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Development of Immune System Teaching Materials to Train High School Students' Understanding

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Abstract

The development of teaching materials are adapted to the needs of students to complement the teaching materials that are already available in schools. The purpose of this study was to develop and determine the feasibility of immune system teaching materials to practice understanding the concepts of SMA / MA students. This study use the *Research and Development* (R&D) method with the ADDIE development design. The sample of this study consisted of 3 classes, XII MIPA 1, XII MIPA 2 and XI MIPA 4 SMAN 10 Semarang in the academic year 2020/2021. The data collection technique is done with interviews, validation questionnaires, response questionnaires, and conceptual understanding questions. This teaching material is said to be feasible if it reaches a validation score of media experts, material expert validation, teacher validation, teacher responses, and student responses ≥51%. Students are said to have a good understanding of the concept of the immune system material if the total average score is ≥70. The results showed that the teaching materials prepared included very feasible criteria (media validation 78.65%, material validation 90.22%, teacher validation 93.9%, teacher responses 98%, student responses 81.13%). The results of the students' conceptual understanding test after using the teaching materials obtained a total average score of 74.5. The conclusion of this study is that the immune system teaching materials are very suitable for use in learning biology and can train students' understanding.

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INTRODUCTION

The 2013 curriculum holds the view that knowledge cannot just be transferred from teachers to students. Students are subjects who have active abilities in seeking, processing, constructing, and using knowledge. The 2013 curriculum provides opportunities for students to construct their knowledge. Students need to be encouraged to work on solving problems, find everything for themselves, and strive to realize their ideas (Nurdyansyah & Fahyuni, 2016).

One of the indicators to be used in measuring the success of learning is learning outcomes (Dimyati & Mudjiono, 2009). Based on observations at SMAN 10 Semarang from July 10 to September 5 2019, it was found that the average score of students in biology learning had not reached the KKM determined by the school, which was 70 .

The success of the learning process can also be seen in the ability to absorb students showing the percentage of mastery of the immune system material on the National Examination of SMAN 10 Semarang in 2018/2019 is 31.26% at the district/city level, 28.48% at the provincial level, and 24.94% at the national level (Ministry of Education and Culture, 2020).

Immune system material is listed in Basic Competence (KD) 3.14. analyze the role of the immune system and immunization on physiological processes in the body and Basic Competence (KD) 4.14. campaign on the importance of various programs and types of immunization as well as disorders in the immune system in various forms of information. In order to achieve the goals in KD 3.14 and KD 4.14, the teacher should use interesting and effective learning media. Teachers need various means to support teaching and learning activities. One of the supporting facilities that are needed in the learning process is teaching materials (Wardhana, 2010).

Teaching materials are all materials (both information, tools, and texts) that are arranged systematically, displaying a complete figure of competencies that will be mastered by students and used in the learning process for planning purposes (Prastowo, 2014). There are several reasons for the need for teachers to develop their own teaching materials, including (1) availability of materials according to curriculum demands (2) target characteristics (3) demands for solving learning problems (Depdiknas, 2008). The low quality of teaching materials will result in low student learning outcomes (Sugiarti, 2013). Therefore, the development of teaching materials is carried out which should be in accordance with the demands of the curriculum, student characteristics, and can solve problems in learning. Assistance from teaching materials makes students more active and not easily bored with the learning process in the classroom (Fajrin *et al*, 2014).

In the material of the immune system, many events are experienced in everyday life. Thus, the teaching materials used are easier for students to understand if they take advantage of events that are often experienced by students on a daily basis. Teachers can analyze understanding in students if they are able to relate students 'daily experiences or concepts that already exist in students' minds with the learning content to be discussed (Wena, 2011). The results showed that biology teaching materials based on conceptual understanding of reproductive materials were feasible and applicable (Nuraida & Alfi, 2019). This is also in accordance with the research of Toharudin (2016) which states that students' understanding of concepts increases after using teaching materials oriented to understanding concepts.

Based on the background described above and as a solution to the problems in SMAN 1 0 Semarang, it is necessary to conduct research to analyze "Development of Materials in the Immune System Material to Train High School Students Understanding.

RESEARCH METHOD

This research was conducted in Semarang (online) in the odd semester of the 2020/2021 school year with samples of class XII MIPA 1, XII MIPA 2 and XI MIPA 4 at SMAN 10 Semarang. This study uses the *Research and Development* (R&D) method. The resulting product is a resource material for the immune system SMA/MA use design ADDIE development (Endang, 2011). ADDIE development design steps include *Analysis, Design, Development, Implementation,* and *Evaluation.* The data obtained in the development of immune system teaching materials are qualitative and quantitative data. The data were obtained from media expert validation, material expert validation, teacher validation, teacher responses, student responses, and student concept understanding test results.

The data obtained from the validation and responses are calculated by the percentage of each aspect. The formulas used in processing are:

$$\textit{Percentage of}\ \text{eligibility}\ (\%) = \frac{The\ observed\ score}{total\ score} \text{x}\ 100\%$$

The data analysis technique uses the likert scale formula. The percent range of qualitative data can be seen in table 1 as follows.

Table 1. Range percent of the qualitative data

Score	Score Interval	Score	Category
1.	76% ≤ Score≤ 100%	4	Very feasible
2.	51% ≤ Score ≤ 75%	3	Well feasible
3.	26% ≤ Score ≤ 50%	2	Less
4.	0% ≤ Score ≤ 25%	1	Very less

The data from the students' conceptual understanding test were analyzed from 30 items on conceptual understanding. Students 'conceptual understanding is reviewed from the results of students' concept understanding tests with the following steps:

1. Calculating the average results of understanding the concept with the formula:

$$(mean) = \frac{Total\ score}{Total\ students}$$

2. The results of the questions were analyzed on average per section using 7 indicators of concept understanding.

$$(mean) = \frac{Total\ point}{Total\ Indicator}$$

3. Based on the calculation, if the average result per indicator of 7 indicators is ≥70 (above KKM), then the student is said to understand the concept of the immune system.

RESULTS AND DISCUSSION

The purpose of this study was to develop and analyze the feasibility of immune system teaching materials to train high school / MA students' conceptual understanding. The instrument used is guided by the assessment of textbooks according to the 2014 BSNP which has been modified and adjusted as needed. This teaching material is said to be feasible if it reaches the media expert validation score, material expert validation, teacher validation, teacher responses, and student responses ≥51%. Students are said to have a good understanding of the concept of the immune system material if the total average score is ≥70. ADDIE development design steps include *Analysis, Design, Development, Implementation* , and *Evaluation* . The analysis phase identifies potentials and problems, collects data and has described the results in the introduction. The steps to *design* teaching materials include analyzing the material that is in accordance with basic competencies, collecting references, making immune system teaching materials,the final stage of *design* is compiling instruments to test the feasibility of teaching materials. The *development* stage is described starting from the validation stage of the teaching material design.

Validation of Media Expert

The media feasibility component consists of (a) graphic feasibility (b) language feasibility. The results of the assessment by media experts are presented in Table 2.

Table 2 . Results of the Media Expert Validator's Assessment of Immune System Teaching Materials.

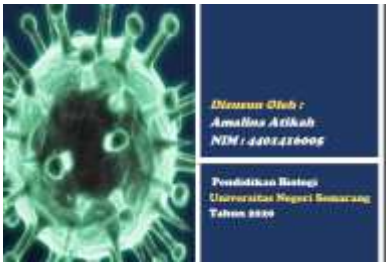
No.	Assessment Validation	Rating Score (%)	
		Validator 1	Validator 2
1.	Aspects of Graphic Feasibility	88.8	72.2
2.	Aspects of Language Eligibility	79.5	75
	Average score	84.15	73.6
	The average score of the validator	78.65	
	Criteria	Very Feasible	

Based on the data that has been obtained from two media expert validators, the average score is 78.65% in the very feasible category. In the graphic aspect, there are 3 indicators, namely (a) the size of the teaching materials (b) the cover design of the teaching materials (c) the design of the content of the teaching materials. In the graphic aspect, it can be calculated that the average score obtained from the 2 media validators is 80.5%. The color of the layout elements on the cover design of teaching materials is harmonious by paying attention to the overall color appearance and can clarify the content of the teaching materials that have been made. Well-designed learning media can help students achieve learning goals (Nurseto, 2011).

In this teaching material, there are many illustrated sections. The existence of color image media can increase student interest in learning (Ramayulis, 2018). Image media can attract students' interest to read teaching materials and make it easier for students to understand the body's defense system material. One of the components related to the elements of teaching materials according to Prastowo (2014) is supporting information which includes additional information that can complement a teaching material. Supporting information on this teaching material is presented in the form of a box you must know in the form of additional information, and pictures that illustrate the material so that the knowledge obtained by students will be more comprehensive. This immune system teaching material is also in accordance with the characteristics of good teaching materials according to Mudlofir, (2012) which is to generate interest in reading by inserting pictures, tables, and using colors.

In the design of the content of teaching materials, there are several improvements regarding the consistency of the layout, namely the spacing and margins of teaching materials that are not neat, so that they get less points. The distance between the caption and the source is also less dense, so there needs to be improvements in teaching materials. The validator also provides suggestions regarding the image, if it can be taken by the author himself then it is better to use the author's own image.

No	Media Expert Assesment
1.	Validator 1 The title is added by the name of the supervisor because it has contributed to the composition of teaching materials. Before assesment :



After assesment:

2. Validator 1

The introduction is replaced with a preface.
Before assesment:

After assesent :

3. Validator 1

Concept map replaced with material map.
Before assesment :

After assesment :

4. Validator 1

The author's original image is better.

Before assesment :

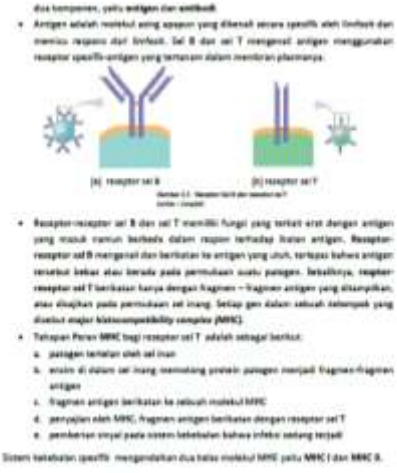
After assesment :

5. Validator 2

Tidy up the layout

Before Assesment:

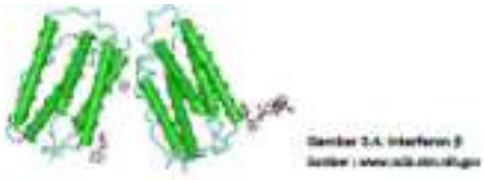
After assesment :



6. Validator 2

The image title space is closer to the source.
Before assesment:

After assesment:



7. Validator 2

The space between the letters and the table is reduced.
Before assesment :

No	Pembeda	Limfosit B (Sel B)	Limfosit T (Sel T)
1.	Tempat Pematangan	Sum-sum tulang	Timus
2.	Jumlah dalam darah	20% dari total limfosit dalam darah	80% dari total limfosit dalam darah

After assesment :

berikut :

No	Pembeda	Limfosit B (Sel B)	Limfosit T (Sel T)
1.	Tempat Pematangan	Sum-sum tulang	Timus
2.	Jumlah dalam darah	20% dari total limfosit dalam darah	80% dari total limfosit dalam darah

8. Validator 2

Adding question processing instructions.
Before assesment :

After assesment :

ightforwardness (b) communicative (c) dialogic and interactive (d) conformity with the development of students (e) conformity to language rules (f) use of terms, symbols, or icons. Learning media that are in accordance with the character of students and implemented correctly by the teacher are the basis for obtaining quality learning outcomes (Mahnun, 2012). Biology teaching materials based on conceptual understanding of reproductive materials are feasible and applicable (Nuraida & Alfi, 2019).

This component of media assessment is important to do, because with good media, the teaching materials developed will attract more readers' interest. This is in accordance with the statement from Korniawati et al., (2016) which states that the teaching materials they have developed are valid, because they have an attractive, harmonious and non-distracting color selection, and use a type and size of fonts that are easy to read and easy to use.

Validation of Material Expert

The results of the assessment by material experts are presented in Table 3 .
Table 3 Results of the Material Expert Validator's Assessment of the immune system teaching materials.

No.	Assessment Validation	Rating Score (%)	
		Validator 1	Validator 2
1.	Content Feasibility Aspects	95.8	83.3
2.	Presentation Feasibility Aspects	95.4	86.3
	Average score	95.6	84.8
	The average score of the validator	90.22	
	Criteria	Very Feasible	

Based on the data that has been obtained from two material expert validators, the mean score of the validators is 90.22 % with a very feasible category. There are 4 indicators on the feasibility of the contents of (a) the suitability of the material with KD (b) the accuracy of the material (c) recency of material (d) encourage curiosity. In the content aspect, the average score of the validator is 89.5 % with the category very feasible. Good teaching materials need to pay attention to accuracy which can be seen from the aspects of the accuracy of the presentation, the latest theory, and the scientific approach concerned (Akbar, 2013). At the beginning of each sub-chapter, questions that are commonly found and experienced in everyday life are presented which serve to encourage students to have the desire to ask questions and to have curiosity. Teaching materials that are arranged with an inductive approach, where students can learn by observing the phenomena of everyday life, it turns out that it can arouse students' curiosity to learn more deeply (Yuliati, 2013).

At the presentation aspect of getting rerat a score of validator of 90.8 % to the category of very decent. Indicators in the presentation aspect include (a) presentation technique (b) presentation support (c) presentation of learning (d) coherence and sequence of thought lines. presents a coherent concept and starts from simple basic things to complex things that are more complicated. Presenting a coherent concept is very important as in research (Hasanah et al, 2015) where the sequence aspect of the material is considered very good because the material presented starts from simple to complex. In the practice questions, there were several improvements including the question options that were less consistent, so that the question options were flattened to 4 options. The sentence which states the statement except, is bolded so that it is more visible. The material expert also suggested adding a grid to see the difficulty level of the practice questions that had been made.

Teacher Validation and Responses

The results of the teacher validation of immune system teaching materials are shown in Table 4.

Table 4. Results of Teacher Validation Sheet Assessment Immune System Teaching Materials.

No.	Validation of teaching materials	Indicator	Rating Score (%)
1.	Media	Graphics	97.2
		Language	87.5
2.	Material	Contents	95.8
		Presentation	95.4
Average score			93.9
Assesment Criteria			Very Feasible

In addition to the validation of teaching materials by the teacher, data was also collected on teacher responses to teaching materials which are presented in table 5 as follows:

Table 5. Results of the Teacher Response Assessment Sheet Immune System Teaching Materials.

No.	Indicator	Assessment score (%)
1.	Theory	100
2.	Language	100
3.	Interest	95
Average score		98
Assessment criteria		Very workable

In the assessment of the validation of teacher teaching materials, a score of 94.6% was obtained with the very feasible category. The assessment of teacher responses to teaching materials also has a very applicable category with a percentage score of 98%. As for the input given by the teacher, some abbreviations were still found, researched again regarding writing, and some questions were still lacking HOTs. This input can add perfection to the teaching materials that have been written.

In the validation of teaching materials by the teacher, there are 2 aspects of validation, namely media validation and material validation. Media validation has several indicators including (a) graphics and (b) language.Media validation has several indicators including (a) graphics and (b) language. The graphic indicator has a percentage score of 97.2% with very feasible criteria. The use of icons and illustrations in immune system teaching materials has characteristics so that the content is more attractive to students. This teaching material can be an alternative that suits the needs of the teacher as student facilitator. An attractive

and contemporary design with a variety of colors and real pictures is needed in a teaching material, so that this teaching material is suitable for use by teachers during learning.

One of the characteristics of good teaching materials is a communicative and semi-formal style (Mudlofir, 2012). In the language aspect, the teacher gives a very good response with a score percentage of 87.5% with the criteria that the teaching material is very suitable for use. A teaching material if it does not pay attention to the structure of the language used and the punctuation marks used, the elements of cohesion and coherence in a paragraph are not fulfilled (Ariningsih et al., 2012) .

In the material aspect, there are 2 indicators in the assessment, namely (a) content feasibility (b) presentation feasibility. The content feasibility aspect gets a very decent score with a score percentage of 95.8%. In indicator (b) the feasibility of the presentation gets a score percentage of 95.4%.

Responses to the immune system teaching materials by the teacher get a percentage of 98% points with criteria very applicable to learning. There are 3 aspects of the teacher's response, namely (a) Material (b) language (c) interest. In the material aspect, the response score obtained is 100%, this shows that the teaching material has met KD and learning objectives. In the language aspect, this teaching material uses language that is simple, effective and easy to understand by students. This is in accordance with the assessment given by the teacher, namely with very feasible criteria with a score of 100%. In the aspect of interest, the teacher gave a score of 95%. The attractive appearance of immune system teaching materials with a variety of colors provides motivation for students to study the body's defense system teaching materials.

The results of the research on the development of teaching materials for the immune system obtained data that the mean percentage of teacher validation scores was 94.6% with very feasible criteria and got the results of teaching materials responses of 98% with very applicable categories. Based on the explanation of the results and discussion of teacher validation and teacher responses, it can be concluded that the immune system teaching materials are declared very suitable for use as learning on the immune system material.

Student Responses

Student responses to teaching materials are in the form of student response questionnaire sheets sent via the *google form* link . Respondents of this study were 70 students consisting of 34 students from XII MIPA 1 and 36 students from XII MIPA 2. The results of students' responses to immune system teaching materials are shown in Table 6 .

Table 6 Results of Student Responses to Immune System Teaching Materials.

No.	Indicator	Rating Score (%)	
		XII IPA 1	XII IPA 2
1.	Theory	81.34	80.81
2.	Language	84.06	80.09
3.	Interest	80.88	79.63
	Average score	82.09	80.17
	Average score of responses	81.13	
	Criteria	Very Workable	

In the student response questionnaire, there are 3 indicators, namely (a) material (b) language and (c) interest. The average score of students' responses from class XII IPA 1 and XII IPA 2 was 81.13%, which shows that the criteria are very feasible.

The first indicator is the material on the immune system teaching materials. The material presented in the teaching material has an average score of 81.07% with the very feasible category. The material presented is in accordance with the established basic competencies. The basic material contained in the textbook is also contained in this teaching material. Additional material on leukocytes, immunization, MHC 1 and 2, factors that affect the body's defense system can add information that students do not get in textbooks and worksheets. This teaching material also uses examples of problems related to everyday life in the preparation of sentences so that they are easy for students to understand. This is in line with the opinion (Daryanto, 2013) that learning materials are arranged regularly and images in such a way can provide information that is easier for students to understand.

The second indicator is language. The average percentage score obtained was 82.07% with very feasible criteria. This is because the teaching materials use language that is easy to understand, simple and effective. The language developed by a teaching material is based on the principles of convenience and communication (Prastowo, 2014).

The third indicator is attractiveness. The average percentage score obtained is 80.25% with a very feasible category. The appearance of teaching materials greatly determines the attractiveness of teaching materials. *Modern* appearance, color, and layout attract students to study this teaching material. This can motivate students to learn the body's defense system and make learning the body's defense system not boring. The teaching materials developed are liked by students because they have an attractive appearance and are not boring (Puspita, 2019).

Results of Student Concept Understanding

Students' understanding of the concept is measured from the test results that have been sent via *google form* . The results of the concept comprehension test were assessed before using the teaching materials and after the students used the teaching materials. The data on the value of concept understanding before using teaching materials from this study were 70 students consisting of 34 students of XII MIPA 1 and 36 students from XII MIPA 2. The sample of student data after using teaching materials was 36 students from class XI MIPA 4. Results of Recapitulation of Indicator Values Understanding the concept before using teaching materials can be seen in table 7 as follows.

Table 7. Results of the Recapitulation of Indicator Values Before Using Immune System Teaching Materials.

No	**Concept understanding indicator**	IPA Average 1	IPA Average 2	Average	Total Average
1.	Restate a concept	71.6	73.3	72.4	
2.	Classify objects according to certain properties according to their concept	73.5	65.7	69.6	
3.	Give examples and not examples	73.6	63.2	68.4	
4.	Expressing concepts in various forms of representation	58	63.8	60.9	69.2
5.	Develop the necessary / sufficient conditions of a concept	62.6	62.5	62.5	
6.	Using and utilizing and selecting procedure	78.4	77.8	78.1	
7.	Apply the concept of solving problems	70.5	75	72.7	

Table 8. Result of the Recapitulation of Indicator Value After Using Immune System Teaching Materials.

No	**Concept understanding indicator**	Average	Total Average
1.	Restate a concept	77.3	
2.	Classify objects according to certain properties according to their concept	77.7	
3.	Give examples and not examples	72.1	
4.	Expressing concepts in various forms of representation	67.3	78.1
5.	Develop the necessary / sufficient conditions of a concept	72.5	
6.	Using and utilizing and selecting procedure	78.1	
7.	Apply the concept of solving problems	76.3	

There are 7 indicators of understanding the concept according to the National Education Standards Agency (2006) including (a) restating a concept (b) classifying objects according to certain properties (c) giving examples and non-examples of concepts (d) developing necessary requirements and the sufficient conditions of a concept (e) using, utilizing, and selecting certain procedures or operations (f) applying the concept or problem solving. In this study, data on students' conceptual understanding of the immune system were obtained before using teaching materials and after using teaching materials.

The first indicator is restating a concept. Concepts are abstract ideas in the form of objects, events, activities, or relationships that have the same attributes (Sagala, 2010). Thus, it can be interpreted that a concept is an abstract idea to classify objects, events, and activities. The average value obtained after using teaching materials was 77.3 with a good category above the KKM. The second indicator is classifying objects according to certain characteristics according to the concept with an average score of 77.7 with categories more than KKM. The third indicator is the ability to give examples and not examples. This understanding is needed to support students in expressing examples of learned immune system mechanisms and examples of immunization. Examples of giving can be easier to understand because of the concrete experiences experienced by students (Miftah, 2013). On this indicator, an average value of 72.1 is obtained with the category of more than the KKM. The fourth indicator is expressing the concept in various forms of

representation. On this indicator, an average score of 67.3 is obtained with the category less than the KKM. This may be due to students' lack of understanding to analyze a concept of the immune system. In the material of the immune system, students' ability to analyze concepts in various representations in Azka et al. (2016) research is less than 50%. Students 'reading interest and thoroughness are also factors in the students' lack of average score. The fifth indicator is developing the necessary or sufficient conditions of a concept with an average value obtained of 72.5 with a good category, which is more than the KKM. The sixth indicator is using and utilizing and selecting procedures. On this indicator, the average value is 78.1 with good category. This shows that students have no difficulty in understanding this indicator. The seventh indicator is to apply the concept to the problem solver. On this indicator, an average value of 78.1 is obtained with a good category. This shows that students have no difficulty in understanding this indicator.

In this study, the average score of students after using immune system teaching materials was 74.5 with a category of more than KKM. There is one indicator, namely the fourth indicator states that the concept in various forms of representation does not reach the average of 67.3. The results showed that the students got low scores on the questions with the difficult category, namely type C4 and C5 with an average score of 70. While for the easy category questions, namely C2 and C3, they got an average score of 79.88. This shows that it is easier for students to understand low-level questions. The difficulties experienced by students are caused by several factors from within the student and factors from outside the student. The student's internal factor is the low ability of the average student's learning achievement so that most students find it difficult to understand the subject matter provided by the teacher. The intensity of HOTS question practice also affects students' ability to answer questions. Factors from outside the students in the form of the teaching approach carried out by the teacher are not perfect and there is too much student population in the class so that the distribution of learning is not optimal (Saraswati & Gusti, 2020).

CONCLUSION

Based on the results of the analysis and discussion that has been carried out, it can be concluded that the immune system teaching materials are very suitable for use in learning biology. The validation of the validation of immune system teaching materials by the validator with details of media experts with an average score of 78.65% got very feasible criteria and material experts an average score of 90.22% got very feasible criteria. The feasibility of the validation of teaching materials from the teacher got a score of 93.9% with the criteria very feasible, the teacher's response got a score of 98%. The criteria are very applicable. Student responses get an average score of 81.13% with very applicable criteria with easy to understand concepts. The value of concept understanding gets an average of 74.5 in the good category, more than the KKM.

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