Differentiated Learning Using ESS-MATH-Based PBL Model on Problem-Solving Ability Reviewed from Learning Style

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Abstract
The development of the era of globalization is accelerating, which must be supported by the ability of expert students. This study aims to find out how content-differentiated learning through the ESS-MATH-based Problem-Based Learning model affects the ability of class X students of SMK N 1 Klaten to solve problems from a learning style. This study uses a descriptive approach with qualitative research methods. The instruments used were David Kolb's learning style questionnaire, the ESS-MATH application and problem-solving ability questions. The results obtained are that the application of content-differentiated learning using the ESS-MATH-based PBL model is able to improve students' skills in problem-solving according to their learning style. The ESS-MATH application is a new alternative in the implementation of content-differentiated learning because it can meet the learning needs of students and ease of use.
Keywords: Differentiated, ESS-MATH, Learning Styles, Problem Solving Ability, PBL.

Introduction

In the era of globalization that is developing, the rapid progress of science and technological innovation requires the role of professional teachers. Students, as the next generation of civilization development, have the demands to have the necessary abilities to be able to adapt and be competent to the development of the times. Therefore, education must be improved (Ministry of Education and Culture, 2018, p.1)

In the 21st century, students must possess critical thinking, creative thinking, collaboration, communication, character building and citizenship skills which are now known as the 6Cs. As one of the talents of the 21st century, students' ability to solve problems involves applying previously acquired knowledge to different conditions (NCTM, 2000, p. 52). This means that the ability to solve problems involves solving problems that are still abstract or not yet clear and require prior knowledge to find related concepts.

Based on the initial ability test for solving mathematical problems at SMK N 1 Klaten, an average score of 52 has not reached the minimum school completeness criteria. This result is also categorized as low because it is less than 60 (Davita & Pujiastuti, 2020). The impact caused by low problem-solving skills is that it results in low-quality human resources. Problem-solving skills are important to have because they are able to solve problems in mathematics and other sciences so as to provide critical, logical and systematic

reasoning skills that are useful in daily life (Nurhayati, Mulyana, Martadipura, 2016). Therezfore, an attractive learning model and media is needed so that it can be used as a facility to improve students' skills in solving problems.

One of the alternative solutions to improving problem-solving skills is the Problem-Based Learning learning model. According to Kurniasari, Koeshandayono, and Akbar (2020), the PBL learning model is a student-centered approach pattern that can help build students' ability to determine and find problems and steps to overcome them. Problem-based learning can improve students' thinking skills in overcoming real problems encountered (Barber, King, & Buchanan, 2015).

The supporting factor in the learning model is the learning media. Learning media is very helpful in the delivery and understanding of the material. The use of media and learning strategies with various sources has yet to be optimal (Bardi & Jailani, 2015). At SMK N 1 Klaten, the use and innovation of learning media have yet to be fully maximized. This is because learning media is information in learning activities that can provide interactivity and effectiveness during learning (Wibowo, 2013). So, it is more effective and efficient to use interactive learning multimedia, especially to improve problem-solving skills.

The use of interactive learning media can be more optimal if it is supported by devices that are easy to operate, one of which is a smartphone (Putri & Muhtadi, 2018). Android is the smartphone operating system with the highest usage in Indonesia. Based on the results of a survey from Sutarsih & Hasyyati (2018, p.15-17) stated that the use of smartphones in learning at the high school/equivalent level reached 73.56%, the junior high school/equivalent level reached 54.84%, and the elementary school/equivalent level reached 36.45%. Therefore, android learning media can be an alternative learning solution that attracts students' interest, has ease of use and is expected to improve students' ability to solve problems.

The following is one of the android learning multimedia that can be used: ESS-MATH. ESS-MATH or Ethnomathematics Sequence and Series is an Android application created using Powerpoint, Ispring Suite and Website 2 APK Builder. This application is used on Sequence and Series materials. In addition to being easily accessible through students' smartphones, this application provides interactivity and adequate content for learning. The learning model used in this application uses the PBL model. In addition to making it easier for students to build and improve problem-solving skills (Agustin, Solfitri

& Anggraini., 2024), this application is also equipped with ethnomathematical content for the Klaten region and its surroundings. This is because the implementation of this learning is carried out at SMK N 1 Klaten.

Students' ability to solve problems varies. Therefore, every student has a special way of understanding learning materials (Rahmi & Samsudi, 2020). In the independent curriculum, every student is given freedom in the learning process. This was conveyed by the Secretary of the Ministry of Education and Culture, Wartanto, who revealed that "Maximum freedom is given to students in choosing learning materials through the Independent Curriculum." Therefore, in the independent curriculum, differentiated learning is then applied (Resa, 2023).

Differentiated learning is based on each learner's diverse learning needs. According to Ki Hadjar Dewantara, the purpose of education is to "Provide guidance to all the potentials that children have, so that they can achieve the highest happiness and safety as individuals and part of society" (Sugiarta, Mardana, Adiarta & Artanayasa, 2019). Therefore, teachers can only direct the development and growth of children's potential to improve their behavior, not their basic nature.

According to Moon, Brighton & Tomlinson (2020), the collaboration of all differences in finding information, developing ideas and being able to provide expression of what has been obtained is the meaning of differentiated learning. In other words, differentiated learning is a diversity strategy to create inclusive learning and provide flexibility to students in improving learning outcomes through content construction and processing ideas more effectively.

Implementation focused on differentiated learning includes three aspects, namely content, process, and product. (1) Content, things to be understood; (2) Process, students can construct information and develop ideas from what was previously obtained; and (3) Products, outputs produced by students. These aspects are then updated and adapted through the sources of the assessment carried out through the source of the level of readiness, interest and learning profile of students (Andini, 2016).

In line with learning differentiation in this study is associated with learning styles. Learning style is the way individuals find, process, and manifest information embodied in their daily behavior (Bire, Geradus, & Bire, 2014). David Kolb divides learning styles into 4 categories: (1) divergers, individuals who are adept at observing concrete situations from various perspectives; (2) convergers, individuals who are adept at finding practical

applications to ideas and theories; (3) assimilators, individuals who can process diverse information and pour it into logical and definite forms, and (4) accommodators, individuals whose primary skill is being able to learn from hands-on experience (Kolb & Kolb, 2017). Students are unique because they have a variety of learning styles. Because of this variation, each student's understanding and absorption of information during learning are different, as is their ability.

SMK (Vocational High School) is a formal education unit that provides vocational education at the secondary education level that prepares students, especially to work in certain fields. One of the vocational schools in Klaten is SMK Negeri 1 Klaten. This vocational school has a demand to produce graduates with high competitiveness to survive the Industrial Revolution 4.0 (which in some developed countries has even reached Industry 5.0). The Ministry of Research, Technology and Higher Education (2018) stated that 75% of jobs in the era of the Industrial Revolution 4.0 involve knowledge of science, technology, engineering, and mathematics. However, data from the International Student Assessment Program (PISA) shows that the science and mathematics skills of Indonesian students in the last five years have not shown a significant improvement (Pratiwi, 2019; Scheicher, 2018).

Some of the problems faced by teachers based on the results of observations made at SMK N 1 Klaten are 1) Many students are not active in learning, still just listening and taking notes during learning; 2) The use of creative teaching materials is still not widely used. This has an impact on the lack of learning that can facilitate students to learn according to their respective learning styles.

This research has a novelty from previous studies, namely applying differentiation learning to the content aspect using the ESS-MATH application. This application is an Android application that is easily accessible by students through smartphones. ESS MATH (Ethnomathematics Sequence and Series) is an application that contains a blend of classical culture and mathematics. In addition, this study also uses the PBL model to improve students' problem-solving skills. This study aims to analyze content differentiation learning to facilitate students according to their respective learning styles and still integrate with technology through ESS-MATH.

Method

The method used in this study is qualitative descriptive. Descriptive research according to Zellatifany & Mudjiyanto (2018) is a research method that characterizes the things or subjects that are studied objectively to methodically describe the facts and qualities of the objects and frequencies studied appropriately. In qualitative research, the goal is to gain a better understanding of what people experience in their daily lives through the use of verbal and linguistic descriptions in certain natural settings (Moleong, 2017).

This research was conducted at SMK Negeri 1 Klaten which is located on Jalan Wahidin Sudiro Husudo No 22, North Klaten District, Klaten Regency. The research subjects used in this study are class X students.

The research procedures carried out are 1) Providing initial problem-solving ability tests to students and learning style questionnaires as diagnostic tests to determine the characteristics of students; 2) Providing treatment by the mapping of students' initial abilities and learning profiles using the PBL learning model assisted by ESS-MATH; 3) Observing and analyzing the learning process carried out; 4) Providing a problem-solving ability test to find out the results of the development of student's abilities.

The data collection techniques carried out in this study are observation, interviews, David Kolb's learning style questionnaire, and problem-solving ability test. Documents, photographs, and statistics all serve as additional data sources for data collection, which is a data mining technique as well as focusing on identifying data sources (such as words and actions) and data categories (Rijali, 2018).

In this study, there are 3 steps in data analysis, namely 1) Data collection, or all data is documented objectively and by observation findings, learning styles, problem-solving ability tests, and interviews in the field; 2) Data reduction, which is the process of condensing information and focusing on the most relevant elements to find similarities or trends (Sugiyono, 2019); 3) Presentation of data presented in the form of narrative descriptions. The learning that is emphasized is differentiated learning, with the focused element being content. Content is what the teacher will teach. The content in this study is integrated with ethnomathematics in the Klaten region and its surroundings which is also adjusted to the needs and abilities of students.

The content taught is rows and rows. The content of this material is implemented with an ESS-MATH (Ethnomathematics Sequence and Series) based PBL model. According to Arends (2012, p. 397), there are five operational steps of PBL, including 1)

Conducting problem orientation for students, 2) Organizing learning through group division, 3) Guiding individual and group investigations, 4) The work made by students is then developed and presented, and 5) Problem-solving with follow-up steps in the form of analysis and evaluation. The following is a synthesis of the PBL learning model that has been modified with the help of ESS-MATH.

Table 1. ESS-MATH-Based PBL Learning Phase

Phase	Information
Phase 1: Orientation to the problem	Students are given a contextual problem through ESS-MATH.
Phase 2: Organizing students	Students are formed in groups that are adapted to the type of learning style.
Phase 3: Guiding the investigation	Students are directed to be able to dig up information to solve problems in ESS-MATH.
Phase 4: Developing & presenting the work	Students were asked to present the results of their discussions to other groups.
Phase 5: Analyzing & evaluating learning	Students and teachers then make summaries, conclusions and reflections of what has been learned.

The content created is adjusted to the student's learning styles. In this study, David Kolb's learning style was used. The method for determining learning styles uses the Learning Style Inventory (LSI) questionnaire. This questionnaire is a standard sourced from Miami University. It has 12 statements that students are directed to fill in according to their habits. The following is a classification of David Kolb's learning style.

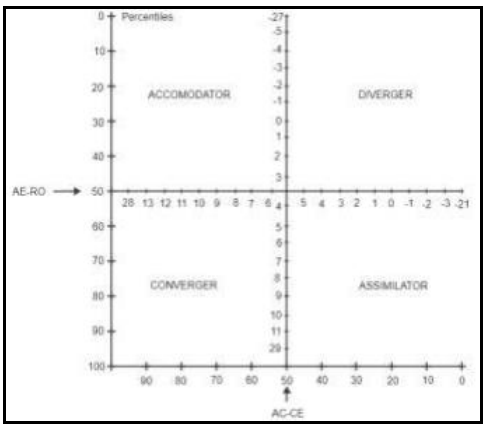

Figure 1. David Kolb's Classification of Learning Styles

In addition, the content emphasized in this study is also to improve students' ability to solve problems. According to Polya (1973), the indicators of students' ability to solve problems are as follows.

Table 2. Problem Resolution Indicators

Stages	Indicators
Understanding the Problem	Students can write down the information provided.
Planning	Students have a problem-solving plan by making mathematical models and choosing strategies.
Executing the plan	The accuracy of students in solving problems.
Interpreting results	Students interpret the results obtained through conclusions.

Results and Discussion

David Kolb's learning style questionnaire was given to class X MPB 3 SMK N 1 Klaten, which had 36 students. The following is a summary of the learning style results. For qualitative research, the results section contains detailed sections in the form of sub-topics that are directly related to the research focus and categories.

Table 3. Learning Style X MPB 3 Recap

Class	Number of Students	LS David Kolb			
		DI	CO	AS	AC
X MPB 3	36	11	8	10	7

Table 3 shows a summary of the results of class X MPB 3 learning style, obtained 11 students with diverger learning styles, 8 students with converger learning styles, 10 students with assimilator learning styles, and 7 students with accomodator learning styles.

The following is an overview of the ESS-MATH (Ethnomathematics Sequence and Series) application that has been created. This application can be accessed easily through students' smartphones.

Figure 2. ESS-MATH Initial View

In Figure 2 on the first page, the name ESS-MATH is displayed which describes mathematics and culture in rows and rows of materials.

Figure 3. ESS-MATH Main Menu

In Figure 3, The menu on ESS-MATH is displayed, namely the introduction, material, practice questions, and evaluation. Students can also bring their music background to life to be more enthusiastic about learning through this application. In addition, there is also a profile menu to be able to see profiles that develop the ESS-MATH application.

Figure 4. Introduction Menu

In Figure 4, students can understand the learning outcomes and learning objectives that will be obtained when studying row and series materials using ESS-MATH. Students can also return to the starting menu by pressing the home button on the top right.

Figure 5. Material Menu

In Figure 5, students are given complete material on rows and series including arithmetic rows, arithmetic series, geometric rows, geometric series, and infinite series. Each material on ESS-MATH is given in detail and complete, accompanied by sample questions to make it easier for students to understand.

Figure 6. Arithmetic Sequence Material

Figure 7. ESS-MATH Practice Questions

Figure 7 is a practice question in ESS-MATH. The practice questions given contain problem-solving skills that are integrated with the culture in the Klaten. As in the picture, it uses the theme of the Umbul Ponggok which is one of the famous tours in Klaten Regency. The exercises displayed contain all the materials in Sequence and Series.

Figure 8. Evaluation Display

Figure 8 is an evaluation question of 10 rows and series materials. This question is given at the end of learning to find out the student's-solving skills based on their learning style.

Figure 9. Developer Profile

Content-differentiated learning using the ESS-MATH-based PBL model shows a positive impact on students' skills in solving problems according to their learning styles. In the initial phase of PBL, which is problem-oriented, students are given Klaten ethnomathematics contextual problems to understand the problem according to their point of view. In this process, students are still heterogeneous or have not been divided according to their learning style.

In this initial process, students' problem-solving skills began to develop because they related what they had learned to ethnomathematical problems in the area around them. This is in line with Sanusi et al.'s (2018) view that problem-based learning makes students proficient in solving problems.

The second phase is organizing. In this phase, students have been grouped according to the results of their learning styles. Each learning style discusses the problems contained in the ESS-MATH application. Students are directed to use problem-solving skills first before seeing the discussion. Therefore, in the ESS-MATH Application, the problems are arranged in the form of PG questions (multiple choice) so that they can try to answer first before seeing the discussion. In addition, learning through discussion can also have a positive impact on students' mathematics learning outcomes (Saadah, 2017).

Through the second and third phases, it provides differentiated learning on the content aspect. This is because the ESS-MATH application can facilitate students' discussion and exploration of information in accordance with the learning styles of divergers, convergers, assimilators and accommodations. This is in line with the opinion of Evendi et al. (2023) that the content aspect is one of the main aspects of differentiated learning, namely providing teaching materials that can meet students' learning needs.

Furthermore, in the fourth phase or the development and presentation of the work that has been made, students who have solved problems using their methods can then present in front of the class to other groups. In this step, students can develop knowledge because they can mature the understanding that has been obtained and can receive responses from other groups. The use of this presentation method has a good influence on developing students' ability to solve problems. This is in line with the view of Putri et al. (2023) that the use of presentations can be a forum for students to process and develop their abilities and provide feedback to other groups.

The last phase of ESS-MATH-based PBL learning is to analyze and evaluate learning. At this stage, students are directed to compile summaries and conclusions from

the material obtained. Then, the teacher as a facilitator can reinforce a series of learning processes carried out by students or can also convey students' misconceptions about the content of the material. At the learning evaluation stage, students and teachers can provide useful reflections for further improvement. In addition, teachers can also provide exercises that contain problem solving so that students' abilities become better.

The ESS-MATH application is one of the alternative differentiated learning solutions in the content aspect. This is because students with different learning styles can use their expertise to see problem situations concretely. In ESS-MATH, the problems are given using the ethnomathematical context of the Klaten region and its surroundings. Students' problem-solving skills with diverger learning styles are good in planning and problem-solving strategies but incomplete in writing down the steps to solve them. This is in line with the research of Wicaksono, Chasanah & Sukoco (2021) that a student with a diverger learning style is incomplete in writing formulas in the stage of rechecking the results.

Furthermore, students with a convergent learning style can use their advantages in solving problems through practical steps from ideas and theories. In ESS-MATH, in addition to problems, a description of the material can help make it easier to understand. The problem-solving skills in this individual are the best of other learning styles because they can do more problems correctly and correctly. This is in line with the research of Kolb & Kolb (2017) which states that students with convergent learning styles have the best solving skills.

Then students who learn with the assimilator learning style can take advantage of their advantages in processing information in the abstract to find ideas. In ESS-MATH, there is a syntax of a problem-based learning learning model, namely the problem-oriented stage. The problem-solving ability in the learning style of the assimilator is good in the problem-solving stage but still not perfect in calculation. This is not to the research of Hazaro, Nayazik & Kusumati (2021) which states that students with an assimilator learning style have high representation abilities but there is still a lack of precision in mathematical representation in writing.

Then, students with an accommodator learning style can use their abilities in learning with direct experience because ESS-MATH can be used independently, has an attraction for design and ethnomathematical problems and is interactive with users. Based on this, the ESS-MATH application can facilitate students' learning content according to

their learning style. Problem-solving skills in this individual are good, but sometimes a lack of confidence tends to make them not focus on their answers but like to see their friends' work. This results in inconsistent problem-solving in these individuals. This is in line with the research of Jalinus, et al. (2020) that individuals with an accommodator learning style have good problem-solving but are still not thorough in writing down the solution steps. This individual is also lazy because he has to learn from first-hand experience.

Conclusion and Suggestion

Differentiated learning using the ESS-MATH-based PBL model is able to improve students' ability to solve problems according to their learning style. Each stage of the PBL model syntax carried out can build and develop problem-solving capabilities. The ESS-MATH application is one of the alternative solutions in the implementation of content-differentiated learning because it can meet the learning needs of students and ease of use. Students with diverger, converger, assimilator, and accomodator learning styles can learn according to their skills and make learning more enjoyable. This has a positive impact on increasing the motivation, activeness, and academic achievement of students. The suggestion for further research is to be able to provide alternative learning solutions for the fulfillment of differentiated learning processes, products, and learning environments that use technology integration media.

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