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Developing Assessment for Learning-Oriented Worksheets to Improve Student Learning Outcomes in Thermochemistry

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Abstract: This study aims to develop assessment-for-learning-oriented worksheets suitable for improving students' learning outcomes in thermochemistry. The study was conducted at SMAN 14 Surabaya with 34 students as the respondents. The research method used was Research and Development (R&D) with the 4D model, limited to the development stage. The criteria for suitable student worksheets were evaluated based on validity, practicality, and effectiveness. Data analysis techniques for validity were conducted using a validation questionnaire method, while practicality was assessed through observation and student response questionnaires. Effectiveness was evaluated using a test method. The validity results obtained a median score of 4 from the three validators, indicating valid criteria. The practicality data showed that student responses to the worksheets received a percentage of 96.7% in the good category. Observations of relevant student activities yielded a percentage range of 84% to 100%. Effectiveness data were obtained from the pretest and posttest scores, which were then statistically tested using the Wilcoxon Test and N-Gain score. The significance value test resulted in 0.000 ($p < 0.05$), indicating a significant difference between the pretest and posttest scores. N-Gain analysis showed that 31 students were in the high category and 3 in the moderate category. Based on validity, practicality, and effectiveness, the student worksheets oriented toward assessment for learning are suitable for use in improving student learning outcomes in thermochemistry.

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Introduction

Chemistry is a subject included in the independent curriculum in learning outcomes phases E and F. The learning outcome for phase F in chemistry states that students are able to use chemical energy transformations in everyday life, including thermochemistry and electrochemistry (Ministry of Education, Culture, Research, and Technology, 2022). Thermochemistry is a branch of chemistry that studies the relationship between energy and chemical reactions or the energy that occurs during chemical processes. This subject is often considered difficult by students because it involves abstract concepts and problem-solving based on chemical calculations, which require a deep understanding (Achmad et al., 2017).

This is evidenced by the results of a pre-research study conducted at SMAN 14 Surabaya, where 86.1% of 36 students considered chemistry to be a difficult subject to understand. Meanwhile, students' difficulty in understanding thermochemistry material can impact their learning outcomes. The low learning outcomes of students are demonstrated in the pre-research study by Achmad et al. (2017) conducted at MAN 1 Pontianak, where Grade XI MIPA students achieved an average score of 62.73 on their thermochemistry exam.

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Thermochemistry material is closely related to subsequent material, and it will be problematic if students do not understand this material, as it will affect subsequent material. Therefore, it is necessary for students to achieve learning outcomes that meet the criteria for achieving learning objectives in thermochemistry material.

The Learning Objective Achievement Criteria (KKTP) are criteria used in the Merdeka Curriculum to determine whether students have successfully completed their subjects. Each educational institution sets its own KKTP. Students are considered to have mastered a learning objective if they achieve a competency score of ≥ 75.

The low learning outcomes are caused by the use of conventional methods by teachers in presenting the material, which makes students feel bored and uninterested in learning the material. The suboptimal learning process at school and students' tendency to be passive in learning activities are due to teachers focusing more on transferring knowledge, which can be a cause of low learning outcomes among students (Fatonah et al., 2016). Therefore, one approach to learning that can improve learning outcomes is assessment for learning.

Assessment for learning is a continuous assessment process aimed at collecting and demonstrating evidence of student learning outcomes to determine the extent of their learning achievements, so that they know what they need to continue and how to obtain it in the best way (Rosana et al., 2020). The approach in learning assessment that prioritises feedback is assessment for learning (Sudarsono & Muchlis, 2023). The advantage of assessment for learning is that students have the opportunity to develop their creativity and activities during the learning process, thereby improving learning outcomes. This is supported by research conducted by Sudarsono & Muchlis (2023), which found that learning outcomes can be effectively improved through the use of student worksheet oriented towards assessment for learning on buffer solution material. The research results were proven by student responses, relevant student activities, and N-gain, which were classified as valid, practical, and effective.

Thus, theoretically and empirically, the assessment for learning oriented learning approach can effectively improve students' learning outcomes. Research that specifically tests the effectiveness of LKPD developed with an AfL orientation to improve learning outcomes in thermochemistry subjects may still be limited. The gap is that the LKPD that was tested has not been able to improve certain field skills in students. The novelty may lie in the emphasis on how this LKPD not only measures results, but also guides students through an active learning process. This means that LKPD is designed to facilitate student reflection on their understanding, identify areas that need improvement, and take corrective action based on feedback. To realise assessment oriented learning, there needs to be a guide to help students carry out the steps of assessment oriented learning. This guide takes the form of a student worksheet. Based on this background, the purpose of this study is to produce a feasible assessment oriented student worksheet to improve student learning outcomes in thermochemistry.

Research Method

This type of research is research and development using the 4-D model designed by Thiagarajan et al. (1974). However, this research is limited to the development stage. The research procedure for developing student worksheet is presented in Figure 1 as follows:

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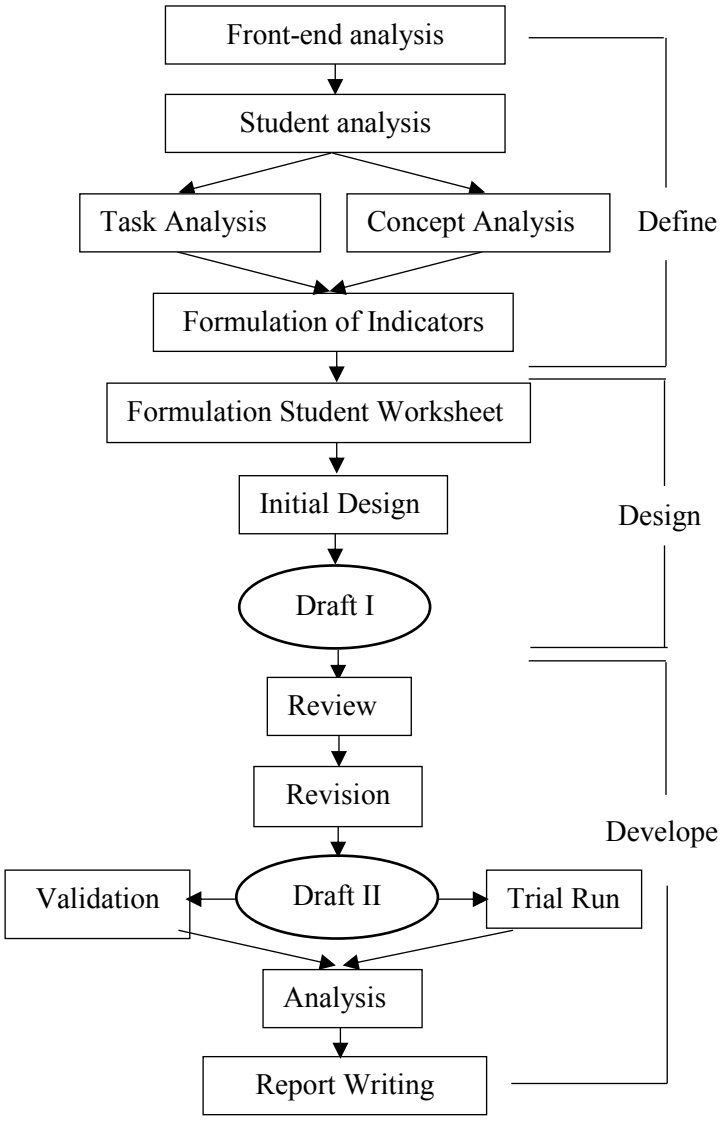

Figure 1. Research and Development Design of the 4-D Model
(Adaptation Thiagarajan *et al*., 1974)

The definition stage aims to determine and define the learning objectives to be achieved in a learning material. This stage consists of five steps, namely front-end analysis, learner analysis, task analysis, concept analysis, and indicator analysis. The design stage aims to design the student worksheet that is being developed and the initial design. The development stage includes expert appraisal and developmental testing (Thiagarajan *et al.*, 1974). This stage involves review, revision, validation, testing, analysis, and report writing. The validity of the student worksheets in this study was assessed by three validators. The validators provided assessments on the validation sheet with a score range of 1–4 using a Likert scale, as shown in the following table:

Table 1. Score Likert Scale

Score	Assessment
1	Not good
2	Not very good
3	Good

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4	very good

(Adaptation Riduwan, 2016)

The validation data is ordinal data. Ordinal data is data that is not comparable and cannot be calculated using mathematical operations (Lutfi, 2021). The validation results can be calculated using the median. Student worksheets are considered valid if the median score obtained is ≥ 3. Student responses are measured as an assessment of practicality aspects. Measurement uses a student response questionnaire and is supported by the results of observations of student activities. The percentage of student responses is calculated using the Guttman scale score in the following table:

Table 2. Guttman Scale

Answer	Score	
	Positive	**Negative**
Yes	1	0
No	0	1

(Riduwan, 2016)

The data obtained was calculated in percentage form. The student worksheets was deemed feasible and received a positive response if the results of the student response questionnaire obtained a percentage of ≥ 61% (Riduwan, 2016). A limited trial was conducted using observation sheets of student activities and was observed by observers. The results of student activity observations can support the questionnaire results if many relevant activities are carried out, namely ≥ 61% (Riduwan, 2016).

The effectiveness of student worksheets can be determined from the improvement in the pretest and posttest results of each student. After the pretest and posttest scores are obtained, they are analysed using a normality test to determine whether the data is normally distributed or not. If it is normally distributed, a paired sample t-test will be performed, but if the data is not normally distributed, a Wilcoxon test will be performed using SPSS 16 software. 0 with the following hypotheses: (1) H0 = there is no difference in the mean between pretest and posttest scores (2) H1 = there is a difference in the mean between pretest and posttest scores. The decision for the paired t-test is based on the significance value (sig.) with the following conditions: (1) If the sig. value (2-tailed) < 0.05, then H0 is rejected and H1 is accepted, indicating that there is a difference in the mean between the pretest and posttest. (2) If the sig. value (2-tailed) > 0.05, then H0 is accepted and H1 is rejected, indicating that there is no difference in the mean between the pretest and posttest.

The pretest and posttest scores will then be analysed using the N-gain test to determine the improvement in pretest and posttest results. The N-gain scores obtained are interpreted based on the following table:

Table Error! No text of specified style in document.**. Interpretation N-gain score**

N-gain Score	Category
g ≥ 0,7	High
0,7 > g ≥ 0,3	Moderate
g < 0,3	Low

(Hake, 1998)

The student worksheet is considered to have improved learning outcomes if it obtains at least a moderate N-gain score (0,7 > g > 0,3).

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Results and Discussion

The define stage consists of five steps, namely front-end analysis, student analysis, task analysis, concept analysis, and indicator analysis. Front-end analysis aims to improve learning effectiveness by identifying problems faced by students in learning chemistry. The results of the pre-research questionnaire in class XI of SMAN 14 Surabaya showed that 83% of students had not achieved the target in learning thermochemistry material. Next, the student analysis involved analysing the subjects that students found difficult to learn, namely thermochemistry material. Then, the task analysis was carried out by determining the tasks that needed to be completed by the students. The tasks are included in the student worksheet. Concept analysis involves detailing concepts relevant to the main topics related to thermochemistry. Indicator analysis involves analysing the learning objectives that students must achieve in accordance with the learning outcomes of phase F as outlined in the independent curriculum.

During the design stage, student worksheets and initial designs were formulated. The design of the student worksheets consisted of a cover page, introduction, table of contents, concept map, instructions for using the worksheets, assessment for learning components with thermochemistry material, and a bibliography. Student worksheets are not only designed as testing or practice tools, but as pedagogical instruments that actively guide students in building their understanding (Gardner, 2012). The student worksheet will also provide space for students to reflect on their learning process, identify which parts they have mastered and which need improvement, before moving on to the next material (Dann, 2014). The initial design of the student worksheets developed is presented in the following image:

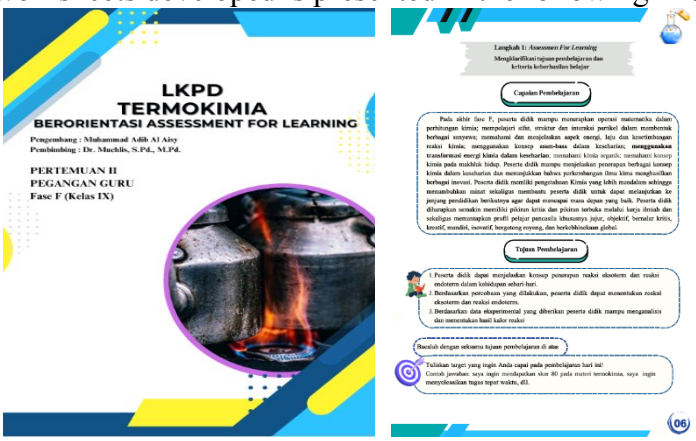

Figure 2. Initial design of student worksheets

Improvements in learning outcomes through Assessment for Learning-oriented student worksheets can be analysed from several aspects, namely

1) Effective Feedback Aspect: Unlike summative feedback, which is merely a score, student worksheets oriented toward Assessment for Learning facilitate formative feedback that is specific, timely, and forward-looking (Hattie & Timperley, 2007). This feedback helps students understand where they currently stand, where they should be, and how to bridge the gap. For example, LKPD can provide feedback columns filled in by teachers or even peers, or a self-reflection section for students.
2) The aspect of improving metacognition and self-regulation, namely assessment-oriented worksheets, encourages students to actively engage in self-assessment and peer assessment (Nicol & Macfarlane-Dick, 2006). When students evaluate their own work or that of their peers using predetermined criteria, they automatically practise

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metacognitive skills—that is, thinking about their own thinking processes (Flavell, 1979). This process increases students' awareness of their learning strategies, enabling them to identify areas of difficulty and modify their learning approaches independently, which in turn enhances self-regulation in learning (Zimmerman, 2000).

3) The aspect of increasing student motivation and engagement is that when students feel they have greater control over their learning and see assessment as a tool to help them grow, rather than merely evaluating them, their motivation to learn tends to increase (Dweck, 2006). Student worksheets designed with AfL can reduce anxiety about assessment and encourage students to see mistakes as learning opportunities, not failures (Crooks, 2001). Active engagement in the assessment process also makes learning more meaningful (Earl & Katz, 2006).
4) The aspect of alignment with the Zone of Proximal Development (ZPD) is that the alignment of assessment for learning-oriented student worksheets with well-designed ZPD learning theory allows teachers to identify each student's ZPD and provide appropriate support at the right time (Vygotsky, 1978). Through analysis of student responses in the worksheets and the feedback provided, teachers can adjust subsequent instructions to meet individual student needs, encouraging them to go beyond their current abilities with adequate scaffolding.

After completing the design stage, the initial draft of the worksheet will be validated by two chemistry lecturers and one chemistry teacher. The validation aspects include content validity and construct validity. Content validity involves the alignment of learning objectives with learning outcomes in the curriculum, as well as the accuracy of facts, concepts, principles, laws, and theories contained in the student worksheets. Construct validity involves the alignment of the student worksheets with the steps of assessment for learning. The results of the student worksheets validation assessment can be seen as follows:

Table 4. Student Worksheets Validation Results

Validity Criteria	Median	
	Student Worksheets 1	Student Worksheets 2
Content validity	4	4
Validity of the construct	4	4

Based on table 4, the student worksheet can be declared valid in terms of content and suitability for assessment for learning-oriented learning, with a median score of ≥ 3. after obtaining the validation assessment, a limited trial will be conducted to determine the effectiveness and practicality of the developed student worksheet. the limited trial of the student worksheet was conducted on 34 grade xi students at sma negeri 14 surabaya, using the one-group pretest-posttest design method, comparing the pretest results before using the student worksheet and the posttest results after using the developed student worksheet. The student response questionnaire was measured to see the results of practicality and supported by the results of observations of relevant student activities during limited trials using student worksheets. The recapitulation of the response questionnaire is described in the following table

Table 5. Results of Student Response Questionnaire

No.	Statement	Positive Response (%)	Category
1	this student worksheet helps me to understand	97	Good

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No.	Statement	Positive Response (%)	Category
	thermochemistry material.		
2	This student worksheet helped me become interested in learning thermochemistry.	94	Good
3	This student worksheet helped me identify thermochemical systems, environments, and reactions in everyday life.	97	Good
4	This student worksheet helped me draw conclusions based on the results of my analysis of environmental system data and exothermic and endothermic reaction experiments.	94	Good
5	At the beginning of the student worksheet, there were achievement targets that motivated me to study in order to achieve those targets.	94	Good
6	The feedback provided in the student worksheet does not improve my learning process **(negative statement).**	94	Good
7	The feedback provided on this student worksheet helped me identify better learning strategies.	100	Good
8	With the provision of learning plans, I am better prepared to participate in the learning process.	100	Good
9	This student worksheet helps me identify my strengths and weaknesses in the learning process.	100	Good
10	Reflecting on the student worksheet has helped me discover the learning methods that work best for me.	97	Good
	Average of all aspects	96,7	Good

Based on Riduwan (2016), the student worksheet developed can be categorised as practical if it obtains a percentage of ≥ 61%. Based on the results of the questionnaire obtained, the student worksheet oriented towards assessment for learning received a positive response from students with an average of 96.7% for all aspects of the statement, which is in line with the research. (Sudarsono & Muchlis, 2023) Assessment oriented student worksheets that received positive responses from students indicate that the developed student worksheets had an effect on increasing student motivation through feedback, helping teachers understand student learning strategies, and identifying students' strengths and weaknesses. The results of the student response questionnaire are supported by observations of relevant activities. The results of the observations during the trial can be seen as follows:

Table 6. Results of Student Activity Observations

Trial	Relevant Activities (%)	Relevant not Activities (%)
STUDENT WORKSHEET 1	95,2	4,8
STUDENT WORKSHEET 2	96,4	3,6

Table 6 above shows that relevant activities in the first meeting were 95.2%, while in the second meeting, relevant activities were 96.4%. Relevant activities included writing learning targets, conducting practical work according to procedures, analysing data, answering

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questions, giving presentations, and reflecting on the learning that had been done. Meanwhile, irrelevant activities included playing with mobile phones, causing disturbances during learning, and asking questions unrelated to the lesson material.

The effectiveness of student worksheets is measured based on improvements in learning outcomes using comparative data from pre-tests and post-tests. Comparative data can be said to be effective if there is an increase between the pretest and posttest results. The data was tested using the N-gain score, the results of the N-gain test can be seen in the following figure:

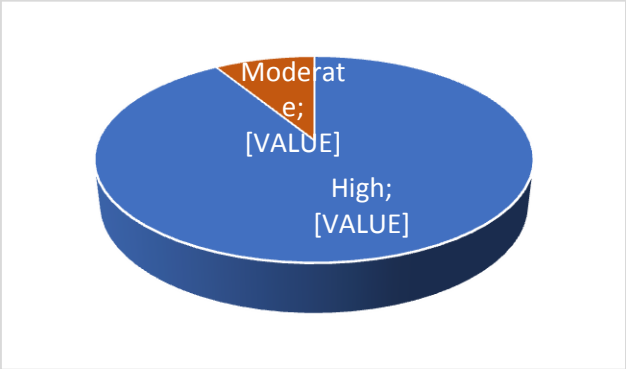

Figure 3. N-Gain Score Test Result

Based on Figure 3 above, it shows that 31 students were classified as high, while 3 students were classified as moderate. Thus, it can be concluded that the use of student worksheet oriented towards assessment for learning can effectively improve student learning outcomes, as evidenced by higher post-test scores than pre-test scores.

The conceptual implications of this study are that it provides stronger empirical evidence that AfL is not only an ideal theoretical concept, but also an effective approach that can be implemented concretely through learning instruments such as LKPD. This demonstrates that the key principles of AfL, such as providing timely and specific feedback, promoting self-assessment and peer assessment, and clarifying learning objectives and success criteria, truly contribute to improving student learning outcomes (Black & Wiliam, 1998; Hattie & Timperley, 2007). These AfL-oriented LKPDs serve as a concrete manifestation of the theory in practice. Furthermore, these findings also indicate that AfL-oriented LKPDs are effective in encouraging students to engage in metacognitive processes, i.e., thinking about how they think and learn (Flavell, 1979). Through self-assessment and reflection activities integrated into LKPDs, students become more aware of their learning strengths and weaknesses, as well as the strategies they need to apply to achieve learning objectives.

The practical implications of this research are that the findings provide a concrete model or guide for teachers in designing LKPD that not only contains questions but also integrates AfL principles. Teachers can learn how to include clear rubrics, reflective prompt questions, and space for constructive feedback in every LKPD they create (Black & Wiliam, 2009). With the implementation of AfL-oriented LKPD, the learning process in the classroom becomes more dynamic and student-centred. Students are not merely passive recipients of material but actively identify their learning gaps, seek solutions, and enhance their understanding based on the feedback they receive. This has the potential to increase student engagement and their intrinsic motivation to learn (Dweck, 2006).

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Conclusion

The conclusion of the research results that have been obtained is that the assessment for learning-oriented student worksheet to improve learning outcomes in thermochemistry material is declared feasible to be used as a learning medium. In terms of validity, it can be stated as valid based on content and construct validity by obtaining a median score of 4. Then the practicality aspect can be stated as practical based on the student response questionnaire of 96.7% and supported by the results of student observations by obtaining a percentage of 84% -100%. In terms of effectiveness, it can be stated as effective as evidenced by the N-gain test, as many as 31 students are included in the high category, as many as 3 students are included in the medium category.

Recommendation

Further research is recommended to implement assessment-for-learning-oriented student worksheets in a wider range of locations and with a larger number of students so that the results can be generalised, and to extend the duration of the research in order to obtain more optimal results.

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