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Development of Puzzles for Chemical Laboratory Glassware Integrated with Islam as A Learning Medium

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ABSTRACT
The current research seeks to develop and assess the feasibility of puzzles for chemical laboratory glassware integrated with Islam as a learning medium. Conducted through research and development (R&D) method with a 4D model (Define, Design, Develop, and Disseminate), the present project was limited to the Develop stage. The chosen product was a puzzle of chemical laboratory equipment integrated with Islam as a learning medium. The puzzle was applied to 41 students of the chemistry education study program of UIN Sunan Kalijaga who joined laboratory management course. The assessment of the puzzle performance includes ten aspects with 32 indicators. The data obtained was in the form of qualitative and was subsequently tabulated and analyzed using the criteria for the ideal assessment category to determine the quality of the puzzle media. The developed media has a very-good quality according to the assessment among 41 students. The media obtained a score of 142.63 out of a maximum score of 160 and an ideal percentage of 89.15%. The findings disclosed that the developed media is suitable for use as a supporting learning resource for students to understand chemical glassware.

Keywords: *puzzle learning media; laboratory tools; integration of science and Islam*

INTRODUCTION

Practical activities in the laboratory are an integral part of science learning activities in formal education (Bretz, 2019). It is constructive for students to test their ability to understand the scientific theory they have acquired (Ural, 2016). In addition to increasing understanding, practicum in the laboratory can also increase students' interest in science (Adane & Abeje, 2012). Therefore, this activity has become an essential aspect of the science curriculum (Högström, Ottander, & Benckert, 2010; Walters, Lawrence, & Jalsa, 2017).

However, laboratory activities are not easy to implement due to the limited laboratory facilities available in schools (White, 1996). The high cost of laboratory equipment, especially chemical equipment and laboratory equipment, is an obstacle to implementing science learning activities in schools (White, 1996). Such formulated limitation should not become a barrier for students to achieve knowledge related to science laboratories. Alternative learning resources can be a solution for the learning process in the laboratory (Januszewski, 2001).

Learning media can be used as an alternative learning resource in chemistry learning in the laboratory. Besides increasing students' knowledge, learning media can help improve students' memory related to learning materials (Arsyad, 2002). In addition, the use of media can make learning clearer, engaging, interactive, efficient, and save energy (Rahadi, 2004). Some research has been done to overcome this problem. Android-based learning media is currently widely used as an alternative laboratory function (Inayah, 2021; Irwansyah, Yusuf, Farida, & Ramdhani, 2018). However, this media demands the availability of mobile phones and the internet. It makes Android-based media useless in some Indonesian areas with labor connection (Rahayu, 2019). The puzzle is an alternative media that can be used to overcome such obvious issue.

The puzzle is a medium that can be discovered easily in everyday life, and this media is closely related to the lives of children (Muslikhah & Rahmasari, 2016). This media involves visual and psychomotor aspects that can assist improve students' understanding and memory. Puzzle media is also a medium that students can use independently (Arsyad, 2002; Sanjaya, 2006; Zamhari & Setiawati, 2017). Puzzles can also be used by students who will work in a chemistry laboratory. Initial knowledge related to the experiments to be carried out, including the equipment to be used, will be very helpful for students when working in the laboratory (Marcella, Susanti, & Dani, 2018; Teo, Tan, Yan, Teo, & Yeo, 2014).

Integrating science and religion is an important matter (Abdullah, 2003). Learning science that is integrated with religion does not only improve the cognitive side but also improve one's affective system and religiosity (Wardhana, 2005). Scientific knowledge integrated with religion will help a person to know him/herself both physically and psychologically (Yaacob, 2013). A person who knows him/herself will know the power of his Lord (Yaacob, 2013). This side is absent in the development of science, thus the increase in knowledge increases natural damage and moral degradation (Wardhana, 2004). The integration of Islam in science can be applied to learning media.

This research seeks to develop and assess the feasibility of puzzles for chemical laboratory glassware integrated with Islam as an alternative learning medium. Such formulated learning media will be an alternative to the problem of limited and expensive chemical laboratory equipment in schools and the lack of learning media integrated with Islam. And thus, students are still able to gain knowledge about the laboratory independently. Furthermore, puzzle media integrated with Islam will assist develop the affective learning and religiosity of students. It also strengthens the role of Islamic Universities as active parties in integrating science and religion.

METHODOLOGY

Conducted through research and development (R&D) method, R&D in education is applied to developing and validating educational products (Sugiyono, 2010). Such formulated development research uses a descriptive procedural development model that describes the flow of procedural steps that shall be followed to produce a specific product (Setyosari, 2010). Adopted The Four-Door (4D), 4D models are divided into 4 steps such as: Define, Design, Develop and Disseminate. However, this research was limited to the development stage. The product developed in this research was puzzle chemical laboratory glassware integrated with Islam. The stages were described as follows,

a. Define stage. This stage was carried out with a needs analysis where it was carried out to ensure that the product developed was in accordance with the needs.
b. Design stage. This stage seeks to design a product with media selection, initiate the media design, and determine the assessment instrument. The instrument consisted of ten aspects:

display quality, concept accuracy, applicability, language, image and text quality, integration of science and Islam, comprehensive performance, cognitive aspects of the game, affective aspects of the game, and psychomotor aspects of the game.

c. Develop Stage. The process of developing puzzles was carried out in the development stage and then applying the product to 41 students. The media was tested during a laboratory management course in the chemistry education study program, faculty of education and teacher training, Universitas Islam Negeri (UIN) Sunan Kalijaga, consisting of 41 students. This media also assessed its product feasibility and application. This stage was applied to obtain feedback on the product implementation and check the feasibility of the product.

The instrument consisted of five categories, and the results were converted into scores (

Table **1**), and then the average score was converted back into the media eligibility category (

Table *2*). The data were analyzed by calculating the average score with the formula,

$$\overline{X} = \frac{\sum X}{N} \quad (1)$$

with $\overline{X}$ as an average score, ΣX as a total score, and N as the number of the assessor.

Table 1. Conversion guideline from category into score

Category	Score
Very-good	5
Good	4
Fair	3
Poor	2
Very Poor	1

Table 2. Average score conversion guideline

Formula	Category
$\overline{X} > (M_i + 1.5\ SB_i)$	Very-good
$(M_i + 0.5\ SB_i) < \overline{X} \leq (M_i + 1.5\ SB_i)$	Good
$(M_i - 0.5\ SB_i) < \overline{X} \leq (M_i + 0.5\ SB_i)$	Fair
$(M_i - 1.5\ SB_i) < \overline{X} \leq (M_i - 0.5\ SB_i)$	Poor
$\overline{X} \leq (M_i - 1.5\ SB_i)$	Very Poor

with $\overline{X}_i$ as ideal average score,

$\overline{X}_i = {}^1/_2$ (ideal max score + ideal minimum score)

SBi as the ideal standard deviation, which SBi = ${}^1/_6$ (ideal max score - ideal minimum score)

RESULT AND DISCUSSION

Define stage

The define stage was executed by needs analysis. A needs analysis was conducted to determine the need for learning media for students in carrying out practical activities in the chemistry laboratory. A literature review investigated this process. Several studies have shown that initial knowledge of chemical laboratory tools is vital for the smooth implementation of practicum

or research in chemistry (Amin, 2020). The chemical laboratory has the potential for accidents because it has chemicals and glassware that can harm the people who work in it. It is crucial to figure out the use of glassware in a chemistry laboratory to prevent potential hazards (Rahmantiyoko, Sunarmi, Kurnia Rahmah, Sopet, & Slamet, 2019). Initial knowledge related to equipment in the laboratory can minimize the occurrence of common accidents in the laboratory (Andriani, 2016).

Previous studies related to the introduction of chemical laboratory equipment have been carried out (Amin, 2020; Rosa, 2012; Wangsa & Prastyo, 2019). However, most of them were android-based media which demands the availability of smartphones and the internet. It is not possible to use it in areas with limited internet access and students from underprivileged groups. As well, none of them has anything to do with integration with Islam. Knowing such nature will increase gratitude to God. Furthermorem, it should be raised in science learning (Hadi, Sofyanita, & Ardiansyah, 2021). These obvious issues can be solved by using puzzles related to laboratory equipment integrated with Islam. In addition to strengthening chemistry knowledge, this puzzle can provide increased expertise in the field of Islam.

Design Stage

The stage of product development was determining the basic design of the puzzle. In addition, a manual configuration for the use of the developed learning media was also determined. Puzzles were designed for self-study. This media provides two sides: the puzzle and the confirmation of the answer. The puzzle consisted of chemical glassware commonly found in the laboratory. Confirmation answers were verses of Al Qur'an that relate to the virtues of science. This design allows students to understand the use of glassware in the chemistry laboratory as well the importance of studying science in Islam

The puzzle allowed for competition between the two teams. This condition enables group work experience and improves both cognitive and affective abilities. The rectangular shape was selected to help the user arrange the puzzle. The compact form was also designed to make it easier to carry this puzzle. The puzzle material is acrylic to provide durability to the developed media.

The assessment instrument is a crucial tool to measure the feasibility of the product. The development of the instrument was conducted based on a literature review on the criteria of good learning media. Prior to its use, the instrument was validated by an instrument expert. The instrument development was based on a theoretical study on the criteria for good instructional media application. The instrument consisted of ten aspects with 32 indicators (Table 3).

Develop Stage

The execution of puzzle production was done in the development stage. The puzzle consisted of the material of glassware commonly used in the chemical laboratory and its uses, such as Erlenmeyer flask, glass tube, mortar and pestle, eyedropper, and volumetric pipet (Figure 1). The other side consists of beaker glass, graduated cylinder, glass stirring rod, volumetric flask, and graduated pipet. These glasswares can be replaced with other glasses or other chemical devices to enrich information related to chemical laboratories.

The correction of the answer puzzle consists of different Al Qur'an verses on each side. These verses relate to the eminence of science. If the arrangement of the puzzle is correct, the verse will be arranged appropriately and legible. However, if the puzzle arrangement is incorrect, the pieces will be random, and thus the verses cannot be read well.

Figure 1. **The developed product: a puzzle for chemical laboratory glassware integrated with Islam as a learning medium**

The verses available on the two sides of the puzzle as follows,

الَّذِي خَلَقَ سَبْعَ سَمَاوَاتٍ طِبَاقًا ۖ مَا تَرَىٰ فِي خَلْقِ الرَّحْمَٰنِ مِنْ تَفَاوُتٍ ۖ فَارْجِعِ الْبَصَرَ هَلْ تَرَىٰ مِنْ فُطُورٍ

"*He Who created the seven heavens one above another: No want of proportion wilt thou see in the Creation of (Allah) Most Gracious. So turn thy vision again: seest thou any flaw?*" (Al Mulk, 67:3)

يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ

"*Allah will exalt those of you who believe, and those who are given knowledge, in high degrees*." (Al Mujadilah, 58: 11)

The developed media was used in the laboratory management course, chemistry education program, UIN Sunan Kalijaga, consisting of 41 students. The class was divided into eight groups, and they competed in the puzzle arrangements. They must collaborate to arrange each piece of the puzzle. Each of the members must be involved in the preparation of the puzzle. The puzzle arrangement must be carried out together, and each member alternately advanced to organize the puzzle pieces. This game requires the ability to do teamwork, speed and accuracy in thinking, and the ability to arrange puzzle pieces well. The winning team has good skills in terms of cognitive, affective, and psychomotor aspects.

The response of the product quality assessment was carried out by 41 students joining the laboratory management courses. Students assessed the developed product. Most students gave a very-good and good category to the media performance (Figure 2). The students' responses on data obtained an average total score of 142.64 from a maximum score of 160 and an ideal percentage of 89.15% considered very good (Table 3).

Ten aspects were assessed in the use of media, for instance, display quality, concept accuracy, applicability, language, image and text quality, integration of science and Islam,

comprehensive performance, cognitive aspects of the game, affective aspects of the game, and psychomotor aspects of the game. Display quality aspect consists of three indicators, i.e., media layout design, compatibility of color and typeface, and presentation of messages in this media makes it easier for students to understand the content of the material independently. It aspects performed a very-good category with the ideal percentage of 87.32%. This performance was obtained because the media design is well-done with an exciting color combination. Such obvious media design also remarkably allows students to use this media and learn independently.

The aspect of concept accuracy consists of three indicators, for example, conformity of the concepts described with the concepts by chemists, well-organized material, and the explanation of the material on the laboratory equipment is well explained. The media was considered very good with the ideal percentage of 90.08%. Such formulated excellent performance shows the media has the accuracy of concepts related to the use of glassware in chemical laboratories. It confirms that the material delivered on this media is well-organized and follows the concepts offered by chemists.

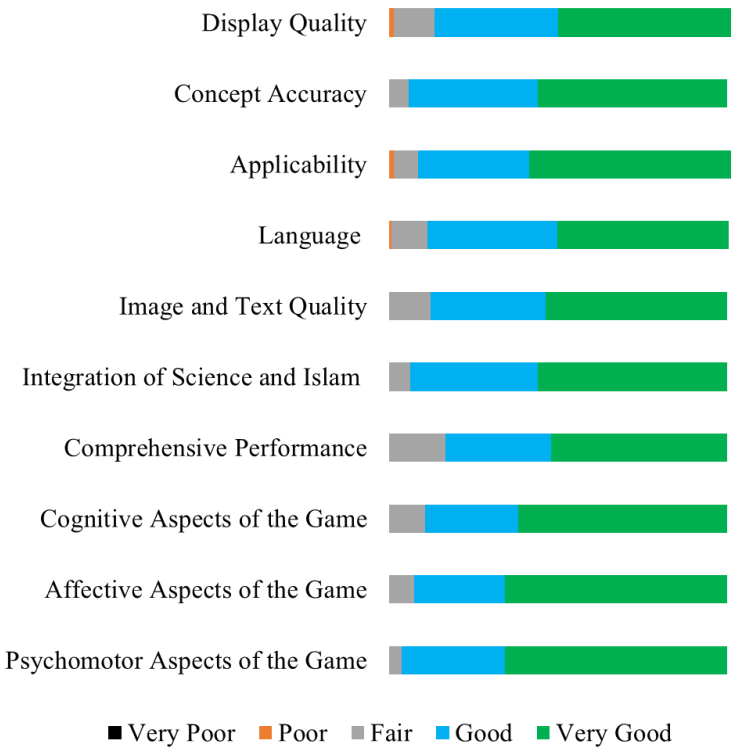

Figure 2. Student assessment on each aspect of the puzzle for chemical laboratory glassware integrated with Islam as a learning medium

Table 3. Product assessment by 41 students joining management laboratory courses, chemistry education program, Faculty of Education and Teacher Training, Universitas Islam Negeri Sunan Kalijaga

Aspect	Criteria	Σ score	Σ each aspect	Average	Ideal Percentage	Category
Display Quality	Media layout design	185	537	13.10	87.32%	Very-good
	Compatibility of color and typeface	172				
	Presentation of messages in this media makes it easier for students to	180				

	understand the content of the material independently					
Concept Accuracy	Conformity of the concepts described with the concepts by chemists.	185	554	13.51	90.08%	Very-good
	Well-organized material	184				
	The explanation of the material on the laboratory equipment is well explained	185				
Applicability	The ease of the material presented for students	178	736	17.95	89.76%	Very-good
	Flexibility of use	181				
	Supporting the independence of students in the learning process	189				
	The proportion of puzzles as entertainment and a balanced educational communication tool	188				
Language	The use of words is clear and easy to understand	183	899	21.93	87.71%	Very-good
	The word selection in the description of the material	175				
	The suitability of words with the use of students' language	180				
	Use of communicative language	179				
	The text leads to understanding the concept	182				
Image and Text Quality	Drawings and writing lead to understanding the concepts described	179	362	8.83	88.29%	Very-good
	Pictures and writings encourage students' curiosity	183				
Integration of Science and Islam	Puzzle provides aspects of the integration of Islam and Science	185	369	9.00	90.00%	Very-good
	The integration side of Islam and science on the relevant puzzle media	184				
Comprehensive Performance	Interesting puzzle media	186	893	21.78	87.12%	Very-good
	orderly and nice design	180				
	Interesting puzzle mold	175				
	interesting letter shape	174				
	Easy-to-read font size	178				
Cognitive Aspects of the Game	The game assessed the ability to recall chemical glassware	183	555	13.54	90.24%	Very-good
	The game assessed the ability to select a list of chemical glassware by name, image and use	184				
	The game assessed the ability to sort chemical tools according to pictures and uses	188				
Affective Aspects of the Game	The game demands teamwork	189	564	13.76	91.71%	Very-good
	The game requires team communication	187				
	The game requires the managerial skills of the team leader	188				
Psychomotor Aspects of the Game	The game requires skill in arrangement	189	379	9.24	92.44%	Very-good
	The game requires the skill of combining puzzles	190				
	Total	5848	5848	142.63	89.15%	Very-good

The implementation aspect of the media was 89.76% considered very good. This aspect consists of four indicators: the ease of the material presented to students, the flexibility of use, supporting students' independence in the learning process, the proportion of puzzles as entertainment, and a balanced educational-communication tool. This investigation shows that the material presented helped students understand the chemical glassware and its use independently. As well, the media provided the flexibility in use with a perfect proportion of edutainment.

Aspects of the language was 87.71% considered very good. This aspect consists of five indicators: the use of words is clear and easy to understand, the selection of the words in the description of the material, the suitability of words with the use of students' language, the use of communicative language, and the text leads to understanding the concept. This performance confirms that the developed media was supported by using clear and easy-to-understand words. This performance is because this media is supported by clear and straightforward terms to understand. The appropriate language, communicative, compelling images, and texts lead students to understand the concept.

Image and text quality aspect consists of two indicators: drawings and writing lead to understanding the concepts described, and pictures and writings encourage students' curiosity. Its aspect was with the ideal percentage of 88.29% considered very good. It also confirmed that this media was able to encourage students' interest. It is essential to enhance students' understanding of chemical glassware before doing laboratory activities.

Integration of Science and Islam is a vital aspect of the developed media. This aspect consists of two indicators: the puzzle provides aspects of the integration of Islam and Science, the integration side of Islam and science on the relevant puzzle media. This developed learning media performed 90.00% of ideal percentage considered very good. It confirms the media can deliver the integration between science and Islam. It also helps students to know the virtue of science in Islam.

The comprehensive performance of the media was assessed by five categories: interesting puzzle media, orderly and nice design, interesting puzzle mold, interesting letter shape, and easy-to-read font size. This aspect was with the ideal percentage of 87.12% considered very good. This shows that this puzzle media is attractive with the support of an orderly and good design, attractive print, attractive and easy-to-read fonts. In addition, this puzzle media is easy to carry with the right size.

The application of this media to improve three aspects of education, namely cognitive, affective and psychomotor, were tested in this study. The cognitive aspect involved three indicators: the game assessed the ability to recall chemical glassware, select a list of chemical glassware by name, image and use, and the ability to sort chemical tools according to pictures and uses. This investigation obtained an ideal percentage of 90.24% considered very good. The application of the puzzle in terms of applying the affective aspect was also studied in this research. This investigation tested three indicators: the game demands teamwork, the game requires team communication, and the game demands the managerial skills of the team leader. This study obtained the ideal percentage of 91.71% considered very good. The last assessment of the product was the application of the puzzle to enhance the psychomotor aspects. This study evaluated two indicators: the game requires skill in arrangement and the skill of combining puzzles. The puzzle obtained the ideal percentage of 92.44% considered very good.

Comparing this work to previous research related to learning media development about chemical laboratory tools was shown in Table 4. Amin (2020) developed augmented reality media for laboratory equipment. However, their study did not test the quality of the product, so the quality of the developed product could not be known. The other research related to the development of laboratory equipment was also carried out by Rakhman, Saraha, and Sugrah (2017). They developed videos on the use of glassware which allowed students to see the use of laboratory equipment. However, the developed media was poor enough by its assessment of ten respondents. Winda, Muharini, and Rasmawan (2020) produced an encyclopedia of chemical tools. Although the quality of the product is higher than in this project, the number of their respondents was minimal. Compared to previous projects, the puzzle development in this project provided high number of respondents and the result considered very good. As well, this formulated project integrates the learning media with Islam.

Table 4. A comparison of learning media on the chemical laboratory glassware material

Learning Media Type	number of respondents	Score	Category	Reference
Puzzle	41	89.1%	Very Good	This Project
Augmented Reality	-	-	-	(Amin, 2020)
Video-Based Media	10	67.8%	-	(Rakhman et al., 2017)
Book-Based Media	4	96.3%	Very Good	(Winda et al., 2020)

The results of this test indicate that the puzzle is ready to use in the learning process as well as the preparation of students to enter the chemistry laboratory. It will assist students understand the use of chemical glassware and the virtue of science in Islam. As well, it is essential for students before conducting laboratory activities. The dissemination stage still needs to be carried out on this media. It addresses to test the product's performance to a broader range.

CONCLUSION

The study successfully developed and implemented the puzzles for chemical laboratory glassware integrated with Islam as a learning medium. The puzzle contains the pieces of glassware and their uses in the chemical laboratory. The product is feasible with the quality of a very-good category. The puzzle's implementation assisted the students understand both chemical glassware and the virtue of science in Islam.

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