VALIDITAS DAN KETERBACAAN BUKU ELEKTRONIK MATERI SISTEM KEKEBALAN TUBUH UNTUK MELATIHKAN KEMAMPUAN LITERASI SAINS SISWA

The Validity and Readability of Electronic Book on Immune System Chapter to Upskill Students' Scientific Literacy

Anindita Rahadinar Kinanti
Pendidikan Biologi, FMIPA, Universitas Negeri Surabaya
Jalan Ketintang Gedung C3 Lt.1, Surabaya 60231, Indonesia
e-mail: aninditakinanti@mhs.unesa.ac.id

Raharjo
Jurusan Biologi, FMIPA, Universitas Negeri Surabaya
Jalan Ketintang Gedung C3 Lt.2 Surabaya 60231, Indonesia
e-mail : raharjo@unesa.ac.id

Abstrak

Literasi sains sangat erat kaitannya dengan era Revolusi Industri 4.0 yang menuntut lulusan berkualitas, mampu bersaing secara global, dan menguasai perkembangan literasi informasi berbasis teknologi. Kualitas bahan ajar seperti buku perlu ditingkatkan dan dikembangkan sejalan dengan kemajuan teknologi informasi dan komunikasi. Salah satu upaya yang dapat dilakukan untuk mengembangkan sumber belajar berupa buku cetak adalah dengan mengemasnya dalam bentuk buku elektronik. Tujuan dari penelitian ini adalah mengembangkan buku elektronik materi Sistem Kekebalan Tubuh untuk meningkatkan literasi sains siswa. Penelitian ini berupa penelitian pengembangan yang menggunakan model 4D (*Define*, *Design*, *Develop*, dan *Disseminate*) namun dalam penelitian ini tidak menyertakan langkah *Disseminate*. Tahap pengembangan dilaksanakan di Jurusan Biologi FMIPA Universitas Negeri Surabaya dan menghasilkan Buku Elektronik Sistem Kekebalan Tubuh. Kemudian, buku elektronik yang dikembangkan dinilai oleh dua validator berdasarkan syarat konstruksi, syarat teknis, dan syarat didaktik yang meliputi aspek literasi sains. Sedangkan keterbacaan diuji menggunakan Grafik Fry. Buku Elektronik ini memiliki 4 fitur yang diharapkan dapat membantu siswa dalam memahami dan melatihkan literasi sains siswa. Hasil validitas buku elektronik berdasarkan syarat konstruksi, teknis, dan didaktik masing-masing memiliki nilai 3,9, 4, dan 3,75. Hasil ini dapat dikategorikan valid dan buku elektronik dapat digunakan di kelas tanpa ada revisi yang berarti. Penilaian keterbacaan menunjukkan bahwa bacaan cocok untuk siswa kelas 9, 10, dan 13 dan masuk dalam kategori sulit. Mengingat materi Sistem Kekebalan Tubuh diajarkan di kelas 11, maka buku elektronik ini sudah cocok diajarkan untuk siswa SMA. Revisi terhadap skor keterbacaan masih perlu dilakukan agar bacaan dan wacana dalam buku dapat spesifik cocok diajarkan untuk siswa kelas 11 SMA.
Kata Kunci: Literasi Sains, Validitas, dan Keterbacaan

Abstract

Science literacy is very closely related to the era of the Industrial Revolution 4.0 which demands graduates of quality, able to compete globally and master the development of technology-based on information literacy. The quality of teaching materials such as books needs to be improved and developed in line with advances in information and communication technology. One effort that can be done to develop learning resources in the form of printed books is to package them in the form of electronic books. The purpose of this research was to develop an electronic book on Immune system materials to upskill students' scientific literacy. This research was constructed as a development study using the 4D model (Define, Design, Develop, and Disseminate) but in this research we didn't include a Disseminate step. Development stage was held in Biology Department of FMIPA Universitas Negeri Surabaya which produced Immune System e-book. Then, the developed electronic book was being assessed by two validators based on its construction requirements, technical requirements, and didactic requirements which include the scientific literacy aspects. Meanwhile the readability assessed by Fry Graphs. This Immune System e-book have 4 features, wish that it will help the students understanding and upskill the students scientific literacy. The results of the e-book's validity based on its construction requirements, technical requirements, and didactic requirements were 3.9, 4, and 3.75 respectively. These results are categorized as valid and the e-book can be used in class without any significant revision. The readability assessments showed that the passages are suited for 9th- grade, 10th grade, and 13th grade students. Even though the results are all in a difficult reading

category which suits for high school students, revision needed to be done so that the passage in the e-book will specifically suits for 11th grade students.

INTRODUCTION

Industrial revolution 4.0, according to Merkel (2014) is a comprehensive transformation of a whole aspects in industry through the diffusion of digital technology and internet with conventional technology. Technically, industrial revolution 4.0 includes the integration of real-world and virtual-world (Schlechtendahl, et al, 2015). According to research held by Prasetyo and Wahyudi (2018), showed that the direction of the industrial revolution development is not only focused on business and technology, but also on education and academics profession. Thus, it pushed the academics profession to increase the research and use of technology on education. Hence, Prasetyo and Wahyudi (2018) further explained that there's the need to promote that kind of transition on the education sector especially on developing countries, in order to prepare the next generation who are ready to face industrial revolution 4.0.

Scientific literacy is the ability to use scientific knowledge, identify problems, draw a conclusion based on scientific evidence, and make the right decisions. The mastery of scientific literacy becomes one of the students demands of 21st century ability. Based on that information, scientific literation will hold important role to participate on society. In everyday life, students are inseparable from the role of science so that generations who have scientific literacy skills need to be present (Bybee, 2009).

Science literacy is very closely related to the era of the Industrial Revolution 4.0 which demands graduates of quality, able to compete globally, and master the development of technology-based on information literacy (Kanematsu and Barry, 2016). Abidin (2014) asserted that students must have learning skills and come up with new ideas, master media, and information technology, and basic abilities that support life and careers that will be undertaken. Sani (2014) said that education should lead to activities that can shape students to be able to deal with environmental problems, the advancement of information technology, the era of globalization, and the impact of science-based technology in life.

Nowadays, the quality of teaching materials such as books needs to be improved and developed in line with advances in information and communication technology. One effort that can be done to develop learning resources in the form of printed books is to package them in the form of Electronic Books or e-Books. Although electronic books can only be accessed through electronic devices, electronic books have the ease of adjusting font sizes and preventing the possibility of damage to books due to erosion or tearing (Lai, 2016).

The materials used in this e-book was Immune System. The materials were built based on Core Competency / *Kompetensi Inti* (KI) and Basic Competency / *Kompetensi Dasar* (KD) from Curriculum 2013. KD 3.14 Immune System for XI Grade High School was written as "analyzing the role of the Immune System and immunization againts physiological processes in the body". KD 4.14 Immune System was written as "conducting campaigns on the importance of community participation in programs, immunization and immune system disorders".

Syafitri (2017) in their research stated that students listed the rank of materials they thought difficult. The difficulty result ranked by the students from less difficult to very difficult were as followed. The students percentage who thought motion system was difficult was 2.5%, the reproductive system result was 7.5%, the circulatory system was 10%, the coordination system was 12.5%, and the immune system was 67.5% . Based on these data, the greatest difficulty found by students is in the material of the immune system. Biology teacher stated that the new term in immune system, immune process, and immune system disorders are that of often considered difficult for students (Syafitri, 2017). This was supported by Azizah's study (2020) which found that 81% of students stated that the immune system is a difficult material. The difficulty experienced by students lies in unfamiliar terms, difficult mechanisms, material that is difficult to visualize, and lack of time to complete the material. Meanwhile, to meet the knowledge and skills competencies, students must be able to grasp the Immune System material comprehensively.

Misconceptions are often happen on the students learning Immune System. Kholifah et al (2014) showed that there were misconception on the mechanism stage for the formation of antibodies. It happened because of its abstract concept that need to be visualized. Hadiyanti and Ari (2015) also added the characteristics of Immune System was also the frequent use of foreign terms that confused the students. Hence, those two characteristics need to be considered in order to develop a learning materials about Immune System.

The existence of this electronic-based textbook makes the learning process well visualized and interactive because it involves a variety of visual and video displays that make it easier for students to understand the concept of the material, so that it becomes one of the good

learning media (Sugianto, 2013). In this book, there will be 4 features that can help facilitate students to practice their scientific literacy. "*Pelajari, yuk*!" contained articles and videos that could help students visualize the mechanism. The "*Cari Tahu, Yuk!*" feature contained articles about immune phenomena that can be found by students. The "*Detektif Bio*" feature facilitated interaction between teachers and students to discuss and make conclusions about an immune phenomenon. Lastly, there was the "*Kamu Harus Tahu*" feature that explained the new terms that students would learn in the book.

RESEARCH METHODS

This research is a development study using the 4D model (Define, Design, Develop, and Dissemination) but on this research, we didn't include Disseminate step which allow the distribution of the e-book. Define, Design, and Develop steps allow the development of the e-book including the choosing a materials until the development and design of the e-book itself. The time and place of research until the development stage was carried out in October 2019 - February 2020.

A. Define

Define step done by analyzing curriculum, students, assignments, concepts, and learning objectives. Define step was done before designed the e-Book.

B. Design

The purpose of Design step was to create an e-Book that being developed by the researchers. The first creation of the e-Book marked as draft I was then reviewed by the researcher's supervisors. This step also included media selection and format selection of the developed e-Book.

C. Develop

Development step and validation step of this e-Book was done in Biology Department of Mathematics and Science Faculty, State University of Surabaya. This research's objectives was a development of e-Book on Immune System to upskill students' scientific literacy.

Immune System Electronic Book firstly developed and consulted. The final product of the e-book then needed to be check its validity. E-book validity that has been assessed by 2 validators, then assessed and categorized based on the following table.

Table 1. Eligibility Score Criteria

Score	Category
1	Bad
2	Pretty good
3	Well
4	Very good

(Source: Riduwan, 2012)

Secondly, the results that have been obtained from the 2 validators, were then interpreted according to the following table.

Table 2. Validity Interpretation

Score Interval	Assessment Criteria	Recommendation
$3,25 < P \leq 4,00$	Very valid	Can be used without any revision
$2,50 < P \leq 3,25$	Valid	Can be used with a few revision
$1,75 < P \leq 2,50$	Less Valid	Can be used with many revision
$1,00 < P \leq 1,75$	Invalid	Can not be used

(Source : Riduwan, 2012)

The readability of the book was tested using Fry Graph. It could measure the grade reading level or reading difficulty of a text. Readability score is obtained from 100 words written in the book, in which those 100 words are counted its average number of sentences (y-axis) and syllables (x-axis). The number of syllables is then multiplied by 0.6 and converted into the Fry Graph (Figure 1). The average number of sentences and syllables that have been obtained, then interpreted according to where the axis meet. Lastly, the meeting axis can be interpreted according to the reading difficulty or grade reading level of a passage. This method needed to be tested to at least 3 passages.
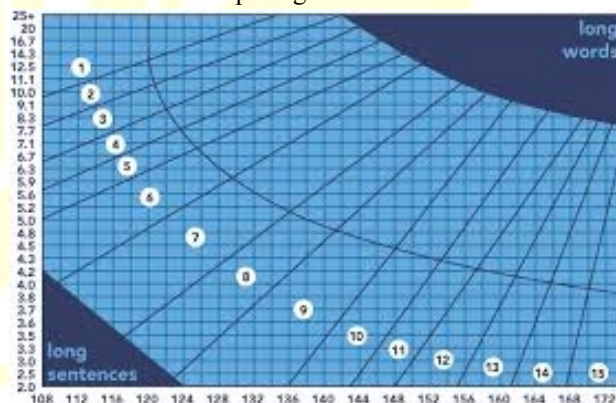

Figure 1. Fry Graph
(Source : Harsasujana, et al., 2015)

Numbers lined in the middle of the graph is the meeting axis of the average number of sentences and syllables. Area number 1 is showing 1st grade. Meaning if the meeting axis is on the area number 1, then the passage is suitable for 1st grade students and considered as easy for the difficulty level. Meanwhile, the shaded area in the upper right corner and lower left corner are invalid area. Meaning that if the meeting axis is on the shaded area, then the passage is invalid to read (Pelissier, etc., 2018).

The result from interpreting the graph, then catagorized based on the following table.

Tabel 3. Interpretation of Difficulty Tests

Graph Interpretation	Reading Difficulty Category
If the meeting axis between the average number of sentences and the syllables then being multiplied by 0.6 is located in between 1st grade until 6th grade.	(1st grade – 6th grade) Easy
If the meeting axis between the average number of sentences and the syllabes then being multiplied by 0.6 is located in between 6th grade until 8th grade.	(6th grade – 8th grade) Moderate
If the meeting axis between the average number of sentences and the syllables then being multiplied by 0.6 is located between 9th grade until 12th grade.	(9th grade – 12th grade) Difficult

(Source : Harsasujana, et.al., 2015)

Thorough calculation from the datas obtained could determine the readability of the immune system e-book. The results could be categorized as good if it was between 10th – 12th grade, also concluded that the e-book developed was suitable and readable for high school students.

RESULTS AND DISCUSSION

This development research was held in order to develop a valid System Immune e-book to upskill students' scientific literacy. Hence, the e-book could be used in a learning process. This Immune System e-book was divided into five sections, which were Antigene and Antibody, Innate Immunity, Adaptive Immunity, Immune System Abnormality, and Immunization.

The outlook, color and media used in the e-book need to be noticed. The color used could affect students' interest on reading the e-book. This proven in Karima (2017) which said that the unattractive and dark color words need to be changed into attractive and bright color words so students could read the e-book better. The outlook of the Immune System e-book can be seen below.

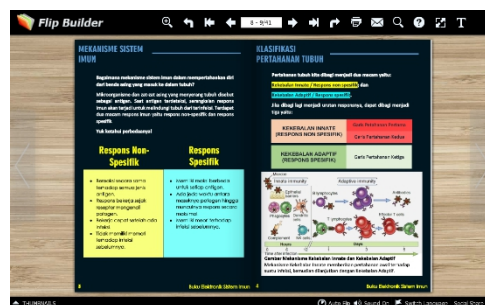Figure 2. The cover of Immune System e-book

Figure 3. Attractive and Bright Color used

Immune System e-book was developed to upskill students' scientific literacy through several provided features inside the e-book. Features included inside the e-book were *Pelajari, Yuk!*, *Cari Tahu, Yuk!*, *Detektif Bio*, and *"Kamu Harus Tahu"*.

Murtiwiyati and Lauren (2013) stated that an availability of information about the features inside a e-book promotes the function of those features. Hence, the explanation about the features inside the e-book was needed. The explanation of the features inside Immune System e-book could be seen in the image below.
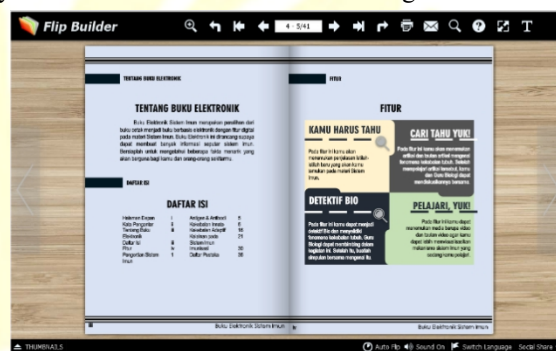

Figure 4. Explanation of the features used inside the e-book

Bybee (2009) stated to upskill students' scientific literacy, the students need to exposed to scientific competences of science content, process science, and science context in scientific literacy. Science content in scientific literacy could be facilitated from *Pelajari, Yuk!* and *Kamu Harus Tahu*. Process science could be facilitated from *Cari Tahu, Yuk!*. Lastly, science context could be facilitated from *Detektif Bio*.

Instrument Development

After carrying out the development process, an indicator is produced which will then be developed into an assessment instrument.

Table 4. These basic competencies and indicators are chosen as the basis for developing instruments based on the 2013 curriculum

Basic competencies	Indicators
Analyzing the role of the immune system and immunization against physiological processes in the body	3.14.1 Explaining the Understanding of the immune system
	3.14.2 Analyzing antigens and antibodies
	3.14.3 Categorize the kinds of immune system
	3.14.4 Linking the body's defense mechanism with the occurrence of an illness
	3.14.5 Analyzing the types of disorders that occur in the immune system
	3.14.6 Predicting ways to prevent and cure a disease
	3.14.7 Describing immunization and its importance

E-Book Validity

Based on the results obtained from the validators (who are experts in the field of material and education), then the average score from each validator was calculated to determine the overall validity of the e-book. The assessment was done by filling out the validation sheet that the researcher has provided. The results of the validators' assessment were listed as below.

Table 5. E-Book Validity

Assessment aspects	V1	V2	Average Score	Category
Construction Requirements				
1. Title				
Including a title in the book				
Including sub-title in the sub-chapter	4	4	4	Valid
The title is relevant to the subject matter				
2. Language and grammar used				
Using straight-forward wording				
The text represents the message to be conveyed	3	4	3.5	Valid
Using PUEBI writing method				
3. Material substances compatibility towards KI and KD of Curriculum 2013				
The importance of immune system on our body				
The differences between antigen and antibody				
Immune system classification	4	4	4	Valid
The kinds of disturbance that occur in the immune system				
The importance of immunization to the society				
4. Concept validity				
The activities presented in the e-book is fit to the concept of immune system				
Pictures presented in the e-book is relevant to the concept of immune system				
Videos attached in the e-book is relevant to the concept of immune system	4	4	4	Valid
Passages presented in the e-book is relevant to the concept of immune system				
Biology terms used in the e-book is fit to the concept.				
5. Learning activities inside e-book is fit to the curriculum 2013 demands				
Activities inside the e-book is fit with KI and KD				
Activities inside the e-book promotes active learning inside the class	4	4	4	Valid
Activities inside the e-book can facilitate competency achievements in the realm of knowledge and skills				
Average Score			3.9	
Technical Requirements				
6. Script				
Font color readability				
Font type readability	4	4	4	Valid
Font size readability				
7. Pictures				
Informative				
Proportional size	4	4	4	Valid
Relevant to the subject studied				
8. E-book design				
Cover design is inline with the e-book's content				
Both e-book's cover and e-book's content are illustrated	4	4	4	Valid
Color variation and pictures used are inline with the learning materials				
Average Score			4	
Didactic Requirements				
9. Compatibility with Science Literacy				
Including the activity of recognizing problems that allow scientific inquiry and recognizing the keys to scientific inquiry (science content)				
Including activities that describe or interpret scientific phenomena (science process)	3	4	3.5	Valid
Including activities that interpret data using scientific evidence				
10. Articles or passages availability				
The availability of articles or passage	4	4	4	Valid

Articles included are related to the material being discussed			
Article's matters are referred from reference			
Average Score		**3.75**	
Overall Average Score	**3.8**	**4**	**3.9**	**Valid**

Based on the results in Table 5, the validity score based on construction requirements got an average score of 3.9 with valid category. Those score showed that e-book developed has fulfilled assessment aspects from construction requirements which were identity aspect, language aspect, and content aspect. Firstly, identity aspect included title, subtitle, and learning indicators. The creation of the e-book's title was based on basic competencies, subject about to be learned by the students, and learning experiences on the curriculum (Depdiknas, 2004). Secondly, language aspect validity was assessed from the the usage of the language, language structure, and straight-forward wordings based on PUEBI. Foreign-words and foreign-phrases used in the e-book need to be written in italic. Language structures used in the e-book were written based on students' grade level. Hence, it could be easily understood by the students. In other words, words used in the e-book were not a new term for the students (Pramita, 2014). Passages and sentences used inside the e-book were also cited from a trustable sources (Widjajanti, 2008). Lastly, content aspect validity was arranged based on a book-writing criteria. Material substances used inside the e-book were based on KI and KD of Curriculum 2013. Basic Competencies / *Kompetensi Dasar* (KD) were derived from Core Competencies / *Kompetensi Inti* (KI), then used to make learning indicators (Prastowo, 2015). Those aspects need to be fulfilled in order to deliver the message of the e-book properly.

The technical requirements validity based on Table 5 got an average score of 4 with valid category. Those score showed that the e-book has fulfilled the assessment aspects of technical requirements which were script, pictures, and design. The scripts written in the e-book were assessed from its color, type, and size readability. Pictures used in the e-book need to be informative, proportional in size, and relevant to the subjects discussed. The design of the cover and content of the e-book need to inline with Immune System. Color variation and pictures used in the e-book were also need to inline with the learning materials (Salirawati, 2011).

The didactic requirements validity based on Table 5 got an average score of 3.75 with valid category. Those score reflected that the e-book has applied the principles of effective teaching and learning (Widjajanti, 2008). Those score also showed that the e-book already included

scientific literacy competencies. Bybee (2009) stated to upskill students' scientific literacy, the students need to exposed to scientific competences of science content, process science, and science context in scientific literacy. Science content in scientific literacy could be facilitated from *Pelajari, Yuk!* and *Kamu Harus Tahu*. Process science could be facilitated from *Cari Tahu, Yuk!*. Lastly, science context could be facilitated from *Detektif Bio*.
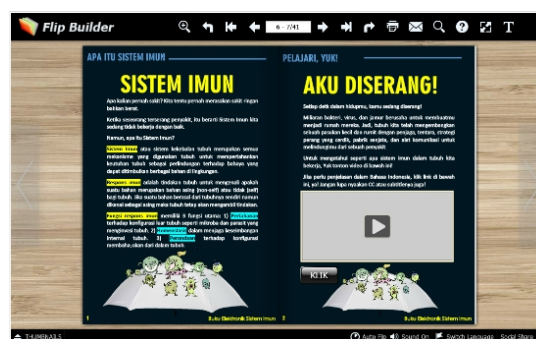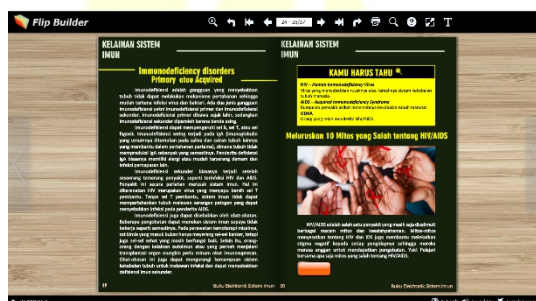

Figure 5. *Pelajari, Yuk!* Feature

Figure 6. *Kamu Harus Tahu* feature

Pelajari, Yuk! and *Kamu Harus Tahu* feature that facilitated content science, contained media such as articles and videos which can help students to visualize the immune system mechanism that they learned.
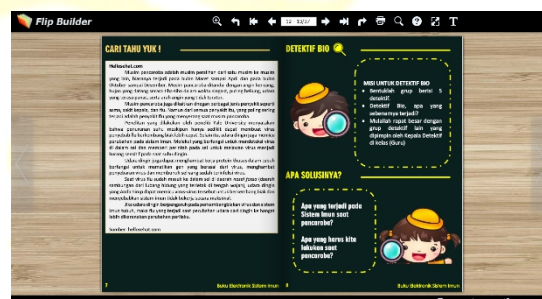

Figure 7. *Cari Tahu, Yuk!* and *Detektif Bio* feature

Cari Tahu, Yuk! feature that facilitated process science, contained an article and asked the students to read up and study the system immune phenomena. The students, guided by the teachers, should identify problems inside an articles and find a way to solve those problems. Lastly, *Detektif Bio* which facilitated context science, asked the students to conclude the articles from

their discussion. The teachers also need to ask the students to explain and conclude what they read and discussed.

The existence of scientific literacy features above could upskill students' scientific literacy such as the ability to interpret, analyze, explain, and inferring. Interpret indicators inside the e-book served in a form of articles about myths and facts about HIV/AIDS. Interpret activities could train the students to categorized and classify regarding the problems solved (Facione, 2015).

Analyze activity inside the Immune System e-book was served in a form of article analysis activity. The problems that being analyzed were contextual problems in daily basis, which analysis the result of categorization from which myths and facts about HIV/AIDS. The analysis activity would make the students able to identify the correlation between the information they read about HIV/AIDS with the problems they need to solve (which was to differentiate between myths and facts about HIV/AIDS) (Peter, 2012).

Explain activity inside the e-book was requisite in a form of explaining the result of the discussion to the teachers and the class. Explain activity can train the students to serve an information from their own thoughts and explain it conclusively (Rositawati, 2018). Inferring activity in the Immune System e-book was reflected from the way it ask the students to conclude the information based on the problems they found in an articles given.

E-Book Readability

Readability is a measurement for the compatibility of reading difficulty to the reader. It is seen from the level of ease or difficulty of a passage. This level of readability is expressed and categorized on reading grade level. Readability assessment of a passage can be used to determine the compatibility of the reading material to a particular grade class (Arif and Fitriani, 2013). Hence in writing a teaching material, readability need to be the main factor to considered. Measured readability is important to consider whether or not the students be able to understand the content of a passage (Zahro, 2015).

Readability of a passage can be measured using Fry Graph. Basically, readability of a passage have 2 basic axis which are the average number of sentence (y-axis) and the syllables multiplied by 0.6 (x-axis). The number given in the graphs are all per a hundred words chosen. The average number of sentences in 100 words as y-axis and the number of syllables in 100 words then multiplied by 0.6 as x-axis. The multiplication to 0.6 is

to adjust the graphs that supposed to use for English passage to Bahasa Indonesia passage, considering the difference in syllables (Harjasujana, 1988; Pelissier, etc., 2018).

Paragraph sampled from the Immune System e-book is 4 paragraphs. All 4 paragraphs are picked from a different sections of the e-book, then being interpreted to the Fry Graph. The results are shown in the following table.

Table 6. Readability results toward four paragraphs of the e-book that was developed.

Attempts	$\sum$ sentences	($\sum$ syllables x 0.6)	Category
1st	7.44	266 x 0.6 = 159.6	10th grade
2nd	5.67	283 x 0.6 = 169.8	13th grade
3rd	4.78	243 x 0.6 = 145.8	9th grade
4th	7	262 x 0.6 = 157.2	10th grade

Based on the results in Table 6, we could interpret that the passages sampled in the e-book are all in the difficult category according to Harasujana, et al. (2015). Given to the e-book that developed for 11th+ grade high school students, the results is on the right difficulty category. The passages are all suits for high school students. However, according to table 6 and table 3, it also shows that the passages sampled are supposed to written for 9th grade, 10th grade, and 13th grade. Even though they all are in the same difficulty category, it will be even better if the writer revised the passages so that they will suit specifically for 11th- Grade High School students, especially for the 2nd passage which showed that it suits for college students

ACKNOWLEDGEMENT

CLOSURE
Conclusion
The validity and readibility of this developed Immune System e-book showed a good result. The result of its validity score based on its construction requirements was 3.9 over 4, technical requirements 4 over 4, and 3.75 for its didactic requirements, considered as very valid. Meaning that the e-book was ready to be used in a class

activity without any significant revision except for the typos. The results of its readability was averagely on a difficult level which suitable for high school students but the change of the passages was needed so that they could suit specifically for 11th Grade High School students.

Suggestion

Further development research is required to apply the e-book on class activities with a little revision on the passage so that they could suit specifically for 11th grade high school students. Further research can also focus on the practical application of the e-book in the class, student responses toward the e-book, and also whether the e-book developed can be used for upskill student's scientific literacy.

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