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Development of AR-based Interactive Teaching Materials Equipped with the IBL-STEM Model to Improve the Scientific Literacy of JHS Students on the Topic of the Human Circulatory System

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ABSTRACT
The purpose of this research was to develop interactive teaching materials equipped with the IBL-STEM model to boost students' scientific literacy on the material of the human circulatory system. The research model used is the 4D model which contains 4 steps: (1) Define; (2) Design; (3) Develop; (4) Dissemination. The validation results from lecturer and teacher as material expert validators show a percentage of 94% (very feasible category). This is supported by the high scores obtained from the suitability of inquiry learning and students' skills in determining the relationship between knowledge possessed and daily implementation of the book content which is the goal of IBL-STEM learning. The results of media validation which was also assessed by lecturer and teacher showed a percentage of 96% (very feasible category). The readability test conducted by 30 students showed a percentage of 86% (very good category). Therefore, AR-based interactive teaching materials equipped with the IBL-STEM model can be implemented in classroom learning to improve the scientific literacy of JHS students on the material of the human circulatory system. It is recommended for future research to use this teaching material product in actual learning in the classroom.

Keywords: *Teaching materials, AR, IBL, STEM, Scientific literacy.*

1. INTRODUCTION

The current curriculum demands that science learning be presented in an integrated manner [1]. One of the Integrated Science materials, namely the Human Circulatory System, has abstract characteristics and processes that cannot be sensed directly [2]. Blood is an important means of transportation in the body. The circulatory system as a supplier of O2 and nutrients throughout the body [3]. However, the material still found difficulties [4] related to concept understanding [2] which is included in scientific literacy [5].

The scientific literacy of students in Indonesia is low [5]. In line with PISA monitoring in 2016. Indonesia ranks 62 out of 70 countries [6]. The analysis by Hasasiyah, et al stated that the scientific literacy ability of JHS students regarding the human circulatory system is still below average, especially aspects of understanding concepts [7]. Research by Panji, applying interactive multimedia learning on the topic of the human circulatory system, has not been able to improve understanding of the concept. The difficulty is caused by presenting dark images and lack of contrast [8]. Therefore, it is necessary to update learning devices with the help of technology that can support students' visualization and understanding, namely AR [9]. Learning the human circulatory system at SMPN 3 Rambatan with lecture and discussion methods has assessed student learning outcomes with the Teacher Performance Assessment Instrument (IPKG), but this does not include the value of all aspects because it only assesses the cognitive aspect [2]. This is overcome by applying a model that supports students' psychomotor assessment, namely the IBL model [10]. Some of the reseacrh listed have not included technological aspects in their learning, so this learning is integrated with STEM to support the success of 21st century learning [11]. Thus the AR solution in IBL-STEM learning is believed to be able to overcome the low scientific literacy of students on the material of the human circulatory system. However, this solution is still rarely done.

Innovation of teaching materials is an effort to boost scientific literacy [12]. AR is a combined system between the real and virtual worlds, interactive in 3D/2D [13]. AR can make students better understand the content of the material presented [9]. IBL is a learning model by requiring students to find their own knowledge [14], is also the best way to achieve scientific literacy [15]. The IBL model consists of: (1) Orientation; (2) Conceptualization; (3) Investigation; (4) Conclusion; (5) Discussion [10]. STEM is supported by the IBL model in learning [16]. STEM is emphasized on the engineering aspect in the form of procedures in designing the engineering process [17]. STEM can improve the quality of learning [11], so that it can improve students' scientific literacy. STEM consists of aspects of Science, Technology, Engineering, and Mathematics [18]. Science is a studies the environment that is contrary to the topic of discussion of physics, chemistry, and biology [19]. Technology consists of several fields that involve knowledge, skills, and abilities in producing products [11]. Engineering includes a product design process along with work steps [11]. Mathematics is the study of numbers, shapes, and operations [19]. Each aspect of STEM has a relationship, namely the scientific aspect plays a role in understanding knowledge and skills in the process of natural phenomena which requires technological aspects to determine the extent to which technological developments can help human work. The technological aspect requires technical aspects in the form of operation, design, assembly, and tool design. While the mathematical aspect plays a role in analyzing, proving, solving problems based on existing data and calculation results [20] Learning with STEM integration to create graduates who are capable of overcoming problems related to technology and innovation [21]. The scientific literacy indicators that are expected to be achieved include: (1) Remembering and applying appropriate scientific knowledge; (2) Identify, utilize, and produce clear models and representations; (3) Describe the involvement of scientific knowledge to the community; (4) Offering a way to explore scientifically the questions given; (5) Reviewing how to observe scientifically given questions; (6) Describe and review the various methods used by scientists to determine the validity and rationality of data and the generality of explanations; (7) Transferring data from one explanation to another; (8) Describe, describe the data and make the right conclusions [22].

Thus, from the description that has been mentioned, the development of AR-based interactive teaching materials with the IBL-STEM model was carried out with the aim of growing students' scientific literacy. So the purpose of this study was to develop and test the feasibility of AR-based interactive teaching materials equipped with the IBL-STEM model as an effort to improve the scientific literacy of JHS students on the material of the human circulatory system.

2. METHODS

This research is a type of research and development (RnD) using the 4D research model by Thiagarajan [23]. The research procedure starts from the define stage [23] which contains the analysis: (1) beginning-end; (2) students; (3) tasks; (4) concept; and (5) goals. Product validation instruments in the form of material validation questionnaires, media and readability tests are arranged in this stage. The material validation questionnaire contains aspects of content feasibility, presentation feasibility, and contextual assessment. The media validation questionnaire contains aspects of the feasibility of graphics and the feasibility of language. The readability test questionnaire consists of understanding the material, language and product interest. Next is the design stage [23] which contains the draft of the test preparation, media selection and format. In this stage, a product storyboard is also designed. Then the develop stage [23] where development, validation, and product readability are carried out. Middle school science teachers and science education study program lecturers filled out material and media validation questionnaires. From the validation it produces qualitative data in the form of input from the validator and quantitative data in the form of scores according to the Likert scale reference [24]. At this stage, a readability test was carried out with a readability test questionnaire to 30 JHS students who had taken the material on the human circulatory system. The data obtained are qualitative data in the form of input from students and quantitative data in the form of scores according to the Likert scale reference [24]. After that, data analysis techniques were carried out with percentage formula [25]. After obtaining the results, it can be concluded that the feasibility of the product is in accordance with the table of product eligibility criteria in Table 1 [25]. Then the last stage is disseminate [23] in the form of testing and product distribution, but this stage was not carried out due to limited time and circumstances.

Table 1. Product eligibility criteria

Percentage (%)	Category
<21%	Very not feasible
21%-40%	Not feasible
41%-60%	Enough feasible
61%-80%	Feasible
81%-100%	Very feasible

3. RESULTS AND DISCUSSION

This study develops AR-based interactive teaching materials equipped with an IBL-STEM model on the human circulatory system material to facilitate students in boosting scientific literacy [12]. AR is a technology that combines the real and virtual worlds in 3D/2D [13]. The teaching materials developed include book covers, preface, table of contents, GPA, subject matter, concept maps, instructions for using applications and symbols, several sub-materials, bibliography, answer keys to practice questions, and the identity of the developer. Broadly speaking, the teaching materials developed are in accordance with the systematic framework of the module development, namely (1) Introduction, in the form of brief descriptions and learning objectives; (2) Presentation, in the form of learning activities containing the titles and contents of learning activities, practice questions, and summaries of the concepts studied; (3) Closing, in the form of formative tests and answer keys [26]. Cover pages, learning analysis, and examples of learning activities in teaching materials are presented in Figures 1, Figure 2, and Figure 3.

Figure 1 Teaching material cover.

The cover of the teaching materials contains: (1) College logo; (2) Description of users of teaching materials; (3) Title of teaching materials; (4) the name of the developer of teaching materials; and (5) Complementary information on the contents of teaching materials.

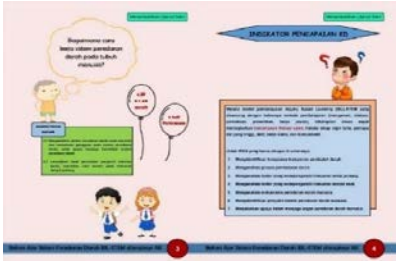

Figure 2 Learning analysis.

Learning analysis consists of Basic Competence (KD) 3.7 Analyzing the circulatory system in humans and understanding disorders in the circulatory system, as well as efforts to maintain a healthy circulatory system and KD 4.7 Presenting experimental results on the effect of activity (type, intensity, or duration) on heart rate. The time allocation used was three meetings or 8 JP (8 × 40 minutes). There are seven basic competency indicators that must be achieved, including: (1) Identifying the components of blood vessels; (2) Analyzing the process of blood clotting; (3) Analyzing the factors that affect the frequency of heart rate; (4) Analyzing the factors that affect the pulse frequency; (5) Analyzing the mechanism of human blood circulation; (6) Identifying diseases of the human circulatory system; (7) Explain the efforts in maintaining the organs of the human circulatory system.

Figure 3 Examples of learning activities.

Learning activities refer to the IBL model with STEM integration. Figure 3 shows an example of a learning activity in the Orientation stage which contains examples of problems in everyday life accompanied by several apperception questions.

The introduction in teaching materials includes the subject matter and concept maps. The presentation section provides five sub-materials, including: (1) Blood; (2) Heart; (3) Blood vessels; (4) Human circulatory system; (5) Diseases of the human circulatory system. In each learning activity, apperceptions are presented in the form of videos or pictures related to daily problems. Videos can be accessed by scanning the QR code provided. Through the videos presented, students are expected to be able to formulate problem formulations and explore information, so that important knowledge is found which is arranged with clear representations. Examples of learning activities for sub material 4 can be seen in Table 2.

Table 2. The relation of IBL-STEM syntax to scientific literacy indicators

IBL-STEM Syntax	Scientific Literacy Indicator
Let's get to know it! (*Yuk kenali!*), representing the IBL syntax for the Orientation section and the STEM aspect for the S (Science)	Remembering and applying appropriate scientific knowledge
Let's hypothesize! (*Yuk berhipotesis!*), representing IBL syntax for Conceptualization and STEM aspects for S (Science)	Identify, utilize, and produce clear models and representations
Let's find answers! (*Yuk mencari jawaban!*), representing the IBL syntax for Investigation section and STEM aspects for S (Science), T (Technology), E (Engineering), M (Mathematics)	(1) Describe the involvement of scientific knowledge to the community; (2) Offering a way to explore scientifically the questions given; (3) Reviewing how to observe scientifically given questions; (4) Describe and review the various methods used by scientists to determine the validity and rationality of data and the generality of explanations
Let's conclude! (*Yuk menyimpulkan!*), representing the IBL syntax of the Conclusion section and the STEM aspects of the S (Science), M (Mathematics) section	(1) Transferring data from one explanation to another; (2) Describe, describe the data and make the right conclusions
Let's discuss! (*Yuk diskusi!*), representing the IBL syntax of the Discussion section and the STEM aspect of the S (Science) section	(1) Transferring data from one explanation to another; (2) Describe, describe the data and make the right conclusions

The teaching materials developed refer to the IBL-STEM model with scientific literacy indicators. The stages in the teaching materials are adapted to the five syntaxes of the IBL model [10] that integrated with STEM aspects and is equipped with scientific literacy indicators.

In addition to activities in the classroom, in the teaching materials there are also practical activities that can be carried out at home in the form of making prototype models of the human circulatory system with simple tools and materials. It is intended that students can apply the knowledge they have acquired in real terms. In addition, it is also to fulfill learning in the STEM aspect of the engineering section [17]. The teaching materials are also equipped with formative assessments based on scientific literacy in the form of practice questions at the end of each sub-material. The development of this product is expected to be a solution to the weaknesses of several studies that have been discussed previously. These weaknesses are in the form of images that are less clear and lack contrast so that they can be overcome with AR technology. In addition, the IBL-STEM model can also be a solution to the lack of assessment of the psychomotor aspect in previous studies.

The product feasibility test was carried out by a lecturer in the Science Education Study Program, State University of Malang and a science teacher at SMPIQu Al-Bahjah Cirebon using a material and media validation questionnaire. The results of material validation can be seen in Table 3. The results of material validation show a percentage of 95% which is classified as very feasible criteria [25]. The results of media validation can be seen in Table 4. The results of media validation show a percentage of 97% which is classified as very feasible criteria [25].

Table 3. Material validation results

Aspect	Sub-aspect	Score (%)	Average (%)
Content Feasibility	The suitability of the material with the curriculum	92	93
	Material accuracy	96	
	Material updates	92	
	Encourage curiosity	94	
Serving Feasibility	Serving technique	94	93
	Serving support	92	
	Serving of learning	88	
	Coherence and confusion in the flow of thought	100	
Contextual Assessment	Contextual nature	100	98
	Contextual component	96	
Overall Average			95

Table 4. Media validation results

Aspect	Sub-aspect	Score (%)	Average (%)
Feasibility of Graphics	Book cover design (cover)	99	97
	Book content design	96	
Feasibility of Language	Straightforward	96	96
	Communicative	100	
	Dialogic and interactive	94	
	Suitability with the development of students	100	
	Suitability with language rules	88	
	Use of terms, symbols and icons	100	
Overall Average			97

Qualitative data in the form of input from the lecturer which reads “This link provides access to change the content of the question. Have there been any rules for teacher users not to change the core of the form? Especially if in the future there are several schools that use it.” From these inputs, improvements were made which can be seen in Figure 4. Figure 4(a) shows the appearance of the teaching materials before they were repaired. Figure 4(b) shows the appearance of teaching materials after repair. Improvements made were to move the questions in the Google Forms into teaching materials with the aim of minimizing changes in content that other teachers might be able to do.

Figure 4 (a) no questions and (b) with questions.

After making improvements, it can be tested to the next stage, namely the readability test by junior high school students who have taken the human circulatory system material (see Table 5).

Table 5. Student readability test results

Aspect	Score (%)
The explanation of the concepts in this book uses problem illustrations in accordance with everyday life	90
The examples of questions in this book are related to daily life problems	86
The material in this book is presented from easy to difficult and from concrete to abstract	83
Several sections in this book allowed me to find my own concept	82
In this book there are questions that improve my thinking skills	92
This book made me discuss with other friends	88
My curiosity is fueled by the material in this book	85
This book made me conclude the material in the “Reflection” column	83
In this book there is a formative test that tests the extent of my understanding of the material of the human circulatory system	91
This book uses clear and easy-to-understand sentences and paragraphs	87
This book uses simple and easy to understand language	85
The font in this book is simple and easy to read	85
This book looks interesting	86
I am interested in learning science because of this book	86
This book can increase my desire to learn	84
This book makes my learning focused and structured	86
I am interested in studying the material in the book because of the illustrations in each material	88
Learning science is not boring when using this book	87
Average	86

The results of the readability test show a percentage of 86% which is included in the very good criteria [25]. Obtained qualitative data which reads "I do not understand the formulation of the problem and the hypothesis" and "if it can be explained more because I do not understand the term". Improvements made were to explain to them directly the meaning of the terms problem formulation and hypotheses.

Based on the results of the validation on the "contextual component" aspect, precisely on the "questioning" assessment item, it obtained a score of 96% where the intent of this aspect is in the form of questions that encourage, guide, and measure students' thinking skills. This is in accordance with the objectives of IBL learning where students are required to find their own knowledge. This statement is also supported by the results of student readability on the aspect of "in this book there are questions that improve my thinking ability" which got a high score of 92%.

According to the results of product validation and readability tests, a statement was obtained that AR-based teaching materials equipped with the IBL-STEM model can be used as facilities to improve the scientific literacy of junior high school students on the material of the human circulatory system. AR is an innovation in teaching materials as an effort to improve scientific literacy [12]. IBL can support STEM in their learning [16]. Through the IBL-STEM model, students can improve scientific literacy by teaching design, utilizing technology, improving cognitive and affective, as well as realizing the knowledge that has been learned [17].

4. CONCLUSION

According to the results of product validation and readability tests, it can be concluded that AR-based teaching materials equipped with the IBL-STEM model as a facility for growing scientific literacy of junior high school students on the human circulatory system are classified as very feasible with a percentage of 95% in terms of material and media by 97%. For the readability test, it belongs to the very good category with a percentage of 86%. Therefore, AR-based interactive teaching materials equipped with the IBL-STEM model on the human circulatory system material can be applied as a facility to build science literacy for junior high school students. The next recommendation is that these teaching materials can be followed up with learning practices in the classroom. The advice obtained is that these interactive teaching materials need to be developed again by considering input from readers, especially those who are experts in their fields so that they can be implemented in learning activities in the classroom.

AUTHORS' CONTRIBUTIONS

All authors conceived and designed this study. All authors contributed to the process of revising the manuscript, and at the end all authors have approved the final version of this manuscript.

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