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Development of Textbooks with Higher Order Thinking Skills (HOTS) on Colligative Properties of Solutions

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Abstract: Development of Textbooks with Higher Order Thinking Skills (HOTS) on Colligative Properties of Solutions. This study aims to develop a textbook containing HOTS, especially on the colligative properties of solutions. The development model in this study adopts the 4D model (Define, Design, Development, and Disseminate). Product assessment was carried out by material experts, media experts, chemistry teachers, and student responses. The research instruments were validation sheets, product quality assessments, and student response sheets. The product is in the form of a textbook containing HOTS on colligative properties consisting of 9 sub-chapters of material and printed in B5 size. The results showed that the results of product assessment by media experts obtained an ideal percentage of 92% with an excellent category; material experts got 94% ideal percentage with the excellent category; chemistry teachers obtained an ideal percentage of 89.4% with an excellent one category. The book containing the HOTS colligative properties of this solution also received a positive response with a percentage of 98%. Therefore, the textbook is suitable for improving students' higher-order thinking**.**

Keywords: development research, Higher Order Thinking Skill (HOTS), colligative properties of solutions

Abstrak: ***Pengembangan Buku Teks Bermuatan Higher Order Thinking Skill (HOTS) pada Materi Sifat Koligatif Larutan.*** *Penelitian ini bertujuan untuk mengembangkan buku teks bermuatan HOTS pada materi sifat koligatif larutan. Model pengembangan dalam penelitian ini mengadaptasi model pengembangan 4D (Define, Design, Development, dan Disseminate). Penilaian produk dilakukan oleh ahli materi, ahli media, guru kimia, dan respon siswa. Instrumen penelitian berupa lembar validasi, penilaian kualitas produk, dan lembar respon siswa. Produk berupa buku teks bermuatan HOTS pada materi sifat koligatif larutan terdiri dari 9 sub bab materi dan dicetak dengan ukuran B5. Hasil penelitian menunjukkan bahwa penilaian produk oleh ahli media diperoleh persentase ideal sebesar 92% dengan kategori sangat baik; ahli materi mendapat persentase ideal 94% dengan kategori sangat baik; guru kimia memperoleh persentase ideal sebesar 89,4% dengan kategori sangat baik. Buku teks bermuatan HOTS pada materi sifat koligatif larutan ini juga mendapat respon positif dengan persentase 98%. Oleh karena itu, buku teks tersebut cocok untuk meningkatkan kemampuan berpikir tingkat tinggi pada siswa.*

Kata kunci: *penelitian pengembangan, Higher Order Thinking Skill (HOTS), sifat koligatif larutan*

- **INTRODUCTION**

The change in the mode of the national exam system using a paper-based test (PBT) to a computer-based test (CBT) has been implemented since 2015 (Alawiyah, 2015). The National Examination (UN) is an activity measuring the achievement of graduate competence in certain subjects nationally by referring to the Graduate Competency Standards (Permendikbud No. 4 of 2018). The chemistry UN in 2017/2018 has implemented the HOTS question type or the ability to think at a higher level with a total of 30% of the total UN questions (Rohayati, 2019). The 2017/2018 National Examination results show that the average UN score for chemistry subjects is 51.13. These results are classified in category D (deficient) (kemendikbud.go.id).

One way that can be done to improve higher-order thinking skills in students is to familiarize students with questions that require reasoning or higher-order thinking skills (Hidayati, 2017). HOTS questions are usually used as standards in various evaluations to determine students' abilities in a region or country (BSNP, 2018). Questions with the HOTS type in every evaluation held by the teacher (Hanifah, 2019). However, the types of questions given by the teacher in learning and evaluation are less varied, especially for HOTS-type questions (Khoirudin et al., 2017).

The evaluation of learning carried out by teachers currently still uses the lower order thinking skill (LOTS) question type (Ardhana, 2017). The use of questions with the HOTS type, which is rarely used during evaluations, is caused by the teacher's lack of ability to develop and use these questions (Julianingsih, 2017). The application of questions with the HOTS model needs to be balanced with increasing the ability of teachers to develop and use HOTS questions in learning (BSNP, 2018). However, teachers' understanding of HOTS questions is still relatively low (Iskandar & Senam, 2015).

The lack of available learning media causes teachers' shared understanding of HOTS questions to measure HOTS (Fajriyatun & Saliman, 2018). Learning media still often used by teachers are only limited to modules, handouts, and less varied practice questions that do not measure HOTS (Octarina, 2017). Therefore, students will find it challenging to ask HOTS questions (Rahmawati, 2016).

Books containing HOTS will make it easier for teachers to apply learning by training students to get used to HOTS questions (Asma, 2018). Chemistry is closely related to students' higher-order thinking skills (Mahfuzah, Munzil & Utomo, 2018). The help of books containing HOTS in chemistry will make it easier for students to learn chemistry and get used to HOTS-type questions (Rahayu, 2017).

Middlecamp and Kean in Erlina (2011) state that chemistry includes a broad material consisting of facts, concepts, rules, laws, principles, theories, and questions. The characteristics of chemistry are (1) abstract, (2) simplification from the truth, (3) sequential and tiered, which makes chemistry difficult for students to understand and requires high intellectual abilities. The colligative property of the solution is one of the materials classified in the problematic category (Auliyani, Hanum & Khaldun, 2017). The results of 2017/2018 senior high school National Examination at the national level in the PAMER application issued by Puspendik (2018) showed that the absorption of students in the colligative properties of solutions with reasoning questions was low with the indicator (1) analyzing the phenomena in the discourse associated with colligative properties of a specific solution of 66.62%, (2) explaining the exact reason for the difference in boiling point/freezing point in the experiment of 46.21%, and (3) calculating the constant value for increasing the molal boiling point/decreasing the molal freezing point constant. Of the two trials by 49.45%.

The development of textbooks containing HOTS in chemistry learning, especially the colligative properties of solutions, is expected to be a means for teachers to train students' higher-order thinking skills, as an alternative guide for teachers to design the complicated

HOTS learning process to be easier and more focused. Teachers are also expected to develop questions that measure higher-order thinking skills independently. The development of HOTS material textbooks on colligative properties of solutions is also expected to train students' HOTS abilities.

- **METHOD**

This type of research is research and development (R&D), which is used to produce products. The development model used is a 4D development model, consisting of four stages: define, design, develop, and disseminate. However, this research is only carried out until the development stage. This research produces a product in the form of a textbook containing HOTS on the colligative properties of solutions. The subjects in this study were one chemistry expert lecturer, one media expert lecturer, four chemistry teachers, and ten students.

The procedure for developing learning media uses a 4D development model consisting of defining, designing, developing, and disseminating. However, this research is only carried out until the development stage. The define stage is carried out by needs analysis and availability analysis. A needs analysis was conducted by conducting interviews with several senior high school chemistry teachers in Yogyakarta. Availability analysis was carried out by observing the availability of HOTS books in schools. The design stage selects software, collects reference materials, and designs the initial product design in a HOTS book. The development stage is carried out by making products and media assessment to material expert lecturers, media expert lecturers, chemistry teachers, and student responses to the product.

The data obtained in this study are media quality assessment data and student response data. Media quality assessment is carried out by material expert lecturers, media expert lecturers, and chemistry teachers. Media quality assessment data in the form of qualitative and quantitative data.

The research instruments used were validation sheets, media quality assessment sheets, and student response sheets. The validation and media quality assessment sheets were prepared using a 1-5 Likert scale. The validation sheet by media experts consists of presentation, graphics, and language aspects. The validation sheet by a material expert consists of aspects of content, language, and HOTS aspects. The media quality assessment sheet consists of presentation, content, graphics, language, and HOTS aspects. Student response sheets using the Guttman scale. Student response sheets consist of material, language, presentation, book design, and HOTS questions.

Media quality assessment by material experts, media experts, and chemistry teachers in the form of qualitative data containing score and comments on the product is used as a reference for improving the developed product. The data from the media quality assessment was analyzed by changing the qualitative data into quantitative with the following conditions as described in Table 1.

Table 1. Scoring Rules

Information	Score
Ver good	Ver good
Good	Good
Enough	Enough
Less	Less
Very less	Very less

Calculate the total score from the assessment of material experts, media experts, and chemistry teachers for all aspects of the assessment with the following formula:

$$\bar{X} = \frac{\sum x}{n}$$

with, $\bar{x}$ = average score
x = total score
n = number of evaluator

Then calculate the average score for each aspect of the assessment and all aspects and convert it into a qualitative value according to the ideal assessment criteria (Widoyoko, 2011), as described in Table 2.

Table 2. Criteria for Ideal Assessment Category

No	Score range (i) quantitative	Qualitative category
1	$x_i + 1{,}80\ SBi < \bar{x}$	Very good
2	$x_i + 0{,}60\ Sbi < \bar{x} \leq x_i + 1{,}80\ SBi$	Good
3	$x_i - 0{,}60\ Sbi < \bar{x} \leq x_i + 0{,}60\ SBi$	Enough
4	$x_i - 1{,}80\ Sbi < \bar{x} \leq x_i - 0{,}60\ SBi$	Less
5	$\bar{x} \leq x_i - 1{,}80\ Sbi$	Very less

With, $\bar{x}$ = score actual
xi = average number of ideal scores
Sbi = standard deviation of the ideal scor

Calculating the ideal percentage of the quality of HOTS high school chemistry textbooks on the material colligative properties of the solution as a whole as assessed by material experts, media experts, and reviewers with the formula:

$$\%\ \text{ideal overall} = \frac{\text{average score of all aspects}}{\text{ideal highest score of all aspect}} \text{x} 100\%$$

Student response data were analyzed by converting qualitative data into quantitative data using the Guttman scale. Furthermore, the Percentage of ideal student responses to the product developed as a whole is calculated.

$$\%\ \text{ideal} = \frac{\text{research score}}{\text{ideal max score}} \text{x} 100\%$$

▪ RESULT AND DISCUSSION

The results of this development research are textbooks containing HOTS on colligative properties of solutions. The book developed is in the form of print media adapted to the National Education Standards (Permendikbud Number 2 of 2008). The chemical material presented is colligative properties of solutions with a HOTS charge. In addition, the book contains practice questions, answer keys, and discussion of questions. This book product is equipped with concept maps and illustration pictures. The development model in this study adopts the 4D development model which has four stages, namely define, design, develop, and disseminate. The development stages used in this study are limited to the develop stage.

The result of this development research is a textbook containing HOTS on the colligative properties of solutions. The book developed is in print media adapted to the National Education Standards (Permendikbud No. 2 of 2008). The chemical material presented is the colligative properties of solutions with a HOTS charge. In addition, the book contains practice questions, answer keys, and a discussion of questions. This book product is equipped with a concept map

and illustration images. This product development adapts the 4D development model, which has four stages: define, design, develop, and disseminate. The development stages used in this study are limited to the development stage.

The define stage is done by analyzing the needs and analyzing the availability. A needs analysis was conducted by interviewing several chemistry teachers at SMA N in Yogyakarta. The interview results show that teachers still have difficulty teaching materials that require HOTS. The learning materials taught tend to be LOTS. There are no questions with HOTS content in textbooks from the government. Availability analysis was carried out by observing the availability of HOTS books at SMA N 8 Yogyakarta, SMA N 1 Wates, and SMA N 1 Galur. The results of these observations and interviews indicate that there are no textbooks with HOTS content, especially on the colligative properties of solutions. Curriculum analysis is also carried out to determine the competencies developed in the HOTS book.

The design stage selects software, collects reference materials, and designs the initial product design in a HOTS book. The software selection is based on observations in the field regarding existing books. The software used is Microsoft Word 2013, Corel Draw X7, and Mathtype. Reference material collected is based on the results of curriculum analysis from various valid sources. The materials collected include the unit concentration of solutions, colligative properties of solutions, application of colligative properties of solutions, and questions. The initial product designs that were made were the cover, the book's layout, and the book's contents.

The development stage is carried out by developing products using Microsoft Word 2013 applications, Corel Draw X7, and Mathtype and product validation by material experts, media experts, and chemistry teachers. The cover and layout of the book were made using the Corel Draw X7 program. The book's contents are designed in Microsoft Word and adapted to the layout that has been made. The Mathtype application uses formula writing. The final product of the textbook containing HOTS material on colligative properties of the solution developed consists of a cover page, beginning, content, and closing.

The initial part includes the introduction, table of contents, core and essential competencies, Olympic syllabus, HOTS, and the benefits of books. The textbook contains HOTS material on colligative properties of solutions containing concept maps, material descriptions, and practice questions. The display of the concept map in the colligative properties of HOTS-charged solution textbooks can be seen in Figure 1.

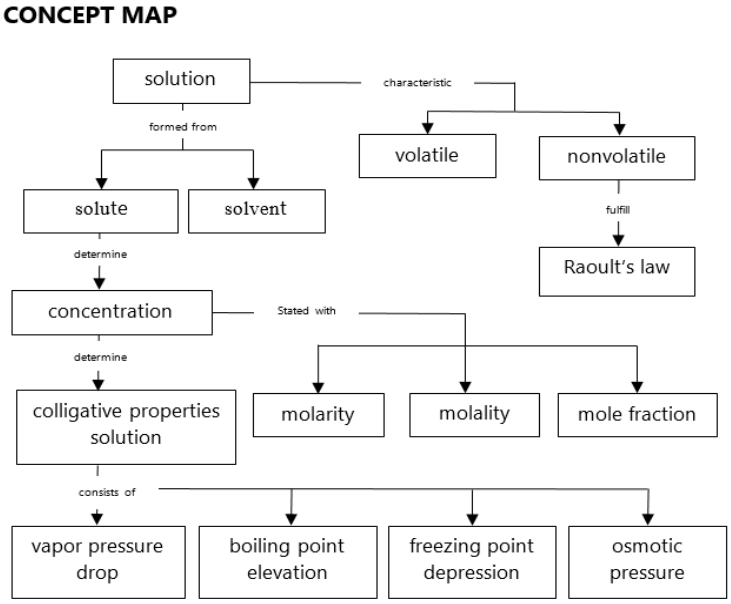


Figure 1. Concept map

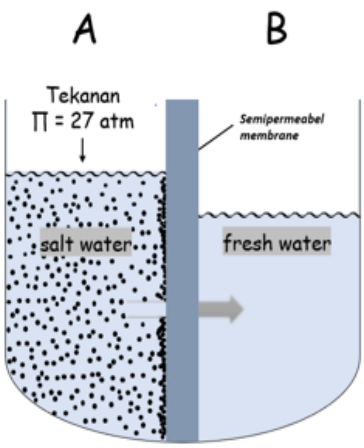
A concept map is a schematic chart representing a meaningful relationship between one concept. Concept maps make it easier for students to learn colligative solutions and the relationship between one concept and another. The appearance of the description of the material in the colligative properties of the solution textbook can be seen in Figure 2.

Ice cream tastes soft because various ingredients used such as sugar, milk, butter, chocolate, and salt will lower the freezing point. Even though the ice cream is cold, it still feels soft and doesn't freeze.

Figure 2. Utilization of the freezing point of the solution

Presentation of the material description of the colligative properties of the solution is associated with the use of the material in everyday life. This follows one of HOTS characteristics; namely, the material is contextual. The material presented is contextual, meaning that the presentation is associated with real-world situations experienced by students so that students can relate the relationship between the material and situations experienced daily to improve higher-order thinking skills. The display of the practice questions is presented in the form of HOTS questions which can be seen in Figure 3.

The clean water crisis is a severe problem faced by many developing countries, including Indonesia. As many as 58.6 percent of residents need proper access to clean water, especially residents in coastal areas. Even though the ocean is a source of water that never runs out and has the potential to be used as clean water, however, seawater has a very high salt content, so if consumed, it can cause dehydration in the body. Seawater contains salts such as sodium chloride (NaCl), which reaches 3.5%. Seawater can be processed into clean water through a technique commonly called desalination, which removes excess salt content in water. The seawater desalination method commonly used is filtering using a reverse osmosis (RO) filter membrane. The working principle of this method is that by applying pressure to the surface of seawater that is greater than its osmotic pressure, water will seep from saltwater (sea) into pure water through a semi-permeable membrane, as shown in the following figure:



If in a desalination process, the volume of seawater treated is 1000 liters (density of seawater = 1.026 g/mL) at 27°C, then what will happen is...

A. no water movement occurs
B. Water moves from tube A to tube B
C. in tube B, purified water is obtained as a result of processing
D. The surface of tube A increases while the surface of tube B decreases
E. The surface of tube B increases while the surface of tube A remains the same

Figure 3. HOTS Problem Colligative Properties of Solutions

The question is a type of HOTS question that includes (1) contextual problem-based or related to students' real-world situations, namely the process of processing seawater into freshwater that exists in students' daily lives, (2) stimulus; the question contains a stimulus in the form of pictures and story scripts, (3) measuring high-level abilities in the form of C4 questions (analyzing), students are asked to analyze the events of the desalination process of seawater into fresh water and then draw conclusions based on the results of the analysis.

The closing section of the textbook containing HOTS consists of a summary of the material, a glossary, a bibliography, and the author. The product developed in a textbook containing HOTS material on colligative properties of solutions was validated by one material expert lecturer, one media expert lecturer, and four chemistry teachers. Media assessment is also carried out with student responses. The results of media validation by material experts can be seen in Table 2.

Table 2. Data Validation by Material Experts

No.	Assessment Aspect	∑ Score	∑ Ideal Max Score	Average	Ideal Percentage (%)	Category
1.	Contents	19	20	19	95	Very Good
2.	Language	18	20	18	90	Very Good
3.	Higher Order Thinking Skill (HOTS)	10	10	10	100	Very Good
	Total	47	50	47	94	Very Good

Based on Table 2, the results of the validation by material experts on the content aspect obtained a percentage of 95% with a score of 19; the language aspect obtained a percentage of 90% with a score of 18; Aspects of HOTS obtained a percentage of 100% with a score of 10. The results of validation by material experts as a whole obtained an ideal percentage of 94% with an average score of 47 and included in the Very Good category. The results of product validation by media experts can be seen in Table 3.

Table 3. Data Validation by Media Experts

No.	Assessment Aspect	∑ Score	∑ Ideal Max Score	Average	Ideal Percentage (%)	Category
1.	esentation	14	15	14	93,3	Very Good
2.	aphics	14	15	14	93,3	Very Good
	Total	28	30	28	93,3	Very Good

Based on Table 3, the results of validation by media experts on the presentation aspect obtained a percentage of 93.3% with a score of 14, and the graphic aspect obtained a percentage of 93.3% with a score of 14. The validation results by media experts obtained an ideal percentage of 93.3% with an average score of 28 and included in the Very Good category.

The assessment of the quality of the media in the form of a textbook containing HOTS material on the colligative properties of solutions was assessed by four chemistry teachers. The results of the media quality assessment by chemistry teachers are presented in Table 4.

Table 4. Data on the results of media quality assessment by chemistry teachers

No.	ssessment Aspect	∑ Score	∑ Ideal Max Score	Average	leal Percentage (%)	Category
	ɔntents	69	20	17,25	86,25	Very Good
	ınguage	75	20	18,75	93,75	Very Good
	esentation	54	15	13,5	90,00	Very Good
	:aphics	56	15	14	93,30	Very Good
	gher Order Thinking Skill (HOTS)	36	10	9	90,00	Very Good
	Total	286	80	71,5	89,40	Very Good

Based on the results of the assessment of product quality by four senior high school chemistry teachers, the Percentage of content obtained is 86.25% with a score of 17.25; the language aspect obtained a percentage of 93.75% with a score of 18.75; the presentation aspect obtained a percentage of 90% with a score of 13.5; the graphical aspect obtained a percentage of 93.3% with a score of 14; Aspects of HOTS obtained a percentage of 90% with a score of 9. The overall media quality assessment results obtained an ideal percentage of 89.4% with an average score of 71.5 and included in the Very Good (SB) category. Ten students of class XII MIPA responded to the textbook containing HOTS. Student response data can be seen in Table 5.

Table 5. Student response data to the media

Aspect	Number of Indicators	Average Score	Ideal Maximum Score	Ideal Percentage
Contents	2	2	2	100%
Language	2	2	2	100%
Presentation	2	2	2	100%
Graphics	2	2	2	100%
Soal *higher order thinking skill* (HOTS)	2	1,8	2	90%
Total	10	9,8	10	98%

Based on table 5, the results of student responses to learning media in the form of an Android-based CBT application show that aspects of material, language, presentation, book design, and HOTS questions have ideal percentages of 100%, 100%, 100%, 100%, and 90%. The overall ideal Percentage is 98%, meaning that the media developed is very good according to the responses of senior high school students and textbooks containing HOTS material on colligative properties of solutions presenting questions that train thinking skills

- **CONCLUSION**

The product developed in this research is a textbook containing HOTS material on colligative properties of solutions which contains material on colligative properties of solutions in more depth, equipped with HOTS exercises and discussion of each question which is expected to be able to train students. Higher-order thinking skills of students. The validation of textbooks containing HOTS from media expert lecturers obtained 46 out of a maximum score of 50 with an ideal percentage of 92% in the Very Good category. The assessment results from material expert lecturers obtained 47 out of a maximum score of 50 with an ideal percentage of 94% and included in the Very Good category. The results of the product quality assessment of four senior high school chemistry educators obtained an average score of 71.50 from a

maximum score of 80 with an ideal percentage of 89.4% and included in the Very Good category. The results of student responses to textbooks containing HOTS received a positive response, and an average score of 9.8 was obtained with an ideal maximum score of 10 so that the ideal percentage was 98%. This shows that according to students the hots book is very helpful in dealing with the chemistry olympiad which has the character of hots questions.

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