

Needs Analysis for Developing a Thermochemistry Learning Module at SMAN 3 Siak Hulu

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Abstract

A needs analysis is an essential initial stage in the development of instructional materials to ensure alignment with students' characteristics and learning problems. This study aimed to analyze students' needs for developing a thermochemistry learning module at SMAN 3 Siak Hulu. The research employed a qualitative descriptive approach involving 36 eleventh-grade science students (Class XI MIPA) and one chemistry teacher as the research participants. Data were collected through a needs analysis questionnaire with dichotomous "Yes/No" options, interviews, and classroom observations. The results indicate that students had not yet understood thermochemistry concepts adequately and experienced difficulties in both conceptual understanding and numerical calculations. In addition, the instructional materials used previously did not optimally support independent learning. Students reported a strong need for supplementary learning materials that are systematic, contextual, and easy to understand. These findings suggest that developing a thermochemistry learning module is necessary as a learning guide to help students learn concepts independently and to support more effective chemistry learning.

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INTRODUCTION

Education plays a strategic role in preparing human resources who are capable of thinking critically, creatively, and adaptively amid rapid advances in science and technology. In this context, learning should not stop at mastery of facts; rather, it should promote higher-order thinking and meaningful conceptual understanding. In line with curricular demands that emphasize student-centered learning, students are encouraged to actively construct knowledge through structured and reflective learning experiences (Kemendikbud, 2017; Kemendikbudristek, 2022). Within this framework, chemistry is a key subject because it helps build scientific literacy through the understanding of chemical concepts, principles, and laws, and their connections to natural phenomena and everyday life. Ideally, chemistry learning equips students not merely to memorize concepts but also to explain, analyze, and apply them across problem situations (Nurmayanti et al., 2017). Nevertheless, chemistry is often perceived as difficult due to its abstract and symbolic nature and the demand to coordinate representations at macroscopic, submicroscopic, and symbolic levels; failure to connect these levels can undermine conceptual understanding and foster misconceptions (Chittleborough, 2017; Bahri et al., 2022).

This situation indicates the need for instructional materials that are designed in accordance with the characteristics of the content and students' learning needs. Instructional materials that are poorly structured and lack contextualization may hinder the construction of conceptual meaning, particularly for complex chemistry topics (Prastowo, 2018). Learning

modules are considered effective in supporting self-directed learning because they are systematically organized and typically include learning objectives, content explanations, examples, exercises, summaries, and assessments, allowing students to learn at their own pace and according to their abilities (Sungkono et al., 2019). The urgency of modules becomes more pronounced for thermochemistry—an area that examines energy changes accompanying chemical reactions—which requires robust conceptual understanding as well as mathematical precision (Chang & Goldsby, 2021). Many studies report that students experience difficulties in determining reaction enthalpy changes, reasoning about the direction of energy transfer, and applying Hess's law, partly due to the limited availability of staged, contextual materials supported by adequate visualizations (Widarti et al., 2018; Fitriani & Ardiansyah, 2020). Consistent with these needs, recent development studies have improved thermochemistry instructional tools through modules and e-modules (Alfirahmi, 2018; Novia & Azhar, 2021; Mardiana et al., 2025), evaluated the feasibility of thermochemistry textbooks (Anwar et al., 2023), strengthened HOTS and critical thinking through modules (Auliyani et al., 2022; Sawitri et al., 2023), and integrated contemporary approaches such as STEM, guided discovery, probing–prompting, PBL, and project-based learning into modules, e-modules, and student worksheets (LKPD) (Badlisyah et al., 2022; Chaira & Hardeli, 2023; Oktaria & Purba, 2024; Pardosi & Dibyantini, 2025; Barus & Purba, 2025; Junari et al., 2025; Ismathulhuda et al., 2022). In addition, the development of HTML5 flipbook e-modules integrated with ethnoscience (Masy & Lestarani, 2022; Ahmad et al., 2024; Arifin et al., 2024; Arifin et al., 2025) and evidence on the impact of electronic modules on learning outcomes (Afriani et al., 2022) reinforce that innovations in format and pedagogy should consider student characteristics, school context, and available learning resources.

Based on this rationale, developing a thermochemistry learning module should begin with a careful needs analysis so that the resulting product is truly relevant, contextual, and operational for improving conceptual understanding and learner autonomy. Although many innovations have been introduced, differences in learner characteristics, instructional practices, infrastructure readiness, and the quality of materials used at schools may result in distinct needs across educational settings. Therefore, this study serves as a strategic initial step to map the actual conditions of thermochemistry learning, identify instructional gaps (e.g., content structure, contextualization, visualization, and problem-solving support), and formulate module specifications that best fit students and teachers. In this way, the study functions not only as an initial diagnostic but also as an argumentative and methodological basis to ensure that subsequent module development has contextual validity, practical feasibility, and stronger potential instructional impact.

RESEARCH METHOD

Design, Setting, and Participants

This study employed a qualitative descriptive approach with a focus on needs analysis as the initial stage for developing a thermochemistry learning module (Anwar et al., 2023). Needs analysis was positioned as a strategy to map instructional material gaps, learning difficulties related to thermochemistry concepts, and module specifications relevant to the actual learning context (Fitriani et al., 2025). The study was conducted at SMAN 3 Siak Hulu, Kepulauan Riau, considering that the need for modules is strongly influenced by school characteristics, instructional patterns, and the learning resources used (Afriani et al., 2022). Participants included Grade XI MIPA students as potential module users and a chemistry teacher as the key informant to describe needs and ongoing thermochemistry instructional

practices. The selection of Grade XI students was based on their direct engagement with thermochemistry, which requires conceptual understanding, representational reasoning, and quantitative reasoning that often become sources of learning difficulty. The chemistry teacher was included to capture pedagogical needs, implementation constraints, and expectations regarding the module format and instructional strategies.

Data Collection, Instruments, Procedures, and Data Analysis

Data were collected through a student needs analysis questionnaire, interviews, and classroom observations to obtain a comprehensive picture of needs. The student questionnaire was used to map the availability and limitations of instructional materials, the level of difficulty in thermochemistry, and the urgency of developing a more systematic and contextual thermochemistry module. The questionnaire was constructed as a closed instrument with dichotomous “Yes/No” options to clarify respondents’ decisions for each indicator (Table 1). Semi-structured interviews were conducted with the chemistry teacher and student representatives to elicit in-depth explanations regarding learning barriers, the quality of existing materials, and the desired characteristics of the module. Classroom observations documented instructional conditions, how materials were used, and patterns of student engagement during chemistry instruction to contextualize and cross-check questionnaire findings.

The research procedure included curriculum analysis and learner analysis as two main pillars of needs analysis in instructional material development (Prastowo, 2018). Curriculum analysis was conducted by reviewing learning objectives, competencies, and the scope of thermochemistry content (Kemendikbudristek, 2022). Learner analysis was conducted using questionnaires, interviews, and observations to map conceptual difficulties as well as the need for visualizations, graduated practice, and problem-solving strategies in thermochemistry (Fitriani & Ardiansyah, 2020). Questionnaire scoring used dichotomous weighting to simplify the interpretation of needs across indicators. Total scores were converted into percentages to determine the category of module need level (Table 2). Interview and observation data were analyzed descriptively and thematically to identify patterns of needs, learning barriers, and expected module specifications, which were then compared with questionnaire percentage results. The final needs analysis results were synthesized into recommendations for module characteristics (content structure, contextual examples, visualizations, types of exercises, and appropriate learning models) as the basis for the next stage of module development.

Table 1. Scoring Criteria for Response Options in the Student Needs Analysis Questionnaire

Response option	Score
Yes	1
No	0

Table 2. Score Intervals and Criteria for the Needs Questionnaire

Score interval	Criterion
81–100%	Highly needed
61–80%	Needed
41–60%	Moderate
21–40%	Low
0–20%	Very low

RESULT AND DISCUSSION

The needs analysis results obtained from the questionnaire administered to 36 Grade XI MIPA students indicate that all students reported not yet understanding thermochemistry concepts well (see Table 3). Most students experienced difficulties in understanding fundamental thermochemistry concepts, such as energy changes in chemical reactions, the distinction between system and surroundings, and determining exothermic and endothermic processes. Students also reported that the instructional materials used so far did not provide a systematic explanation that supports independent learning. Interviews with the chemistry teacher corroborated the questionnaire findings, noting that students tend to struggle with thermochemistry because it is abstract and requires stepwise conceptual explanations. The teacher further emphasized that supporting materials that students can use as guides for independent study remain limited. Classroom observations showed that instruction was still dominated by textbook use and teacher verbal explanations, and consequently, students' active engagement in developing thermochemistry understanding was not yet optimal.

Table 3. Student Needs Analysis Results

No.	Item	%	Category
1	Do you like chemistry as a subject?	88.89%	Highly needed
2	Do you think chemistry is one of the most important subjects?	88.89%	Highly needed
3	Do you find it difficult to solve chemistry calculation problems?	77.79%	Needed
4	Do you often experience difficulties in understanding chemistry lessons?	83.33%	Highly needed
5	Do the media used by the teacher help you understand the material?	88.89%	Highly needed
6	Do you need additional learning materials besides the textbook?	94.44%	Highly needed
7	Do you need digital learning media to study chemistry?	77.78%	Needed
8	Are you interested in learning chemistry using videos or animations?	72.22%	Needed
9	Are you interested in using interactive digital books to learn chemistry?	80.56%	Needed
10	Are you interested in learning using simulations or virtual practicums?	69.44%	Needed
11	Do you understand lessons more easily with pictures or diagrams?	69.44%	Needed
12	Do you like doing chemistry laboratory activities?	83.33%	Highly needed
13	Do you want chemistry learning to be more interesting and easier to understand?	97.92%	Highly needed

The needs analysis indicates that although most students show a high interest in learning chemistry, they still experience difficulties in understanding the material, particularly in conceptual reasoning and quantitative problem solving. This pattern suggests a gap between students' learning interests and their capacity to grasp chemical concepts optimally. Such

difficulties are common in chemistry learning due to the abstract nature of many topics and the need to coordinate macroscopic, submicroscopic, and symbolic representations simultaneously (Sirhan, 2007; Talanquer, 2011; Yusuf & Widyaningsih, 2019). The findings also show that students strongly need supplementary instructional materials beyond the textbook as a learning guide. The textbook currently used is perceived as not fully supporting independent learning because the material presentation is not sufficiently systematic and not fully tailored to students' characteristics and learning needs. Therefore, additional instructional materials that are structured, contextual, and easy to understand are needed to support students' self-directed learning (Prastowo, 2018; Lestari, 2020).

Students also expressed the need for more varied and interactive learning media, including videos, animations, interactive digital books, and simulations or virtual practicums. Visual and interactive media can enhance conceptual understanding, particularly by helping students visualize abstract chemical concepts (Arsyad, 2019; Mayer, 2020; Widodo et al., 2021). This is especially important for thermochemistry, which requires a deep understanding of energy concepts and enthalpy changes that are not directly observable (Talanquer, 2011; Sihaloho et al., 2018). Overall, the needs analysis confirms that developing a thermochemistry learning module is essential as a structured learning guide to help students build independent conceptual understanding, bridge the gap between interest and comprehension, and support more effective and meaningful chemistry learning (Prastowo, 2018; Lestari, 2020).

CONCLUSION

Based on the needs analysis, Grade XI MIPA students have not yet understood thermochemistry concepts adequately and experience difficulties in chemistry learning. The instructional materials used so far have not fully supported independent learning, thereby creating a clear need for additional learning resources. Accordingly, developing a thermochemistry learning module is necessary as a systematic, contextual, and accessible learning guide to support a more effective chemistry learning process.

RECOMMENDATIONS

It is recommended to develop a thermochemistry learning module that is systematic, contextual, and easy to understand to support students' independent learning. The module should include clear concept explanations, applied examples, and graduated practice items. Future research is recommended to test the validity, practicality, and effectiveness of the developed module so that it can be optimally implemented in chemistry learning.

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