Indonesian Society for Science Educators
Journal of Science Learning
journal homepage: ejournal.upi.edu/index.php/jslearning

HAIBIO: Development of an e-magazine to Improve Biological Literacy

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ABSTRACT The purpose of this research is to develop the learning media, i.e., a digital magazine, to improve the biological literacy skills of the students. The research method used Research and Development (R&D) with ADDIE develops models. The developed learning media, HAIBIO, consists of biofact, bio lab, bioword, and biogame. The instrument test of biological literacy consists of 30 multiple-choice items based on four stages of biological literacy: nominal, functional, structural, and multidimensional. The validity test is conducted by paying attention to presentation, content, and language by two expert validators who say that media is valid to use in the class. The test of empirical validity is conducted for 30 students in class XI Science 1 in MAN 1 Bogor City. The empirical validity test results show that learning media are valid, and the instrument test found that 15 items are valid and five items are not. The reliability test result shows that 88% of respondents said that the instrument of biological literacy is reliable. The result of the normality test shows a significance value of 0,117 in $\alpha = 0.05$, indicating that the data is normally distributed. The T-dependent test result shows a significance value of -7.679 with a t-table of -2.042 in $\alpha = 0.05$. It shows that there is a higher enhancement score post-test than pre-test. The result of the N-Gain test is 0,44 in the medium category, and the effect size score is 2.93. That shows that HAIBIO e-magz is improving the biological literacy skills of the students.

Keywords E-magz, Biology literacy, Bacteria.

1. INTRODUCTION

Biology education in the 21st century is focused on solving problems, skills, and making decisions. That is related to issues in the future, especially in society zones, such as improving health, preserving the environment, alternative energy to replace fossil fuels, and sustainable food production (National Research Council, 2009). A comprehensive understanding of the field of biology is needed to reach a solution known as biological literacy. Someone with biological literacy skills will look at problems from various biological perspectives to make the right decision based on multiple considerations. For example, tuberculosis is a disease caused by *Mycobacterium tuberculosis*. If someone has a low level of biological literacy, can't they can not identify the steps that should be taken to prevent tuberculosis from spreading to other people. Therefore, biological literacy skills are vital for students.

Biological literacy consists of four stages: nominal, functional, structural, and multidimensional. The nominal of biological literacy is students able to recognize the domain of biology and identify the terminology and concepts in biology. The function of biological literacy is for students to be able to define the meaning of the terminology and concepts in biology.

The structure of biological literacy is students can comprehend the main concept in biology and explain the use of their language, understand the processes involved, and place the material into the larger area of biology. In multidimensional biological literacy, students widely comprehend biology, details, and related to other lessons(Uno & Bybee, 1994).

There is a lot of research that focuses on biological literacy. The research concerns students' opinions on biological literacy in Palestine (Zeidan, 2010), measuring biological literacy skis among Medina secondary school students(Anakara, 2021). Moreover, there is research in Indonesia correlating biological literacy with socio-scientific cases based on biology (Suwono, Pratiwi, Susanto & Susilo, 2017). That indicates global and local attention to the importance of biological literacy. However, students

Received: 06 January 2023
Revised: 11 September 2023
Published: 16 October 2023

have low skills in biological literacy (Adnan, Mulbar, Sugiarti & Bahri, 2021; Huryah, Sumarmin & Effendi, 2017). So, it is important to increase biology literacy among students.

Media have long been used in education to enhance teaching and learning in the classroom (Jonassen, Spector & Driscoll, 2008). Learning Media can help teachers develop knowledge, skills, and attitudes that are important for students. Based on our investigation on Google Scholar, only a few media specifically promote biological literacy skills. For example, the Bio-reprobed RMS website concentrates on the reproductive system (Djamahar, Rifan & Ristanto, 2021). Therefore, we must develop learning media as an alternative or variation for teachers.

One method to improve students' biological literacy skills is reading scientific articles in mass media, such as science newspapers and magazines (Elliott, 2006; Herculano-Houzel, 2002). Science magazines' content has educative and actual information that enhances knowledge (Prastiwi, Lukitasari, & Utami, 2020). While reading and analyzing the article, students can correlate the lesson material in the class and the real problem to develop literation skills (Elliott, 2006).

The learning media that develop is digital magazine. This magazine is made interesting with the goal of improving students students' literacy skills. The digital magazine contains science articles and exciting features, such as games, that can make students curious to read (Allred & Murphy, 2019; Sari, Agustini & Widodo, 2021). In addition, the strength of the digital magazine is accessible on mobile phones or laptops through the link that facilitated students to access it (Henderson, Finger & Selwyn, 2016).

Many research and developments in digital magazines, such as digital magazines that discuss the respiratory tract (Akbar & Mukminan, 2019), digital magazines that discuss excretion systems to increase literation in science (Prastiwi, Lukitasari, & Utami, 2020), and digital magazines discuss the disease on digestion systems (Nurseha, Miarsyah, & Ristanto, 2021). According to previous research, a digital magazine has not yet addressed the structure and character of bacteria. Furthermore, this research aims to develop the learning media, i.e., a digital magazine named HAIBIO e-magz, to improve students' biological literacy, according to Uno & Bybee (1994).

2. METHOD

This research aims to develop the learning media, i.e., HAIBIO e-magz in monera. This research uses Research and Development (R&D) with ADDIE expanding models as seen in Figure 1. The research was conducted in MAN 1 Bogor City, Indonesia, on November, 4-11th 2022, during three meetings in the classroom. The sampling technique used *multistage random sampling*. *Multistage random sampling* was prepared through *purposive sampling* from MA (Islamic High School) in Bogor City. Then, *cluster random sampling* was used to choose MAN 1 Bogor City. Next, selecting the population used *purposive sampling* in class 10 Science in the academic year 2022/2023. Last, a *random sample* was used to select 30 students from class 10, Science 4.

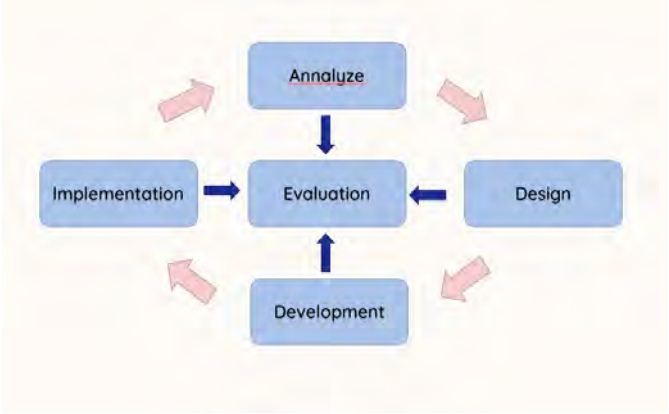

Figure 1 The Scheme of increasing ADDIE

Table 1 shows that ADDIE had five stages: *analysis*, *Design*, *Development*, *Implementation,* and *Evaluation* (Department of the Air Force, 2001)

Table 1 The stages of ADDIE

No.	Stages	Description
1.	*Analyze*	• Perform study literature to analyze students' characteristics as media user • Analyze the material by identifying the material that has not utilized the media maximally • Analyze students' competencies that need to improve
2.	*Design*	Designing HAIBIO e-magz through determine the content, concept, and materials
3.	*Development*	• The experts' validation through lecturer of Biology Education and Biology teacher who certified • The students' validation of the legibility of using HAIBIO e-magz
4.	*Implementation*	• Implementing HAIBIO e-magz to 30 students' of 10 MIPA 4 MAN 1 Bogor City • Implementing pre-test and post-test to see the effectiveness of developing the media
5.	*Evaluation*	• Evaluating HAIBIO e-magz based on pre-test and post-test score of students • Evaluating strengths and weaknesses HAIBIO e-magz

The data collection used questionnaires and instrument tests (Table 2). The questionnaires were used to validate media and instruments. The instrument was used to assess

Table 2 The technique and the instrument of data collecting

No.	The Technique of Data Collecting	Instrument	Assessment Criteria	Object
1.	Media Validation	Questionnaire	Component of: • Presentation • the Content • the Language	• Lecturer • Teacher
		Questionnaire	Legibility of using HAIBIO e-magz	5 students' class 11 Science
2.	Validation of instrument test of biological literacy			
	Experts Validation	Questionnaire	Component: material construction language	• Lecturer • Teacher
	Empirical Validation	Test of biological literacy	• Validation items • Reliability test	Students class 11 Science 5
3.	Result of Media Implementation	• Pre-test • Post-test	• Normality test • Homogeneity test • T-dependent test • N-Gain test • Effectiveness test	Students class 11 Science 4

Table 3 Level of biological literacy

Biological Literacy	Characteristics
Nominal Literacy	• Able to identify the terminology and question biologically • Able to explain the concept of biology in general
Functional Literacy	• Able to define the terminology appropriately • Able to responding to face the problem
Structural Literacy	• Able to have procedural skills • Able to explain the concept of biology using own language
Multidimensional Literacy	• Able to correlating the biology with lots of sciences • Able to comprehend the interaction between the biology and society

Table 4 Result of experts' validation of the instrument of biological literacy

No.	Component of Assessment	Validator		Mean
		Lecturer	Teacher	
1.	Component of material	3.60	4.00	3.8
2.	Component of construction	3.00	3.25	3.13
3.	Component of language	3.00	3.33	3.17
Mean		3.20	3.52	3.36
Category		Valid	Valid	Valid

Table 5 Validator's suggestions toward the instrument of biological literacy

Validator	Suggest
Lecturer	The picture should exchange to be more proper Synchronization in question items and answers Note in the picture should made larger There are some incorrect answers
Teacher	Many items should have interrogative question There are some typographical errors

HAIBIO e-magz media's effectiveness toward students' biological literacy and the concept of monera.

The instrument was completed based on the indicator of biological literacy and the concept of monera. Biological literacy consists of four stages: nominal, functional, structural, and multidimensional (Table 3). Each of the four stages of literacy has its character.

The instrument of biological literacy was 20 multiple-choice items. Afterward, the experts' validation and empirical validation were completed (Table 4). The experts' validation was assessed through a lecturer of Biology Education and a Biology teacher who was certified.

Based on the result shows that the instrument of biological literacy was valid. In addition, the instrument needs revision based on the suggestions (Table 5). The validator gives suggestions to the instrument test used maximally. After the suggestions, the instrument was revised. A correction was made, such as in question number 15 on the indicator of nominal biology (Figure 2). Picture (a) shows the question before revised. The question was revised because it had two answers, B and C. Picture

Indicator: Students analysing based on the graphic
Answer Key: C

(a)
15. Look at the graphic below!

The research using three variables: presence of visitors, temperature, and quantity of microbe found. Based on the following graphic, the point is….
a. Presence of visitors cannot affect the quantity of bacteria
b. Temperatures affect the quantity of bacteria significantly
c. Bacteria come from outside by visitors
d. No visitors make the temperature lower
e. The visitors should wear masks to prevent the bacteria

(b)
15. Look at the graphic below!

The research using three variables: presence of visitors, temperature, and quantity of microbe found. Based on the following graphic, the point is….
a. Presence of visitors cannot affect the quantity of bacteria
b. The sun light affects the quantity of bacteria significantly
c. Bacteria come from outside by visitors
d. No visitors make the temperature lower
e. The visitors should wear masks to prevent the bacteria

Figure 2 Sample of questions that revised (a) before revision, (b) after revision

Table 6 The items' grid that valid

Sub-Concept	Indicator of Biological Literacy				Score
	1	2	3	4	
Character and Structure of Monera		1,2,3	4,5		5
Classification of Monera		11	6		2
Reproduction of Monera	8		7		2
Monera's role in life	13,14,15			9,10,12	6
Total	4	4	4	3	15

Note: (1) Nominal Literacy, (2) Functional Literacy, (3) Structural Literacy, (4) Multidimensional Literacy

(b) showed the question after revision, so in the question, this was only an answer, C.

After revised through experts' validation, empirical validation was tested. The empirical validation was conducted in 11 Science 4 MAN 1 Bogor City, Indonesia, on October 27th, 2022. The validation test was calculated using a biserial point. The validation test result sh owed that 15 items are valid and five are not. The 15 items can test students' biological literacy. The reliability test used the KR-20 formula. The reliability calculation showe d the instrument of biological literacy had a coefficient of 0.94. It is possible to interpret that 88% of respondents considered the instrument of biological literacy reliable (Table 6).

This research used one one-group pre-test – post-test design. The pre-test and post-test results If the data were normally distributed and homogenous, the t-dependent formula was tested with $\alpha = 0.05$. The t-dependent test showed how the pre-test and post-test scores had increased after using HAIBIO e-magz.

The effectiveness test was used to see HAIBIO e-magz's e ffect on improving students' biological literacy. This was calculated with the normality of the gain formula (N-Gain) (Hake, 1998). The effect size test was used to see the effect of using HAIBIO e-magz to improve students' biological literacy. The effect size test was calculated using Cohen formula (Cohen, Manion & Morrison, 2007).

3. RESULT AND DISCUSSION

The learning media was developed with ADDIE models. The analysis step assessed toward the chapter of monera on class 10 in curriculum 2013. Chapter of Monera was in 3.5, i.e., students could analyze the structure and character of monera and its roles in human life.

The design step was arranged through a draft outline, i.e., the content concept in HAIBIO e-magz (Figure 3). Besides, this stage designed how the material can be well-presented through various contents. This magazine had several contents, such as *biofact, bio lab, bioword,* and *biogame. Biofact* contains words describing an object or interesting things in Biology. *Biolab* is contain lots of previous scientific research. *Bioword* is contain an interesting vocabulary that related with material in the class. *Biogame* contains evaluation of learning which formed in the game, that can test students. HAIBIO e-magz also providing scan QR-code that accessible and relate to the concept in the class.

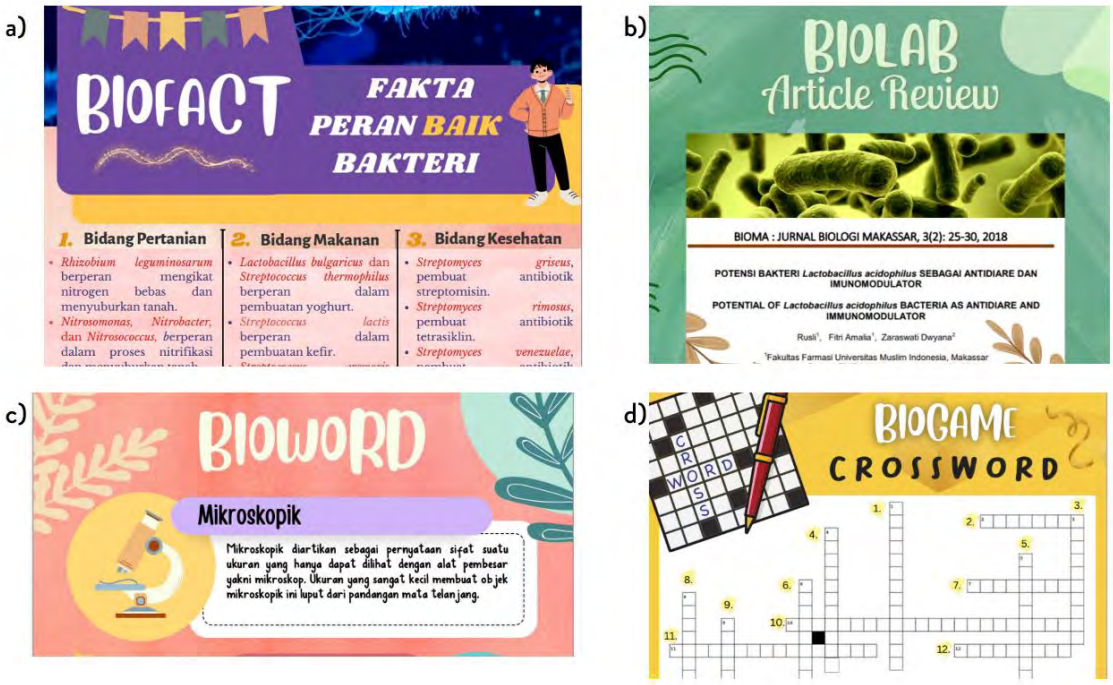

Figure 3 The contents of the digital magazine HAIBIO a) biofact, b) bio lab, c) bioword, and d) biogame

Table 7 Result of validation through the learning media of HAIBIO

No.	Component of Assessment	Validator		Mean
		Lecturer	Teacher	
1.	Component of material	3.4	3.8	3.6
2.	Component of construction	3	3.8	3.4
3.	Component of language	2.8	3.4	3.1
Mean		3.1	3.7	3.4
Category		Valid	Valid	Valid

The development stage was conducted through several tests of validation and instruments of biological literacy (Table 7). The expert validation was assessed through a lecturer of Biology Education and a certified Biology teacher. Moreover, the validation test also assessed students' legibility in using HAIBIO e-magz. Students who contributed to suggesting the researcher were five students from class XI Science. There were the results of validation through the expert validator. The expert validator also assesses the development of a media. The validators assessed based on three components: material, construction, and language. The result can be used in the next stage.

Based on the result shows that the instrument of biological literacy was valid. In addition, the instrument needs to be revised based on the suggestions. The validator gives suggestions to the instrument test used maximally.

Table 8 Validator's Suggestion Toward Learning Media of HAIBIO

No	Validator	Suggest
1.	Lecturer	Give a note in all picture that presented
2.	Lecturer & Teacher	Biology scientific text should proper with binominal nomenclature
3.	Teacher	The letter font should revised so that read clearly
4.	Students	The choice of colour should more modify

Then, suggestions from validators were reviewed and revised. Revisions were made in all content of HAIBIO e-magz thoroughly. The revision can be seen in Table 9.

Table 9 shows the before and after revision of HAIBIO e-magz. For example, the first revision was a note in the picture classifying bacteria based on the quantity and location of flagella. The second revision was correcting biology scientific text appropriately, such as biological scientific text on the role of bacteria, and adding a different color to facilitate students. Other revisions were made through suggestions from validators.

The next step was an implementation conducted on 30 students in class X. The research was conducted in MAN 1 Bogor City, Indonesia, on November, 4-11th 2022, during three meetings in the classroom. Students can access HAIBIO e-magz free with the link https://online.fliphtml5.com/dkesg/vtbe/. This stage was produced pre-test and post-test before analysis, using the normality test Kolmogorov-Smirnov and the homogeneity test Levene (Table 10).

Table 9 HAIBIO display before and after revision

No.	Before revision	After Revision
1.		
2.		

Table 10 Data results

Test	α	T-table	Sig.	Result
Normality Test	0.05	-	0.117	Data normally distributed
Homogeneity Test	0.05	-	0.34	Data was homogenous
T-dependent Test	0.05	-7.679	-2.042	There are increasing score of pre-test and post-test

Table 11 Data of pre-test – post-test

Data	Sample	Standard Deviation	Mean	N-Gain	Effect Size
Pre-test	30	14.09	50	0.44 (Medium)	2.93
Post-test	30	18.08	72		(Strong Effect)

The normality test showed that the data were normally distributed, and the homogeneity test showed that the data was a homogenous variant. The t-dependent test revealed that the pre-test and post-test have increased. The pre-test and post-test data were used to analyze the effect of using HAIBIO e-magz in the class.

The effect size test was used to analyze the effect of HAIBIO e-magz in the class. The n-Gain test score was 0.44, which showed a medium category, and the effect size score was 2.93, which showed a strong effect. Based on the result, using HAIBIO e-magz positively affected students' biological literacy (Table 11).

The evaluation stage was conducted by reviewing the effect of using HAIBIO on students' biological literacy skills. The post-test result showed the effect of using HAIBIO from biological literacy aspects. The aspects are nominal, functional, structural, and multidimensional.

The result of the N-Gain formula showed an enhancement in every aspect of biological literacy (Table 12). The highest N-Gain score was nominal biology, i.e. 32.20. The enhancement in that aspect was outstanding, besides other aspects, multidimensional, functional, and structural.

The result was that it was found based on the learning indicator toward a monera concept (Table 13). The highest N-Gain score indicated Monera's role in regular life, i.e., 54.75. The enhancement on that indicator had outstanding besides other indicators: reproduction of monera, character and structure of monera, and classification of monera.

3.1 Discussion

HAIBIO e-magz was the learning media developed to improve students' biological literacy, especially in monera. During the research, students were on fire because the media had an interesting color, a proper picture, and a QR-code technology that facilitated internet browsing. Nowadays, technology facilitates humans to solve the occupational (Baety & Munandar, 2021). The result of implementing HAIBIO e-magz was improving pre-test and

Table 12 Result of computing based on biological literacy aspect

Aspect	Pre-test		Post-test		N-Gain
	Mean	SD	Mean	SD	
Nominal Biology	30	38.68	63	39.94	32.20
Functional Biology	54	9.62	72	10.72	17.23
Structural Biology	65	37.56	68	40.41	2.68
Multidimensional Biology	65	23.49	89	14.24	23.52
Mean	53.5	27.34	73	26.33	17.66

Table 13 Result of computing based on aspect of monera

Aspect	Pre-test		Post-test		N-Gain
	Mean	SD	Mean	SD	
Character and structure of monera	57	39	75	37	17.43
Classification of monera	37	33	38	49	1,3
Reproduction of monera	62	20	81	16	18,27
Role of monera	25	35	80	9	54,75
Mean	45.25	31.75	68.5	27.75	22.93

post-test scores. In addition, the effect of using HAIBIO e-magz was strong. That was attached from the excellent content: *biofact, biolab, bioword*, and *biogame*.

Biofact contained the essence of monera, such as five facts on monera and seven roles of monera. That means that students can be concerned about substantial points kept in their short-term memory. The short-term memory will be long-term memory if the information is vital. Biofact contained interesting, colorful pictures. According to Dryden & Vos (2001), when the information has only words, that will be kept in the left brain, and when the information has words and colorful pictures, that also will be kept in the right brain. Therefore, the information that contains words and pictures will be kept in the brain faster. Many colors might increase visual memory more than monochrome (Spence et al., 2014). In the class, a colorful picture increases students' motivation and spirit (Nurjannah, 2018; Rany, Nitiasih & Santosa, 2021).

Biolab contained the research article that related to monera. HAIBIO e-magz had a QR code that facilitated students to access the research link. The research article aims to increase students' knowledge and literacy. Literacy requires students to recognize the science related to social problems (Suwono, Pratiwi, Susanto & Susilo, 2017). That means the research article provided an idea about the research, such as creating an introduction, using research methods, and finding the results. The latest research used that students got the new information and associated through students' knowledge, thus constructing their comprehension through that article.

Bioword contained foreign vocabulary that exists in HAIBIO e-magz. The purpose of bioword was to facilitate students to find the meaning of foreign vocabulary. That was that foreign vocabulary can be understood and kept in long-term memory. Biogames contain games, such as crossword and matching games. The game increased students' retention and kept continuously (Agustina, Indrowati & Probosari, 2018; Ramadah, Juanengsih & Mardiati, 2019).

The result also showed an increase in biological literacy after using HAIBIO e-magz. This finding was related to research (Baram-Tsabari & Yarden, 2005) that analyzing scientific articles increased literation skills in general. The highest N-Gain score was nominal, multidimensional, functional, and structural. Nominal biology was increased with the highest N-Gain score. Because the data was available on diagrams and tables at biolab, supporting students' skills. Therefore, students got the chance to learn how to read the data. Students who can read the data based on the context have nominal literacy skills (Mahmud & Pratiwi, 2019).

Multidimensional biology was the second level. The article on biolab provided the literation for students by correlating the concept of monera to regular life. That made the learning more meaningful. Meaningful learning will be preserved in the brain without difficulty and students will apply it daily (Nofiana & Julianto, 2018).

The enhancement of literation skills is also found in biological literacy in functional biology. That was related to Uno & Bybee (1994) when students analyzed the HAIBIO e-magz scientific article. Students can understand the meaning of the terminology or concepts in biology. Students had structural literacy skills when they comprehended a scheme of biology concepts and procedural literacy skills. That is a basic concept that exists in school books. Therefore, some enhancement in these aspects might occur. Other research showed that two of three students had functional knowledge because the concept was available in their book, and the teacher would give the test about its context (Anakara, 2021).

Based on an indicator of monera, the enhancement from the highest to lowest, the role of monera in regular life, reproduction of monera, character and structure, and classification of monera. HAIBIO e-magz's content emphasizes the role of monera in life based on scientific

articles. The article also mentions the reproduction, structure, and function of Monera. Meanwhile, the classification of monera was not intensely discussed in the article, resulting in the low monera classification, unlike many other sub-concepts. Furthermore, other research shows that students have high difficulty learning the sub-concept of monera (Maisari & Pranoto, 2021).

HAIBIO e-magz, which has been developed, has advantages and disadvantages as a learning medium. Based on the use of HAIBIO e-magz, it can be seen that the advantages of HAIBIO e-magz are that it has four excellent features (biofacts, biolabs, biowords, and biogames), easy to use, interactive because one magazine can be connected with various links, has attractive colorful pictures. Meanwhile, the drawback is that two devices are needed to scan the QR Code. HAIBIO is an electronic magazine that can only be opened on a laptop or mobile phone, so another device is needed to scan the QR code. Besides that, the crossword game needs to be evaluated, and this is because the crossword on HAIBIO e-magz cannot be written directly. So, this can be a reference for further research.

4. CONCLUSION

Based on the result, HAIBIO e-magz is valid and worth using in biology class. HAIBIO e-magz has been effective in improving students' biological literacy. This media is also used to assist the school's learning process. Hopefully, digital magazines could better measure students' thinking skills and biological literacy.

ACKNOWLEDGMENT

A gratitude to Mr. Eman Supryatman, M.Pd as the headmaster of MAN 1 Bogor City, Ms. Sugihartini S.Pd, and Ms. Ida Nursanti, S.Pd as Biology teacher in class10 and 11, who allowed to conduct the research. The next gratitude is to Ms. Dina Rahma Fadlilah, M.Si, as the lecturer of the Biology Education Program Universitas Islam Negeri Syarif Hidayatullah Jakarta, Mr. Haryanto, M.Pd as Biology teacher in SMAN 1 Manggar East Belitung and also as an expert validator, and all participant so that the research can be done well.

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