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Feasibility of Student Worksheets based on Critical Thinking Skills on the Topic of Heat and Temperature

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Abstract

In the industrial era 4.0, critical thinking is indispensable in dealing with various daily life problems. However, these skills are less practised in schools. Therefore, this study aims to produce feasible worksheets to train students' critical thinking skills on temperature and heat. Five worksheets are developed: solid expansion, liquid expansion, gas expansion, heat and Black's principle. The research design used Tessmer's formative evaluation, including self-evaluation, expert review, individual trials, small group trials, and field trials. The validity of the worksheet was obtained through assessment by three experts and two science learning practitioners. Individual tests on three students, small group tests on nine students, and field tests on 32 students. The results showed: (1) the worksheets are valid because the results of content and construct validation on the five worksheets are 91.88; 92.81; 93.44; 93.75; and 92.81 with very valid categories; and (2) the worksheets are feasible because the content, expected, and actual feasibility scores are 84.44; 87.62, and 86.41 respectively with very good categories. Thus, the worksheets are feasible to use in science learning. These worksheets can be an alternative for educators in increasing the activity of students to improve learning outcomes, especially critical thinking.

Keywords: Critical Thinking Skills; Temperature and Heat; Worksheets

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INTRODUCTION

21st-century education emphasizes a student-centered learning process. (Afandi et al., 2016; Panjaitan et al., 2022). Students have 21st-century skills, including critical thinking and problem-solving, communication, collaboration, creativity and innovation (Kemendikbud, 2017; Maharani et al., 2021). This is consistent with Fardani's (2017) assertion that it is relatively easy for everybody to gain knowledge at any time and anywhere in the twenty-first century. Everyone is able to congregate and work together to solve the numerous problems they face. However, not all submitted results, methods, or opinions can correctly answer each query (Inganah et al., 2023; Zhan et al., 2022). This is where critical thinking skills are required

to deal with novel situations (Fardani, 2017). These abilities aid individuals in problem-solving and deriving effective conclusions from various possibilities. (Hsu et al., 2022; Wahyudiati, 2022).

Critical thinking is making decisions based on meticulous analysis, which enables higher-order problem-solving (Berestova et al., 2022; O'reilly et al., 2022). This competency positively impacts student learning outcomes (Hartini et al., 2020; Hsu et al., 2022; Wahyudiati, 2022; Yani et al., 2021). In this case, the habituation of critical thinking into the physics curriculum is in accordance with the 2013 curriculum's learning objectives.

Physics learning is a process of discovery that encourages students to acquire direct experience and the ability to reason when solving problems (Sutarto, 2018). Students are presented with complex and concrete problems, then instructed to apply critical thinking to find solutions (Lumbantoruan et al., 2019).

In fact, Hidayanti et al. (2016) revealed evidence that students were still less critical in problem-solving. Frequently used student worksheets less encourage students to think critically (Mukarram et al., 2014). Initial observations by Hidayanti et al. (2020) showed that students' critical thinking skills are categorized as low, although some students have demonstrated the ability to think critically. The researchers' initial findings based on observations of seventh-grade pupils at one SMPN in Banjarmasin indicate that the average value of critical thinking skills is 62, below the Maximum Completeness Criteria (MCC= 70). This is supported by the findings of interviews with science-physics instructors, who reported using worksheets from textbooks rather than creating them themselves. In student worksheets, critical reasoning skills are less developed. In addition, the results of the questionnaire given to students in a class also showed 87.5% of students felt a strong need to use student worksheets to support the science learning process in the classroom.

The researchers' efforts to enhance students' critical thinking skills include providing innovative teaching to support science learning. One of the ways is developing worksheets based on critical thinking abilities. The student worksheets is a means of facilitating learning implementation (Aperta et al., 2018; Misbah et al., 2018; Mahtari et al., 2020). Students can actively partake in the learning process by using the student worksheets as work guidelines for themselves (Budi et al., 2021; Dewantara et al., 2019; Haqsari, 2014). To familiarize students with critical thinking, teachers must be able to design the student worksheets with creativity and originality. Students are more active and imaginative during science learning when worksheets are utilized (Aminuddin et al., 2022; Zainuddin et al., 2022). This student worksheets also makes it simpler for teachers to assist students in achieving classroom science learning objectives (Setianingrum et al., 2022). This is supported by the conclusion of Purwanto et al. (2019) that using student worksheets has an immense effect on increasing students' critical thinking skills.

Wahyuni et al. (2022) have successfully designed worksheets based on indicators from Facione (1990) that measure critical thinking skills. The average skill score for students' critical thinking was 88, which was excellent, but the test was still administered in small groups. Mukarram et al. (2014) successfully created student worksheets and science learning media based on critical thinking skills. The test results indicated that the student's critical thinking skills were in the very good category, with a score of 93.32. Meanwhile, Islamia (2019) has utilized an R&D strategy to create workbooks

based on critical thinking skills in biology content that are feasible and engaging to use as educational media.

Based on the preceding description, the researchers seek to create worksheets based on critical thinking skills but using a different development model, namely the Educational Design Research model, and on junior high school physics. Like the previous student worksheets, students are actively encouraged to think critically when solving problems. However, the stabilization phase of this student worksheets provides students with more opportunities to implement the knowledge and critical thinking skills they have acquired to solve other authentic problems.

METHOD

This present research included *Educational Design Research* by adapting the Formative Tessmer evaluation model, as shown in Figure 1.

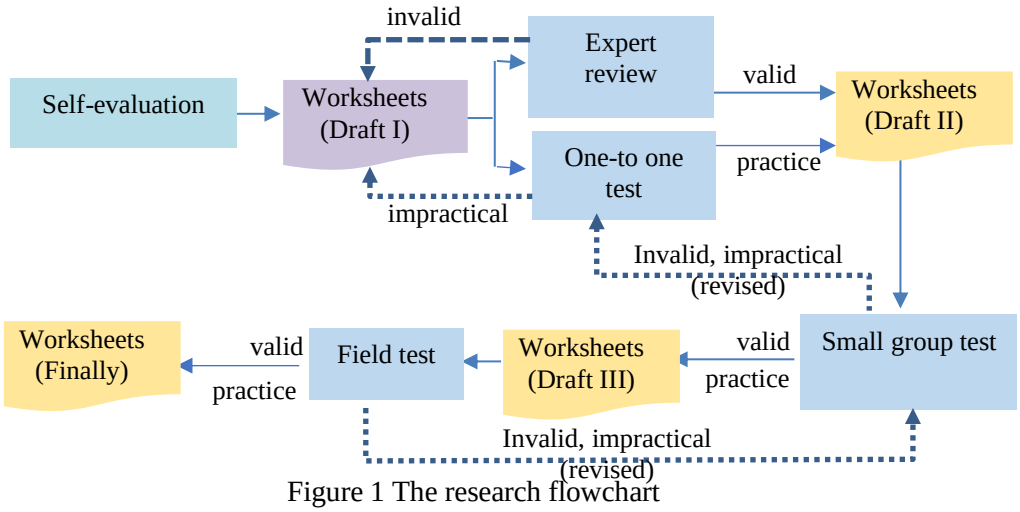

Figure 1 The research flowchart

In this self-evaluation stage, curriculum analysis, basic competencies, indicators and subject matters were carried out. The results of the student worksheets design from Fatmawati (2019) contained indicators of critical thinking skills referring to Ennis (1995). Five student worksheets developed: the material expansion of solids, liquids, and gases, heat and the Black principle.

In the expert review stage, the student worksheets draft was validated by three experts and two learning practitioners in physics, as well as content readability tests on three students who have studied temperature and heat. After the student worksheets met the valid and feasible criteria for content, it was continued with feasibility tests on small groups of nine students, followed by field tests on 32 class VII students of a state junior high school in Banjarmasin. The school was chosen because apart from that the teachers were very interested and open to science learning innovations, the results of the initial study showed that the level of students' critical thinking skills was still low.

The data was validated using the student worksheets validation instrument filled out by experts and practitioners, content feasibility data obtained through the readability assessment instrument by students, and actual and expected feasible data obtained using student response instruments after participating in limited trials and field tests. Furthermore, the data from the results of the validation and feasibility tests were analyzed descriptively and qualitatively; namely, the score obtained was divided by the maximum score multiplied by 100 and then adjusted to the criteria in Table 1.

Table 1 Assessment criteria

Range	Category
$85 < X \leq 100$	Very valid
$70 < X \leq 85$	Valid
$55 < X \leq 70$	Pretty valid
$40 < X \leq 55$	Less valid
$0 < X \leq 40$	Invalid

(Adapted from Widoyoko, 2016)

RESULT AND DISCUSSION

This research focuses on developing worksheets based on critical thinking skills. The feasibility of the student worksheets is reviewed from the aspect of validity and feasibility of the content, expected feasibility, and actual feasibility.

Self-evaluation results

An evaluation of the development of the student worksheets based on critical thinking skills has been carried out in the self-evaluation stage. The steps for developing student worksheets were: 1) reviewing the curriculum, syllabus and basic competencies; 2) determining the concept by analyzing basic competencies, indicators and physics material; 3) analyzing the temperature and heat student worksheets from Fatmawati (2019); 4) revising the student worksheets according to the indicators of critical thinking skills; 5) examining the language, vocabulary, accuracy and mechanics; 6) determining opportunities for the student worksheets implementation according to time allocation at school; and 7) modifying the tasks of the student worksheets according to the availability of facilities and infrastructure.

The critical thinking skill-based worksheet components developed are presented in Figure 2.

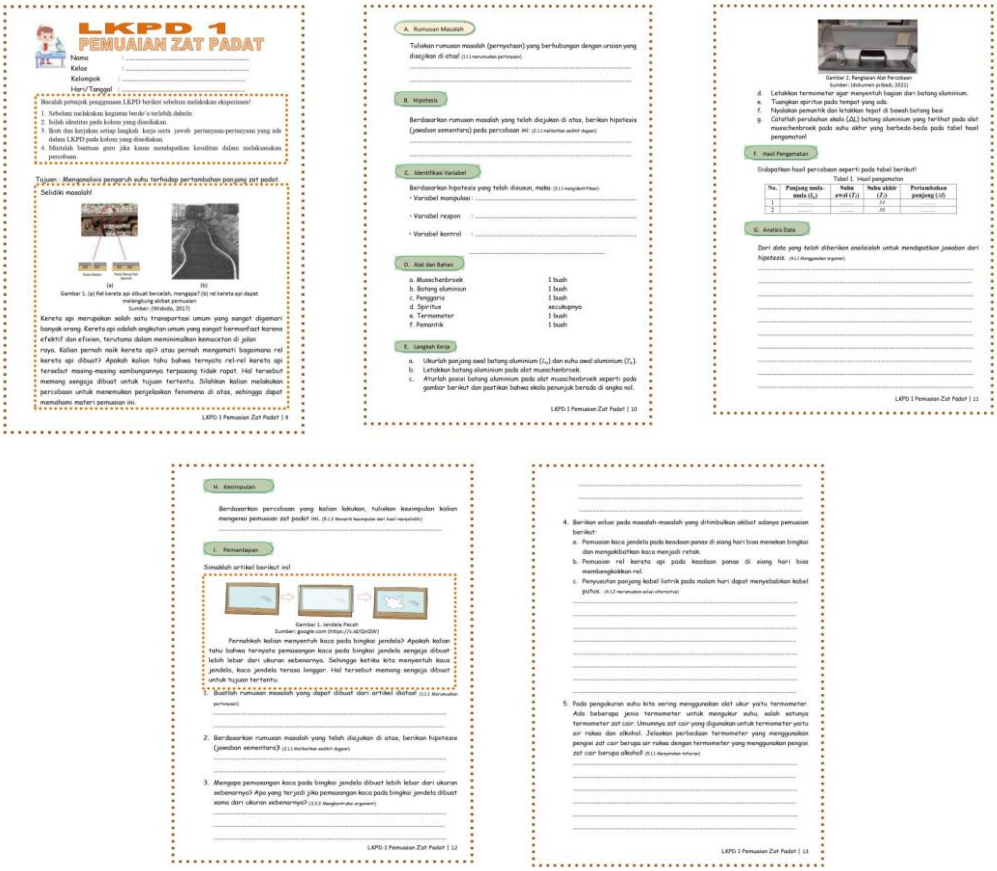

Figure 2 Critical thinking skill-based worksheets that have been developed

Based on Figure 2, the first part of the student worksheets 1 presents identity, learning objectives, and problems that attract students' attention. Through these problems, students are encouraged to be more active in Critical Thinking by interpreting and making assumptions or formulating correct hypotheses. Students are also trained to identify manipulation, response, and control variables and carry out exploration through experiments to obtain the necessary data. Based on the data obtained, students are encouraged to actively think critically by analyzing data and drawing conclusions appropriately. At the stabilization stage, students are given greater opportunities to apply their knowledge and critical thinking skills to solve real-life problems. Thus, the indicator of critical thinking has become characteristic of the developed student worksheets designs.

Expert Review Results

The expert review aims to determine the level of validity of the developed student worksheets and determine the quality of the content and construct according to the opinions of experts and practitioners. The validation results are presented in Table 2.

Table 2 The student worksheets validation results

Student worksheets	Score
1. Solid expansion	91.88(VV)
2. Liquid expansion	92.81(VV)
3. Gas purification	93.44(VV)
4. Heat	93.75(VV)
5. Black Principle	92.81(VV)

Description: VV = Very Valid

Based on Table 2, the five student worksheets have met the valid category because the components of the student worksheets are in accordance with the aspects specified in the content and construct validation instruments. This student worksheets design has been revised according to the validators' suggestions. The student worksheets design also considered the results of previous studies (Puspita et al., 2021; Wardani et al., 2016; Zulmi et al., 2020), where the student worksheets is considered valid because it meets predetermined indicators/ aspects. The student worksheets validity is based on aspects of material, presentation, language and readability, and others that affect the quality of scientific worksheets (Rianti et al., 2021; Wardani et al., 2016).

Individual test results

The individual test aims to examine the feasibility of the contents, or the readability level of the student worksheets developed based on student assessments. The results of the feasibility of the contents of the student worksheets are presented in Table 3.

Table 3 Results of the student worksheets content feasibility

Aspect	Readability value
1. Every part studied is easy to understand.	80.00 (G)
2. Include indicators or learning objectives.	88.33 (VG)
3. Include the subject matter.	91.67 (VG)
4. Instructions for use and how to carry out the task is clear.	88.33 (VG)
5. The entire complete content is based on a logical sequence.	85.00 (VG)
6. The words used are easy to understand.	78.33 (G)
7. The images are of good quality and understandable.	86.67 (VG)
8. Typo or grammar errors not found.	76.67 (G)
9. The photo on the cover is clear and understandable.	85.00 (VG)
The average of content feasibility	**84.44(G)**

Description: VG = Very good, G = Good

Based on Table 3, the developed student worksheets has feasible content in the good category, meaning that the readability level of the student worksheets by students is in a good category. This is due to each part of the student worksheets being easy to understand and containing indicators/ purpose, as well as the subject matter of heat temperature. Also, the instructions for use and the entire contents are complete and given in a logical order. The words are easy. The pictures are of good quality and easy to understand. Moreover, the typing and grammar are appropriate. The section "every part that is learned is also easy to understand", hence it is in a good category. The students are able to understand and carry out each part of the student worksheets properly. Nieveen (Rajabi et al., 2015) means that the product feasibility considers convenience, namely, the product is easy to implement or use in line with Panjaitan et al. (2022). This student worksheets has fulfilled the feasibility of the contents in the good category, which means the product is fit for use in the next test.

Small group and field test results

The small group test functions to find out the feasibility of expectations and continued with field tests to determine the actual feasibility. This study obtained the expected and actual feasibility data from students' responses to student worksheets. The feasible results of expected and actual feasibility are given in Table 4.

Table 4 The expected and actual feasibility results

Aspect	Feasible Value	
	Expected	**Actual**
The content is easy to learn and understand.	87.22 (VG)	87.97 (VG)
Commands given to acquire skills (such as observing, experimenting, etc.) can be understood.	89.44 (VG)	84.22 (G)
There is enough time to study.	86.11 (VG)	85.94 (VG)
The contents related to (equipment, method, and source of materials) are already known.	83.89 (G)	85.78 (VG)
Learning methods (such as orders/assignments) have been implemented before.	87.22 (VG)	83.28 (G)
Fun learning atmosphere.	90.00 (VG)	88.91 (VG)
Interesting learning materials to learn.	89.44 (VG)	88.75 (VG)
Average	**87.62 (**VG**)**	**86.41 (**VG**)**

Description: VG = Very good, G = Good

The comparison between the expected and actual feasibility results is not much different, namely obtaining scores of 87.62 and 86.41, respectively, in the very good category. The expected and actual feasibility results obtained the lowest score on the aspect of "the content and method of teaching student worksheets has been carried out before" obtained a good category. The students assume they do not use student worksheets based on critical thinking skills (Hidayanti et al., 2020; Mukarram et al., 2014). Therefore, they need to get used to it and participate actively in learning physics, supported by worksheets based on appropriate critical thinking skills (Noorruwaida et al., 2022; Novitasari et al., 2022).

Based on the actual feasibility data (Table 4), all aspects of the feasibility are in the very good category. Still, critical thinking is in a good category for

guidance on acquiring exploratory skills (observing, experimenting, etc.) and ways to teach (forms of orders/tasks). In contrast, they are in the very good category in the limited trials. In fact, the average actual feasibility value was lower than the expected feasibility value. This is due to the feasibility of results obtained from field tests with more students and various abilities. The difference in the number of students is much more so that students have a more diverse understanding and ability to understand and use student worksheets. In addition, the field tests were carried out during the day, where the stamina and concentration of students tended to be less than when the small group test was done in the morning. However, the expected and actual feasibility results in the very good category are still the same. Thus, the student worksheets fulfills expected feasibility as well as actual feasibility. It is in line with the results of the previous studies (Gani et al., 2022; Wardani et al., 2018) that student worksheets meets feasibility criteria so that it is feasible to train students' critical thinking skills. Through the student worksheets, students are accustomed to thinking critically in solving problems (Santyasa et al., 2022; Siswanto et al., 2022, Thoyibah et al., 2022).

The weakness of this student worksheets is that the indicators of critical thinking skills that are trained do not cover all sub-critical thinking skills according to Ennis (1995), but they already represent all indicators, one sub of each indicator. In addition, the validation and research trials results showed that the student worksheets met the expected and actual valid and feasible categories so that it was suitable for use in physics learning. Thus, this student worksheets can be an alternative for creative teachers to increase student learning activities and outcomes, especially their critical thinking.

CONCLUSION

This research has produced five student worksheets student worksheets that are appropriate for training students' critical thinking skills on temperature and heat because these student worksheets have met valid and feasible criteria in terms of content, expected and actual feasibility. This student worksheets makes it easier for teachers to guide students to develop their critical thinking skills in dealing with real-life problems. Further research is needed to test the effectiveness of student worksheets on various science material topics and at the high school level.

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