



Development of Project-Based E-worksheet to Improve Critical Thinking Skills on Boyle's Law Materials

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ABSTRACT

The complexity of the problems that occur in classroom learning, lead students to have 21st century skills to support their lives in the future. The 21st century skills that students must have consist of 4C, namely critical thinking and problem solving, creativity and innovation, communication and collaboration. This research aims to develop a valid, practical, and effective project-based e-worksheet to improve critical thinking skills on Boyle's legal material. This type of development research is Design and Development Research (DDR) which were adapted from Richey & Client (2007) using an assesment of validity tests, practice tests consisting of readability tests, teacher perception tests and student response tests. In the validity test results, the average score from the three validators was very valid, with the average result of material and design validation being in the very valid category and material and construct validation in the very valid category. The results of the practicality test obtained an average very practical for the readability test in the legible category, the student response test was very good category, while for the teacher perception test it was very good. So the average practicality test in the very practical category.

INTRODUCTION

Problems in learning activities in the classroom are increasingly complex, but students are required not only to have process skills but also to have 21st-century skills. These skills will be used as provisions for entering the world of work in the future. The 21st-century skills that students must have include the 4Cs, namely critical thinking and problem-solving, creativity and innovation, communication, and collaboration (Kembara et al., 2019). One of the skills students must possess is critical thinking skills, which can be obtained through education (Ritonga et al., 2021). Educators as facilitators play an essential role in the learning process, one of which is by placing students as the center of learning so that students can be more active and accustomed to practicing their critical thinking skills (Femanda et al., 2024). Critical thinking skills are an effort to deepen awareness and intelligence by comparing several problems to produce conclusions and ideas that can solve problems (Zulfaneti & Mukhni, 2018). Someone who has high critical thinking skills will be able to connect new knowledge and previous knowledge to be able to solve the problem being faced for a rational concept (Mahzum, 2024). If we look closely, critical thinking skills are highly correlated with other HOTS abilities, including the relationship between critical thinking skills and problem solving, creativity, digital literacy, collaboration, and communication skills (Kocak et al., 2021). The world of science education is also experiencing development and having an impact on people's lives, which means that critical thinking skills are very important for science education (Samadun & Dwikoranto, 2022).

The context of this research focuses on overcoming the challenges of students' critical thinking skills, especially on Boyle's Law material. Boyle's Law is material that is difficult for students to understand and is abstract or complex to describe, so it really requires a medium that can explain Boyle's Law, of course, through a practical activity. Through practical activities to overcome learning difficulties such as difficulty understanding the material, difficulty associating the relationship between pressure, volume, and temperature, difficulty understanding formulas, and operating formulas when solving problems. The use of practical activities in the learning process allows teachers to see students' skills (Sarwanto & Chumdari, 2021).

One learning support that can help students understand the material is through practicums using e-worksheet teaching materials. An e-worksheet is a worksheet that can make it easier for students to understand the material in electronic form, which can be applied to computers, laptops, cell phones, etc. (Putriyana et al., 2020). The use of e-Worksheet will make students more active in participating in learning because they do not only being an object of learning but also a subject of learning so that the concepts studied are discovered by the students themselves. Apart from that, an e-Worksheet can be a combination of multimedia elements such as text, audio, video, and animation, which aims to guide students to achieve basic competencies in a targeted manner (Awe & Ende, 2019).

This developmental research is motivated by previous research. Previous research conducted by (Anugerah, 2020) developed Boyle's legal practicum tools but still needed supporting teaching materials. Based on research conducted by (Redhana, 2019), it is proven that the teaching materials developed can help students understand the three levels of representation to improve students' critical thinking skills. In line with research conducted by (Wahyuni et al., 2021), it was concluded that e-worksheets can improve critical thinking skills. Based on research results (Khalifa et al., 2021), it is proven that the Worksheet developed is very suitable for practicing critical thinking skills. Based on this explanation, the development of teaching materials or e-worksheets with various learning models and research methods can improve students' critical thinking skills. As a solution to this problem, product development was carried out in the form of project-based e-Worksheet to improve students' critical thinking skills.

RESEARCH METHODS

Research Approach

This research uses Design and Development research development adapted from Richey and Client (2007) which consists of four development stages. The development stages used are analysis, design, development, and evaluation. This research used two assessments, namely a validity test carried out by 3 experts and a practicality test seen from readability tests, student responses, and teacher perception tests.

Research Participants

The subjects of this research consisted of 1 expert lecturer and 2 physics teachers as validators, as well as 8 teachers as teacher perception testers and 20 class XI students at SMAN 1 Tanjung Raya.

Research Instruments

The instrument used in this research is a questionnaire, where the questionnaire used in this research is a list of questions given to respondents regarding a problem that exists in the e-worksheet being developed. The questionnaire consists of a needs analysis questionnaire, validity test questionnaire, readability test questionnaire, student response test questionnaire and teacher perception test questionnaire.

Data Collection

Validity test data collection was obtained from three experts, namely the first expert from the education department at Lampung University and 2 other experts from physics teachers. This data collection was taken from the results of the recapitulation of scores from the three experts, based on the two aspects

that had been determined by the author, namely media and design as well as materials and constructs in the e-worksheet that had been developed

Data Analysis

This research consisted of two data analyzes, namely validity test data and practicality test data. Analysis of validity test data to find out whether the e-worksheet that has been developed by researchers is valid and good or not when applied to classroom learning. Meanwhile, practical test data analysis is used to describe observation data obtained by researchers in the field while using e-worksheet in project-based learning model activities.

1. Validity Test Results

This product validation was carried out by three experts consisting of one Physics Education Lecturer at the University of Lampung and two High School Physics teachers. This product validation consists of two categories, namely media aspects and design aspects, the second is material and construct. The product validation test results are then categorized accordingly (Ratumanan & Laurent, 2011). With data analysis techniques using data from expert validation tests, it is calculated using the following equation:

$$P = \frac{\text{average skor}}{\sum \text{Total}}$$

The calculated results are then interpreted to obtain the quality of the product being developed. The score interpretation is adapted from Ratumanan and Laurent as seen in Table 1.

Table 1. e-workseet Validity Test Criteria

Assesment Result Score Interval	Criteria
3,25 < skor < 4,00	Very Valid
2,50 < skor < 3,25	Valid
1,75 < skor < 2,50	less Valid
1,00 < skor < 1,75	Invalid

(Ratumanan & Laurent, 2011)

2. Practicality Test Results

The practicality of the Project-based e-worksheet being developed refers to the extent to which e-worksheet is used effectively and efficiently in classroom practice. The practicalities developed consisted of a readability test questionnaire for students, a student response questionnaire and a teacher perception test for teachers. The results of the answers to the questionnaire will be analyzed using percentage analysis based on the formula according to (Arikunto, 2011) as follows.

$$\%X = \frac{\sum \text{skor obtained}}{\text{Maximum}} \times 100\%$$

Data from filling out the readability test questionnaire were analyzed using percentage analysis adapted by (Arikunto, 2011) as in data to determine product practicality.

Table 2. E- worksheet Practicality Test Criteria

Assesment Result Score Interval	Criteria
0.00% - 20%	Very Low Practical
20,1% - 40%	Low Prantical
40,1% - 60%	Medium Practical
Assesment Result Score Interval	Criteria
60,1% - 80%	Practical
80,1% - 100%	Very Practical

(Arikunto, 2011)

RESULTS AND DISCUSSION

Validity Test Results

This validity test was carried out by 3 experts, where the first expert was a physics education lecturer at the University of Lampung, while the second expert was an experienced high school physics teacher. This validity test is seen from 2 aspects, namely media and design and material and construct. The results of the validity test can be seen in table 3 below:

Table 3. Validity Test Results

Validity	Aspect	Average Score From 3 Validatots	Criteria
Media and Design	Cover	3.63	Very Valid
	Contents	3.43	Very Valid
Materials and Constructs	Suitability of Material	3.55	Very Valid
	Content		
	Construction	3.66	Very Valid
Total		14.21	
Overall Average		3.57	Very Valid

Practicality Test Results

This practicality test is seen based on the results of the readability test, student response test and teacher perception test which has received approval from the validator that the e-worksheet can continue with the next test. The results of the practicality test data can be seen in the table below:

Table 4. Practicality Test Results

Practicality	Aspects	Average	Criteria	
Readability	Structure	83.7%	Very Practical	
	Spacing, type, and font size	85%	Very Practical	
	Layouts	80%	Practical	
	Language	83.7%	Very Practical	
	User Interface	83.7%	Very Practical	
	Instructions and Questions	81.2%	Very Practical	
	Step Of Activities	82.5%	Very Practical	
	Pesentation	85%	Very Practical	
	Phenomenon	86%	Very Practical	
	Learning Activities	83.7%	Very Practical	
Students Response	Pictures, Graphics, Illustrations, and Videos	81.2%	Very Practical	
	Average	83.1%	Very Practical	
	Characteristics Of Interantive Teaching Materials	81.4%	Very good	
	The Implementation Of Knowledge and Skills	81.1%	Very good	
	Students Perception Of Satisfaction	81.7%	Very good	
	Students Perception Of Project	83.7%	Very good	
	Average	81.9%	Very good	
	Teacher Perceptions	Determine Basic Questions	94.7%	Very good
		Designing Project Questions	92.1%	Very good
		Prepare a Project Creation Schedule	93.7%	Very good
Monitoring		93.7%	Very good	
Test Results		94.5%	Very good	
Practicality	Aspects	Average	Criteria	
	Evaluation Of Teaching Experience	95.3%	Very good	
	Average	94%	Very good	
	Total Average	86.3%	Very Practical	

Discussion of Validity Test

The product produced is a project-based e-worksheet to train critical thinking skills. The product produced by the author was then validated by 3 experts, where the examiners consisted of 1 physics education lecturer at the University of Lampung and 2 high school physical teachers in Bandar Lampung. A. This product validation consists of two categories, namely media aspects and design aspects, the second is material and construct. The product validation test results are then categorized according to Ratumanan and Laurent.

Table 4 presents the results of a comprehensive validation test evaluation of an e-Worksheet, which is categorized into 2 aspects, namely media and design and material and construct. Based on the results of the validity test questionnaire, it is known that in media and design validation, especially the cover section of the e-Worksheet developed, it is categorized as very valid with an average score of all validators of 3.63. Likewise, with the content section, the average value obtained for all validators was 3.43 in the very valid category. This means that the media and design of the e-worksheet developed are appropriate and can be implemented into learning.

Then, in material and construct validation, there are 2 parts, namely the material content suitability section and the construction section. In the content suitability section, the average score obtained for all validators was 3.55 in the very valid category. This also happened in the construction section, the average score obtained for all validators was 3.66 in the very valid category. This means that the materials and constructs of the e-Worksheet developed are appropriate and can be implemented into learning. This is in accordance with Matodang's opinion, where a teaching material is said to be valid if it meets two concepts of validity, namely content and construct. Content validity is used to measure how far the level of mastery of the content or content of a material that must be mastered is in accordance with the learning objectives. At the same time, construct validity is seen from the relationship between the components of the learning tools applied and the very valid category (Matodang, 2018).



Figure 1. E- worksheet validity test result

Discussion of Practicality

After making improvements suggested by the three validators, the e-Worksheet was then tested for practicality by racing on 3 aspects, namely the readability test, student response test, and teacher perception test. Based on the results of the readability test, the average percentage was 83.1% in the very good category. This shows that the e-worksheet being developed can be easily understood by students. Apart from that, the e-worksheet products produced have utilized technological developments

in the form of gadgets or smartphones, so students are more interested in using this teaching material because it is easy to use anywhere and anytime. This is in line with what was said by Haryanto et al., (2019) which states that in current technological developments, most students are more interested in teaching materials that utilize other media such as computers/laptops, even smartphones compared to teaching materials in the form of printed worksheets.

The second practicality test is seen from the results of the student response test assessment, where this student response test has 4 aspects of assessment criteria consisting of characteristics of interactive teaching materials, application of knowledge and skills, students' perceptions of satisfaction, and statements on the use of e-Worksheet based Projects. From these four aspects, there was a very good response from students, with a score of 83.7% in the very good category. This is stated in the fourth aspect, namely the Statement on the Use of Project-based e-Worksheet, which means that students feel happy with the overall learning experience using Project-based e-Worksheet. A person's learning satisfaction will arise if individual needs are met, but satisfaction will not arise if individual needs are not met (Wibowo, 2017). Judging from these four aspects, there was a very good response from students, this was indicated by the acquisition of a very good average score of 82% in the very good category. This means that a project-based e-Worksheet to improve critical thinking skills can be implemented in learning.

The third practical test is seen from the results of high school Physics teachers' perceptual tests on Project-based e-worksheets. This teacher perception test was carried out with the aim of finding out how feasible the developed e-worksheet can be implemented in the learning process. This teacher perception questionnaire is regarding the suitability of project-based learning activities for the abilities being trained. This teacher perception test was carried out on 8 high school physics teachers consisting of SMAN 01 Tanjung Raya, SMAN 02 Krui, SMAN 01 Mesuji Timur, SMAN 1 Menggala, SMA Muhammadiyah 01 Mestim, SMAN 01 Banjar Agung, SMA IT Daarul Ilmi, SMA IT Daar El Fikri. This teacher perception test consists of 19 questions which can be seen in the attachment. The average score obtained was 94.7% in the very good category. This means that the e-Worksheet that has been developed is very good for implementation in Boyle's law learning process and every activity in the e-Worksheet that is developed to improve students' critical thinking skills.

Based on data analysis that has been carried out on the readability test aspect completed by students, the aspect that dominates the highest achievement is number 9, namely 86% in the very good category. In question 9, it presents a phenomenon in everyday life; this is in line with the opinion of Wiyanto and Hidayah, who state that through a given phenomenon, students will be able to train their imaginative abilities (Wiyanto & Hidayah, 2021). Through events or phenomena that students often encounter in the surrounding environment, it can be a source that can be used by teachers to stimulate students' abilities. Next, namely the students' responses, the aspect that dominates the highest achievement is at number 4, namely 83.7%, in students' perceptions regarding the project. In this experimental activity, students felt happy with the activity, so they were more active in learning activities. This is in line with Nisa's opinion, which states that experimental activities make more active, motivated, and enthusiastic in learning (Nisa, 2017). Meanwhile, in terms of student responses, the most dominant aspect was aspect 5, namely 95.3% of the learning experience evaluation activity; the teacher said that through evaluation activities on an e-worksheet, the teacher could find out how far the students could understand the material they had studied.

Teaching materials can be said to be practical if the teaching materials developed can be easily used by teachers and students in the learning process (O'gradi & Alwis, 2021). Based on the results of the analysis that has been carried out on the three aspects, namely readability tests, student responses and teacher perception tests, an average score of 86.3% was obtained in the very practical category. This means that project-based e-worksheets to train critical thinking skills on Boyle's Law material are practically used in the learning process so that students and teachers feel helped by the e-worksheet. The higher the involvement of students in the learning process, the higher the level of understanding, skills, and learning experiences of students (Divia et al., 2022).

CONCLUSION

The conclusion is based on the findings of the validity assessment by considering media and design as well as materials and constructs. It was found that the results from the three experts regarding the e-Worksheet, which was developed on a project basis to train critical thinking skills, with an average score obtained, were categorized as very valid. Furthermore, when the e-worksheet developed was tested for its practicality using a readability analysis test, student responses, and teacher perceptions, it was found that the e-worksheet developed was categorized as very practical. It is recommended that future researchers better understand e-Worksheet in its application, which is based on project-based learning, to improve students' critical thinking skills.

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References

- Anugrah, A. 2020. *Development of Inquiry-Based e-Worksheet Integrated Stem to Train Creative and Collaborative Thinking Skills*. Lampung University.
- Arikunto, S. 2011. *Research Procedures, a Practical Approach*. Bumi Literacy: Jakarta
- Awe, EY, and Ende, MI. 2019. Development of Electronic Student Worksheets Containing Multimedia to Improve Students' Cognitive Abilities on the Theme of the Area Where I Live for Class IV Students at Sdi Rutoso in Ngada Regency. *DIDIKA Journal: Scientific Forum for Basic Education*, 5(2), 48-61.
- Divia, BC, Herlina, K., Viyanti, V., Abdurrahman, A., & Ertikanto, C. 2022. Learning of Inquiry Sequences-Based E-Student Worksheet Assisted by Canva to Stimulate Hands-On Skills, Mind-On Activity, and Science Process Skills. *Indonesian Journal of Science and Mathematics Education*, 5(3), 318–329.
- Fenanda, H. E., Herlina, K., & Abdurrahman. 2024. Practicality and Effectiveness of E-Worksheet Based on ExPRession Learning Model Activities to Train Critical Thinking Skills. *Asian Journal of Education*. 6(1), 118-128
- Haryanto, Asrial, Ernawati, MDW, Syahri, W., & Sanova, A. 2019. E-Worksheet Using Kvisoft Flipbook: Science Process Skills and Student Attitudes. *International Journal of Scientific & Technological Research*, 8(12), 1073–1079.
- Khalifah, I., Sakti, I., & Sutarno. 2021. Development of Worksheet based on project based learning to train critical thinking skills on electromagnetic induction material. *Scientific Journal of Science Education*, 1(2), 69-80.
- Kocak, O., Coban, M., Aydin, A., & Cakmak, N. (2021). The Mediating role Of Critical THinking and Cooperativity In THE 21st Century Skills Of Higher Education Students. *Journal Thinking Skills and Creativity*, 42(1), 100967. <https://doi.org/https://doi.org/10.1016/j.tsc.2021.100967>.
- Mahzum, E., Rezeki, S., Kasli, E., Saputri, M., & Nasarudin, M. F. 2024. The Effect of the Rumah Belajar Portal on Critical Thinking Skills of High School Students. *Asian Journal of Science Education*. 6(1), 108-117.
- Matodang, Z. 2018. Validation and Reliability of a Research Instrument. *UNIMED PSS Tabulation*, 2(1), 87-97.
- Nisa, U.M. 2017. Practical Methods to Improve Understanding and Learnig Outcomes Grade V MI YPPI 1945 Babat On Single Subsances and Materials Mix. *Procceeding Biology Education Conference*. 14(1), 62-68.
- O'Grady, G., and Alwis, WAM. 2002. One Day, One Problem: PBL at the Republic Polytechnic. Paper Presented at the Sia Pacific In Conference in PBL, Hatyai, Thailand.

- Putriyana, AW, Auliandari, L., & Kholillah, K. 2020. Feasibility of Student Worksheets Based on the Search, Solve, Create and Share Learning Model in Fungi Material Practicum. *BIODICS* , 6(2), 106–117.
- Ratumanan, TG, & Laurent, T. 2011. *Assessment of Learning Outcomes at the Education Unit Level* (2nd ed). Unesa University Press: Surabaya
- Redhana, W. 2019. Developing 21st Century Skills in Learning Chemistry. *Journal of Chemical Education Innovation*, 13(1), 2239-2253.
- Ritonga, S., Areeisty, K., & Zulkarnaini. 2021. Enhancing Students Critical Thinking Skills Through Problem Based Learning Integrated with Mind Mapping. *Asian Journal of Science Education*, 3(1), 63-69.
- Samadun, S., & Dwikoranto, D. (2022). Improvement Of Students Criticl Thinking Ability Sin Physics Materials Through The Aplication Of Problem Based Learning. *IJORER: Iternational Journal of Recent Education Research*, 3(5), 534–545.
<https://doi.org/https://doi.org/10.46245/ijorer.v3i5.247>.
- Sarwanto, LEW Fajari, and Chumdari. 2021. *Critical Thinking Skills and Their Impacts on Elementary School Students* , Malaysian J. Learn. Instr., 18 (2).
- Wahyuni, S., Rizki, LK, Budiarmo, AS, Putra, PDA, & Narulita, E. 2021. The Development of E-Student Worksheet on Environmental Pollution to Improve Critical Thinking Skills of Junior High School Students. *Journal of Science Education Research* , 7(4), 723–728.
- Wibowo. 2017. *Performance Management. Fifth Edition* . Depok: Pt. Raja Grafindo Persada
- Wiyanto, W., and Hidayah, I. 2021. Review of a Scientific Creativity Test Of The Tree-Dimensional Model. *Journal of Physics : Conference Series* .
- Yuriza, P. E., Ardisyahputra, & Sigit, D. V. (2018). Hubungan Antara Kemampuan Berpikir ingkat Tinggi Dan Tingkat Kecerdasan dengan Kemampuan Literasi Sains Pada Siswa SMP. *Jurnal Pendidikan Biologi*, 11(1), 13–20.
- Zulfaneti, Edriati, S., & Mukhni. 2018. Enhancing Students' Critical Thinking Skills through Critical Thinking Assessment in Calculus Course. *Journal of Physics : Conference Series* 948(1):012031.