force students to be proficient in all fields. According to research conducted by Ramadhana et al. (2022), Data were obtained: 1) Students who have a visual learning style had a very poor mathematical representation ability of 51.59. Conversely, pupils using an auditory learning approach have a moderate

mathematical representation of 64.29. Students that learn best by doing demonstrated a kinaesthetic learning style with a very low meaning of 49.89 for mathematical representation; and 2) Auditory learning style students have the best mathematical representation ability compared to visual and kinesthetic learning style students. Therefore, when teaching in the classroom, educators must be aware of the needs of their students.

SMAN Sumatera Selatan is a boarding school, with students from all regencies and cities in South SumatraProvince, this is what forms diversity in schools and dormitories. Learning with a differentiated strategy is very likely to be applied at SMAN Sumatera Selatan, because it can educate students to become responsible, independent, cooperative, and respectful human beings for each other. Based on the author's initial observations, students at SMAN Sumatera Selatan have conducted an interest and aptitude test at the beginning of the school year to find out their respective learning styles and interests. This certainly makes it easier for the author to learn with a differentiated strategy based on students' interests and learning styles. By looking at this background, the author is interested in creating a PTK with the title Efforts to Improve Mathematics Learning Outcomes in Sequences and Series Materials Using a Problem Based Learning Model with a Differentiated Strategy at SMAN Sumatera Selatan.

The problem in this study is: How to use the Problem Based Learning model with differentiated learning strategies in improving mathematics learning outcomes in sequences and series materials at SMAN Sumatera Selatan? Finding out if using diversified learning techniques in conjunction with the Problem Based Learning paradigm can enhance mathematics learning outcomes in sequences and series materials at SMAN Sumatera Selatan is the aim of this research on learning improvement.

**Mathematics Learning**

One of the most important basic sciences is mathematics, which is also the key to the level of mastery of technology in a country. School math is mathematics taught in schools. It consists of parts of mathematics that are selected to improve personal abilities and combine with the advancement of technology and science (Hardianto & Baharuddin, 2019). Particularly in terms of meters and applications, mathematics has advanced quite quickly as a foundational science in recent years. So, when schools develop or study the progress of science, they must also consider its developments in the past, present, and future. According to Puspaningtyas (2019), math isn't just about numbers; it covers a much deeper aspect. One way to measure the achievement of mathematics education is to see if students are able to complete tasks related to mathematics and are able to apply the goals of mathematics education to their daily lives, and make mathematics an important part of their lives. Mathematics learning is

a collaborative process; it's not just about how teachers and students do things, but also about how both use all available resources to achieve math learning goals, (Putra & Milenia, 2021).

This description leads to the conclusion that mathematics learning is a process and effort that is regulated in such a way by educators to help students actively carry out mathematics learning activities so that a reciprocal relationship is created between educators and students, as well as students with their learning environment to achieve certain goals. Learning math in elementary school is often a challenge for students because it causes a lot of problems. This can be caused by many things, such as students themselves, teachers who use methods that are not suitable for the situation or conditions, lack of utilization of learning media, and monotonous teaching, (Nurulaeni & Rahma, 2022). Growing pupils' enthusiasm in learning is a major responsibility of teachers. Therefore, it is very important for teachers to continue to develop their skills in teaching mathematics so that students are more interested and no longer consider mathematics as something difficult (Permatasari, 2021). So students should be trained to think critically, logically, and creatively through learning mathematics so that they can expand their knowledge and contribute to everyday problems (Naufal, 2021).

**Problem Based Learning**

A problem-based learning approach is one that starts with the assignment of realistic investigations, or investigations that call for genuine answers to problems that are presented to students. Meanwhile, according to Prayogi & Estetika (2019), A learning approach known as "problem-based learning" helps students develop their ability to think critically and analytically as well as locate and utilize relevant learning materials. As an instructive step, at the beginning of learning, students are given problems in a real-world context that have a direct connection in students' lives. Then students are directed to work together in unraveling the problems raised. This learning process encourages students to solve problems with their abilities, and at the same time look for relevant new information. The problem-based learning model allows for assessment by looking at students' work as a product of their work followed by discussing their work together, and it is this process assessment that can be used to assess students' work, (Saputra, 2021). The PBL model itself has advantages and disadvantages. According to Isrok'atun (2018), some of the advantages possessed by PBL are the focus on meaningfulness, increasing students' ability to take initiative, developing skills and knowledge, developing interpersonal skills and group dynamics, and also developing *a self-motivated* attitude. In addition, the PBL model has several shortcomings, including academic achievement from individuals and students, the time required for implementation, modifications to students' roles in the educational process, changes in the role of teachers in teaching activities and good problem formulation.

The following are the steps in problem-based learning (PBL): 1) An emphasis on problems; 2) Setting up the students; 3) Directing both solitary and collective research; 4) Working on the project and presenting it; and 5) Examine and assess the process of fixing problems. Meanwhile, according to Yulianti & Gunawan (2019) the advantages of problem-based learning (PBL) are as follows: 1) Problem-solving in PBL improves students' understanding of the subject matter; 2) Solving problems while undergoing education tests students' skills and gives them a sense of accomplishment 3) PBL can boost educational activities; 4) PBL facilitates students' understanding of challenges in everyday life; 5) PBL encourages students to grow in their knowledge and take ownership of the lessons they study; 6) Assisting pupils in grasping the fundamentals of learning as a mode of thought, rather than merely comprehending instructor learning through textbooks; 7) PBL gives pupils an enjoyable and caring learning environment; 8) Allows real-world applications; and 9) Increase students' desire to learn continuously. While the disadvantages of PBL are as follows: 1) Students will not try again if they fail or lack confidence or have low interest; 2) PBL requires enough time for preparation; and 3) Students do not understand why problems are solved.

Improving all the advantages and disadvantages of the problem-based learning model, of course, this PBL model has been applied by previous researchers and shows positive results on student learning outcomes. Based on research conducted by Budiarsa (2020) in grade XII students of TKJ A SMK Negeri 3 Tabanan Academic Year 2017/2018 that the application of the problem-based teaching model can improve the learning achievement of derivative functions by using group discussion techniques. The same thing was also expressed by Brata & Mahatmaharti (2020), that the following impacts on students' soft skills result from using the PBL learning model: students gain a contextual understanding of the materials; they practice gathering data using a qualitative method; they gain greater insight into interacting directly with village communities; and they enhance their soft skills in speaking and writing, critical thinking, creativity, and logic; problem-solving; teamwork; interpersonal and work ethic.

Study conducted by Aang dan Muhaemin (2020) found that students' learning outcomes in mathematics can be enhanced via problem-based learning approaches. During the learning process, student learning outcomes improve. This is shown by the increase in students who reach the completion limit with a KKM score of more than 75; the activeness of asking teachers about unclear material; the courage of students to respond to the opinions of other students; and students' enthusiasm to complete the tasks assigned by the instructor. Furthermore, research conducted by Saputra et al. (2020), showed the following results : (1) the learning activity of students in the treatment group with the problem-based learning model (PBM) was higher in percentage and category compared to students in the treatment group with the direct learning model; (2) the mathematics learning outcomes of students in the treatment group with the PBM model were better than those in the treatment group with the

direct learning model; and (3) the results of the t-test show that the problem-based learning model is better than the direct learning model.

**Differentiated Learning**

Differentiated learning is student-centered learning, where teachers value and accommodate differences that exist in students. Students and teachers will evaluate every learning activity that has been carried out, in order for pupils to enjoy and be actively involved in the process. Differentiated learning activities are not carried out individually, but are flexible, meaning that learning activities can be carried out in large groups, small groups, or individuals, depending on the conditions and interests of the students who are carrying out learning activities. According to Gusteti & Neviyarni (2022), differentiated learning is a method of instruction that gives each student the freedom to choose how best to meet their individual needs, interests, and abilities. Content, processes, products, and learning environments or classroom climate are the four areas of differentiated learning that teachers master or influence. How these four elements are applied to learning in the classroom depends on the teacher. Differentiated learning has five goals: 1) helping all students achieve learning goals; 2) increase student motivation through stimuli that improve their learning outcomes; 3) creating a harmonious learning environment so that students are more excited; 4) encouraging students to become independent students and respecting diversity; and 5) increasing teacher satisfaction because there is a sense of diversity. While Marlina (2020) mapping students' learning needs is the first step in implementing individualized instruction in the classroom. Three perspectives learning readiness, student interests, and learning profiles—can be used to map out the needs of students.

*Readiness*

The ability to learn new information is readiness. Although an assignment that considers the student's readiness level will force them to step outside of their comfort zone, they can still acquire the new content if the proper learning environment and resources are provided. The thing that needs to be underlined is that learning readiness is not just about the level of intellect (IQ) alone. This is more information about whether the knowledge or skills that students currently have, are in accordance with the new skills or knowledge that will be taught.

*Interest*

Interest is a mental state that results in a focused reaction to something good and satisfying for the self, like a situation or object. To help teachers consider the options that may be given to students, teachers can consider areas of interest and modes of expression that their students may use.

*Learning Profile*

Profile refers to the best way for an individual to learn. Giving pupils the chance to learn effectively and spontaneously is the goal of determining or mapping their learning needs based on learning profiles. The learning profile of students is related to many factors, including: Preferences for the learning environment, for example, are related to room temperature, noise level, amount of light, structured/unstructured learning environment, and so on. For example, there are students who cannot study in a room that is too cold, too noisy, or too bright. Cultural influences, for example, relaxed - structured, quiet - expressive, personal - impersonal.

Preferences for learning styles, learning style is how students choose, obtain, process, and remember new information. In general, there are three learning styles, namely: 1) Visual, which is learning by seeing, for example through materials in the form of pictures, displaying diagrams, power points, notes, maps, graphic organizers; 2) Auditory, which is learning by listening, for example listening to the teacher's explanations, reading aloud, listening to opinions during discussions, listening to music; 3) Kinesthetics, namely learning while doing, for example moving and stretching the body, *hands-on* activities. Given that our students have different learning styles, it is important for teachers to strive to use a combination of teaching styles. Preferences based on different intelligences, such as logical-mathematical, naturalist, verbal-linguistic, musical, bodily-kinaesthetic, interpersonal, and intrapersonal. Then, to achieve optimal learning goals, in differentiated learning, three strategies are carried out in the learning process, namely content, process and product.

*Content Differentiation*

Content is the material that will be taught to students. The selection of learning content is based on students' learning readiness, students' interests, student learning profiles or a combination thereof. Tomlinson made an analogy to an equalizer tool that can help teachers measure students' learning readiness. Teachers can find out the student's readiness to learn, whether the student is ready to learn concretely or learn in the abstract.

*Process Differentiation*

Process difference pertains to how students assimilate, interpret, and comprehend material. Students can understand and interpret the material information learned during the learning process. The selection of learning activities is also included in this differentiation, be it in large groups, small groups, or individuals, depending on the conditions and interests of students who are carrying out learning activities.

*Product Differentiation*

Product differentiation is a differentiation strategy to show what students know, understand and can do. The resulting products are in the form of bills or expected results from students after the learning process, either in the form of test results, presentations or discussions, performances, speeches, diagrams and others that reflect students' understanding of the expected goals in learning. With the differentiation of this product, it can provide students with their own challenges, and also give students the choice of how to express the desired learning.

## B. Methods

This type of research is Classroom Action Research (PTK), conducted in the odd semester of the 2022/2023 academic year. The subject of the study was a student of class X of SMAN Sumatera Selatan. The object of the study is student activities and learning outcomes. This research consists of two cycles, each cycle contains Planning, Action, Observation and Reflection activities. Data on student learning outcomes before being given actions with the learning process without applying the PBL learning model is used as a comparison with data on student learning outcomes after being given actions in cycles I and II, so that later it will be obtained whether there is an improvement in learning outcomes. Data on student learning outcomes after being given actions in each cycle were collected by *post-test* techniques after the end of the action. Student activity observation sheets and learning outcome tests are the instruments employed in this investigation. The data that has been collected is then analyzed using descriptive statistical analysis for learning outcome test data, while for student activities it is analyzed using descriptive analysis. Learning outcome data is quantitative data realized by mathematics learning outcomes obtained through written tests that are carried out at the end of each meeting. Furthermore, quantitative data was analyzed using descriptive analysis techniques.

**Table 1. Mapping Students Learning Needs**

| Differentiation | Audio | Visual | Kinesthetic |
|---|---|---|---|
| **Process** | Students in this group will get learning through videos that have been prepared by the teacher. Additionally, students might look for pertinent video resources that connect to the subject matter they are studying. | Students in this group can use various learning resources, such as books and search on the internet. | Students in this study group are given the freedom to learn from various sources in a certain place that makes them comfortable in learning. |
| **Product** | Students in this group will display the results of their understanding in the form of videos | Students in this group will display their works in the form of writing on plano paper. | Students in this group will explain their understanding of the material of rows and geometric series to the front of the class. |

## C. Results and Discussion

### Description of Learning Improvement Research Results

**Table 2. Analysis of the Results of the Evaluation of First Cycle Learning Improvement)**

| No. | Score | Number of Students | Cumulative Score | Percentage |
|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 0% |
| 2 | 90 | 1 | 90 | 5% |
| 3 | 80 | 15 | 1200 | 65% |
| 4 | 70 | 3 | 210 | 11% |
| 5 | 60 | 5 | 300 | 16% |
| 6 | 50 | 1 | 50 | 3% |
| **Total** | | **25** | **1850** | **100%** |
| **Class Average** | | | **74** | |

Note: Pass: 16 students (64%), Don't Pass: 9 Students (36%), Total: 25 students (100%)

Based on the analysis of the results of the first cycle of learning evaluation which can be seen in table 4.2, out of 25 students in class X of SMAN Sumatera Selatan, there are 16 students who can meet the minimum completeness criteria, which is 64%. Meanwhile, as many as 9 students, namely 36%, have not been able to meet the minimum completeness criteria.

**Table 3. Analysis of the Results of the Evaluation of Second Cycle Learning Improvement**

| No. | Score | Number of Students | Cumulative Score | Percentage |
|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 9% |
| 2 | 90 | 1 | 90 | 30% |
| 3 | 80 | 15 | 1200 | 61% |
| **Total** | | **25** | **2110** | **100%** |
| **Class Average** | | | **84,4** | |

Note: Pass: 25 students (100%), Don't pass: 0 (0%), Total: 25 students (100%)

Based on the analysis of the results of the 2nd cycle learning evaluation which can be seen in table 4.4, out of 25 students in class X of SMA Negeri Sumatera Selatan, all students were able to achieve the minimum completeness criteria. Learning improvements in cycle 2 have obtained satisfactory results. The level of student understanding of geometric rows and series material increased and all students were able to achieve the expected competencies.

### After the Improvement of The First Cycle

After implementing the first cycle of learning improvements and conducting assessments through the test sheets of student evaluation results, there were 16 students who could meet the minimum completeness criteria, which was 64%. Meanwhile, 9 pupils, or 36% of the total, were unable to achieve the minimal requirements for completion. The minimum completeness criterion at SMA Negeri

Sumatra Selatan is 75, so students must try even harder to achieve the KKM.

A teacher must be able to achieve what he wants or will achieve in a learning process, namely teaching something to his students so that students understand what is being taught. As a teacher, the author feels obliged to improve the learning that has not been completed in the first cycle of activities. By recording all the factors of learning failure in the first cycle with colleagues, the author decided to continue learning at the stage of improving the second cycle of learning.

**After the Improvement of The Second Cycle**

After the implementation of the second cycle of learning improvement, by using a problem-based learning model with a differentiated strategy, and conducting assessments through test sheets of student evaluation results, the author found an increase in the average class score. In the first cycle, the average class score was 74 and increased in the second cycle to 84.4. Every student was able to meet the 75-point Minimum Completeness Criteria (KKM) set by the school.

As has been done in previous research on the application of differentiated learning which shows that differentiated learning can improve students' mathematics learning outcomes (Syarifuddin & Nurmi, 2022). The learning process carried out by applying *the problem-based learning* model is active. Students become more active in responding to questions from educators, including asking questions to educators and other students. Learning activities designed in accordance with *the syntax of problem-based learning* require students to be active during the learning process. In math lessons, it is better if the teacher makes a connection between the material and real-world situations so that students become more interested in learning. In addition, teachers should use more varied and interesting learning approaches, such as role-playing or using games, so that students are more interested in learning mathematics, (Friantini & Winata, 2019). In addition, the application of *the problem-based learning* model with a differentiated strategy increases the ability of students to find the learning process according to the student's student profile. This can be seen from the level of student participation to ask and respond to the material discussed in learning, and more importantly, there is an increase in student learning outcomes. Additionally, this aligns with studies carried out by Herwina (2021), Differentiated learning can help students achieve optimal learning outcomes, because the product arena will be made according to students' interests. Therefore, the differentiated learning process must give students a wide space to show what they have learned.

## D. Conclusion

The utilization of the Problem Based Learning paradigm in sequences and series materials is commendable due to its potential to enhance students' problem-solving

skills and facilitate reflection during the learning process. In addition to offering a learning environment that puts students' needs first, problem-based learning activities also benefit formative and summative learning through the third step of differentiation.

Based on the results of good learning practices with this Problem Based Learning learning model, the following are relevant recommendations. In order for students to be confident that learning with *problem-based learning* can help them master the learning material better, educators provide a brief explanation of the what, how, why, and benefits of learning by mapping and prioritizing learning needs. In the next research, other strategies in differentiated learning can be developed, for example in terms of learning readiness and material content. In assessing product differentiation, teachers also need to involve students in providing assessments of the work of other students, so that students feel valued for their opinions and existence. Teachers encourage students to learn, explore ideas, and prepare presentations at any location that suits them in order to overcome the kinaesthetic type of learning style.

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