

Improving Student's Critical Thinking Ability Using HOTS-Based Modules in Chemistry Learning

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Abstract

Learning the 21st century obliges student for have three Skills that is Skills think critical, skills think creativity and skills solve problem. Skills the known with Skills think level tall or HOTS (Higher Order Thinking Skill). Study This aim to: (1) know appropriateness module HOTS based on the material acid-base in accordance with criteria that have been determined by BSNP. (2) knowing is ability think critical student use module HOTS based more tall rather than ability think student use book packages at school and. (3) knowing response student to module HOTS based on the material acids and bases that have been developed. This study made with Research & Development approach using ADDIE model paradigm. Study This conducted at Medan State University and Medan 21 State High School. Research result This show that through development module HOTS based on the material average acid-base result analysis is 91% (valid) and no need revised while the average response student is 85% (very interesting). This matter show that module HOTS based on the material solution sour developed language worthy and very interesting for student. And the average value ability think critical student use developed module is 81 while the average value ability think critical student use book package at school of 70.8. This matter show ability think critical student use module Based on developed HOTS more tall compared to ability think critical student use book package at school.

Keywords: HOTS; appropriateness; ability think critical; acid-base solution.

Introduction

Learning this 21st century demand participant educate so you can in a way active and independent For form 4C skills consisting from *critical thinking, communication, collaboration, and creativity* (Indarta, 2022). Chemistry subjects use a combination of theoretical and mathematical concepts, so these 4C skills need to be applied in chemistry learning. To fulfill this, evaluate the current curriculum.

The Indonesian government has completed the curriculum revision based on the evaluation that has been carried out. The curriculum as an educational design has a very central position in a learning activity. The curriculum greatly influences the success of the learning process and outcomes. Therefore, the curriculum should be developed in accordance with the student's environment, work demands, current and future life developments (Tusyana et al., 2020). The aim of implementing the Merdeka curriculum is to prepare people to have productive, creative and innovative personalities (Lince, 2022).

Chemistry and critical thinking are two things that cannot be separated, chemistry contains complex concepts. To be able to understand it requires very in-depth reasoning. One of the chemical materials that requires a high level of understanding because it is conceptual is Acid-Base material (Murtiningrum, 2013). Acids and bases are basic materials that require high-level thinking skills, not just remembering and understanding because they are a link between concepts such as thermodynamics, chemical reactions and chemical equilibrium (Pebucu, 2012). Research results (Polat & Aydın, 2020; Silberman et al., 2021) still show the low critical thinking abilities of Indonesian students. Teachers provide routine and procedural practice questions. Students only note down or copy material and tend to memorize mathematical formulas or rules without meaningful understanding (Dwijayanti et al., 2020; Wu & Wu, 2020).

This fact shows that the use of HOTS-based test instruments is still rarely used in learning evaluation. This was obtained from experience and the results of initial observations carried out by researchers at SMA Negeri 21 Medan. The test instruments used by teachers on average come from cognitive domains C1-C3. Apart from that, the use of teaching materials in schools only uses textbooks and the textbooks used still use low cognitive level questions. From the results of interviews that have been conducted,

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schools still need teaching materials that are able to contain questions with a high cognitive level. The constant availability of online distractions, such as social media and online gaming, can interfere with concentration, time management, and study habits. Social interactions are also impacted by technological addictions (Suprayitno, 2023).

To overcome these problems, improvements, changes and updates need to be made. Procurement of quality learning materials is one effort to improve the quality of education, and can be done with quality teaching materials (Fitriani, 2017). Teaching materials that can be adapted to the needs and abilities of students can be in the form of modules (Siregar, 2022). Modules are one learning resource that has been proven to be effective in increasing students' understanding of learning material (Dumitrescu, 2014). A module is a set of teaching materials that are presented systematically and completely so that users can learn with or without a teacher, with the module students can study individually at school or at home according to their individual learning pace (Yerimadesi, 2016; Omar et al., 2023; Onmonya et al., 2024). One of the aims of preparing modules is to provide teaching materials in accordance with curriculum demands by considering student needs. Organizing good material in modules is one way that can be done to help students understand the material better, so that it is hoped that students can achieve learning completeness (Anisa, 2018).

Previous research, Ayuliani (2022) stated that the development of a HOTS-based thermochemical material module was able to improve students' critical thinking skills with the average critical thinking ability of students before and after implementing the HOTS-based chemistry module stated to be better than the module without Hots. Students' critical thinking skills can be trained by working on HOTS questions, and in the development of the curriculum students are required to work on high-level thinking chemistry questions (Risadiana, 2022). This situation occurs under the conditions that school institutions tend to be shackled for the growth and development of children because the teacher only accumulates knowledge in the learning process without allowing students to think critically and build creativity (Doris Apriani Ritonga, 2022).

Setiawati (2018) believes that HOTS questions in the assessment context measure the ability to: 1) transfer one concept to another, 2) process and apply information, 3) look for connections between different pieces of information, 4) use information to solve problems, and 5) examine ideas and information critically. Romiah E's research (2016) found that developing HOTS-based modules was able to improve students' critical thinking skills with a gain value of 0.49 or in the medium category. Meanwhile, Puspita (2022) said that developing HOTS-based modules can improve students' critical thinking abilities and learning independence with an average score of 0.44 and 0.65 in the medium category. The HOTS-based chemistry learning module developed in this research is on Acid-Base material to see the suitability of the HOTS-based learning module using BSNP (National Education Standards Board) standards, in order to determine students' critical thinking abilities and responses to the use of the module. Development research is a type of research that aims to produce learning products, starting from needs analysis, product development, product evaluation, revision, and product distribution (dissemination). Educational Research and Development known with term *Research & Development* (R&D) is method research used For produce product specific and testing its effectiveness (Sugiharti , 2018). Many development models are possible used, one of them is the ADDIE development model developed by Dick and Carry for designing system learning (Purba , 2022). This model arranged in a way programmed with sequences systematic activities in effort solution problem related learning with source ADDIE learning includes five stages, namely *Analysis, Design, Development, Implementation, and Evaluation* (Hartini , 2020).

Development module here aim for provide appropriate teaching materials with demands curriculum with consider need student. organizing good material inside module be one way that can be done to help student more understand material more OK, so expected student can reach completeness learning (Anisa, 2018). The material developed in the Acid-Base material module is divided into several main sub-materials, namely: properties of acids and bases, identification of acids and bases, determination of the acidity scale.

The module developed in this research is based on *HOTS (Higher Order Thinking Skills)*. Cahyani (2022) states that HOTS-based modules are teaching materials that are prepared in a structured and systematic manner which is equipped with high-level thinking questions known as HOTS. Rofiah (2018) stated that the preparation of material in modules with critical thinking indicators equipped with HOTS questions

was able to improve students' critical thinking skills. Furthermore (Sugiharti, 2021) also states that *Higher Order Thinking Skills* are high-level thinking skills that involve the processes of analyzing, evaluating and creating. Meanwhile, Hamzah (2022) wrote that the main aim of *Higher Order Thinking Skills* is to improve students' thinking abilities at a higher level, especially those related to the ability to think critically in receiving various types of information, think creatively in solving a problem using existing knowledge. own and make decisions in complex situations.

Other development research related to HOTS, including Panggabean (2021), Yusuf (2020), found that the development of general chemistry modules on biochemical material can improve students' high-level thinking abilities, where the modules developed were declared valid and proven to be effective in increasing students' HOTS and providing positive response from students. Furthermore, Yusuf (2020), also found that the HOTS-based module developed using the ADDIE model obtained valid, effective and practical results for use in learning with Vaiken > 0.76 and valid for every aspect.

Underbakke, Borg, and Peterson (1993) linked HOTS to critical or strategic thinking, namely the capacity to use information to solve problems, negotiate problems, analyze arguments, or make predictions. McDade (1995) defines HOTS as a well-organized process of active and skilled conceptualization, application, analysis, synthesis, and/or evaluation of information produced by observation, experience, reasoning, reflection, or communication used as a rubric for beliefs and actions. Haladyna (1997) describes HOTS as understanding about facts, concepts, principles, and procedures. Petress (2005) states that HOTS involves inspection assumptions and values, evaluation evidence, and judgment conclusion. Mainaili (2012) relates HOTS to the teacher's classroom setting which includes arrangement students and teaching strategies going to learning effective. According to McDavitt (1993), HOTS consists of from analysis, synthesis, and evaluation, and requires mastery level before, like apply routine rules on known issues or problem new

Research Methodology

This research is research and development (R & D). The development model used is the Four D (4D) model proposed by Thiagarajan, Semmel, and Semmel (1974). This model generally consists of four stages, namely (i) Define, (ii) Design, (iii) Develop, and (iv) Disseminate. Each stage in this 4D model consists of several activities. Details of the development stages in the 4D model are described in chart form, as shown in Figure 1.

Population in study This divided into two, namely: (1) population for module form a number of book lesson chemistry circulating in Medan City, lecturer in the department chemistry and teachers who teach chemistry at Senior High School 21 Medan, and (2) namely high school students in class XI Science at Senior High School 21 Medan Years 2022/2023 teachings.

Deep sample study This divided into two, namely First sample for module as many as 3 books lesson chemistry, 3 already a chemistry lecturer Once teach chemistry general, and 2 chemistry teachers at Senior High School 21 Medan. Whereas sample that second that is 2 high school students in class XI Science (as class experiments and classes Control as comparison). Taking all sample done in a way *purposive*).

Type of research used in study This is study development or *Research and Development (R&D)* is oriented towards a development of HOTS-based modules on the material Acid-Base Solution with using the ADDIE (*Analysis, Design, Development, Implementation and Evaluation*) development model.

Instruments used in study This are test and non- test instruments. Test instrument used is 15 questions choice multiple for measure ability think critical student. Meanwhile, non- test instruments are used is questionnaire for appropriateness teaching materials/modules based on BSNP (National Education Standards Agency) and questionnaires response student. For non-test data analysis, feasibility validation module BSNP based is shown in table 1 below This.

Table 1. Category appropriateness module.

Percentage (%)	Describe
100 - 80	Eligible/no need for revision
79 - 60	Eligible sufficient/partial revision

59 – 30	Inadequate/partial revision
< 30	Not worth/total revision

To determine the average level of answer scores from expert validators, this research uses the following formula:

$$\text{Average} = \sum(\text{score} / \text{max score}) \times 100 \% \text{ (S riadhi, 2019).}$$

The aspects available in the module include: appropriateness of content, appropriateness of language, appropriateness of presentation and appropriateness of graphics. Analysis of response data student calculated with percentage Then converted to criteria results percentage questionnaire response student with use category table 2 as following.

Table 2. Satisfaction student to module.

Percentage	Describe
3.26-4.00	Very interesting
2.51-3.2	Interesting
1.76-2.50	Quite interesting
1.00-1.75	Less interesting
3.26-4.00	Very uninteresting

For now is ability think critical student use module HOTS based more tall rather than ability think student use book package at school so used t-Party test right with count ability think critical student use module based on HOTS developed and textbooks used in schools.

Criteria testing If $t_{\text{count}} > t_{\text{table}}$ at $\alpha = 5\%$ then H_0 rejected It means ability think critical taught students use module-based HOTS has developed more tall rather than ability think critical taught students with book normal package used.

Results & Discussion

Analysis Stage (Analysis)

Stage analysis is step initial work done in study This. The analysis stage includes needs analysis, syllabus analysis and book analysis.

1) Analysis Book

Analyzed book as in table 3 below:

Table 3. Analyzed book.

Title Book	Author	Publisher
CHEMISTRY for SMA/MA Class X (BOOK A)	Budi Utami, Agung Nugroho CS, Lina Mahardiani, Sri Yaminah, Bakti Mulyani	Book Center Department National Books
Actively Study Chemistry for SMA/MA Class X (BUKU B)	Hermawan, Paris Sutarjawanata, Heru Pratomo	Book Center Department National Books
Concept and Application of SMA/MA CHEMISTRY Class X MIPA Specialization Group (BUKU C)	Tine Maria Kuswati and Sri Rahayu Ningsih	Bailmu - Earth of Letters

Analysis carried out to third the teaching materials that is analysis from fill book, analysis of sub chapters principal discussion and analysis use the BSNP instrument for see appropriateness content, suitability language, and eligibility presentation. The data in the BSNP instrument is a list of statements and researchers give sign tick (✓) the appropriate statement with the book being analyzed. Analysis results third book as in table 4 below:

Table 4. Results of analysis of three high school chemistry books by researchers.

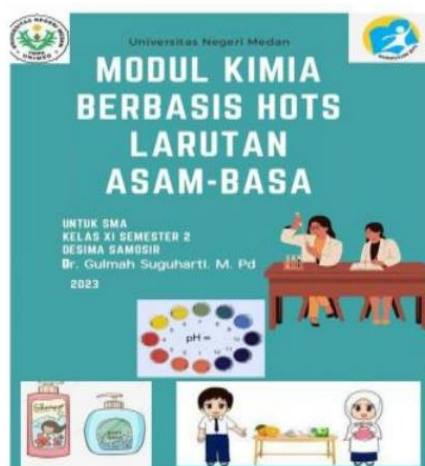
Analyzed book	Excess	Lack
CHEMISTRY for SMA/MA Class XI Specialization Author: Suwardi Munthe, Publisher: PT. Bina Pioneer Media	<ul style="list-style-type: none"> ➤ Has an introduction to the book, glossary, bibliography, summary, and evaluation questions ➤ Complete acid-base sub-subjects 	Do not have key answers and index
CHEMISTRY for SMA/MA Class XI Author: Excellent Sudarmo Publisher: Erlangga	<ul style="list-style-type: none"> ➤ Has an introduction to the book, glossary, bibliography, summary, index, and evaluation questions as well ➤ Complete acid-base sub-subjects 	Doesn't have an answer key
SMA CHEMISTRY Class XI Author: Muchtaridi Publisher: Yudhistira	<ul style="list-style-type: none"> ➤ Own glossary, bibliography, summary, index, key answers, and questions evaluation ➤ sub subject of acids and bases 	Do not have introduction book

Design Stage (Designing)

Module design involves several processes, namely:

- Design of module components, including cover, foreword, instructions for using the module, table of contents, KI and KD curriculum 2013, indicators, concept map, apperception, interior material, examples of HOTS questions, assignments, practicum, you need to know, let's study at internet, reflection, glossary, competency test, answer key, bibliography and profile.
- Material/content design, in this research the material used by researchers is acid-base material in accordance with K-13 in the sub-chapter on the concept of acids and bases, properties of acid and base solutions, determining the pH of strong acid and strong base solutions and determining the pH of solutions weak acid and weak base.
- Designing module designs such as selecting colors, selecting *backgrounds* for material/content, selecting covers that are expected to attract students' interest in learning and selecting models and forms of module writing.

Example results development cover design textbook "Chemistry module HOTS based Acid-Base Solution"

**Figure 1.** Cover of the teaching module developed.*Development Stage (Development)*

Developed module based on syllabus and from book high school package that has been analyzed previously. The order of the material is arranged in accordance with the material contained in the 2013 syllabus. Modules developed according to material experts and media experts do not need to be revised again. The

results of expert validation are two lecturers in chemistry at FMIPA Unimed and two teachers chemistry at SMA Negeri 21 Medan is as follows:

Table 5. Average validation results by lecturers and teachers.

No.	Assessment Components	Evaluator		Average
		Lecturer	Teacher	
1.	Content Eligibility	95%	92.5%	93%
2.	Feasibility of Presentation	89.2%	82.1%	85.7%
3.	Language Eligibility	100%	88%	94.4%
4.	Graphic Eligibility	83%	83%	83%
Average		91.8%	86.4%	91%

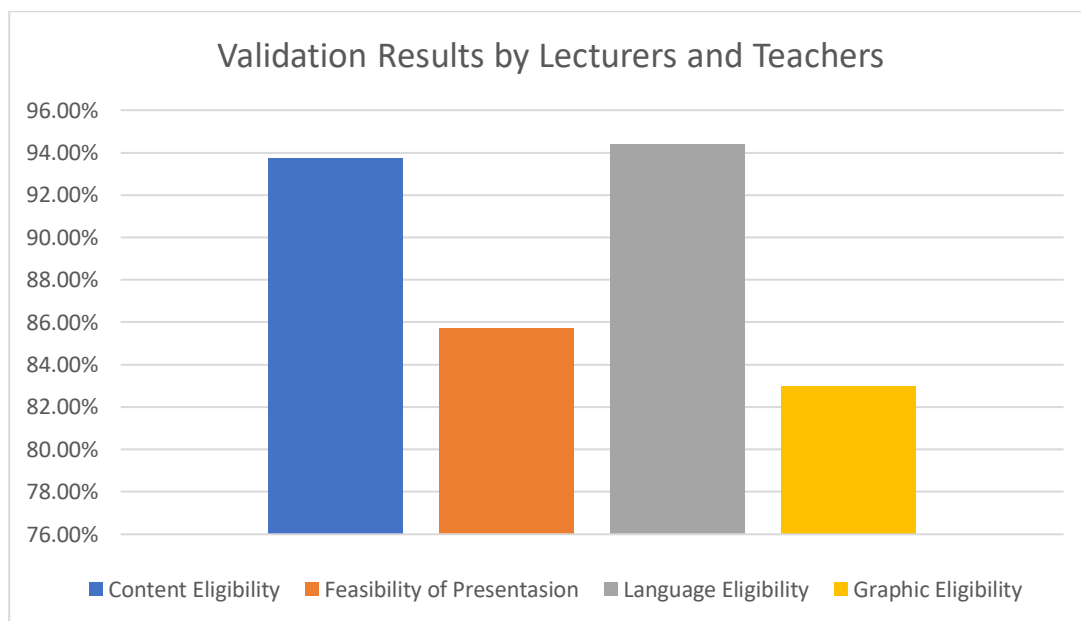


Figure 2. Module assessment by chemistry lecturers and teachers.

From picture 2 you can see seen results validation module HOTS -based developed by researchers. The assessment includes aspects of appropriateness of content, appropriateness of presentation, appropriateness of language and appropriateness of graphics. The average analysis of HOTS-based modules that have been developed is 91%, which means the module is valid and does not need to be revised, with an average description of content feasibility aspects of 93.7%; the graphic feasibility aspect is 85.7%: the language feasibility aspect is 94.4%: and the graphic feasibility aspect is 83%, it is concluded that the HOTS-based module on the subject of acid-base solutions for class XI SMA is suitable for use.

Stage (Implementation)

Module based HOTS worthy used furthermore implemented to student. In research This using two classes sample. Where is the implementation module used in class experiment that is class X Science 1 and as class comparison that is class control class X IPA 3 uses book package at school. Learning is carried out using a scientific approach in accordance with the 2013 syllabus and RPP. Before conducting the research, a pretest was first given as an initial test for students to see students' initial abilities in the acid-base solution material so that it could be seen that the initial abilities of the two sample classes were almost the same. From the results of the limited trial, the pretest average in the control class was = 37. 50 and the average pretest in the experimental class = 43, which means the initial abilities of the two samples are almost the same.

To find out whether students' critical thinking abilities using HOTS-based modules are higher than students' thinking abilities using textbooks at school, a hypothesis test was used. Hypothesis testing continued after it turned out that the data was normally distributed and *homogeneous*. The question given to

student as many as 15 items question choice multiple. During the learning process given module based on HOTS which has been developed in class experimentation and learning with book package in class control as comparison. Then at the last meeting the final text was given, namely *the posttest*. The results of the normality test and Homogeneity can be seen in the following table:

Table 6. Test the normality of critical thinking ability data.

Data source	Class	N	Average	Standard deviation	L _{table}	L _{counts largest}	Conclusion
Critical thinking skills	Experiment	30	81	5.85	0.170	0.1332	Normal
	Control	30	70.8	5.75	0.170	0.1308	Normal

Table 7. Test the homogeneity of critical thinking ability data.

Data source	Class	S ² _{count}	F _{count}	F _{table}	Information
Ability thinks critically	Experiment	30.96	1.43	1.99	Homogeneous
	Control	44.57			

Because it is known that the data is normally distributed and homogeneous, then furthermore Hypothesis testing is carried out that is with the party t test right. The test criteria is if $t_{count} > t_{table}$, then H_0 is rejected at the real level $\alpha = 0.05$. Data from hypothesis test calculations can be seen in the following table:

Table 8. Hypothesis test results (right side t test) data on critical thinking abilities.

Class	Average value posttest	Variance	Probability	t _{count}	t _{table}	Information
Experiment	81	33.15	0.05	5.74	1.6788	Ha accepted
Control	70.8	34.23	0.05			Ho rejected

Evaluation Stage (Evaluation)

The evaluation stage is the final revision stage of the module (product being developed). Improvements or evaluations carried out are based on input obtained from student response questionnaires and field notes during research. The aim of this is so that the module (product developed) is truly suitable and can be used further on acid-base materials.

Response Results Response Student

Questionnaire response student given after all learning processes teach done. Questionnaire given to the class experiment totaling 30 students who use it module HOTS- based developed. As for the average results response students on the module HOTS -based developed obtained a percentage of 85% with high response with very interesting criteria that are meaningful the modules developed are very interesting and satisfying for student.

Discussion

One of the steps included in the core steps of developing teaching materials is validation testing. Expert validation is the process of assessing the product design being developed to determine the weaknesses and advantages of the product being developed (Winarso, 2017). The validation test aims to produce teaching materials that are standard and suitable for use (gultom, 2017). Validation is an activity process to assess whether a product design, in this case the acid-base module, will rationally be more effective than the old one or not. It is said to be rational, because validation here is still an assessment based on rational thinking, not field facts. Therefore, each expert is asked to assess the product, so that its weaknesses and strengths can be identified (Sugiyono, 2017). The criteria used to evaluate the suitability of chemistry learning teaching materials are adapted to the standard criteria for evaluating teaching materials from the National Education Standards Agency (BSNP) which outlines three components, namely the content assessment component, the linguistic component and the presentation component. . Based on the validation results, the teaching materials received the "eligible" criteria with a percentage value of 91.0. This shows that the Hots-based acid-base teaching module developed can be used in the next research step.

Meanwhile, the critical thinking ability of students using HOTS-based modules is higher than the critical thinking ability of students using textbooks available at school . Students experience increased critical thinking skills after the learning process because students are directed to develop their critical thinking

skills through the use of Hots-based modules. Developing optimal critical thinking skills requires interactive classes so that students can be actively involved in the learning process (Afriansyah et al., 2020; Oktavia Wahyu Ariyani & Prasetyo, 2021; Wibowo et al., 2022). Critical thinking includes high-level thinking skills that require a lot of cognitive resources (Meilana et al., 2020; Ningsih et al., 2018). Learning using Hots-based modules allows students to obtain more cognitive load than conventional ones.

Ahmad et al. (2017) stated that Hots is an important element in education because of its benefits in improving student learning achievement, reducing weaknesses, interpreting, synthesizing, solving problems, and controlling information, ideas and daily activities. Zohar and Dori (2003) emphasize that developing HOTS is one of the important goals of educational institutions because of its influence on learning performance. It was also found that students with higher learning outcomes had higher learning performance as well. Miri et al. (2007) suggested that teachers should develop professional programs to support and encourage students in completing their tasks required by higher order thinking skills.

Heong et al. (2016), in His research suggests that HOTS is needed to determine the quality of a person's thinking in fostering a positive attitude in developing skills. Therefore, Retnawati et al. (2018) wrote that developing learning models, teacher knowledge and skills, and learning resources are necessary conditions for improving students' thinking skills. According to Fisher (1999), promote student HOTS is an integral part of indoctrination learning lifetime life. Therefore that is necessary 'thinking' learners who can Keep going continuously fulfil real world demands (Vijayaratnam, 2012). HOTS got it developed through learning active and student- centered learning (Akyol & Garrison, 2011; Limbach & Waugh, 2010) such as learning based project (Vidergor & Krupnik-Gottlieb, 2015) or through role active teacher in planning , implementing , and evaluating learning HOTS oriented (Bartell, 2012). In other words, for developing HOTS, students must involved active in activity supportive learning HOTS development (Retnawati et al., 2018). This also shows that the role of the teacher is very important in development of student HOTS.

The discussion above shows how necessary Hots-based teaching modules are to improve students' critical thinking.

Conclusions

The results of the validity of HOTS-based module teaching materials on acid-base solution material obtained an average of assessment results based on validator instruments by chemistry lecturers and chemistry teachers, namely an assessment of content suitability of 93.7%; language eligibility 85.7%; feasibility of presentation 94.4%; and graphic feasibility 83%. So an overall average rating of 91% was obtained with the criteria being suitable for use as teaching material. Meanwhile, the critical thinking ability of students using HOTS-based modules is higher than the critical thinking ability of students using textbooks at school with the average critical thinking ability score of students in the experimental class being 81 while the average critical thinking ability score of students in the control class is 70 .8. Based on student responses to the module developed, a percentage of 85% was obtained with a high response criteria of very interesting, therefore the HOTS-based module teaching materials on acid-base solution material developed can be used as an interesting and good teaching material in learning.

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