1st BICONE (Bhinneka Conference)
Empowering Society 5.0: Education, Technology, and Social Transformation
Vol 1 No 1 , 2025

Implementation of PBL-Based E-Worksheets to Enhance Students' Mathematical Representation

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Abstract **- This study aims to improve students' mathematical representation skills in work and energy by applying PBL-based E-LKPD. This study used a one group pretest posttest design involving 32 students of class XI-D SMAN 1 Nglames. The research instruments included a student response questionnaire and a pretest-posttest sheet. The results of this study indicate that students responded positively to the application of PBL-based E-LKPD with a percentage of 84.84% in the excellent category. The average pretest and posttest scores for mathematical representation were 40.31% and 76.25%, with an N-Gain percentage for mathematical representation skills in the moderate category of 0.575. The results of this study indicate that the application of PBL-based E-LKPD can improve students' mathematical representation skills in the subject of work and energy.**

Keywords : e-LKPD, Problem Based Learning, Mathematical Representation

I. INTRODUCTION

In the learning process, there needs to be support, one of which is LKPD, which is intended to increase student motivation and adapt students to the modern era. In an effort to adapt learning to the modern era, the LKPD used by teachers cannot be separated from the use of technology (Ama;l (Amalia et al., 2022). E-LKPD is digital teaching material designed to develop students' cognitive abilities (Weny, 2023). This is in accordance with the E-LKPD, which utilizes advances in multimedia technology to implement learning in the form of media or learning models in an interactive learning process (Budiasih et al., 2023). Problem-Based Learning (PBL) is a learning model in which students are given real-world problems and is considered an innovative learning model that can stimulate student learning activity (Hotimah, 2020). With this, a sense of responsibility will arise in students to determine how to solve the problem with the guidance of the teacher (Syaifulloh, 2016). Students use mathematical representation skills to express their thoughts regarding mathematical problems (Surya, 2017). There are three forms of mathematical representation: visual, symbolic, and verbal. Visual representation includes images, Cartesian diagrams, and reading graphs. Symbolic mathematical representation is a mathematical expression in the form of mathematical models and mathematical symbols, while verbal expression is in the form of words or writing. Thus, research conducted in the development of E-LKPD to improve mathematical representation in the subject of work and energy requires that E-LKPD contain material that can develop mathematical representation skills. (Ira Yoshita Cahyaningrum, 2023)

II. RESEARCH METHOD

This research is a pre-experimental study with a quantitative approach. The research was conducted using a one-group pretest-posttest design to determine the effect of implementing PBL-based E-LKPD on business and energy material to improve students' mathematical representation skills. One Group Pre-Test: A design in which observations are conducted twice: before the experiment, called the Pre-Test, and after the experiment, called the Post-Test (Rahmawati, el al, 2020). The research was conducted at SMAN 1 Nglames, involving 32 students from class XI-D. Students were given a pretest sheet before learning with PBL-based E-LKPD on the subject of work and energy. After the learning activities were completed, students filled out the posttest sheet that had been given.

Pretest	Treatment	Posttest
O_1	X	O_2

Description:
X: Treatment in the form of PBL-based E-LKPD implementation.
O1: Pre-test before treatment.
O2: Post-test after treatment.

The data collected consisted of student responses and pre-test and post-test average scores, as well as N-Gain scores. Student responses were obtained from the results of a response questionnaire filled out by students, which contained four assessment aspects. The pretest and posttest questions consisted of 10 multiple-choice questions that measured students' mathematical representation skills. The pretest and posttest scores obtained were then tested using the N-Gain Test. The N-Gain scores were then analyzed and grouped into categories according to the following formula and criteria. Formula used:

$$N - Gain = \frac{\text{Posttest} - \text{Pretest}}{\text{Maximum score} - \text{Pretest}}$$

N-Gain results are categorized based on the following criteria:

Score Range	Criteria
0,7 < g < 1,00	High
0,30 < g < 0,70	Medium
0,00 < g < 0,30	Low

Source: (Nurlaili et al, 2022)

III. Results and Discussion

PBL-based E-LKPD on business and energy was implemented for 32 students in class XI-D at SMAN 1 Nglames. Learning using PBL-based E-LKPD was conducted for 2 lessons, each lasting 45 minutes. The learning activities were divided into 5 stages, including problem orientation, organizing students into learning groups, investigation activities, discussion, and application of results, as well as analysis and evaluation of the problem-solving process.

Assessment of improvements in mathematical representation skills was carried out using a pretest-posttest instrument containing 10 multiple-choice questions. Furthermore, an analysis of the pretest results with the posttest results was carried out, as well as an N-Gain test to determine the improvement in students' mathematical representation skills.

Table 4. Comparison of Pretest and Posttest Average Scores

	Mathematical Representation Skills	
Average	*pretest*	*posttest*
	40,31	76,25

The data in Table 4 shows a significant increase in the students' average scores. The students' average score at the beginning (pre-test) was 40.31, and after learning with PBL-based E-LKPD, the students' scores increased to 76.25. The increase in the students' average scores represents an improvement in their mathematical representation skills. Improved mathematical representation skills indicate that the use of PBL-based E-LKPD has a positive effect in helping students understand problems in mathematical form. The improvement in mathematical representation skills was also proven by the N-gain test. The following are the results of the N-Gain test on the pretest and posttest results of students' mathematical representation skills.

Table 5. N-Gain Test Results

	Representation Capabilities Mathematical		N-Gain Score	% N-Gain	Category
Average	*pretest*	*posttest*			
	40,31	76,25	0,575	57,5	Moderate

From the average results, it is known that there was an increase in pretest and posttest scores from 40.31 to 76.25. Overall, the average N-Gain Score was 0.57 and was categorized as "moderate." This data can be classified as moderate according to the study (Nurlaili et al., 2022) if the effectiveness criteria with a value range of $0.30 < g < 0.70$, then the criteria are moderate. In addition, the study (Nurlaili et al., 2022) cited Karianingsih, 2010, with a normality gain value of $0.30 < n < 0.70$, which is classified as moderate. In line with the study (Kurniawan & Hidayah, 2021) citing Meltzer & David, 2002, a gain value of $0.3 < g < 0.7$ is classified as moderate

Table 6. Results of the Mathematical Representation Ability Pretest

Responden	S1	S2	S3	VI1	VI2	VI3	VE1	VE2	VE3	VI4	Total
AAA	1	1	0	1	1	0	1	0	0	0	5
APA	1	0	0	0	1	0	0	1	0	1	4
AK	1	0	1	1	0	0	1	0	1	0	5
ARN	1	0	1	0	1	0	1	0	1	0	5
CODA	1	1	0	0	1	0	0	1	0	0	4
DPA	1	0	0	1	0	1	0	0	1	1	5
FSN	1	1	1	1	1	1	1	1	1	1	10
FRA	0	1	0	1	0	1	0	1	0	0	4
FF	1	0	0	0	1	1	0	1	0	0	4
FPS	1	0	0	1	0	0	0	1	0	0	3
FQA	1	1	1	1	1	1	1	1	1	1	10
FML	1	1	1	1	1	1	1	1	1	1	10
GZA	1	0	1	1	0	1	1	0	0	0	5
HBS	0	1	1	1	0	1	1	1	0	0	6
HNA	1	0	0	1	1	0	1	1	1	1	7
JAK	1	0	1	0	0	1	1	1	0	0	5
KNA	0	1	0	1	0	0	1	0	1	0	4
MFE	1	0	0	0	1	0	0	1	0	0	3
MPJ	1	0	0	0	1	0	0	1	0	0	3
MAPP	0	0	0	0	1	0	0	0	1	0	2
MAPA	1	0	0	0	0	1	1	1	0	1	5
MPP	1	0	0	0	1	1	0	0	1	1	5
NRAP	1	0	0	0	1	1	0	0	1	0	4
RFM	1	0	0	0	1	0	1	0	1	0	4
RFA	1	0	0	0	0	1	0	0	1	0	3
SBS	0	0	1	1	0	1	1	0	0	1	5
SUKP	0	1	0	0	1	0	1	1	1	1	6
SAP	1	0	1	1	0	0	1	1	0	1	6
TGD	0	0	0	1	0	0	0	1	1	1	4

USA	1	0	0	0	1	0	0	0	1	0	3
YTP	1	0	0	0	1	1	0	1	0	1	5
INA	0	0	0	1	0	0	0	1	1	0	3
	24	9	10	16	18	15	16	19	17	13	
SI	44,79%										
VI	48,43%										
VE	54,16%										

Table 7. Posttest Results for Mathematical Representation Skills

Responden	S1	S2	S3	VI1	VI2	VI3	VE1	VE2	VE3	VI4	Total
AAA	1	1	1	1	1	0	1	1	0	0	7
APA	1	0	1	1	1	1	1	1	0	1	8
AK	1	1	1	1	1	0	1	0	1	0	7
ARN	1	1	1	1	1	1	1	1	1	1	10
CODA	1	1	1	0	1	0	0	1	1	0	6
DPA	1	1	0	1	1	1	1	0	1	1	8
FSN	1	0	1	1	1	1	1	1	1	1	9
FRA	0	1	1	1	0	1	1	1	1	1	8
FF	1	1	0	0	1	1	0	1	1	1	7
FPS	1	0	1	1	0	0	1	1	0	1	6
FQA	1	1	1	1	1	0	1	1	1	0	8
FML	1	0	1	1	1	1	1	1	0	1	8
GZA	1	0	1	1	1	1	1	0	1	0	7
HBS	0	1	1	1	1	1	1	1	1	0	8
HNA	1	1	1	1	1	1	1	1	1	1	10
JAK	1	1	1	0	0	1	1	1	1	0	7
KNA	0	1	1	1	1	0	1	1	1	0	7
MFE	1	1	1	1	1	1	1	1	1	0	9
MPJ	1	1	1	1	1	0	1	1	0	1	8
MAPP	1	1	1	1	1	1	0	1	1	0	8
MAPA	1	0	1	1	0	0	1	1	0	1	6
MPP	1	1	0	0	1	1	0	1	1	1	7
NRAP	1	1	0	1	1	1	1	0	1	1	8
RFM	1	0	1	1	1	1	1	0	1	0	7
RFA	1	0	1	1	0	1	0	0	1	0	5
SBS	1	1	1	1	1	1	1	0	0	1	8
SUKP	0	1	1	0	1	1	1	1	1	1	8
SAP	1	0	1	1	0	0	1	1	0	1	6
TGD	0	1	1	1	1	1	0	1	1	1	8
USA	1	1	0	0	1	1	0	1	1	1	7
YTP	1	0	1	1	1	1	1	1	1	1	9
INA	1	1	1	1	1	1	0	1	1	1	9
	27	22	27	26	26	23	24	25	24	20	
SI	79,16%										
VI	74,21%										
VE	76,04%										

Explanation:
SI = Symbolic questions
VI = isual questions
VE = Verbal questions

Percentage formula:

$$\frac{number\ of\ correct\ answers\ for\ each\ indicator}{total\ correct\ number\ for\ each\ indicator} \text{ x } 100\%$$

Based on the data above, there was an increase in students' mathematical representation skills after the implementation of PBL-based E-LKPD in their learning. Symbolic mathematical representation skills increased from 44.79% to 79.16%. Similarly, visual mathematical representation skills increased from 48.43% to 74.21%. Verbal mathematical representation skills also increased from 54.16% to 76.04%. This occurred due to the provision of PBL-based E-LKPD. This is in line with the research conducted by (Hardianti et al., 2021), which found that students with high mathematical representation skills were able to solve symbolic representation indicator questions very well, while students were able to solve visual and verbal representation indicators, but with a few errors. This is in accordance with the classification quoted from Kusmaryono & Dwijanto, 2016 for moderate qualifications with a range of 55 < RM < 75 (Hajriyanto et al., 2024). Similarly, research conducted by (Jenita et al., 2017) found that the highest increase in mathematical representation skills occurred in symbolic representation.

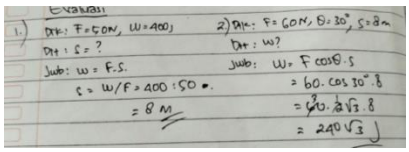
Judging from the increase, the highest indicator of improvement was in symbolic mathematical representation skills. Students better understood and were able to answer questions using symbolic description models, such as calculating from a story problem using equations with mathematical symbols. An example of this can be seen in the description of student answers using equations with mathematical symbols in PBL-based E-LKPD activities.

The results of the data recapitulation obtained by researchers from the questionnaire responses of students regarding E-LKPD can be seen in the following data recapitulation table

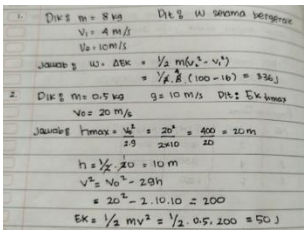
Table 8. Recapitulation Data of Student Response Questionnaires

	Score (%)	Criteria
Average	84,84%	Very Good

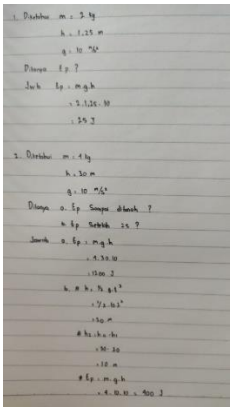
The summary table of questionnaire responses shows that the mean of the data values described in the table above is categorized as "very good," so it can be concluded that students are considered to have an interest in the E-LKPD that has been developed. The questionnaire response data is considered very good in line with the qualifications explained by researchers (Wisman et al., 2022) citing Riduwan, 2015 regarding the questionnaire response criteria of 81% - 100% which is classified as very good. In addition, there are researchers (Asih & Muslim, 2023) quoting Riduwan, 2011, who state that a percentage of 81-100 has a very good criterion. Another quote also supports this, namely Khairiyan, 2018 in (Mardianto et al., 2022), which states that a percentage of 85% < RS is included in the very positive criterion



Picture 1. Symbolic answers for activity 1



Picture 2. Symbolic answers for activity 2



Picture 3. Symbolic answers for activity.

IV. CONCLUSION

Based on the results of research and data analysis, it can be concluded that the development of E-LKPD based on Problem Based Learning (PBL) in physics learning has proven to be effective in improving the mathematical representation skills of high school students. Especially in symbolic mathematical representation, the improvement that occurred was higher than in visual and verbal mathematical representation. The developed product not only facilitates conceptual understanding through a problem-based approach but also offers interactive, contextual learning media that aligns with the characteristics and needs of high school students. This E-LKPD can serve as an innovative alternative solution in physics education, as it guides students to think critically, solve problems systematically, and connect physics concepts with real-world situations.

As for further development, the researchers recommend several directions for development, including:

1. Integration of interactive multimedia (such as animations, simulations, or virtual experiment videos) to increase engagement and visualization of abstract concepts in physics.
2. Application of E-LKPD to other physics topics, so that its benefits are not limited to one subject.
3. Conducting trials on a larger scale, both in terms of the number of students and the variety of school backgrounds, so that the findings can be more generalized and representative.

As a result, the E-LKPD product has the potential to be further developed and adapted as part of 21st-century learning transformation that emphasizes digital literacy, collaboration, and higher-order thinking skills.

REFERENCES

[1] Amalia, D., Zaini, M., & Halang, B. (2022). The quality of electronic student worksheets (E-WS) on the Plantae concept based on critical thinking skills at the senior high school level. *Journal of Mathematics Science and Computer Education*, *2*(1), 1. https://doi.org/10.20527/jmscedu.v2i1.4768

[2] Asih, R. M., & Muslim, A. H. (2023). Development of snakes and ladders learning media based on local wisdom in theme 3 sub-theme 2 learning 4 in grade V of SD Negeri 1 Dukuhwaluh. *Jurnal Jendela Pendidikan*, *3*(03), 330–341. https://doi.org/10.57008/jjp.v3i03.557

[3] Budiasih, Y., Abdurrahman, A., Lengkana, D., Hasnunidah, N., & Aini, N. R. (2023). Studi Pendahuluan: Pengembangan e-LKPD dalam Upaya

Pemahaman Keterampilan Berpikir Kreatif pada Pembelajaran Ilmu Pengetahuan Alam. *Al Jahiz: Journal of Biology Education Research*, *3*(2), 158. https://doi.org/10.32332/al-jahiz.v3i2.6929

[4] Hajriyanto, M. H., Ratnaningsih, N., & Rahayu, D. V. (2024). Analisis kemampuan representasi matematis Peserta didik pada materi relasi. *Primatika : Jurnal Pendidikan Matematika*, *13*(1), 9–24. https://doi.org/10.30872/primatika.v13i1.2935

[5] Hardianti, S. R., Nia, K., & Effendi, S. (2021). Analysis of students' mathematical representation ability in grade XI senior high school. *Jurnal Pembelajaran Matematika Inovatif*, *4*(5), 1093–1104. https://doi.org/10.22460/jpmi.v4i5.1093-1104

[6] Hotimah, H. (2020). The application of problem-based learning method to improve storytelling ability in elementary school students. *Jurnal Edukasi*, *7*(3), 5. https://doi.org/10.19184/jukasi.v7i3.21599

[7] Jenita, G., Sudaryati, S., & Ambarwati, L. (2017). Efforts to improve mathematical representation ability through the implementation of the problem-based learning (PBL) model in grade X MIA 1 students of SMAN 4 Bekasi. *Jurnal Riset Pembelajaran Matematika Sekolah*, *1*(1), 11–18. https://doi.org/10.21009/jrpms.011.02

[8] Kurniawan, A. B., & Hidayah, R. (2021). The effectiveness of the Zuper Abase Android-based game as a learning medium for acids and bases. *Jurnal Pembelajaran Matematika Inovatif*, *5*(2).

[9] Mardianto, Y., Abdul Azis, L., & Amelia, R. (2022). Analyzing students' responses to learning comparison and scale material using a contextual approach. *Jurnal Pembelajaran Matematika Inovatif*, *5*(5), 1313–1322. https://doi.org/10.22460/jpmi.v5i5.1313-1322

[10] Nurlaili, R., Zubaidah, S., & Kuswantoro, H. (2022). Development of a discovery learning-based e-module to improve critical thinking skills of grade XII students based on canonical correlation analysis of soybean plant crosses. March.

[11] Rahawati, L & Tyas A. (2020). Pengaruh Model Pembelajaran Inquiry Berbasis Daring Terhadap Hasil Belajar Dan Keterampilan Berargumen pada Muatan Pelajaran IPS di Sekolah Dasar. *Jurnal Basicedu*, *4*(4), 1035-1043..

[12] Surya, Y. F. (2017). Penerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas IV SDN 016 Langgini Kabupaten Kampar. *Jurnal Pendidikan Matematika*, *1*(1), 38–53. https://bit.ly/2MXn3xs

[13] Suryaningsih, S., & Nurlita, R. (2021). The importance of innovative electronic student worksheets (E-LKPD) in the 21st-century learning process. *Jurnal Pendidikan Indonesia*, *2*(7), 1256–1268. https://doi.org/10.36418/japendi.v2i7.233

[14] Syaifulloh, A. (2016). Pengaruh Strategi Problem-Based Learning (PBL) Terhadap Motivasi dan Hasil Belajar Peserta Didik. *Wahana Akademika*, *3*(2), 121–136.

[15] Wisman, Y., Uket, U., Cukei, C., & Saputra, Y. (2022). Students' responses to online physical education learning. *Jurnal Ilmiah Kanderang Tingang*, *13*(1), 60–71. https://doi.org/10.37304/jikt.v13i1.149