International Journal of Educational Research Excellence (IJERE)
https://ejournal.ipinternasional.com/index.php/ijere
Volume 04, Issue 01, January-June 2025
e-ISSN:2830-7933
DOI: 10.55299/ijere.v4i1.1140

Development of Teaching Materials to Support Learning of the Merdeka Curriculum on Thermochemistry Material Phase F SMA/MA

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Article history: received October 25, 2024; revised November 04, 2024; accepted January 16, 2025

Abstract. This study aims to develop a teaching material on thermochemistry to support learning in Phase F SMA/MA Merdeka Curriculum. Educational Research Design (EDR) were used as the design approach and limited to prototyping stage. The subjects were three chemistry lecturers, two teachers who teach chemistry subjects and nine phase F students. Data was collected using validity and practicality questionnaires which resulted average content validity of 0.85 and construct validity of 0.87, where it can be classified as valid. Furthermore, the percentage of practicality is 96% for teachers and 94% for students, which can be classified as very practical. From these findings, it can be concluded that the developed teaching material is valid and practical.

Keywords: *Thermochemistry, Teaching Material, Merdeka Curriculum.*

I. INTRODUCTION

The Merdeka Curriculum is a new curriculum in Indonesia. This curriculum was born as an effort by the Ministry of Research, Technology and Higher Education Indonesia to overcome the long-standing and increasing learning crisis due to the Covid-19 pandemic (Amanda & Mawardi, 2023). This Merdeka Curriculum emphasizes the thoughts and ideas of Ki Hajar Dewantara, namely, education based on facilitating students to grow in accordance with the nature of nature and the nature of the times (Irianti, 2023). In order to improve competence and understanding of concepts, Merdeka Curriculum presents a variety of extracurricular activities that are integrated with the learning process (Fadila & Mawardi, 2023). Implementing the independent learning curriculum, teachers have a very important role (Bahri, 2023). Teachers not only act as guides to the learning process who master four main competencies: professional, pedagogical, personality, and social (Aditya Rigianti & Karimah, 2024) but also one of the learning resources for students.

Apart from teachers, another form of learning resource is teaching materials. Teaching materials are not just a collection of information, but rather a structured series of learning content that serves as a guide. The goal is to help learners to study the material independently. Thus, teaching materials act as a tool that facilitates students' independent learning process, not just as a source of information (Magdalena et al., 2023). Teaching materials play a very crucial role in the teaching and learning process, especially in efforts to improve students' insights and abilities. The existence of teaching materials is an important element to support the development of knowledge and skills of students during learning (Kosasih, 2021).

One of the branches of science studied at the SMA/MA level is chemistry. In the Merdeka Curriculum, the material to be studied focuses on essential material (Agustina et al., 2024). Thermochemistry is one of the essential materials contained in chemistry learning at the SMA / MA level (Murniati et al., 2018). The characteristics of thermochemistry material ideally involve chemisty representations in the presentation of teaching materials (Delfianza & Mawardi, 2023). The goal is to improve the understanding of chemical concepts due to students' tendency to memorize ideas without properly understand them (Nor Fahmi et al., 2022). To realize a deep understanding of chemical concepts, the Merdeka Curriculum applies a multi-representational approach in the preparation of teaching materials (Fauzan & Mawardi, 2023). The internal representation that a person builds to understand a concept that helps them to explain and predict something is called a mental model (Ni Made Ary Suparwati, 2022). With the presentation of chemisty representations of chemistry can build a mental model of learners as a whole (Hasnawati Haili, 2022). In expressing chemical concepts, the learning process produces three learning levels consisting of symbolic, macroscopic, and sub-microscopic/molecular levels, which are important aspects for students in understanding chemistry (Mawardi & Fitriza, 2019).

Based on research conducted by (Dewi et al., 2018) it is known that misconceptions often occurs in thermochemistry learning materials which caused students cannot built their mental model. In the research, he also revealed the main causes, such as students' condition, teachers, teaching methods, and teaching materials. Referring to the results of observations that have been made, in three high schools in solok selatan it was found that there is still limited availability of teaching materials that contain chemisty representations s in it. Preliminary study conducted by (Firdausya, 2024) also stated that phase F chemistry books for

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e-ISSN:2830-7933
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thermochemistry topics in class XI SMA/MA need to be developed because there is material content that has not been thoroughly analyzed.

In previous research, studies on the development of teaching materials for the topic of chemical bonds within the framework of the Merdeka Curriculum have been done (Alamanda & Mawardi, 2023), (Berlianda & Mawardi, n.d.) studies on the development of teaching materials for the topic buffer solution, (Hamsil & Mawardi, 2024) studies on the development of teacing materials for the topik reaction rate, (Rizal & Mawardi, 2024) studies on the development of teaching materials for the topik chemical equilibrum. The results showed that the developed teaching materials valid and practical can increase students' interest in learning, then the research about the development of teaching materials for the topic of chemical bonds was continued by (Luthfi & Mawardi, 2024) and the results obtained the use of relevant chemisty representations in teaching materials helps learners connect various concepts, thus having an impact on improving learning outcomes and students' mental models. However, in thermochemistry there has been no development of teaching materials that contain chemisty representations of chemistry so that it is necessary to develop teaching materials on thermochemistry material which is integrated with chemisty representations and modified to adapt with learning in Merdeka Curikulum. The developed teaching materials are expected to serve as a supporting resource, both for teachers and students, in implementing the Merdeka Curriculum for the topic of thermochemistry.

II. METHODS

This research used Educational Design Research, or EDR, as the development approach.Education Design Research (EDR). There are three main stages in the EDR model, the initial investigation stage, the prototyping stage and the assessment stage (Plomp & Nieveen, 2010; Ananda & Mawardi, 2023).

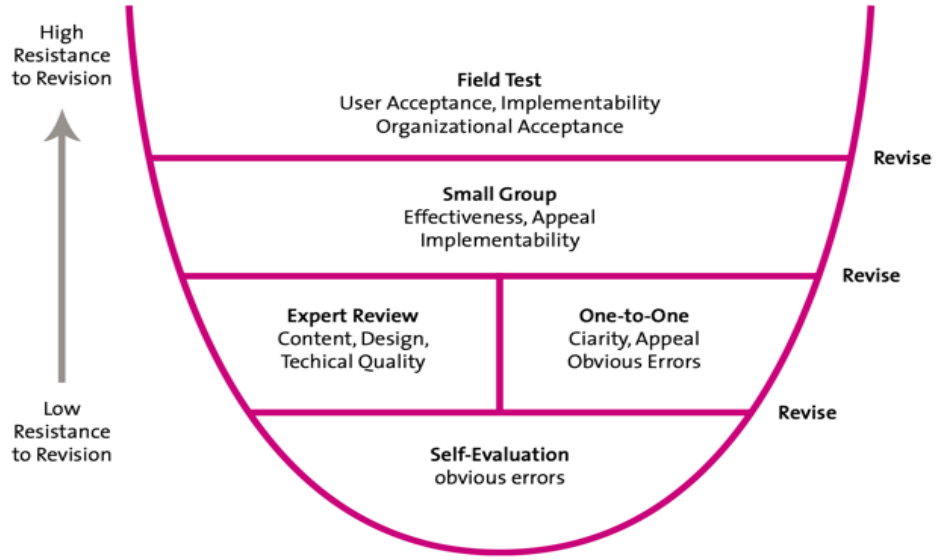

Fig 1. Layers of Formative Evaluation from Tessmer

In this study, the instruments used for data collection are validity instruments and practicality instruments and then the data obtained in the results of this study will be analyzed with descriptive statistics so that average numbers and percentages are obtained. Data from validity instruments obtained in this study will be processed using Aiken's V formula.

$$V = \frac{\Sigma s}{n(n-1)} \quad (1)$$

Description:

s : the score assigned by the validator minus the lowest score of the category used
n : number of validators
V : Aiken's V scale

Based on Aiken's validity index table when using five validators and five categories of voters, the scale used is as follows

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Table 1. Aiken's Validity Index Criteria 5 validator

Skala Aiken's V	Category
V ≥ 0,80	Valid
V < 0,80	Invalid

Source: (Aiken, 1985)

Then for processing practicality obtained from giving a questionnaire for students' responses will be analyzed using the formula:

$$NP = \frac{\bar{R}}{SM} \times 100\% \quad (2)$$

Description:
NP : Percentage value sought or expected
R : Raw score obtained by students
SM : Ideal maximum score of the test that took place 100 = Fixed number

The percentage values obtained are then grouped into several modified criteria (Purwanto, 2010)

Table 2. Category of practicality level

Value	Aspects assessed
86% - 100%	Very practical
76% - 85%	Practical
60% - 75%	Practical enough
55% - 59%	Less practical
≤54%	not practical

Source : (Purwanto, 2010)

III. RESULTS AND DISCUSSION

This research aims to produce a valid and practical product in the form of teaching materials that can support independent curriculum learning on thermochemical material. The type of research used is EDR with the application of the Plomp model. the research was carried out only until prototyping and did not proceed to the assessment stage, after the research was carried out the following results were obtained.

Preliminary Research

In the first stage of preliminary research, a needs and context analysis were onducted to collect an overview of the problems faced by the school, literature study and development of a conceptual framework (Rizal & Mawardi, 2024).

Needs analysis

At the needs analysis stage, data were collected through interviews with three chemistry teachers from SMAN 1 Solok Selatan, SMAN 3 Solok Selatan and SMAN 5 Solok Selatan to find out how the problems faced by schools in the process of learning chemistry, in thermochemistry material. Based on the results of interviews conducted with Chemistry teachers at SMAN 1 Solok Selatan, SMAN 3 Solok Selatan and SMAN 5 Solok Selatan, it was found that the government's books. used in schools was not sufficient as the only learning reference. Additional teaching materials are needed to complement learning resources, improve knowledge and understanding of both teachers and students. Based on the distribution of questionnaires, thermochemistry material in the textbook is considered difficult by most students because the concept is abstract. Research (Hatimah, 2015) emphasized that this material requires real analogies and experimental proofs. (Elvina & Dj, 2022) suggests the use of chemical chemisty representations visualizations to understand these abstract concepts. chemisty representations can also minimize misconceptions in students' understanding of learning concepts (Setia Ningsih & Mawardi, 2024).

Context Analysis

The context analysis implemented in the form of an analysis of the curriculum used in schools today and it can be seen that the three schools have implemented an Merdeka Curriculum since 2022. The context analysis stage begins by analyzing the learning outcomes (CP) for SMA/MA phase F chemistry. The learning outcomes are adjusted to the thermochemistry material to be studied, then formulated into learning objectives (TP).

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Literature Study

This literature research aims to understand the various obstacles faced by teachers and students in independent curriculum learning, by reviewing scientific articles from various journals to find solutions to the problems faced. Based on these problems, product development is needed in the form of teaching materials to improve learning of thermochemical material in the Merdeka phase F SMA / MA curriculum. Furthermore, a literature study was conducted which included the Merdeka Curriculum, teaching materials and thermochemistry materials.

Conceptual Framework

The next stage of developing this conceptual framework contains an overview of the relationship between the problems that have been identified through needs analysis, context analysis and literature study with the solutions provided (Arif & Mawardi, 2023). The depiction of the conceptual framework can be seen in the following figure.

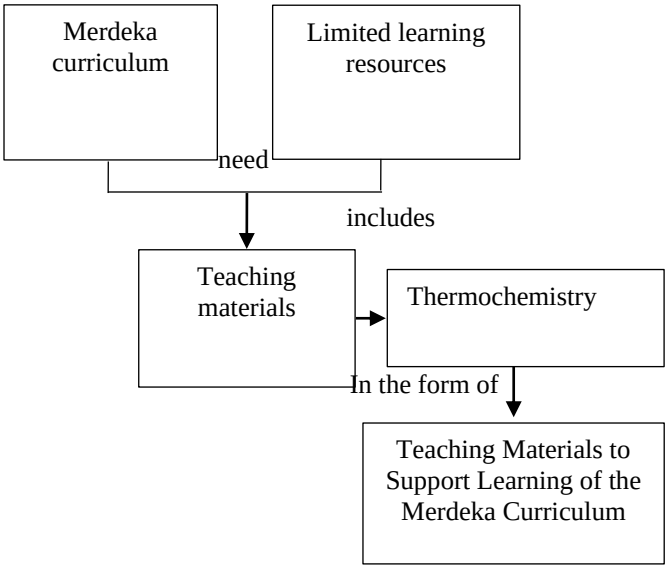

Fig 2. conceptual framework

Development and Prototyping Phase

At this stage there are 4 prototypes where there is development/improvement of the quality of the product produced through formative evaluation. Each stage is described as follows.

Prototype I

At this stage, a draft in the form of teaching material products was produced to support Merdeka Curriculum learning on thermochemistry material in phase F SMA / MA. The components of the teaching materials are based on available books and research that has been conducted by (Farras & Mawardi, 2023). The result of the design can be seen in the following image.

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Fig 3. cover of teaching materials and display of instructions for use of teaching materials

Fig 4. learning objectives

Prototype II

Prototype II is the result of improvements from prototype I. In line with the research conducted (Sonnya & Mawardi, 2023) at this stage a self-evaluation is carried out which is part of the formative evaluation stage. Checking the completeness of the components in the teaching materials is carried out. The components contained in the developed teaching materials are cover, preface, table of contents, instructions, learning objectives, concept map, chapter cover, sample problems and solutions, chapter cover, sample problems and solutions, and chapter cover, instructions for using the book, learning objectives, concept maps, chapter covers, sample problems and solutions, exercises, summaries, end-of-chapter exercises, activities, reflections, bibliography, glossary, and index.

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Prototype III

Prototype III is the revised result of Prototype II after formative evaluation, which includes expert review and one-to-one evaluation. The following results were obtained: At the expert assessment stage, validation of the teaching materials made was carried out. Validation was carried out on 5 validators consisting of three chemistry lecturers FMIPA UNP and two chemistry teachers at SMAN 1 Solok Selatan. The validation value can be seen in the following graph.

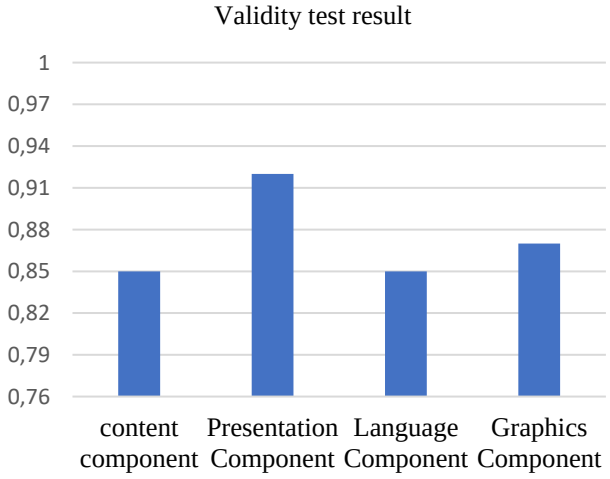

Fig 5. Validation test result

Based on the results of the analysis of the level of validity of the data, the results of prototype III are categorized as valid with an average Aikens'V index value on content validity of 0.85 and construct validity of 0.87. Even though it has been categorized as valid, there are several suggestions from the validator on the teaching materials developed and then improvements are made in accordance with the validator's suggestions, these improvements include the following points.

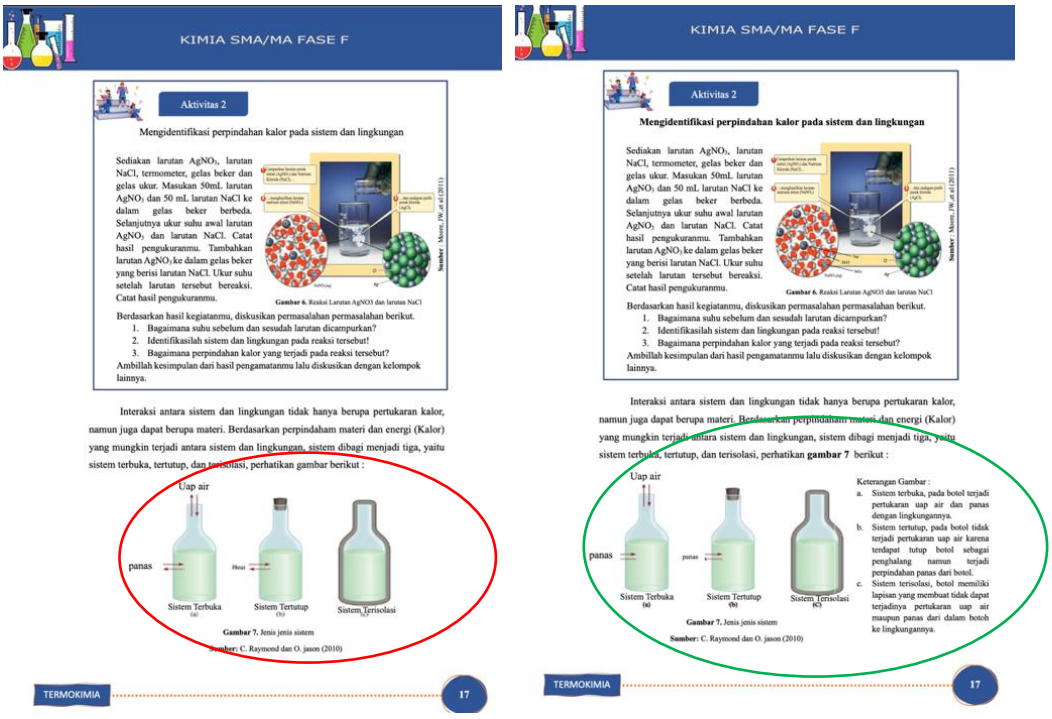

Fig 6. Before revision and after revision

Seen in Figure 6 before the revision of teaching materials, there is no picture caption that explains the concept of the image of the type of system type after the revision is seen in the green circle, a picture caption is added that helps explain the image displayed.

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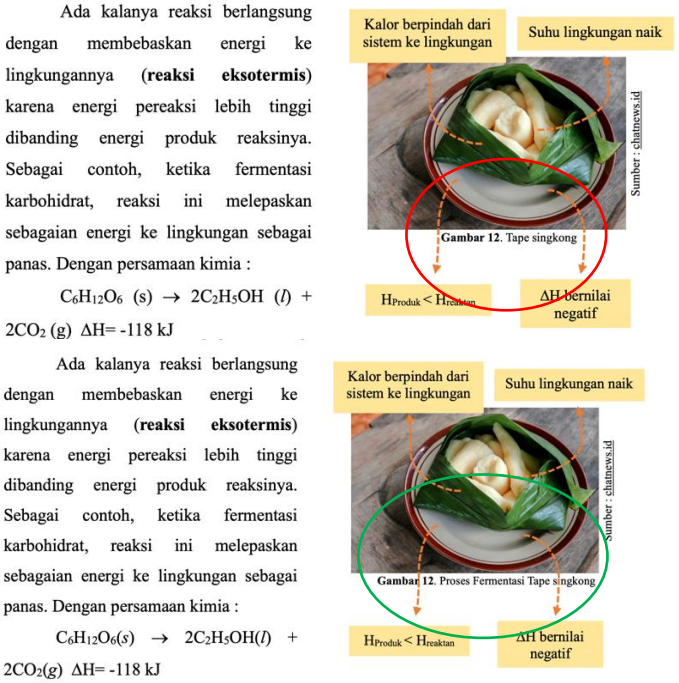

Fig 7. before revision and after revision

In Figure 7 before the revision, it can be seen that the caption does not explain what is in the picture, so the revision added a clearer picture caption.

Prototype IV

After the validation process and improvements based on the criticisms and suggestions of the validators are in accordance with the eligibility criteria, an assessment of the use of teaching materials developed for teachers and students is carried out. The purpose of this stage is to ensure that the teaching materials are not only theoretically qualified, but also easy to use and apply in the learning process (Januarita & Mawardi, 2023) Practicality relates to the ease of use and application of teaching materials by teachers and students in real situations (Firdaus & Mawardi, 2023). The results of practicality can be seen in the following diagram.

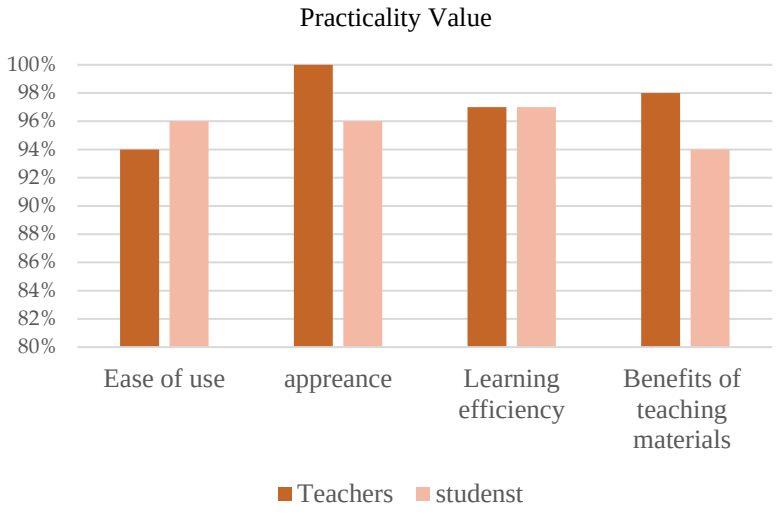

Fig 8. Teacher and Student Practicality Test Results

Based on Figure 8, the average percentage of practicality test results in small groups of students on thermochemical teaching materials that support learning the Independent Curriculum is 96% and the average percentage of practicality test results on chemistry teachers on thermochemical teaching materials that support independent curriculum learning is 97%, which is included in the very practical category. In addition, the teaching materials contain chemisty representations of chemistry which can be seen in the following figure

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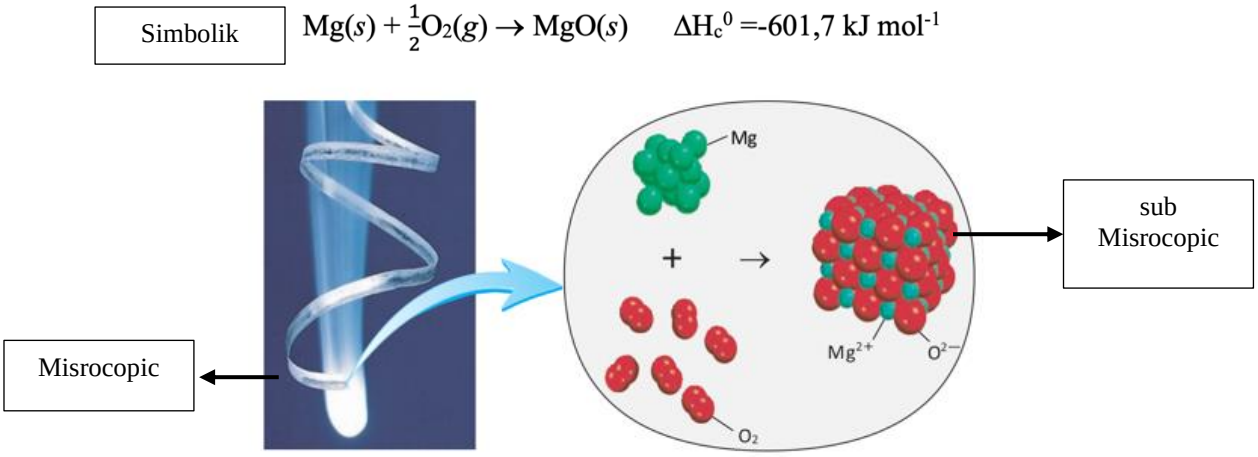

Fig 9. Multi-representation model in teaching materials

Source : (Chang, 2010)

Figure 9 showed one of the chemical chemisty representations models contained in the teaching materials. The picture explains how a standard combustion reaction occurs. This chemisty representations plays an important role in building learners' mental understanding of chemical concepts (Marsella & Mawardi, 2024). By displaying information in various forms, this method makes it easier for students to grasp chemical ideas that are both abstract and concrete.

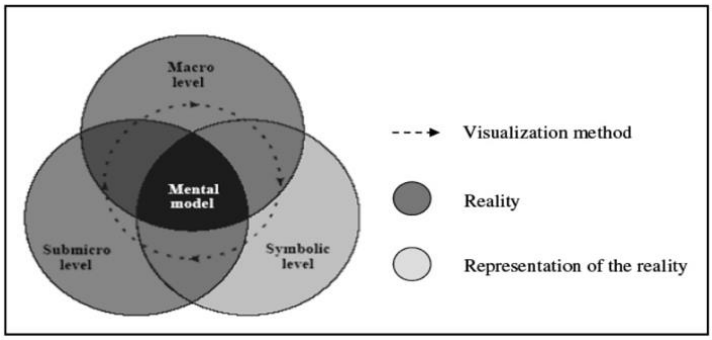

Fig 10. the interpendence chemisty representations with mental models

(Halim et al., 2013; Treagust et al., 2003)

Figure 10 shows how the three levels of chemisty representations relate to mental models, then Figure 9 is one of the chemisty representations on the concept of thermochemistry, showing The enthalpy change of standard combustion is the enthalpy change that accompanies the complete combustion reaction of 1 mole of substance in the standard state (Chang, 2010). So Figure 9 illustrate how students' ideas can understand the concept of enthalpy in standard combustion. The purpose of this stage is to assist students in developing a better mental model in connecting to the three levels of chemisty representations.

Based on the results of data analysis obtained, it is found that the construct and content validity values of teaching materials are 0.87 and 0.85, respectively. This shows that the teaching materials developed are categorized as valid according to the Aikens scale index category table. For construct validation, the content component has an average value of 0.85, meaning that the material presented in the teaching materials is in accordance with the learning outcomes and learning objectives of the independent curriculum. Thus, in line with statement (Kosasih, 2021) teaching materials must be able to convey material according to the learning outcomes of the curriculum that passes systematically.

The language component has an average value of 0.85. This means that the teaching materials developed contain writing procedures that are in accordance with correct language rules and the language used is easy to understand. This is in accordance with the provisions of language and readability in the guidebook for writing teaching materials by (Wisnu setiawan, 2021) that teaching materials must contain clear, straightforward and unambiguous language.

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e-ISSN:2830-7933
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In terms of graphic feasibility, it has an average value of 0.87, which means that the appearance of teaching materials is attractive and in accordance with the theme of thermochemical material and the systematics of teaching materials that have been developed have met the demands of the Merdeka Curriculum teaching materials. This is in line with the statement of (Setia Ningsih & Mawardi, 2024) which states that attractive images and illustrations can attract students' interest. Based on the validation results, it means that the quality of the product (teaching materials) that has been developed is feasible where teaching materials can be used in the learning process.

After the validation process and improvements based on the criticisms and suggestions of the validators are in accordance with the eligibility criteria, an assessment of the use of teaching materials developed for teachers and students is carried out. The purpose of this stage is to ensure that teaching materials are not only theoretically qualified, but also easy to use and apply in the teaching-learning process. Practicality relates to the ease of use and application of teaching materials by teachers and students in real situations.

There are four aspects that are assessed including ease of use, appearance, and learning efficiency. In terms of convenience, teaching materials are considered very practical by teachers with a percentage of 94% and by students with a percentage of 96%. The language used is easy to understand, the font used is clear, the layout is neatly organized, and the material is arranged systematically and connected between chapters. The pictures provided are in accordance with the material of Thermochemical forms, the questions are related, and the activities in the teaching materials are designed to be interesting.

In terms of appearance, teaching materials are considered very practical by teachers with a percentage of 100% and by students with a percentage of 96%. Teaching materials have a cover design that is relevant to thermochemical material, pictures and illustrations are able to increase students' reading interest, and have attractive teaching material components. In terms of learning efficiency, teaching materials are considered very practical by teachers and students with a percentage of 97% The use of teaching materials makes learning time more efficient, learning activities become more varied, and are able to increase student creativity. In terms of the benefits of teaching materials, teaching materials are considered very practical by teachers with a percentage of 98% and students with a percentage of 94% Teaching materials can assist teachers in facilitating students to learn and solve problems independently through various components and problems presented in them.

Overall, the teaching materials developed have met the criteria of being very practical according to teachers and students, with an overall average of 97% and 96% respectively. Therefore, this teaching material is considered easy to use, has an attractive appearance, is efficient in supporting learning, and provides significant benefits.

IV. CONCLUSIONS

Based on the results of research on the development of teaching materials for thermochemistry material adapted to the Merdeka Curriculum, the level of construct validity was obtained with a value of 0.87. This teaching material also received a very positive response in terms of practicality, indicated by an assessment of 96% from teachers and 94% from students. These results indicate that teaching materials are feasible to implement as a support for thermochemistry learning in the context of the Merdeka Curriculum.

ACKNOWLEDGEMENTS

This development research project was supported by various people, both directly and indirectly. The researcher would like to thank the following people: Okta Suryani, M. Sc, Ph.D; Hesty Parbuntari, S.Pd: Dwi Finna Syolendra, M.Pd who acted as content validators as well as Arwansyah, S.Pd and Elin Novita, S.Si as chemistry teachers who also acted as content validators. Thanks also go to the students of class XI IPA SMA Negeri 1 Solok Selatan who have helped in the implementation of this research.

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