Implementation of differentiated learning with problem-based learning model assisted by Mebel InterTika

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Abstract:
Problems that often arise in mathematics subjects include low student achievement in learning. This research aims to analyze the differences in learning outcomes of students who learn by implementing differentiated learning strategies with the PBL model assisted by MeBel InterTika with students who learn by implementing the PBL (Problem-Based Learning) model in class VIII on statistics material. A quantitative approach with a quasi-experimental research type was used in this research. Data collection used questionnaire techniques, test techniques, and observation techniques. The main research instruments included learning style questionnaires, learning outcome tests, and observation sheets. Supporting research instruments were Learning Implementation Plans and MeBel InterTika. The data analyzed was quantitative data obtained from pretest and posttest data on student learning outcomes in the experimental and control classes. The results of the nonparametric test using the Mann-Whitney test, with a significance level of 5%, obtained a significance value of 0.0175, so it was found that the increase in student learning outcomes through the application of differentiated learning strategies with the PBL model assisted by MeBel InterTika was significantly higher than students who received the PBL model in class VIII of Junior High School.

Keywords: Differentiated Learning, Problem-Based Learning, Learning Results

Introduction

The most important thing that must be obtained in life is education. In its implementation, the teacher's role becomes essential in planning, implementing, and evaluating (Makovec, 2018). Yestiani & Zahwa (2020) said that teachers have many roles; besides teaching, teachers also act as educators, trainers, mentors, advisors, motivators, innovators, facilitators, learning resources, managers, demonstrators, and elevators. In this context, teachers' role in implementing various teaching techniques is crucial because student learning outcomes can determine the success of education implementation (Nabillah & Abadi, 2019). Mbagho & Tupen (2020) said good teaching techniques will provide quality results.

However, in practice, the implementation of education in mathematics still experiences problems that cause students to fail in this subject, from primary to secondary education levels. Among the problems often encountered in mathematics lessons are learning outcomes (O.I., 2021; Ratna Wati, 2020; Wahono et al., 2020). The results of the 2022 PISA show that out of 81 countries, Indonesia is in the 68th position in reading, mathematics, and science. In mathematics, Indonesia experienced a learning loss of 13 points compared to 2018.

In line with the PISA results, researchers found similar results when conducting a pre-research study at Bintan 4 State Junior High School. These results reveal that students tend to get low scores in mathematics. Namely, only 40% of students can achieve a complete score on each daily math test. Furthermore, the report card scores of class VIII students in the 2023/2024 Academic Year in the odd semester at Bintan 4 State Junior High School given by the mathematics teacher, with a passing grade of 67, students got an average mathematics score of 73.43. The teacher said that the score still needed to be more satisfactory. On the other hand, researchers also found that statistics is one of the materials with low learning outcomes, with only 40% of students able to understand it. Students' lack of understanding of the material will impact the learning outcomes obtained.

The low learning outcomes are caused by teachers who dominate teaching and learning activities (teacher-centered learning). From the observations on teachers' teaching, researchers found that teachers dominate the learning process more than students. Teachers provide learning materials through lecture methods; students are given questions to work on. In fact, teachers who dominate learning will tend to make students inactive (Wang, 2021), and less involved in building their knowledge, resulting in students not understanding the material. (Awalia, 2018). Djonomiarjo (2019) said that learning by implementing the lecture method has yet to profoundly influence students because the teacher plays a more active role.

Apart from that, low learning outcomes are also caused by using teaching materials that are difficult for students to understand. Pavešić et al. (2019) stated that learning resources influence learning outcomes. Students said that learning resources that are difficult to understand make them bored with learning, so their interest in learning is low. In addition, the absence of media as a teaching aid, especially on statistics topics, causes students to lose motivation and interest in learning. According to Aminingtyas & Wardhani (2023), learning interest determines learning outcomes; with high interest in learning, students' learning outcomes will also increase.

Based on the problems above, student learning outcomes can be improved by improving teaching techniques in class. Teachers can present strategies that can accommodate the needs of each student in the class, namely through the application of differentiated learning strategies. Tomlinson (2001) said that differentiated learning maximizes students' abilities according to their learning readiness, interests, and learning profiles. Furthermore, Tomlinson (2001) said that aspects of students' learning needs in differentiated learning are divided into three, one of which is learning styles.

Learning styles are how students choose, obtain, process, and remember new information (Purwowidodo & Zaini, 2023). Someone can learn well if they find a learning style that suits them (Putri et al., 2019). In general, learning styles are classified into three, namely visual, auditory, and kinesthetic learning styles (Tomlinson, 2001). In their research, Muslimin et al. (2022) found that differentiated learning strategies based on learning styles have proven effective in increasing student engagement and

academics in cycle I, showing an average completion of 92%, then increasing to 96% in cycle II.

Selecting an appropriate learning model is crucial to optimize the implementation of differentiated learning strategies (Hermuttaqien et al., 2023). According to Muslimin et al. (2022), relevant models that can support achieving learning objectives in applying differentiated learning strategies include the PBL (Problem-Based Learning) model. Aung (2020) said that through PBL, teachers guide students in problem-solving so that they become active learners. Furthermore, Aung (2020) also said that students' interests and abilities could emerge during learning because students were placed in the main focus. Indriati (2022) proves that less-than-optimal statistics learning outcomes can be overcome by implementing the PBL model. His average was 76.19 before the cycle; an increase of 76.59 was recorded in cycle I, becoming 82.75 in cycle II. Furthermore, the research also showed a positive influence on student activity.

On the other hand, the role of interactive learning multimedia in the current digital era is essential for creating adaptive learning following the times. Innovative and creative mathematics learning can be improved by combining differentiated learning strategies with the PBL model assisted by interactive multimedia learning. Hakim & Windayana (2016) stated that interactive learning multimedia influence improved mathematics learning outcomes. The research also shows a significant effect. Furthermore, Hakim & Windayana (2016) also stated that interactive learning multimedia in mathematics can arouse students' curiosity, self-confidence, and motivation. An interactive media can be utilised to facilitate the application of differentiated learning strategies with the PBL model, namely 'MeBel InterTika'.

In this research, the MeBel InterTika is a product the researcher developed. MeBel InterTika is specifically designed to meet the learning needs of students based on their learning styles based on the PBL model to understand statistical concepts. The selection of MeBel InterTika is based on the consideration that MeBel InterTika is by the strategies and models applied in this study. By presenting materials and learning activities that are adjusted to students' learning styles based on PBL, MeBel InterTika helps students more easily understand and apply the concepts taught in real-life contexts. Furthermore, MeBel InterTika provides interactive elements that can make learning more exciting and support student involvement in learning activities.

Interactive learning multimedia 'MeBel InterTika' is a supporting media for differentiated learning strategies based on PBL. MeBel InterTika presents three learning activities based on PBL on statistical material designed based on students' needs, including visual, auditory and kinesthetic learning styles. MeBel InterTika also presents text and video teaching materials to enrich students' understanding of the material and evaluate questions to hone students' knowledge. Furthermore, MeBel InterTika has won 1st place nationally in the learning media innovation competition, and its validity has been tested, involving two validators of mathematics education lecturers and two validators of mathematics teachers in each validation aspect. The validation results in the media, material, and language aspects, MeBel InterTika obtained very valid criteria. The percentage in the media aspect was 92.27%, the material aspect was 87.31%, and the language aspect obtained a percentage of 90% (Izzati & Yuniarti, 2023). The interactive learning multimedia 'MeBel InterTika' can be used on a smartphone or PC in APK format and HTML so that it can be used easily. Using media with APK format allows learning applications to be accessed via Android. It can be used on various Android devices to increase student involvement, making learning more interactive and personal

(Ally, 2009). In addition, learning by utilizing HTML-based media can be accessed via the web, making it effective to be accessed via various devices and increasing student participation and involvement (Means et al., 2009). So, it can be concluded that using media in APK and HTML-based learning can increase accessibility and user convenience with different devices (Hew & Cheung, 2014).

This research positions itself in mathematics education, especially in applying differentiated learning strategies with the PBL model assisted by InterTika Furniture to improve student learning outcomes in statistics material. The low learning outcomes of students, one of which is in statistics subjects, indicate the need to improve student learning outcomes by improving strategies, models, and teaching materials used in learning. The low learning outcomes inhibit students' understanding of the concepts taught and affect their academic achievement. If not addressed immediately, this will inhibit students' understanding of more complex mathematics material. Therefore, this research must be carried out to improve student learning outcomes. Judging from the existing problems, applying differentiated learning strategies can improve student learning outcomes. The differentiated learning implemented accommodates students' needs according to the three categories of learning styles—visual, auditory, and kinesthetic. For the implementation to run optimally, researchers apply a PBL model appropriate for meeting students' learning needs. Furthermore, researchers present interactive learning multimedia MeBel InterTika as a supporter of differentiated learning strategies using the PBL model.

The wording of the issue highlighted in this research is whether there is a significant increase in student learning outcomes through the application of differentiated learning strategies using the PBL model assisted by MeBel InterTika compared to students who received the PBL model. Based on the problems raised, this research aims to analyze whether the increase in student learning outcomes by applying the differentiation learning strategy with the PBL model assisted by MeBel InterTika is significantly higher than students who receive PBL. With these efforts, researchers expect pupils' learning results to be enhanced.

Research Methods

The location of this research is Bintan 4 State Junior High School, which has a population of 3 classes, from VIII A to VIII C. Cluster sampling is the technique used to select the sample for this research. According to Sugiyono (2019), the Cluster Sampling technique means that samples are not selected from individuals but from certain groups or areas. Two sample groups were obtained, experimental class VIII C and the control class VIII B, with 30 and 28 students. In this research, the researcher acts as a teacher who directly carries out learning activities by the Learning Implementation Plan that has been prepared. This study employs a quantitative research approach. The research design adopted for this study is a *Nonequivalent Control Group Design* involving two classes: the experimental class that applied a differentiated learning strategy with the PBL model assisted by MeBel InterTika and the control class that used the PBL model. Questionnaires, tests, and observation techniques were used to collect data. The main instruments of this research consist of a learning style questionnaire, learning results tests, and observation sheets. While the supporting instruments include the Learning Planning Plan and Mebel InterTika.

This research aims to analyze whether the increase in student learning outcomes by applying differentiated learning strategies with the PBL model assisted by MeBel InterTika is significantly higher than that of students who receive the PBL model. First, the N-gain between the pretest and posttest is calculated for each student to determine the significant difference in improving student learning outcomes in both classes. Then, the N-gain data is tested inferentially to determine whether the learning outcomes in the experimental class are significantly higher than those in the control class. Furthermore, a prerequisite test is carried out to determine the appropriate test statistics by testing normality using the Shapiro-Wilk test. After ensuring that the data is Normally distributed, a homogeneity test is carried out to determine whether the data taken from the same population has sufficient uniformity. The homogeneity test is carried out using the Levene test with the help of SPSS with a significance level of 0.05. If the Asymp.sig value is $a \geq 0.05$, then the data is considered homogeneous. Conversely, if the Sig value is $a < 0.05$, the data is considered non-homogeneous (Uyanto, 2009). After conducting the normality and homogeneity test of the N-gain data of student scores, the Independent T-Test is carried out to see the difference in improvement. However, the Mann-Whitney test will be carried out if it is not normal.

Results and Discussions

The Learning Implementation Plan is the basis for researchers to conduct learning activities in experimental and control classes. Researchers implemented a differentiated learning strategy with the PBL model assisted by MeBel InterTika in the experimental class and applied the PBL model in the control class. All students in both classes participated in the pretest and posttest. Because there are more students in class VIII C than in class VIII B, 30 and 28 students, respectively, and the pretest and posttest data are paired data, the data being analyzed is complete. Using Microsoft Office Excel LTSC Professional 2021, Table 1 shows the calculation of the N-gain and the average learning outcomes of students in both classes.

Table 1. Results of Descriptive Statistical Analysis of Experimental Class and Control Class

Components	Experimental Class			Control Class		
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
Highest score	29.27	97.56	0.97	24.39	95.12	0.94
Lowest score	0.00	36.59	0.37	0.00	31.71	0.24
Average	10.38	67.94	0.65	9.93	57.06	0.53

Source: processed from research data, 2024

Table 2 shows the differences in the completion percentage in the two sample classes.

Table 2. Learning Outcome Completion of Experimental Class and Control Class

Score	Categories	Experimental Class		Control Class	
		Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
67 ≤ x ≤ 100	Complete	0	71.43	0	50
0 ≤ x < 67	Not Complete	100	35.71	100	50

Source: processed from research data, 2024

Based on Table 1, the average value of N-gain in the experimental class is 0.65 with a medium N-gain category, with the smallest N-gain of 0.37 and the highest N-gain of 0.97. Meanwhile, the average value of N-gain in the control class is 0.53, including the medium N-gain category, with the smallest N-gain of 0.24 and the highest N-gain of 0.94. When viewed from the completion percentage, the experimental and control classes showed a completion percentage in the posttest of 71.43% and 50%, respectively. Thus, the experimental class achieved higher learning.

From these results, the N-gain data in both classes were then subjected to inferential testing to determine whether the learning outcomes obtained by students in the experimental class were significantly higher than those in the control class. A prerequisite test, the normality test, was first carried out to determine the appropriate test statistics. The normality test was calculated using SPSS software and the Shapiro-Wilk test.

Table 3. N-Gain Data Normality Test

Tests of Normality		
Shapiro-Wilk		
	Class	Sig.
N-gain	Experiment	0,115
	Control	0,034

Source: processed from research data, 2024

Referring to Table 3, with a significance level of 5% ($\alpha = 0.05$), in the experimental class, the N-gain data normality test shows the results of Sig. N-gain $> \alpha$, which is $0.115 > \alpha$, then in the control class, the results of Sig. N-gain $< \alpha$, which is $0.034 < \alpha$. These results indicate that the data in the experimental class is normally distributed but not in the control class. Because the data in the control class is not normally distributed, no homogeneity test is carried out, so it goes directly to the Mann-Whitney test. The Mann-Whitney test is used as the appropriate non-parametric statistical test with the following statistical hypothesis formulation:

$H_0 : \eta_1 = \eta_2$ The median N-gain of the increase in learning outcomes of students who received the application of differentiated learning strategies with the PBL model assisted by MeBel InterTika (η_1) is the same as the median N-gain of students who received the application of the PBL model (η_2).

$H_a : \eta_1 > \eta_2$	The median N-gain increase in learning outcomes of students who apply differentiated learning strategies using the PBL model (η_1) assisted by MeBel InterTika is significantly higher than the median N-gain of students who receive the application of the PBL model (η_2).

The use of the equal sign (=) in H_0 is based on the consideration that there is no initial difference between the two groups, so the study can focus on proving a significant difference. This means that the study focuses on testing whether the application of differentiated learning strategies with the PBL model assisted by MeBel InterTika produces a significantly different learning outcome than the application of the PBL model alone. So, if there is a significant difference, then H_0 will be rejected. The testing criteria used are: If the Asymp Sig. value is < 0.05, then reject H_0. Conversely, if the Asymp Sig. value ≥ 0.05 H_0 cannot be rejected. The test results using the Mann-Whitney test can be seen in Table 4.

Table 4. Mann-Whitney Test Results

Test Statistics[a]

	N-gain Valur
Mann-Whitney U	263.500
Z	-2.106
Asymp. Sig. (2-tailed)	0.035

Source: processed from research data, 2024

Based on Table 4, the Asymp. Sig. (2-tailed) value is 0.035 < α. Because this study uses a one-sided test, the p-value must be divided by two, namely 0.035/2 = 0.0175. The Asymp. Sig. A one-tailed test is smaller than 0.05, namely 0.0175 < α, so H_0 is rejected. It means the learning outcomes of students who study by applying differentiated learning strategies with the PBL model assisted by MeBel InterTika are significantly higher than those of students who study by applying the PBL model. Based on the findings described, there was a difference in the increase in learning outcomes between students who applied differentiated learning strategies with the PBL model assisted by MeBel InterTika and students who received the PBL model. The results of the Mann-Whitney test with a significance level of 5% obtained a significance value of 0.0175. Because the P-Value = 0.0175, this one-sided test obtained a value smaller than α = 0.05, so H_0 is rejected. Thus, it can be said that students who used differentiated learning strategies with the PBL model assisted by MeBel InterTika had significantly higher scores than those who only applied the PBL model.

Teaching and learning procedures in both sample classes ran efficiently and produced optimal output. The impact of the PBL model has been extensively demonstrated in theory. Many researcs have proven this (Arnidha & Noerhasmalina, 2018; Indriati, 2022; Orhan, 2024; Pelealu et al., 2022; Trullàs et al., 2022; Zuhrotunnisa & Fitrianto, 2022). Researchers also found the same results: both classes obtained optimal results. Optimal results show that applying the PBL model effectively increases the percentage of student completion. This means students who learn with the PBL model show higher learning outcomes than the previous method. In the preliminary study that the researcher conducted, the teacher said that the % of participants who

completed and understood the statistics material was only 40%. The percentage of students' completion increased after PBL was implemented, by 71.43% in the experimental class and 50% in the control class. Furthermore, optimal results are also strengthened by observation results, which indicate that applying the PBL model encourages students to actively find solutions with their groups collaboratively, making them feel more involved and enthusiastic about learning.

However, PBL combined with differentiated learning strategies provides superior results compared to applying the PBL model alone. Combining the PBL model with a differentiated learning strategy gives the students a richer learning experience in accordance with their learning needs. The observation results show that the students feel more involved and confident because they can contribute appropriately (based on their learning style). Furthermore, the students can be directly involved in forming their knowledge, developing their problem-solving skills, and practicing making decisions. Combining the PBL model with differentiated learning strategies can increase students' curiosity and foster students' interest and motivation to learn and actively participate. These positive changes impact implementing learning that activates student involvement and accommodates every student's learning needs. As a result, students can be directly involved in forming their knowledge, encouraging academic progress, increasing students' self-esteem, encouraging deeper involvement, and having problem-solving skills.

The existence of positive changes in students' attitudes and behavior influences student learning outcomes. Syarifuddin & Nurmi (2022) proved that applying differentiated learning strategies effectively improves students' learning outcomes. Differentiated learning can make learning fun (Iskandar, 2021) meaningful and pay attention to the characteristics of each student (Muslimin et al., 2022). These results are relevant to previous studies, which confirmed that student learning outcomes improved after implementing differentiated learning strategies (Iskandar, 2021; Muslimin et al., 2022; Suwartiningsih, 2021). Muslimin et al. (2022) in their research showed that the implementation of differentiated learning strategies resulted in progress in student learning outcomes; from cycle I to cycle II, the percentage increased from 92% to 96%, and in the aspect of activity, there was an increase from cycle I to cycle II by 90.25% to 92%. Furthermore, In his research, Iskandar (2021) also showed that implementing differentiated learning strategies in the classroom has proven effective in improving learning outcomes with an increase from cycle I of 66.67% to 90.91% in cycle II.

In addition, the increased learning outcomes of students are also influenced by the use of interactive learning multimedia as a support for differentiated learning. Implementing differentiated learning strategies with the PBL model assisted by MeBel InterTika benefits students. Learning using MeBel InterTika can attract students' attention, marked by increased enthusiasm, motivation, activeness, and high interest in participating in learning. The enthusiasm of students began to be seen when using MeBel InterTika. Researchers observed that using MeBel InterTika, students could focus for a long time on solving problems, actively participate in group discussions, not hesitate to ask questions, actively collect data, and increase their curiosity. Furthermore, students are also active in asking questions, submitting comments, and providing input to presentation groups. Students said that they prefer to learn using MeBel InterTika.

The increase in motivation, interest, and enthusiasm of students is due to students being able to explore their knowledge freely. Based on previous research, wherein students' attention, concentration, enthusiasm, participation, and enthusiasm can

appear when interactive multimedia is used in the learning process (Darnanta et al., 2020; Hanif et al., 2023; Nini et al., 2015; Rahdiyanta et al., 2020; Zuhrotunnisa & Fitrianto, 2022), support learning success, increase motivation, facilitate active learning, make the concept easier to understand, guide effective learning (Husna et al., 2017). Students can independently repeat the lesson material at home to improve their mastery of mathematical concepts.

Research conducted by Paseleng & Arfiyani (2015) shows that interactive media can foster student interest; in terms of student attention to learning, it is categorized as very good at 82.7%, then with a percentage of 75% student interest is in the outstanding category, while the aspect of student involvement in learning gets a percentage of 69.7% including the excellent category, this situation is not the same as the control class that does not utilize media, which gets a percentage below 50% in terms of interest. Furthermore, using media in learning can increase student interest and significantly different learning outcomes, with a Sig.2-Tailed of 0.00. So, Higher student learning outcomes are correlated with improved student engagement in studying through learning media (Zuniari et al., 2022).

Conclusions and Suggestions

Based on the research and findings discussed, it is possible to conclude that, at a significance level of 5% and a significance value of 0.0175, students who apply differentiated learning strategies in conjunction with the PBL model in grade VIII of junior high school achieve significantly higher learning outcomes than students who receive the PBL model. Thus, substantial evidence is obtained that applying differentiated learning strategies with the PBL model assisted by MeBel InterTika improves student learning outcomes more effectively than using the PBL model alone. Referring to the researcher's findings about the implementation of differentiated learning with the PBL model assisted by MeBel InterTika, it is recommended that teachers be able to apply differentiated learning strategies with the PBL model assisted by MeBel InterTika to enhance student learning outcomes. This research is limited to two elements of differentiated learning: content and process. The researcher recommends that further research consider other elements of differentiated learning, namely products.

Acknowledgements

References

Ally, M. (2009). Mobile Learning: Transforming the delivery of education and training. *International Review of Research in Open and Distance Learning,* 10(4). 1-3. https://doi.org/10.56059/jl4d.v3i2.153

Aminingtyas, M., & Wardhani, J. D. (2023). Hubungan minat dan motivasi belajar

berbasis portal rumah belajar terhadap hasil belajar kognitif anak [The relationship between learning interest and motivation based on the learning home portal on children's cognitive learning outcomes]. *Murhum : Jurnal Pendidikan Anak Usia Dini*, *4*(1), 590–601. https://doi.org/10.37985/murhum.v4i1.268

Arnidha, Y., & Noerhasmalina, N. (2018). Model problem based learning (PBL) pada Pembelajaran Matematika [Problem-based learning (PBL) model in mathematics learning]. *JURNAL E-DuMath*, *4*(2), 46–51. https://doi.org/10.26638/je.755.2064

Aung, M. M. (2020). The analysis of the using student-centered learning Method at Dawei University. *Taiwan Education Review Monthly*, *7*(7), 1–9. https://doi.org/10.13140/RG.2.2.26907.41764

Awalia, F. H. (2018). Penerapan model pembelajaran problem based learning untuk meningkatkan hasil belajar matematika SD [Implementation of problem-based learning model to improve elementary school mathematics learning outcomes]. *Primary*, *7*(1), 40–47. https://doi.org/http://dx.doi.org/10.33578/jpfkip.v7i1.5338

Darnanta, I. W., Pradnyana, I. M. A., & Agustini, K. (2020). Development of mathematics interactive learning media with gamification concept for mentally disabled students. *Journal of Physics: Conference Series*, *1516*(1), 1–9. https://doi.org/10.1088/1742-6596/1516/1/012043

Djonomiarjo, T. (2019). Pengaruh model problem based learning terhadap hasil belajar [The influence of problem-based learning model on learning outcomes]. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *5*(1), 39–46. https://doi.org/10.37905/aksara.5.1.39-46.2019

Hakim, A. R., & Windayana, H. (2016). Pengaruh penggunaan multimedia interaktif dalam pembelajaran matematika untuk meningkatkan hasil belajar siswa SD [The influence of using interactive multimedia in mathematics learning to improve elementary school students' learning outcomes]. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, *4*(2), 1–13. https://doi.org/10.17509/eh.v4i2.2827

Hanif, A., Herman, Mudinillah, A., & Rahmi, P. W. L. (2023). Development of the quizizz platform as an interactive quiz-based learning media for arabic language lessons at Madrasah Ibtidaiyah. *International Journal of Membrane Science and Technology*, *10*(2), 372–384. https://doi.org/10.15379/ijmst.v10i2.1207

Hermuttaqien, B. P. F., Aras, L., & Lestari, S. I. (2023). Penerapan model pembelajaran problem based learning untuk meningkatkan hasil belajar siswa [Implementation of problem based learning model to improve student learning outcomes]. *Kognisi: Jurnal Penelitian Pendidikan Sekolah Dasar*, *3*(1), 16–22. https://doi.org/10.56393/kognisi.v2i4.1354

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review*, *12*(June 2014), 45–58. https://doi.org/10.1016/j.edurev.2014.05.001

Husna, M., Degeng, I. N. ., & Kuswandi, D. (2017). Peran multimedia interaktif dalam pembelajaran tematik di sekolah dasar [The role of interactive multimedia in thematic learning in elementary schools]. *Prosiding TEP & PDs*, *1*(7), 34–41.

Indriati, W. (2022). Peningkatan keaktifan dan hasil belajar siswa pada pembelajaran statistika melalui model problem based learning berbantuan microsoft excel

[increasing student activity and learning outcomes in statistics Learning through the problem-based learning model assisted by microsoft excel]. *Ideguru: Jurnal Karya Ilmiah Guru*, *7*(2), 157–163. https://doi.org/10.51169/ideguru.v7i2.321

Iskandar, D. (2021). Peningkatan hasil belajar siswa pada materi report text melalui pembelajaran berdiferensiasi di kelas IX.A SMP Negeri 1 Sape tahun pelajaran 2020/2021 [Improving student learning outcomes on report text material through differentiated learning in class IX.A of Sape 1 state junior high school 2020/2021 Academic Year]. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *1*(2), 123–140. https://doi.org/10.53299/jppi.v1i2.48

Izzati, N., & Yuniarti, R. (2023). The development of interactive learning multimedia support differentiated learning with problem-based learning implementation. *Jurnal Pendidikan MIPA*, *x*(x). https://doi.org/10.21831/jitp.vxix.xxxxx. (not yet published).

Makovec, D. (2018). The teacher's role and professional development. *International Journal of Cognitive Research in Science, Engineering and Education*, *6*(2), 33–45. https://doi.org/10.5937/ijcrsee1802033M

Mbagho, H. M., & Tupen, S. N. (2020). Pembelajaran matematika realistik dalam meningkatkan hasil belajar matematika materi operasi bilangan pecahan [Realistic mathematics learning in improving mathematics learning outcomes in fractional number operation material]. *Jurnal Basicedu*, *5*(1), 121–132. https://doi.org/10.31004/basicedu.v5i1.632

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Washington D.C: Department of Education, Office of Planning, Evaluation, and Policy Development,

Muslimin, Hirza, B., Nery, R. S., Yuliani, R. E., Heru, Supriadi, A., Desvitasari, T., & Khairani, N. (2022). Peningkatan hasil belajar matematika siswa melalui pembelajaran berdiferensiasi dalam mewujudkan merdeka belajar [Improving students' mathematics learning outcomes through differentiated learning in realizing independent learning]. *Jurnal Pendidikan Matematika RAFA*, *8*(2), 22–32. https://doi.org/https://doi.org/10.19109/jpmrafa.v8i2.14770

Nabillah, T., & Abadi, A. P. (2019). Faktor penyebab rendahnya hasil belajar siswa [Factors causing low student learning outcomes]. *Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika Sesiomadika 2019*, *2*(1), 659–663. https://journal.unsika.ac.id/index.php/sesiomadika/article/view/2685/1908

Nini, Y., Aunurrahman, & Faadillah. (2015). Pemanfaatan multimedia interaktif pada model problem based learning (PBL) dalam pembelajaran matematika di Kelas VIII [Utilization of interactive multimedia in the problem-based learning (PBL) model in mathematics learning in class VIII]. *Jurnal Pendidikan Tambusai*, *4*(11), 832–840. https://doi.org/http://dx.doi.org/10.26418/jppk.v4i11.12314

O.I., O. (2021). Effects of graphic organizer and animation on students learning outcomes in Mathematics. *International Journal of Research and Innovation in Applied Science*, *06*(05), 47–51. https://doi.org/10.51584/ijrias.2021.6502

Orhan, A. (2024). Investigating the effectiveness of problem based learning on academic

achievement in EFL classroom: A meta - analysis. *The Asia-Pacific Education Researcher*, 1–11. https://doi.org/10.1007/s40299-024-00889-4

Paseleng, M. C., & Arfiyani, R. (2015). Pengimplementasian media pembelajaran berbasis multimedia interaktif pada mata pelajaran matematika di sekolah dasar [Implementation of interactive multimedia-based learning media in mathematics subjects in elementary schools]. *Sholaria: Jurnal Pendidikan Dan Kebudayaan*, *5*(2), 131–149. https://doi.org/https://doi.org/10.24246/j.scholaria.2015.v5.i2.p131-149

Pavešić, B. J., Koršňáková, P., & Meinck, S. (2019). *Dinaric perspectives on TIMSS 2019 A series of in-depth analyses based on data of the international association for the evaluation of educational achievement (IEA) Teaching and learning mathematics and science in south-eastern europe* (13th ed.). Springer Nature Switzerland AG. https://link.springer.com/bookseries/14293

Pelealu, A. A., Pitoy, C., & Pesik, A. (2022). Penerapan model problem based learning pada pembelajaran matematika materi statistika [Implementation of problem-based learning model in mathematics learning statistics material]. *Adiba: Journal of Education*, *2*(2), 253–262. https://doi.org/https://adisampublisher.org/index.php/adiba/article/view/106/102

Purwowidodo, A., & Zaini, M. (2023). *Teori dan praktik model pembelajaran berdiferensiasi implementasi kurikulum merdeka belajar [Theory and practice of differentiated learning models for implementing the merdeka belajar curriculum]*. Yogyakarta: Penebar Media Pusaka.

Putri, F. E., Amelia, F., & Gusmania, Y. (2019). Hubungan antara gaya belajar dan keaktifan belajar matematika terhadap hasil belajar siswa [The relationship between learning styles and mathematics learning activity on student learning outcomes]. *Edumatika: Jurnal Riset Pendidikan Matematika*, *2*(2), 83–88. https://doi.org/10.32939/ejrpm.v2i2.406

Rahdiyanta, D., Prasetya, H. T., & Rezani, R. (2020). Development of interactive learning media in producing straight gears of milling subjects. *Journal of Physics: Conference Series*, *1446*(1), 1–6. https://doi.org/10.1088/1742-6596/1446/1/012011

Ratna Wati, E. D. (2020). Keefektifan model realistic mathematics education berbantuan media dakon terhadap hasil belajar perkalian [The effectiveness of the realistic mathematics education model assisted by dakon media on multiplication learning outcomes]. *Joyful Learning Journal*, *9*(1), 1–5. https://doi.org/10.15294/jlj.v9i1.39114

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D [Quantitative, qualitative, and R&D Research Methods]* (7th ed.). Bandung: Alfabeta.

Suwartiningsih, S. (2021). Penerapan pembelajaran berdiferensiasi untuk meningkatkan hasil belajar siswa pada mata pelajaran ipa pokok bahasan tanah dan keberlangsungan kehidupan di kelas ixb semester genap SMPN 4 Monta tahun pelajaran 2020/2021 [Implementing differentiated learning to improve student learning outcomes in science subjects on land and sustainability of life in class IXB even semester of Monta 4 state junior high school in the 2020/2021 Academic

Year]. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *1*(2), 80–94. https://doi.org/10.53299/jppi.v1i2.39

Syarifuddin, & Nurmi. (2022). Pembelajaran berdiferensiasi dalam meningkatkan hasil belajar matematika siswa kelas IX semester genap SMP Negeri 1 Wera tahun pelajaran 2021/2022 [Differentiated learning in improving mathematics learning outcomes of grade IX students in even semester of Wera 1 state junior high school in the 2021/2022 Academic Year]. *JagoMIPA: Jurnal Pendidikan Matematika Dan IPA*, *2*(2), 93–102. https://doi.org/10.53299/jagomipa.v2i2.184

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms* (2nd ed.). Virginia: Association for Supervision and Curriculum Development.

Trullàs, J. C., Blay, C., Sarri, E., & Pujol, R. (2022). Effectiveness of problem-based learning methodology in undergraduate medical education: a scoping review. *BMC Medical Education*, *22*(1), 1–12. https://doi.org/10.1186/s12909-022-03154-8

Uyanto, S. S. (2009). *Pedoman analisis data dengan SPSS [Data analysis guidelines with SPSS]* (3rd ed.). Yogyakarta: Graha Ilmu.

Wahono, B., Lin, P. L., & Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*(1), 1–18. https://doi.org/10.1186/s40594-020-00236-1

Wang, C. C. (2021). The process of implementing problem-based learning in a teacher education programme: an exploratory case study. *Cogent Education*, *8*(1), 1–13. https://doi.org/10.1080/2331186X.2021.1996870

Yestiani, D. K., & Zahwa, N. (2020). Peran guru dalam pembelajaran pada siswa sekolah dasar [The Role of teachers in learning for elementary school students]. *Fondatia*, *4*(1), 41–47. https://doi.org/10.36088/fondatia.v4i1.515

Zuhrotunnisa, & Fitrianto, E. S. (2022). Implementasi problem based learning berbantuan aplikasi web pada materi statistika [Implementation of problem-based learning assisted by web applications on statistics material]. *Jurnal Pembelajaran Matematika Inovatif*, *5*(4), 959–970. https://doi.org/10.22460/jpmi.v5i4.959-970

Zuniari, N. I., Wahyuni, S., Ulfa, E. M., & Dharmawan, M. K. S. (2022). The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course. *Journal of Physics: Conference Series*, *2392*(1), 1–13. https://doi.org/10.1088/1742-6596/2392/1/012010