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Higher-Order Thinking Abilities for Improved Critical Thinking in Thermochemical Materials Module

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ABSTRAK

Penggunaan bahan ajar yang mendukung higher order thinking skills (HOTS) tentang materi termokimia masih kurang sehingga menyebabkan keterampilan berpikir kritis (KBK) peserta didik masih rendah. Penelitian ini bertujuan untuk mengetahui kelayakan modul pembelajaran kimia berbasis HOTS pada materi termokimia dan peningkatan KBK serta respon peserta didik terhadap implementasi modul tersebut. Penelitian ini tergolong kedalam jenis penelitian pengembangan dengan model ADDIE. Subjek yang terlibat dalam penelitian ini yakni 3 orang ahli materi, 3 orang ahli media, dan 3 orang guru. Sampel yang digunakan yakni 35 orang sebagai kelas kontrol dan 36 orang sebagai kelas eksperimen. Pengumpulan data dalam penelitian dilakukan dengan menggunakan metode non tes dan tes. Metode non tes dilakukan dengan menggunakan instrumen penelitian berupa lembar kuesioner validitas produk, sedangkan pada metode tes instrumen yang digunakan yakni tes kemampuan berpikir kritis siswa. Teknik yang digunakan untuk menganalisis data yaitu analisis deskriptif kualitatif, kuantitatif dan statistik inferensial (uji-t). Hasil analisis penelitian menunjukkan bahwa terdapat perbedaan rata-rata KBK peserta didik sebelum dan setelah menerapkan modul kimia berbasis HOTS pada materi termokimia. Hasil yang diperoleh membuktikan bahwa penggunaan modul kimia berbasis HOTS lebih baik dibandingkan modul biasa dalam usaha meningkatkan KBK peserta didik. Disimpulkan bahwa penggunaan modul kimia berbasis HOTS dapat meningkatkan keterampilan berpikir kritis pada siswa.

ABSTRACT

The use of teaching materials that support higher-order thinking skills (HOTS) on thermochemical materials still needs to be improved, which makes students' critical thinking skills (CBC) low. The goal of this study is to find out if HOTS-based chemistry learning modules on thermochemical materials and improving CBC are possible and what students think of them when they are used. This study is a type of development research called "ADDIE" research. Three experts on materials, three experts on the media, and three teachers took part in this study. As the control group, 35 people were used, and as the experimental group, 36 people were used. In this study, both non-test and test methods were used to collect data. The non-test method was done with the help of a product validity questionnaire sheet, which was a research tool. On the other hand, the instrument test looked at how well students could think critically. Descriptive qualitative analysis, quantitative statistics, and inferential statistics are used to look at the data (t-test). The average CBC of students was different before and after they used HOTS-based chemistry modules to study thermochemistry materials. The results show that using HOTS-based chemistry modules to improve students' CBC is better than using standard modules. It was decided that chemistry modules based on HOTS could help students learn how to think more critically.

1. INTRODUCTION

The demands of learning in the twenty-first century have changed many aspects of learning, including the transformation of the teacher center into a student center (Andrian & Rusman, 2019; Rahayu et al., 2022). Students who were previously merely expected to memorize and understand

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concepts are now asked to examine and solve diverse problems that occur in the surrounding world through a critical thinking process in 21st century learning (Chalkiadaki, 2018; Saputri et al., 2019; Suryaningsih & Nurlita, 2021). Critical thinking is essentially a student's capacity to study a phenomenon/problem systematically, discern difficulties carefully, find and analyze information, and design problem-solving techniques (Agnafia, 2019; Azizah et al., 2018; Benyamin et al., 2021). Furthermore, critical thinking skills are defined as an individual's ability to explain arguments based on data assembled into a complex decision or notion (Anggraeni et al., 2019; Umam, 2018; Wahyuni et al., 2018). Based on this, the ability to think critically is a cognitive ability that can assist pupils in making a decision. Students with strong critical thinking skills will be able to consider a variety of factors while making decisions (Jamaluddin et al., 2020; Wijayanti & Siswanto, 2020).

It's just that the reality on the ground demonstrates that pupils' critical thinking skills remain inadequate (Dewi et al., 2020; Laura et al., 2022). This is consistent with the findings of observations and interviews done at MAN 1 Aceh Barat. According to the findings of observations and interviews, students' critical thinking skills in the chemistry learning process remain relatively low. This is reflected in the level of mastery of student material on all thermochemical material indicators during the last five years, which remains relatively low, namely 73.15; 22.75; 11.11; 54.55; and 31.25. The low ability of students' thinking in chemistry content is related to the fact that the teacher's teaching materials are still not diverse and have not offered questions that might increase students' thinking abilities during the learning process. Learning resources that are limited and less diverse cause challenges in grasping the information and have an impact on learning results. If these issues are not addressed, they will undoubtedly have an impact on the low quality of learning and failure to meet chemistry learning objectives.

Using learning modules to facilitate the learning process is one method for overcoming these obstacles. Modules are independent, dispersed, and non-group-study-oriented instructional resources (Andriani et al., 2019; Hasanah et al., 2021; Simangunsong & Pane, 2021). Modules typically feature material, methodologies, limitations, and evaluation techniques that are structured in a logical and appealing manner to attain the desired outcomes (Gazali & Ningsih, 2019; Roziyah & Kamaludin, 2019). Schools have widely used and produced learning modules. The designed module also serves as a learning guide, making it easy to comprehend, comprehend, and be guided through the content (Astuti & Olensia, 2019; Utari et al., 2021). The learning modules must be comprehensive, engaging, and purposeful in order to effect the development of student learning outcomes (Herawati & Muhtadi, 2018; Viani & Kamaludin, 2020). In addition, modules must not only be able to pique students' interest in learning, but also incorporate exercises that help strengthen their critical thinking (Lestari & Premono, 2019; Romayanti et al., 2020). Therefore, the application of the module will be enhanced by the development of higher order thinking skills.

Higher order thinking skills (HOTS) are the ability of pupils to think at a higher level, or the process of thinking at a higher level (Masitoh & Aedi, 2020; Widyawati et al., 2021). Higher order thinking skill (HOTS) is the capacity to think beyond simple memorization, repetition, or connection without processing (recitation) (Rapih & Sutaryadi, 2018; Suherman et al., 2020). Students with higher-order thinking skills will be able to analyze incorrect situations and generate novel solutions (Syapudin, 2019; Umami et al., 2021). The development of learning modules based on HOTS will assist students enhance their critical thinking skills in all aspects of education. Several prior research have demonstrated that the creation of HOTS-based modules is a viable method for enhancing students' CBC (Rofiah et al., 2018).

The findings of additional research indicate that this HOTS-based module has a good impact on learning outcomes and is utilized successfully in the learning process (Hikmah & Wibowo, 2020; Suherman et al., 2020). Subsequent research demonstrated that the problem-based learning biology module substantially enhanced students' critical thinking abilities (Kimianti & Prasetyo, 2019; Selviani, 2019). On the basis of some of these research' findings, it can be concluded that HOTS-based module learning media is utilized effectively to enhance students' learning outcomes and critical thinking abilities. However, there were no previous research that specifically addressed the construction of thermochemical material modules based on higher order thinking skills to enhance students' critical thinking abilities in chemistry learning. The purpose of this project is to establish the viability of HOTS-based chemistry learning modules on thermochemical materials, as well as to enhance CBC and student responses to module deployment.

2. METHODS

This study is an example of the type of development research conducted utilizing the ADDIE paradigm. The ADDIE approach includes five stages of research: analysis, design, development, implementation, and evaluation (Syahrial et al., 2019). This study includes three material specialists, three

media specialists, and three educators. In addition, for the analysis of students' critical thinking abilities, a sample of 35 students was used as the control class and 36 students as the experimental class. This study's data collecting employed both non-test and test approaches. The non-test approach was conducted using a questionnaire instrument sheet, and the product validity instrument was a test of students' critical thinking abilities. The study's collected data were then evaluated utilizing qualitative and quantitative descriptive analysis methods. The percentage analysis was used to analyze the product's validity, whereas the equation N-gain and the independent sample t-test were used to assess the improvement in learning outcomes.

3. RESULTS AND DICCUSSION

Results

This HOTS-based module has undergone the ADDIE model's development phases. The outcomes of each phase of development are as follows: The initial stage of development is analysis. The analysis phase involves examining the needs of the students. The results of the analysis indicate that the difficulties that exist in schools or other relevant information are based on preliminary research and a search for relevant literature. The results of a student analysis indicate that thermochemical material is one of the subjects that students find difficult to comprehend and tedious because it is typically presented without a diversity of learning resources. Based on the results of a needs analysis completed at MAN 1 Aceh Barat, it was determined to create a thermochemical module based on the HOTS system. The HOTS module is suitable for testing so that it may be used to solve the issues encountered in MAN 1 Aceh Barat.

The second stage of development is the design/design phase. The design/design phase results in the production of a thermochemical module based on HOTS. The modules are designed using Microsoft Word, A4-sized paper, 12 font sizes, and typefaces. To grab students' attention, the modules are designed with a range of colors and loaded with images that correspond to the learning material. The planned courses have been validated by specialists and chemical professors. It is anticipated that the produced modules will be implementable for students. The third stage is the development of media products. The development of media products is adapted to the design that has already been created. Figure 1 shows the results of media product development.

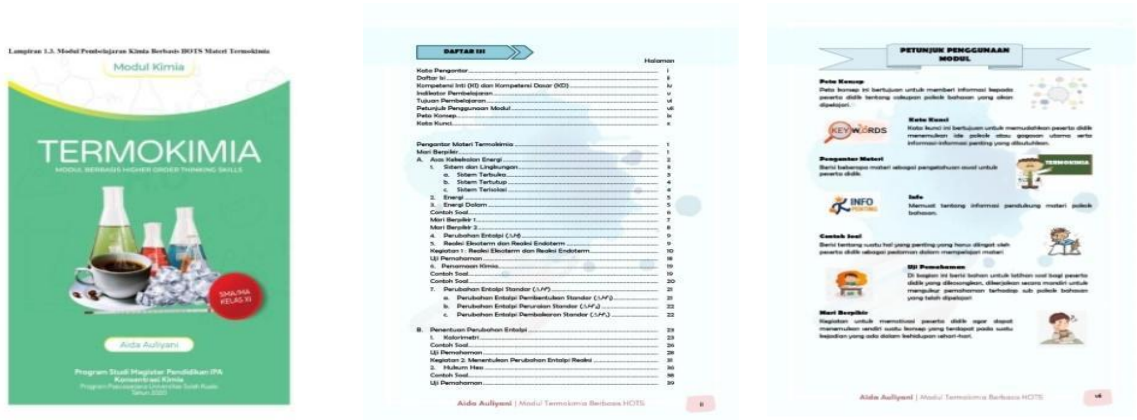

Figure 1. Preliminary Design of the HOTS

The development and testing of the validity of a media-based module by material expert validators, media specialists, and teachers. There are portions of the validation procedure that must be altered. 95.23 percent were the findings of the evaluation conducted by learning material experts (very good). The findings of the evaluation conducted by professionals in learning media were 90.69 percent (very good). The results of the teacher's evaluation were 88.05 percent (very good). Table 1 displays the findings of the specialists' evaluation.

Table 1. Product Validity Test Results

No	Subject	Eligibility Results (%)	Qualification
1.	Material Expert Test	95.23	Very good, no revision
2.	Media Expert Test	90.69	Very good, no revision
3.	Expert Test by Teacher	88 .05	Very good, no revisions

The fourth level of media learning is the implementation stage. The implementation phase was conducted at the MAN 1 Aceh Barat. The research sample had a total of 18 respondents, including 15 IPA class XII students and 3 chemistry teachers. The results of the implementation are the responses of students and teachers to the produced module's benefits and drawbacks. In addition, the module is implemented utilizing a single type of research design, namely the one-group pretest-posttest design. This study's design seeks to determine the efficacy of a treatment by comparing the outcomes of the pre- and post-tests. The treatment consists of HOTS-based module development outcomes. The specialists validate the modules, which are then implemented for students. This investigation was implemented on a restricted scale, specifically at MAN 1 Aceh Barat, which consisted of six meetings. Based on the prior material test scores in each class, the same average score was acquired for the implementation stage: class XI MIPA 4 with 35 students (24 girls and 11 boys) and class XI MIPA 5 with 36 students (24 girls and 11 boys) had the same average score (26 female, 10 male).

The objective of the implementation is to assess the extent to which students' learning outcomes have improved and to gauge their reactions to the newly-created HOTS module. In the meanwhile, before the module is assessed, students will be given a pretest, followed by a posttest at the conclusion of the course. The utilized questions have been evaluated for their quality prior to their implementation. Forty of the fifty questions produced were separated into pretest and posttest questions based on the results received. Activities during implementation in general, including the distribution of HOTS-based modules to groups, students discussing the material and conducting practicums before filling out their respective worksheets contained in the module, students presenting the results of practicum discussions and conducting questions for each group. In this study, the students' critical thinking skills were evaluated using six indicators: interpretation, analysis, conclusion, evaluation, explanation, and self-regulation. The N-gain can be used to examine the improvement in students' critical thinking skills before and after the use of learning therapies. Table 2 provides a breakdown of the outcomes of the analysis of increasing students' critical thinking skills in the experimental and control classes.

Table 2. Results of Analysis of Increasing CBC of Students in

Class	Pretest	Posttest	N-gain	Category
Experiment	50	78	0.56	Moderate
Control	49	64	0.28	Low

The findings of the analysis of the growing CBC of students in the experimental class and the control class are displayed in Table 2. Based on the findings of the analysis, it was determined that the average rise in students' CBC after utilizing the HOTS-based module was greater than that of the control group, which utilized the standard module. After getting the findings of the examination of the increase in pupils' CBC, the hypothesis was tested. The purpose of the hypothesis test was to determine the difference between the average CBC of students in the experimental and control classes. Utilizing an independent sample t-test, the hypothesis is examined. Normality and homogeneity tests are necessary precondition for testing the hypothesis. The purpose of the normality test is to assess whether or not the data used is normally distributed. The Kolmogorov-Smirnov test is used to assess normalcy. The data homogeneity test is a test that determines whether the study data for each data group originates from a population with little diversity. The hypothesis test utilized is a t test on independent samples. Table 3 displays the results of the hypothesis test to determine the difference between the average CBC of students before and after receiving the experimental class and control class learning treatments.

Table 3. Results of Hypothesis Test Analysis

Class	Normality	Homogeneity	Significance
Experiment	0.200 > 0.05 (normal distribution)	0.196 > 0.05	0.000 <0.05
Control	0.200 > 0.05 (normal distribution)	(homogeneous)	(Significantly different)

Test results independent sample the t test for the experimental and control groups yielded a two-tailed significance level of 0.000. If Sig. (2-tailed) is less than 0.05, there is a statistically significant difference between the CBC of students in the experimental class and those in the control class. This demonstrates that there is a difference in the average CBC of students after implementing HOTS-based modules in the experimental class versus regular modules in the control class; therefore, the hypothesis, Ho, that there is a significant improvement in student learning outcomes using HOTS-based modules is rejected.

The results of the analysis indicate that after implementing learning activities with HOTS-based modules, students' CBC in each indication increases. Different treatments during the learning process will impact learning outcomes, as seen by the posttest results. The experimental group outperformed the control group on the posttest, demonstrating that the created HOTS-based module can enhance CBC. Several indicators demonstrate that CBC exists; some students have been able to identify and answer questions based on the indicators as a whole and can do so accurately and clearly, indicating that they have a solid grasp of the content.

On the basis of the CBC study of students in the control group, it was determined that the average CBC of indicator students was lower than that of the experimental group. This demonstrates that HOTS-based modules are implemented more effectively than standard modules. After knowing the average results of the pretest and posttest CBC for each indicator in the experimental class and control class, the N-gain analysis can reveal the effects of boosting students' CBC. Table 4 showing the findings of N-gain CBC.

Table 4. Results of CBC Analysis of Students

Question Number	Indicator	*N-gain* Experiment	Category	*N-gain* Control	Category
1: 1	Interpretation	0.49	Moderate	0.17	Low
CBC 2: 2	Analysis	0.36	Moderate	0.11	Low
CBC 3: 4	Conclusion	0.79	High	0.33	Medium
CBC 4: 3,5,6,7, 9, 10,11,12,13	Evaluation	0.52	Moderate	0.34	Moderate
CBC 5: 9.15	Explanation	0.58	Moderate	0.31	Moderate
CBC 6: 16,17,18,19,20	Self-regulation	0.59	Moderate	0.25	Low

Based on Table 4, it can be determined that the average N-gain CBC of students using HOTS-based courses for each indication falls into the moderate group. While the control class comprises the low and medium groups. The collected results demonstrate that the experimental class experienced a greater increase in CBC than the control group.

Discussion

Based on the results of the conducted data analysis, it can be seen that the use of HOTS-based modules in the classroom increases students' critical thinking abilities. Critical thinking is one of the cognitive abilities that students must develop since it enables them to tackle a variety of issues (Oktaviani & Anugrahi, 2019; Umam, 2018). Critical thinking is the ability of a learner to methodically study a phenomenon/problem, carefully differentiate problems, and discover and analyze information to design problem-solving techniques (Azizah et al., 2018).

Students with strong critical thinking skills will be able to consider a variety of factors while making decisions (Jamaluddin et al., 2020; Oktaviani & Anugrahi, 2019; Sumardiana et al., 2019). The existence of a growth in students' critical thinking abilities as a result of the use of teaching modules is influenced by a number of elements, including the fact that the generated media meets students' needs. High school pupils require media that can strengthen their critical thinking skills when studying chemistry. This is because thinking skills are essential for 21st century learning (Jamaluddin et al., 2020; Wijayanti & Siswanto, 2020). In the 21st century, students are expected to actively participate in the learning process, with the teacher serving mostly as a facilitator (Azizah et al., 2018; Benyamin et al., 2021).

The second factor is that the developed medium is consistent with the content and learning objectives. One of the aspects contributing to the success of media development is the compatibility between media and learning objectives and materials, because learning media is a tool that teachers can use to facilitate the learning process (Andriani et al., 2019; Hasanah et al., 2021 ; Simangunsong & Pane, 2021). In teaching and learning activities, media serve as a conduit between the teacher and students for the delivery of content. The use of media will facilitate the teacher's ability to deliver instructional material and boost student comprehension (Gazali & Ningsih, 2019; Roziyah & Kamaludin, 2019). The third success criteria is that the designed medium is visually appealing. Design is associated with the utilization of colors, images, and forms of writing (Astuti & Olensia, 2019; Utari et al., 2021). The utilization of visuals and colors in instructional materials will aid pupils in comprehending media information (Herawati & Muhtadi, 2018; Viani & Kamaludin, 2020). In addition, the use of visuals and colors might facilitate students' comprehension of abstract concepts presented in instructional materials (Lestari & Premono, 2019; Romayanti et al., 2020).

This study's findings are consistent with those of prior research, which also shown that the construction of HOTS-based modules was successfully employed to increase students' CBC (Rofiah et al., 2018). The findings of additional research indicate that this HOTS-based module has a good impact on learning outcomes and is utilized successfully in the learning process (Hikmah & Wibowo, 2020). Subsequent research demonstrated that the problem-based learning module in biology substantially enhanced the critical thinking abilities of high school pupils (Selviani, 2019). Consequently, based on research findings that are supported by prior research findings, it can be stated that HOTS-based module learning media is utilized effectively to enhance students' learning outcomes and critical thinking skills.

4. CONCLUSION

On the basis of the findings of the data analysis and discussion, it is possible to conclude that the HOTS-based module has a very high validity value, and thus its development is highly viable. Additionally, modules based on HOTS can enhance students' critical thinking in thermochemical materials.

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