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DEVELOPMENT OF A PROBLEM-BASED LEARNING FLIPBOOK E-WORKSHEET ON RIGID BODY EQUILIBRIUM

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Abstract

This research aims to emphasize learning that pays attention to student intelligence and improving students' thinking skills based on Problem Based Learning on the material of rigid body equilibrium. This research method is Research and Development. The design used is ADDIE which consists of Analyze, design, develop, implementation, and Evaluation. The research population was the 11th grade students of Cinta Kasih Catholic High School, Tebing Tinggi. The class 11A research sample consisted of 38 students. The small group feasibility test consists of 10 students and the large group consists of 28 students. Both samples are applied with the same model. The technique of collecting data directly through a validation process. The E-Worksheet developed was validated by 3 experts, namely material experts, media experts, teachers in the field of study. The effectiveness test is seen from the student learning outcomes test given 8 essay questions that have been validated. Based on the research results, the data obtained for the small group was 0.71 and the large group was 0.81. The results of data analysis show that E-Worksheet based on the PBL model improves student learning outcomes regarding students' problem solving abilities in the material of rigid body equilibrium.

Keywords: Equilibrium, Rigid Bodies, Problem Based Learning, E-Worksheet

Education is an effort to increase knowledge gained from both formal and informal institutions to produce quality individuals. To achieve this goal, it is necessary to determine the process of developing high-quality individuals (Aziizu 2015). The purpose of education mentioned in the preamble of the 1945 Constitution is to educate the nation's life, where intelligence is not just cognitive intelligence but a broader kind of intelligence, as defined in Law No. 20 of 2003 (Kesuma 2020).

Physics is a mandatory subject taught in schools with educational material that can enhance creative, innovative, effective, active, and fun physics learning. Physics learning is successful if the teacher has teaching materials. Teaching materials are materials or lesson content used by teachers and students during the learning process (Magdalena et al. 2020). Physics learning is often linked to practical activities, and teachers can design interesting physics lessons by involving students, for example through simple experiments that can be applied in daily life. Simple experiments designed by teachers are already written in teaching modules called Student Worksheet and are carried out during the teaching process. The teaching and learning process (PBM), or simply learning, is a process where teachers and students interact with each other in an educational context to achieve certain goals.

The right teaching materials are needed to tackle curriculum challenges (Arrohman & Lestari, 2023). Student-critical thinking-based teaching materials can come in the form of handouts, modules, textbooks, or presentations like audio or video (Hamdani et al., 2019). There are various teaching resources that can be used during the teaching process. Student Worksheets are a type of printed teaching material that teachers often use in the learning process. SWs are used in the KTSP curriculum or are called LKS (student worksheets). SWs can also help teachers assess students' ability to understand specific lesson topics or ideas.

Interviews with the teacher and 11th-grade A students at SMA Katolik Cinta Kasih Tebing Tinggi revealed that the researcher obtained information from the subject teacher that everything from teaching materials approved by the school, semester exams, to entering report card grades is all done using digital technology. The learning process itself is still mostly done conventionally, and usually, practical sessions are only held once per semester due to inadequate physics laboratory facilities. According to Humaira et al. (2020), if the teaching method used is not appropriate or relevant to what is being taught, students will struggle to solve problems when given challenges. This variety in learning models meets the requirements of the independent curriculum, specifically the problem-based learning (PBL) model. The PBL model uses problem-solving activities to help students find solutions to problems given by the subject teacher (Borges et al., 2014).

From the questionnaire given to 38 students in class XI A, 78% said that they couldn't understand physics material if they only used the textbook. The teacher also admitted that using the teaching module wasn't effective or efficient because there wasn't enough time. The practicum only happens once per semester due to insufficient tools and materials in the physics lab. Because of this, the teacher often just explains what's in the textbook, but physics requires conceptual understanding, not just explanations.

Therefore, it's very important for teachers to improve their students' understanding. A flipbook is one type of learning media that can be used in physics classes. This media can have a psychological effect on students and can even increase their desire and interest (Junaidi, 2019). A flipbook is a sheet of calendar or album paper measuring 21 x 28 cm (Saparina et al., 2020). Flipbooks have many advantages, such as being able to present learning material in the form of words, sentences, and pictures, being easy and cheap to make, easy to share, and can enhance students' learning activities. In previous research, a journal titled “Profile of Improving Students' Critical Thinking Skills in Learning Using Problem-Based Worksheet on Rigid Body Equilibrium Material” found that the Worksheet learning method based on PBL has several advantages, one of which is

that it can improve students' critical thinking skills, encourage them to participate in the learning process, and increase their willingness to engage in learning (Cesilia Elwi et al., 2017). In the Worksheet learning process, the PBL model can enhance students' critical thinking skills and help them face and solve problems (Arif et al., 2019). A similar study was conducted by Atika Nur Hidayah, Puji Hariati Winingsih, Ayu Fitri Amalia with the title "Development Of Physics E-Worksheet (Electronic Worksheets) Using 3D Pageflip Based on Problem Based Learning on Balancing And Rotation Dynamics" found that overall, students felt that the developed E-Worksheet was interesting and easy to learn. They also suggested doing more compared to previous research which was still related to printed Worksheet; the developed E- Worksheet has several advantages, and the output format of this E- Worksheet uses the Exe format.

Based on the explanation presented, the Worksheet that was developed can be used to emphasize learning that considers students' intelligence as well as improving their thinking skills. In developing a web-based Worksheet that allows students to learn the concept of rigid body equilibrium interactively, the application can include animations, simulations, and interactive questions to enhance students' understanding. The media used to create the E- Worksheet is Canva. Canva is graphic design software that will be used to design the E- Worksheet, which can be accessed via an HTML website. Therefore, the researcher conducted a study titled 'Development of E- Worksheet Using a Flipbook Based on Problem-Based Learning on the Topic of Rigid Body Equilibrium for Class XI A at SMA Katolik Cinta Kasih Tebing Tinggi.'

RESEARCH METHODS

This research was conducted at SMA Katolik Cinta Kasih Tebing Tinggi during the even semester of the 2024/2025 school year. The type of research is Research and Development (R&D). The material taught is the equilibrium of rigid bodies. The research population includes all 11th-grade students at SMA Katolik Cinta Kasih Tebing Tinggi. The research sample was class 11 A, consisting of 38 students. The sample was taken using a cluster random sampling technique. The research design used is ADDIE, which consists of Analyze, Design, Develop, Implement, and Evaluate. Data was collected directly through the validation process. The developed E-Worksheet was validated by 3 experts, namely a material expert, a media expert, and a subject teacher expert. The data collection tool used was a validation instrument sheet for feasibility testing, with a small group of 10 students from class 11 A and a large group of 28 students from class 11 A. Both samples were applied using the same model. This was done to find out the improvement in students' learning

test results using the Problem Based Learning-based E- Worksheet. Data analysis to determine feasibility from experts and teacher responses can be seen from the questionnaires and will produce Likert scale data in the form of a checklist. The validation results will later be used as material for evaluation and improvements to the development results until the product can be implemented. The steps for processing expert validation data are as follows:

1. Calculate the total score from the validators.
2. Calculate the maximum total score.
3. Calculate the percentage score for each question.

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

Note:

P : percentage (%)

Σ : total score

N : maximum total

Calculating the percentage of student responses to determine the practicality of the E- Worksheet using a flipbook with the formula.

$$P = \frac{f}{N} \times 100\% \quad (2)$$

Note:

P : percentage (%)

f : the number of students who answered "yes" to the question

N : total number of students

Table 1. Determining Product Feasibility Criteria Through Interpretation

Interval Percentage	Criteria	Qualification
81% - 100%	Highly Feasible	E- Worksheet does not require revisions.
60% - 80%	Feasible	E- Worksheet Requires partial revision.
40% - 60%	Moderately Feasible	E- Worksheet Some of the material and answers need to be revised.
20% - 40%	Infeasible	E- Worksheet requires partial revision and a review of the material.
0% - 20%	Highly Infeasible	E- Worksheet needs to be completely revised.

(Dwi Pangestu et al., 2019)

The N-Gain score calculation determines the difference in mean scores after an intervention or treatment—specifically, administering practice tests before and after instruction, often referred to as pretests and posttests.

$$g = \frac{Sposttest - Spretest}{Smaksimal - Spretest} \quad (3)$$

Note:

g : N-Gain score

$S_{maksimal}$: maximum scores from the initial and final exercises

Table 2. N-Gain Test Result Criteria

Criteria	Score
High	g > 0,7
Medium	0,3 < g > 0,7
Low	g < 0,3

RESULT AND DISCUSSION

The result of this development research is an E-Worksheet based on Problem-Based Learning on the topic of equilibrium of rigid bodies. This research product was developed independently with the aim of serving as a teaching aid for educators in delivering the material. This research utilized the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation.

The analysis phase consists of a needs analysis and a literature review, which includes an analysis of the need for development, a feasibility analysis, and criteria for developing new instructional materials. Development was undertaken due to problems with the existing teaching methods. The needs analysis was conducted by interviewing teachers and students regarding problems at the school, analyzing the curriculum using the Merdeka Curriculum, and observing teaching and learning activities that used the conventional lecture approach. The literature review utilized scientific articles published in the last ten years in national and international journals.

Design: This stage involves determining the subject matter, creating the E-Worksheet, developing the lab exercises, and obtaining expert validation. The results of the design phase are as follows: (1) the material was determined—specifically, the equilibrium of rigid bodies; (2) the E-Worksheet was designed using the Canva application; (3) the lab sessions were conducted in the science lab using equipment and materials that are easily accessible to students; (4) expert validation

was performed to ensure the effectiveness of the instrument.

Development: During this stage, an assessment is conducted to determine how valid, effective, and practical the instructional materials developed by subject matter experts, media experts, and subject teachers are. The results of the validation by subject matter experts;

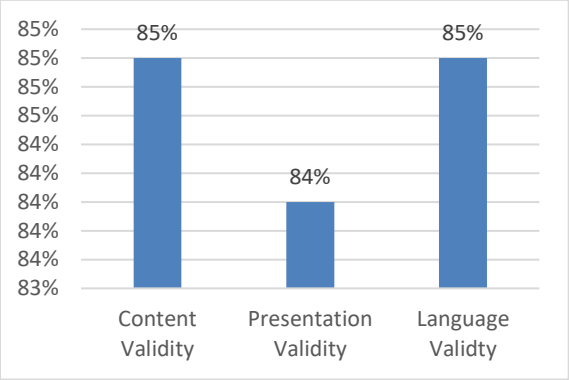

Fig. 1. Results of subject matter expert validation

The Fig 1 above shows the validity results for each aspect: content validity at 85%, categorized as "acceptable"; presentation validity at 84%, categorized as "highly acceptable"; and language validity at 85%, categorized as "highly acceptable." The average score from the subject matter experts' validation was 84.66%, which can be categorized as "highly acceptable with revisions." The revisions made are as follows:

Table 3. Product Improvements According to Materials Experts

Suggestions	Before the repair	After the repair
The images in the E-Worksheet are credited with their sources, and the text has been corrected.		

2. Results of the media expert validation

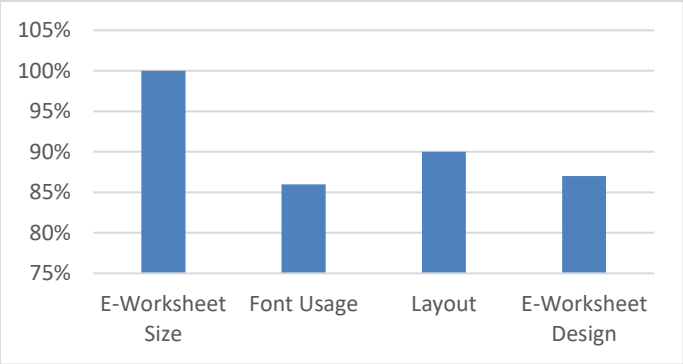

Fig. 2. Results of the Media Expert Validation

The diagram above shows the validity results for each aspect: the E-Worksheet size scored 100% in the "very suitable" category; the font usage scored 86% in the "very suitable" category; the layout scored 90% in the "very suitable" category; and the E-Worksheet Design scored 87%. The average score from the subject matter experts' validation was 92%, which can be categorized as "highly acceptable with revisions." Regarding the E-Worksheet visual design, the following improvements were made:

Table 4. Media Experts' Validation Recommendations

Suggestion	Before the Adjustment	After the Adjustment
The font size should be adjusted, and there should be a combination of fonts; use a watermark.		

3. Teacher Validation

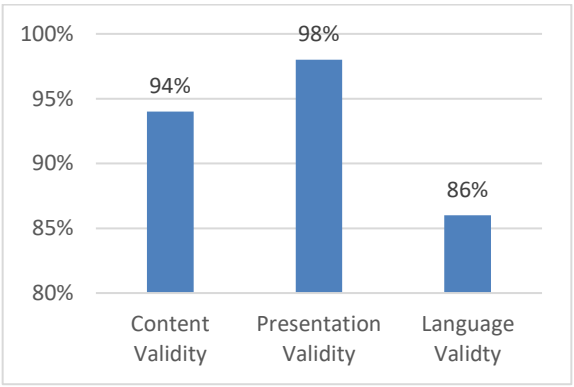

Fig. 3. Teacher validation results

Validation results from physics teachers showed that the developed E-Worksheet achieved

a content validity score of 94%, a presentation validity score of 98%, and a linguistic validity score of 86%. The average score from the validation by subject matter experts was 93%, which places it in the "highly acceptable" category. This indicates that the E-Worksheet is highly valid without the need for revision and can proceed to the product testing phase.

Implementation. At this stage, the E-Worksheet that was developed was pilot-tested with a small group of 10 students and then tested with a larger group of 28 students in Class 11A. During this pilot test, students took a pretest and a posttest and were given a feedback questionnaire to assess the product's effectiveness and practicality.

1. Response from the small group of students

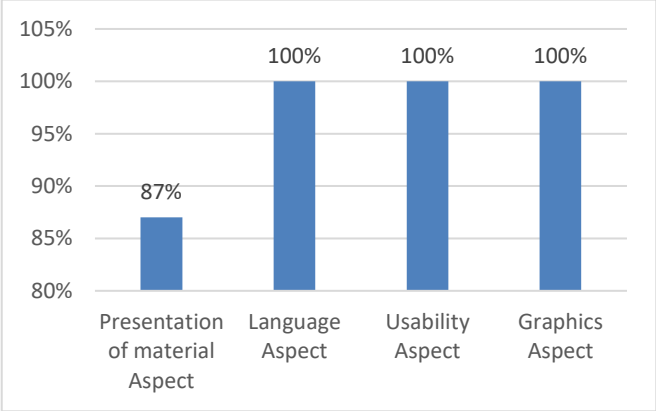

Fig. 4. Results of the E-Worksheet responses by students in small groups

The student response survey for small groups consisted of four aspects: presentation of material, language, usability, and graphics. The results obtained for the four aspects were as follows: presentation of material 87%, language 100%, usability 100%, and graphics 100%; thus, the E-Worksheet can be classified as very practical. The average percentage of student responses in the small group was 98%, so the E-Worksheet can be classified as very practical.

2. Responses from students in large groups

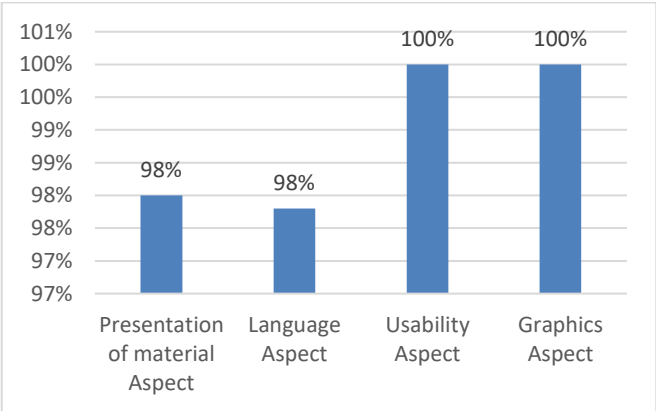

Fig. 5. Results of E-Worksheet Responses by Students in the Large Group

Next, students in the large group were given a feedback questionnaire covering four aspects, with the following results: presentation of material—98%; content—97.80%; practical application—100%; and visual presentation—100%. The average percentage of positive feedback from students in the small group was 98%, so the E-Worksheet can be classified as highly practical.

3. N-gain

The effectiveness of E-Worksheet was determined based on student learning outcomes in small and large groups, which were assessed through pretests and posttests. The second set of learning outcomes aimed to demonstrate improvement in assessment scores by comparing N-Gain values. The calculated results are presented in Table 5 below.

Table 5. N-Gain Test Results

N	Pretest Score		Posttest Score		N-Gain	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
28	45,10	6,54	89,14	7,66	0,81	0,13
10	40	4,16	83	4,08	0,71	0,05

Table 5 above shows that the calculated N-gain score for the large group was 0.81, which falls into the high category, while the average N-gain score for the small group was 0.71, which also falls into the high category. Thus, it can be concluded that the use of E-Worksheet based on the Problem-Based Learning model significantly improves student learning outcomes in the study of the equilibrium of rigid bodies.

The evaluation at this stage was conducted to identify the strengths and weaknesses of E-Worksheet. 1) Strengths of E-Worksheet: it is accessible, can be designed with interactive elements, can be updated, and is easy to share. 2) Weaknesses of E-Worksheet: it requires stable internet access and appropriate devices, which poses a challenge for students.

CONCLUSION

Based on the findings of the development study, the website-based E-Worksheet incorporating the Problem-Based Learning (PBL) model for the topic of rigid-body equilibrium was developed using Canva, a graphic design platform that facilitates the creation of educational materials, including posters and worksheet templates. The validation results indicate that the E-Worksheet achieved a material expert validation score of 84.66%, categorized as highly valid with

minor revisions, a media expert validation score of 92%, categorized as highly valid with minor revisions, and a teacher validation score of 93%, categorized as highly valid without revision. These findings demonstrate that the developed E-Worksheet is suitable for use as a learning resource. Furthermore, the learning outcomes, as measured through pretest and posttest assessments, yielded N-gain scores of 0.71 in the small-group trial and 0.81 in the large-group trial, indicating a high level of effectiveness in improving students' learning outcomes. The student response results also reached 98% in both the small- and large-group trials, demonstrating that the E-Worksheet was perceived as highly engaging, useful, and appropriate for supporting the learning process.

Based on the development process and evaluation results, several recommendations can be proposed for further implementation and development. The developed E-Worksheet can serve as a reference for teachers in implementing technology-based learning, particularly because the development procedure demonstrates its validity, feasibility, and effectiveness as an instructional resource. Future developers are encouraged to utilize website platforms that provide more engaging video, animation, and interactive features to enhance students' learning experiences. In addition, accessibility should be carefully considered to ensure that the E-Worksheet can be easily accessed and used by all students, including those with physical limitations or limited access to technological resources. These improvements are expected to enhance the usability, inclusivity, and overall effectiveness of the E-Worksheet in future learning contexts.

REFERENCES

Arini, N. K., Syahrudin, H., & Sudatha, I. G. W. (2013). Pengaruh model pembelajaran addie terhadap keterampilan berpikir kritis dalam pembelajaran IPA siswa kelas V di desa pedawa. *Mimbar PGSD Undiksha*, *1*(1).

Arrohman, D. A., & Lestari, T. (2023). Analisis keragaman peserta didik dan implementasi kurikulum merdeka pada mata pelajaran fisika. *Journal of Science and Education Research*, *2*(2), 1-11.

Dermawati, N., Suprata, S., & Muzakkir, M. (2019). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Lingkungan. JPF *(Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 7(1), 74-78.

Gusvita, A., Purwanto, A., & Syarkowi, A. Profil Peningkatan Keterampilan Berpikir Kritis Siswa Dalam Pembelajaran Menggunakan LKPD Berbasis Problem Based Learning (Pbl) Materi Kesetimbangan Benda Tegar. *Jurnal Pendidikan Fisika*, *12*(1), 44-51.

Herman, H., & Aslim, A. (2015, October). Pengembangan LKPD Fisika Tingkat SMA Berbasis Keterampilan Proses Sains. In Prosiding Seminar Nasional Fisika (E-Journal) (Vol. 4, pp. SNF2015-II).

Kasanah, N., Hafana, R. F., Wulandari, P. N., Subiki, S., & Mahardika, I. K. (2022). Analisis Efektifitas Lembar Kerja Peserta Didik (LKPD) Hukum Ii Newton Terintegrasi Phet Simulation Terhadap Hasil Belajar Siswa Sma Nuris Jember. Jpft (*Jurnal Pendidikan Fisika Tadulako Online)*, 10(1), 59-63.

Komalasari, B. S., Jufri, A. W., & Santoso, D. (2019). Pengembangan bahan ajar IPA berbasis inkuiri terbimbing untuk meningkatkan literasi sains. *Jurnal penelitian pendidikan IPA*, 5(2), 219-227.

Kurniawan, A. B., & Hidayah, R. (2021). Efektivitas permainan zuper abase berbasis android sebagai media pembelajaran asam basa. *Jurnal Penelitian Pendidikan Matematika Dan Sains*, *5*(2), 92-97.

Magdalena, I., Sundari, T., Nurkamilah, S., Nasrullah, N., & Amalia, D. A. (2020). Analisis bahan ajar. Nusantara, 2(2), 311-326.

Model, M. (2014). Problem based learning (PBL). *Jurnal Pendidikan Manajemen Perkantoran,* 1.

Nicholson-Nelson, K. (1998). *Multiple intelligences. New York: Scholastic Professional Books.*

Nikmah, F., Yulianto, A., & Wahyuni, S. (2020). Bahan Ajar Kesetimbangan dan Dinamika Rotasi dengan Pendekatan Filosofis. *EKSAKTA: Jurnal Penelitian dan Pembelajaran MIPA*, *5*(2), 122-132.

Nurjanah, N., & Trimulyono, G. (2022). Pengembangan E-LKPD Berbasis Problem Based Learning untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Hereditas Manusia. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *11*(3), 765–774.

Purnamasari, A., Karoma, K., Bukhori, K. A., & Sairi, A. P. (2020). Analisis Persepsi Peserta Didik Terhadap Lembar Kerja Peserta Didik Pembelajaran Fisika SMA Negeri 8 Palembang. *Jurnal Ilmu Fisika dan Pembelajarannya (JIFP),* 4(1), 6-15

Rahayu, R., Rosita, R., Rahayuningsih, Y. S., Hernawan, A. H., & Prihantini, P. (2022). Implementasi Kurikulum Merdeka Belajar di Sekolah Penggerak. *Jurnal Basicedu*, *6*(4), 6313–6319.

Safriandono, A. N. (2014). Rancang Bangun E-Lembar Kerja Siswa sebagai Media Pembelajaran yang Praktis, Fleksibel dan Edukatif Berbasis Web. *Tatal,* 10(1), 221635.

Sihombing, E. (2010). FISIKA DASAR 1.

Silka, S., & Bethony, F. R. (2022). Analisis Lembar Kerja Peserta Didik (LKPD) Praktikum Fisika di SMA Negeri Kabupaten Toraja Utara. *Jurnal Penelitian Pembelajaran Fisika,* 13(2), 243-250.

Wati, D. A., Hakim, L., & Lia, L. (2021). Pengembangan E-LKPD interaktif hukum newton berbasis mobile learning menggunakan live worksheets di SMA. *Jurnal Pendidikan Fisika*,10(2), 72-80.