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# Development of General Chemistry Teaching Materials in Integrated Network Based on High Order Thinking Skills

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**Abstract.** The big challenge in the education process in the 21<sup>st</sup> century is not only preparing the nation's generation that is able to live today, but also a generation equipped with the ability to live in the future that requires problem solving with a critical and creative mindset and has high order thinking skills (HOTS). This research belongs to the type of research and development (R&D) which aims to produce products in the form of online teaching materials integrated with HOTS-based media in the General Chemistry Course for Organic Chemistry. Teaching materials are developed in an integrated manner with HOTS-based media using the application Adobe Flash CS6 and Articulate Storyline which can train students to think critically, creatively, analytically towards information and data to solve problems and can be accessed by students online so they can be learned and understood by students by repeating-rework existing concepts or materials anytime and anywhere. The teaching materials in the HOTS-based integrated media network developed have been declared valid and proven effective in increasing student HOTS.

## INTRODUCTION

The quality of an education always refers to the results or academic achievements achieved by students, where good quality education is the goal of education itself. However, in reality, the results of the international PISA study show that the achievement of reading literacy, mathematical literacy, and scientific literacy achieved by Indonesian students is very low and can only occupy the 10 bottom of 65 countries. Of course there are many factors that cause the low results of the PISA study and one of the contributing factors is because students in Indonesia are not trained in solving contextual problems, demanding reasoning, argumentation and creativity in solving them, where these questions are characteristic of the questions. TIMS [1].

The big challenge for the ideal education process is not only to prepare the nation's generation that is able to live today, but the generation that is equipped with the ability to live in the future. Challenges in the global era are increasingly complex and require problem solving with a critical mindset and full of creativity [2]. Most of the problems faced by higher education institutions are how to transfer knowledge and how to develop and ensure professional and up-to-date practical skills [3].

Principles 21<sup>st</sup> century learning uses a learner-centered learning approach where teachers and lecturers act as facilitators. During the learning process teachers and lecturers must be able to design strategies, models and appropriate learning media to create an atmosphere that encourages and motivates students to actively participate in learning activities [4].

In addition to the use of strategies or learning models by teachers/lecturers, other factors what also determines the success of students in learning is the teaching materials used by students as learning resources. Supporting the

implementation of an effective learning process cannot be separated from the use of teaching materials. Improving the quality of the learning process in higher education can be done with various strategies and one alternative that can be taken is the development of teaching materials. The development of teaching materials is carried out by a lecturer to solve learning problems by paying attention to the targets or students and also adjusting to the competencies that must be achieved [5]. Teaching materials that can be used by students as independent learning resources have an important role in improving and developing higher-order thinking skills. Teaching materials can be packaged in printed and non-printed forms [6].

An educator, including lecturers, is also required to be able to design teaching materials that are oriented towards active student involvement and can stimulate students to be able to think at a higher level. This is also in accordance with the concept of 21<sup>st</sup> century education, namely century skills, scientific approach, authentic learning, and authentic assessment. One of the 21<sup>st</sup> century skills is learning and innovation skill, namely being able to think creatively, work creatively, and create new innovations. When students are directed to be able to think critically and creatively, it means that students are targeted to have higher order thinking skills (HOTS). The development of appropriate teaching materials and in accordance with student learning needs is the best effort to improve student academic achievement and grow student HOTS. To produce tools or teaching materials of good quality, teaching materials must be carefully prepared and planned to produce a good learning activity. In addition to the use of teaching materials as learning resources for students, another factor that also needs to be considered by a lecturer is the use of innovative and constructive learning media in reconstructing students' knowledge, abilities and creativity.

In the 21<sup>st</sup> century or known as the era of the industrial revolution 4.0, various human resources in all fields are required to have digital skills, especially in the field of education. Various kinds of technology should have been able to be applied in learning activities in the classroom. Utilization of processes and products of communication and information technology to solve educational problems has many benefits or advantages. By taking into account the advantages of learning technology, appropriate and optimal utilization strategies can be drawn up to improve the quality, efficiency and effectiveness of education and learning at various levels of education units [7].

Technological developments trigger the rapid development of e-learning , various kinds of software or programs that has been provided for learning media that can be accessed at any time and any place. The development of e-learning triggers the creation of interactive learning media [8]. The use of computer media (multimedia) can be an alternative because it can integrate molecular animation and video demonstrations [9]. An educator, both teachers and lecturers, needs to plan innovative and creative strategies, teaching materials and learning media by utilizing technology-based learning. One of the media that can be applied in the learning process is media Adobe Flash and Articulate Storyline (online based).

Adobe Flash CS6 is a program that is able to process text and objects with three-dimensional effects so that the results are more attractive [10], and is an animation program that supports programming with Action Script and is appropriate for use in developing interactive learning media [8]. Adobe Flash CS6 has all multimedia elements so that it can be used optimally to improve the learning process and student achievement [10]. This application, Adobe Flash CS6 is a medium that contains elements of motion, images, and sound. For example in the form of presentation media, interactive media [11]. The use of interactive learning media with Adobe Flash CS6 can be used as an alternative learning media and is able to make learning more varied, attract students' interest in learning, and get a positive response from students [8], and it is expected that students could [12]. The advantages of Adobe Flash CS6 software are that it has many features so that it is able to connect images, sounds and animations simultaneously, has high-extension features so that media can be stored in a mobile phone to make it more practical, it is software good to use to support interactive learning, because interactive learning media with applications Adobe Flash CS6 can combine graphics, animation, sound, and have the ability to interact with users [13].

Articulate Storyline Software is a software that functions as a medium of communication and presentation. Media Articulate Storyline can also be developed into a medium of learning to cope with the difficulties students in learning [14], can be developed to attract the attention of students [15], motivating and stimulating students to learn, provides an integral or comprehensive from the concrete to the abstract [16]. Learning media using software Articulate Storyline is no less interesting than other interactive media [17]. Articulate Storyline is a sophisticated software that can build interactive e-learning modules and their appearance similar to Powerpoint but offers more facilities [18]. Program Story Line Articulate supports features like flash in the making of animation but it has interface a simple such as PowerPoint. The complete Articulate Storyline features like flash and the interface as easy as Power Point makes Articulate Storyline can be used as interactive multimedia. In addition, this program has a characteristic that there are menus such as the button zoom to enlarge the image, the question button to see a deeper explanation of the material, as well as navigation buttons in the form of next, back and submit which are always at the bottom of the screen and are automatically available in the program media [19].

The online teaching materials in this study were developed and designed to be integrated with HOTS-based media, meaning that the developed teaching materials are integrated, coordinated, or connected in a whole and round manner with HOTS-based media and can be accessed and downloaded by students online. The integration of teaching materials with HOTS-based media aims to make it easier for students to learn and understand the concepts or materials contained in teaching materials in a theoretical manner and fully integrated with HOTS-based media so that they can really help and make it easier for students to observe, understand and master the material. available and can train students' higher order thinking skills (HOTS).

## **METHOD**

This research belongs to the type of research and development (R&D), is a process used to develop and validate research products, test the effectiveness of the products developed and can be accounted for. This research and development is carried out with the aim of producing products in the form of online teaching materials or digital books integrated with HOTS-based media that are valid (appropriate) and effective in increasing the HOTS of students in the General Chemistry Course for Organic Chemistry. The model used refers to the ADDIE development model (Analysis, Design, Development, Implementation and Evaluation). The subjects and participants involved in this study were lecturers or validators of material experts and media experts and 30 students of the Chemistry Education Study Program, Universitas Negeri Medan. The object of this research and development is teaching materials in the network (online) integrated media (Adobe Flash and Articulate Story Line) based on HOTS in the General Chemistry Course for Organic Chemistry.

The techniques and instruments used in this research and development include: interviews, validation sheets and test instruments. Interviews are used for data collection when conducting research as a preliminary study material to look for field problems to be researched and used in product validation to expert validators (material experts and media experts) as considerations in improving and revising teaching materials and HOTS-based media developed. The validation sheet is used to obtain data about the validation results by expert validators (material experts and media experts) about the developed HOTS-based integrated media teaching materials, the measurement scale used on the validation sheet uses a Liker scale (scale 5), and the results of the expert validator's assessment will tested for feasibility or validity. The test instrument was used to obtain data on students' higher order thinking skills (HOTS). The test is structured and developed on the knowledge (cognitive) aspect according to the HOTS indicators on Organic Chemistry material including: C4, C5 and C6 as many as 20 questions in the form of multiple choice.

The research data were analyzed in stages to determine the feasibility (validity) and effectiveness of teaching materials in the HOTS-based integrated media network developed. Feasibility is analyzed based on the validation result sheet by the expert validator and considers input, comments, and suggestions from the validator. The data from the expert validators were analyzed and used as a guide for revising the developed HOTS-based teaching materials and media. Meanwhile, the effectiveness of integrated online teaching materials based on HOTS-based media is obtained from the achievement of students' HOTS test results. The effectiveness was analyzed from the increase in student HOTS using a pretest-posttest design using a single sample group or approach t-test paired sample t-test using the SPSS program. Before testing the hypothesis (product effectiveness), the data normality test was conducted using the Kolmogorov-Smirnov test technique.

## **RESULTS AND DISCUSSION**

The products developed are: (1) teaching materials online and (2) HOTS-based media in Organic Chemistry General Chemistry courses. Product development is carried out in accordance with the results of the analysis and preliminary studies related to students' higher-order thinking skills, student needs and characteristics, characteristics of the General Chemistry subject for Organic Chemistry, as well as literature review related to teaching materials, media, HOTS learning and software. Adobe Flash and Articulate Storyline. Based on the results of the analysis of the preliminary study, the product was developed by making an initial design or design in the form of teaching materials in an integrated network (online) based on HOTS-based media in the General Chemistry Course for Organic Chemistry. The next stage is development to realize the design into a product that is ready to be implemented. The development stage is carried out by evaluating or assessing expert validators to assess the feasibility of the product being developed. The validity (feasibility) of online teaching materials and HOTS-based media developed are validated by practitioners or validators of material experts and media experts (lecturers).

**TABLE 1.** Validation Results of Online Teaching Materials

Aspect Assessment	Validator (Mean Score)			Total Mean	Criteria
	I	II	III		
Content Feasibility	4.25	4.42	4.17	4.28	Valid
Presentation Feasibility	4.10	4.30	4.20	4.20	Valid
Language Feasibility	4.00	4.44	4.22	4.22	Valid
Graphic Feasibility	4.00	4.27	4.27	4.18	Valid
Mean Total Validation Results				4.22	Valid

Table 1, shows the results of the assessment of 3 expert validators on teaching materials in the Organic Chemistry material network and obtained an average total score of 4.22 or declared valid, so that overall the results of the assessment by expert validators concluded that the teaching materials in the developed network had classified as valid and feasible to be applied in learning Organic Chemistry.

**TABLE 2.** Results of HOTS-Based Media Validation on Material

Aspect Assessment	Validator (Mean Score)			Total Mean	Criteria
	I	II	III		
Coverage and Depth of Material	4.11	4.33	4.33	4.26	Valid
Presentation Accuracy (Systematic)	3.67	3.89	4.22	3.93	Valid
Animation Suitability and Clarity	3.56	4.11	4.22	3.96	Valid
Clarity of Formulas/Symbols	4.00	4.00	4.22	4.07	Valid
Accuracy of Sample Questions in Each Activity	4.00	4.00	4.67	4.22	Valid
Accuracy of Questions Answers in Each Activity	4.00	4.00	4.00	4.00	Valid
HOTS Assessment	4.40	4.00	4.80	4.40	Valid
Mean Total Validation Results				4.12	Valid

Table 2, shows the results of the assessment of 3 material expert validators on the HOTS-based media for Organic Chemistry that was developed, and obtained an average total score of 4.12 or declared valid so that the overall results of the assessment of the material expert validators concluded that the developed HOTS-based media classified as valid or feasible to be applied in learning Organic Chemistry.

**TABLE 3.** Results of HOTS-Based Media Validation on Media Aspect

Aspects of Assessment	Validator (Mean Score)			Total Mean	Criteria
	I	II	III		
Software Engineering	4.20	3.70	4.30	4.07	Valid
Interface Display	4.00	4.22	4.22	4.15	Valid
Visual Communication	4.13	4.00	4.00	4.04	Valid
Mean Total Results Validation				4.09	Valid

Table 3, shows the results of the assessment of 3 media expert validators on the HOTS-based media for Organic Chemistry developed, and obtained an average total score of 4.09 or declared valid so that the overall results of the assessment of the media expert validators concluded that the HOTS-based media developed classified as valid or feasible to be applied in learning Organic Chemistry.

The results of the assessment (evaluation) of the expert validators as a whole show that the online teaching materials and HOTS-based media developed have been declared valid (appropriate) to be applied in Organic Chemistry learning both based on material aspects and media aspects. The next stage is the implementation or application of the products produced in online and integrated (integrated) Organic Chemistry learning/lectures to 30 students and an evaluation is carried out to analyze student HOTS learning outcomes and analyze the effectiveness of the products produced.

**TABLE 4.** Student HOTS Learning Outcomes

	N	Min	Max	Mean	Std. Deviation	Kolmogorov-Smirnov Test	
						Statistic	Sig
Pretest	30	48	68	59.87	5.606	0.143	0.060
Posttest	30	72	96	87.20	6.509	0.149	0.070

Table 4 shows the students' initial HOTS learning outcomes (pretest) before being given the action, the average score was  $59.87 \pm 5.606$  and the data had a normal distribution with the Kolmogorov-Smirnov test score of 0.143 ( $p = 0.060$ ). After the action of implementing learning using online teaching materials integrated with HOTS-based media from the posttest results obtained an average student HOTS score of  $87.20 \pm 6.509$  and the data has a normal distribution with the Kolmogorov-Smirnov test value of 0.149 ( $p = 0.070$ ).

The effectiveness of the application of HOTS-based integrated online teaching materials in Organic Chemistry learning was analyzed based on the HOTS learning outcomes obtained by students using a pretest-posttest design and analyzed using a t-test or approach paired sample t-test using the SPSS program.

**TABLE 5.** Product Effectiveness Test Results (t-test)

		Paired Differences		t	df	Sig. (2-tailed)
		Mean	Std. Deviation			
Pair 1	Posttest - Pretest	28.000	9.523	16.104	29	0.000

Table 5 shows the results of the t-test with the approach paired sample t-test, the average difference or difference in student HOTS learning outcomes (posttest-pretest) is  $28.00 \pm 9.523$  and the t-count value is 16.104 and the Sig or probability ( $p$ ) is 0.000. Thus, it is concluded that the application of integrated online teaching materials based on HOTS media has proven to be effective in increasing student HOTS in organic chemistry learning.

The results of the research and development that have been carried out have resulted in the final product in the form of online teaching materials integrated with HOTS-based media in the General Chemistry Course for Organic Chemistry. Teaching materials are an important part of the learning process because their presence is needed to overcome problems that occur in learning and are able to support learning activities both for classical learning and independent learning. In this study, teaching materials were developed online so that they can be accessed and used by students using laptops, computers or androids. Teaching materials are also developed integrated with HOTS-based media using the application Adobe Flash CS6 and Articulate Storyline with the aim of making it easier for students to learn and understand the concepts or materials contained in teaching materials in a theoretical manner and fully integrated with HOTS-based media so that can really help and facilitate students in observing, understanding and mastering the existing material and can train students' higher order thinking skills (HOTS). Online teaching materials that are integrated with HOTS-based media are also prepared by containing the concepts or materials of Organic Chemistry and are systematically designed according to indicators and learning outcomes of the General Chemistry subject (CPMK) of Organic Chemistry. The initial design of HOTS-based integrated online teaching materials that have been developed is then validated by expert validators to realize the design into a product that is ready to be implemented in online learning.

The results of the research findings that have been carried out show that the teaching materials in the network (online) integrated with HOTS-based media in the General Chemistry Course, the resulting Organic Chemistry material has been declared valid (feasible) to be implemented in learning and proven effective in measuring and improving students' HOTS abilities. The research findings have implications for lecturers and practitioners that improving students' HOTS abilities can be done by developing innovative teaching materials that are integrated with HOTS-based media that can be accessed and downloaded by students online as teaching materials or independent learning resources for students. Through teaching materials in the resulting HOTS-based media integrated network, it is hoped that it can help lecturers in delivering concepts and materials remotely online and be able to improve the quality of learning, can help improve students' understanding, mastery and HOTS abilities because through online teaching materials integrated media-based HOTS students are trained to think critically, creatively, analytically to information and data in solving problems. Therefore, as competent and professional lecturers, it is expected that lecturers can design, develop and utilize innovative teaching materials that are integrated with HOTS-based media that are able to create an interactive learning and lecture atmosphere and can help students to study independently at any time. and anywhere, training students to be more critical, creative and have higher order thinking skills (HOTS) without having to reduce the essence of the lecture material delivered.



## CONCLUSION

This research and development produces teaching materials in an integrated network (online) HOTS-based media on Organic Chemistry materials through the ADDIE development model. Teaching materials are developed and designed in an integrated manner with HOTS-based media using the application Adobe Flash CS6 and Articulate Storyline which can train students to think critically, creatively, analytically towards information and data to solve problems that exist in the teaching materials and media developed. The resulting HOTS-based integrated media teaching materials can also be accessed by students online so that students can learn and understand by repeating existing concepts or materials anytime and anywhere. The teaching materials in the HOTS-based integrated media network developed have been declared valid and proven effective in improving students' HOTS abilities.

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