Digital Flipbook Imunopedia (DFI)

A Development in Immune System e-Learning Media

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Abstract—Changes that occur rapidly in the ecology of learning have not been able to respond to learning carried out in class by teachers. The technological disruption that occurs requires learning activities to optimize the use of information technology. Likewise, the biology learning pattern is included in the category of science learning. Immune system content along with body defense mechanism tends to be an abstract content that is hard to comprehend by students. Digital flipbook learning media become an innovative learning medium to facilitate the immune system content understanding for students. Method used in the research is ADDIE research and development with the following stages: analysis, define, design, implement, and evaluation. The research is limited to the development stage. The number of respondents in the research consists of 30 senior high school students aged 17-19 years and 3 (three) Biology teachers aged 30-40 years for needs analysis. Learning media expert validation includes 3 (three) teachers and ten students for small group test. The medium is developed using applications of Microsoft PowerPoint 2010, Movavi Video Editor 14 and Flip PDF Professional. The assessment results of Digital Flipbook Imunopedia (DFI) learning media development by the three Biology education experts indicate valid and feasible to be used in immune system learning process. Average of each feasibility test aspect is content aspect (3.05), media aspect (2.95), and language aspect (2.95). The trial test results to small group regarding the DFI content, display, and benefits indicate a very feasible criterion (3.62). DFI provides a solution to the absence of learning media for the immune system based on digital flipbooks. Biology teachers and students can take advantage of learning media to achieve learning goals of the immune system.

Keywords—Digital Flipbook, Research and Development, Immune System, Validation

1 Introduction

Biology Curriculum in Indonesia emphasizes on learning in knowledge aspect as well as skills and attitude [1]–[4]. The three aspects are developed and measured in each Biology learning in various levels of education [5]–[7]. Biology is a science that studies everything related to living organism. It also studies the physiological processes occurred in the living organism [8]–[11]. High school students study the immune system in human body that plays a role in defending human body from disease threats [12], [13]. In this learning stage, students learn the immunity activation process in human body as a complex mechanism of coordination of organs, tissues, and cells in the body that work together to protect body from bacterial, viral, and foreign object infections [14], [15].

In the 2013 Biology Curriculum for science and mathematics program of senior high school, the immune system content is studied in Grade 11. Basic competence must be achieved by students is students are capable of applying immune system concept to improve life quality [16]. In addition, immune system learning could also improve characters and positive values by linking the immune system concept to the values of life [15], [17]. Biology learning in Indonesia puts the immune system topic as a content with the highest incompleteness percentage [15]. Report of National Examination Result 2019 from the Ministry of Education and Culture (Kemendikbud) indicates the percentage of students who give a correct answer on immune system content is the lowest compared to other content than Biology. The fact is influenced by various factors, among others: broad content scope that causing a lot of contents are missing [14], [18]. The immune system misconception brings difficulties in achieving the objectives of immune system learning in students [19]–[21]. Biology learning should provide opportunities for students to learn how to manage their knowledge [22]–[24]. Traditional learning is researched to give the impact of boredom on students [25]. Learning by involving technology in its implementation can help increase learning motivation [25]–[27]. Students who have good learning knowledge and management will have good metacognitive skills [28], [29]. Metacognitive skills are required by students in learning Biology to improve learning achievement [23], [30], [31].

Immune system is perceived as content with a lot of concepts that should be memorized by students [14], [15], [19]. Research results indicate the limited use of learning media in conveying content has an effect on students' immune system concept mastery [15], [32], [33]. Learning media utilization plays an important role in improving immune system learning quality [15], [19], [34]. Learning media could improve students' knowledge and skills in biology learning [35]–[37].

Learning media implemented in the biology learning could also improve students' activeness [38], [39]. The reasons are related to features provided in learning media. Supporting features, such as, display, content presentation, and evaluation facilitate biology teachers in teaching [5], [40], [41]. The learning media utilization could assist students who have disabilities. Another function of the biology learning media is related to the improvement of student interaction [42], [43]. Interaction process between students is believed could help biology learning achievement [44], [45].

Learning media could help visualize the abstract immune system concept thus facilitate students in mastering the biology concept [46], [47].

Learning that integrates digital technology in learning has been widely used [48], [49]. Digital Flipbook is one of learning media that has been applied in science [50], [51]. The medium is a digital book that has the advantages of a book as well as contains animation and video that could not be found in a book. It could be accessed through smart phone, computer or tablet; thus, its development and implementation could support students' digital literacy. Smartphones and tablets are becoming a new trend in the implementation of instructional media technology [52]–[55]. The unique characteristics of smartphones and tablets have great potential to enrich the learning experience of students [56]. Smartphone is the main device used by students in accessing learning media which is implemented online [57].

Digital learning media are needed by teachers in learning the immune system [15], [35]. Learning the immune system is expected to help students to master the body's defense mechanism against something that can harm their body [19], [58]. Learning related to physiological processes cannot be directly observed by students [59]. Learning media helps students to achieve this understanding through pictures and videos equipped with explanations in the form of sound and text [37]. The results showed students who learned the immune system with learning media facilities showed better learning achievement.

The digital flipbook (DF) utilization in immune system learning is not implemented optimally in learning process [60], [61]. The flipbook utilization in learning process could improve concept mastery [62]. Flipbook is proven to be able to significantly improve concept mastery [63]. It could also improve critical thinking skill in learning [60]; thus supports students in empowering metacognitive skills. Another study also proves that it improves concept mastery for students (Darmawan, Surya, & Jamilah, 2017).

Entering the learning 4.0, immune system learning should be based on technology [41], [45], [65]. Utilizing technology in learning helps students in cognitive development [66]. Research on digital flipbook has been conducted on learning at school. There are, however, no researches that develop digital flipbook to students who learn immunology; thus, this research is conducted. Various studies have been carried out to develop flipbook as Biology learning media [50], [51], [63], but none in immune system content. The virtue of the research at the need of a biology learning medium that is developed in the form of digital flipbook imunopedia (DFI) that could assist in immune system learning. The DFI potentials ought to be developed to help senior high school students to learn immune system. The research aims to produce DFI learning media that are feasible to be applied to senior high school students.

2 Methods

The research used a research and development method. The research and development design conducted in every step of ADDIE is illustrated in Figure 1.

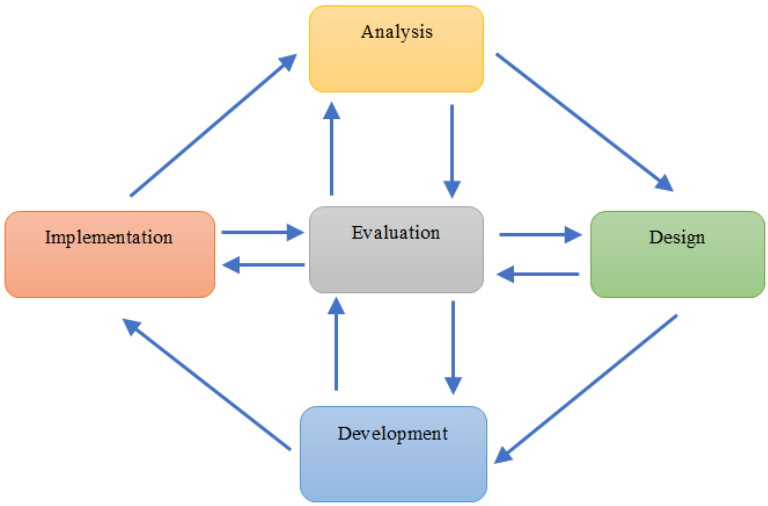


Fig. 1. Stages in ADDIE Model in DFI development implementation.

The research was limited to analysis up to the development stage. The DFI development stage is elaborated in the following section.

2.1 Analysis

The analysis stage aimed to find out obstacles in biology learning, especially immune system in school. In this stage, distribution of needs analysis instruments to students and teachers in a senior high school of Cibinong, Indonesia was conducted. The needs analysis instruments of students were carried out for 30 students who learned immune system content using Google Form, whereas needs analysis instruments of biology teachers were intended to biology teachers who taught immune system. The student respondents involved were selected randomly, while the teacher respondents were biology teachers who taught in class XI majoring in Mathematics and Natural Sciences. There was one biology teacher who taught in the class; therefore, teacher's needs analysis was limited to one respondent. The research instruments used at this stage were questionnaires and interviews. The instruments used in the study have been validated by biology instructional media experts and declared fit for use. The instrument grid for the analysis of learning media needs for biology students and teachers is shown in Table 1.

Table 1. Needs Analysis Instrument Grid of Students and Teachers

Respondents	Indicator	Technique
Learners	Perception of students' difficulty level on immune system learning	Questionnaire
	Perception of students' difficulty based on topic in immune system learning	Questionnaire
	Knowledge of the Immune System	Interview
	Student responses to learning media used on the topic of the immune system	Questionnaire and Interview
Teacher	Immune system learning tools and media	Interview
	The teacher's response to the media for clearing the immune system	Interview
	Obstacles to the immune system learning process	Interview
	The use of Fliipbook in biology learning	Interview

2.2 Design

The design stage was intended to analyze content and compile storyboard. The content analysis aimed to adjust immune system content to be presented on DFI by considering core competences, basic competences, and learning objectives in accordance with the 2013 Biology Education Curriculum. The last activity in the stage included designing storyboard based on content analysis previously prepared.

Based on the 2013 Curriculum, learning in the immune system has core competencies, basic competencies and specific learning objectives. The core competency referred to is the third competency, namely Understanding and applying factual, conceptual, procedural knowledge in science, technology, arts, culture and humanities with insights into humanity, nationality, statehood and civilization related to phenomena and events, and applying procedural knowledge in the field specific studies according to their talents and interests to solve problems. The basic competence of learning the immune system is applying an understanding of the principles of the immune system to improve the quality of human life with immunity through immunization programs so that physiological processes can be maintained in the body. Presenting data on the types of immunization (active and passive) and the types of diseases they control. The learning objectives consist of eight which will be achieved including:

1. Carefully describing the components of the immune system
2. Carefully describe the body's defense response mechanism against pathogens
3. Suggests self and non-self mechanisms
4. Analyze immune system factors against immune system disorders appropriately
5. Correctly describe the unique components of the immune system
6. Provides data on the types of immunizations and diseases that are controlled carefully and systematically
7. Admire the order and complexity of God's creation regarding the immune system that exists in living things

8. Behave honestly, discipline, responsibility, care for the environment, and cooperate in carrying out learning activities inside and outside the classroom.

2.3 Development

The development Stage conducted included three activities, namely: DFI development, product validation by biology education experts, and small group trial. The DFI development carried out in accordance with the storyboard created and used several supporting applications, Microsoft PowerPoint 2010, Movavi Video Editor 14 and Flip PDF Professional. The developed DFI media went through a validation test by three biology education experts. The expert validation assessed the DFI learning media feasibility based on three aspects: content, media, and language. The assessment results as well as expert comments became a basis in the DFI learning media improvement. The final development stage comprised trial and assessment to students who had learned immune system. Students involved in the stage were 10 students. Aspects appraised by the students consisted of display content and DFI media benefits. The assessment by biology education experts and students referred to BSNP indicators. The results of DFI feasibility is categorized into four criteria as indicated in Table 2.

Table 2. Feasibility Test Assessment Scale

Criteria	Score
Very Good	4
Good	3
Poor	2
Very Poor	1

Source: (BSNP, 2014)

The DFI feasibility quality score was obtained based on Formula 1. Once the percentage value was obtained, the DFI feasibility could be identified according to the feasibility test score interpretation from BSNP (2014) in Table 3. The research result data were analyzed descriptively in the form of average and percentage and equipped with opinions from students and biology education experts.

$$\text{Score} = \frac{\text{value obtained}}{\text{maximum value}} \times 100\%$$

Table 3. Interpretation of Flipbook Imunopedia Feasibility Test Score.

Category Interval	Criteria	Description
3.25 > x < 4.00	Very Valid	Could be used without revision.
2.50 > x < 3.25	Valid	Could be used with a slight revision.
1.75 > x < 2.50	Less Valid	Could be used with many revisions.
1.00 > x < 1.75	Invalid	Could not be used and need consultation.

Adaptation Ratumanan & Laurens [67]

3 Results and Discussion

The research results were discussed based on every step done, namely: analysis, design, and development.

3.1 Analysis

Students' needs analysis: The needs analysis on students was conducted in December 2019 through survey method assisted with Google Form. The survey carried out for 30 students of Grade 11 of science class in a senior high school of Cibinong, Indonesia. The point of view of students in assessing learning and the media devices they use is important because students are the main users [68]. Several survey results on the needs of immune system learning media had been analyzed. The survey results on difficulty level analysis and immune system content topic by students are presented in Figure 2 and 3.

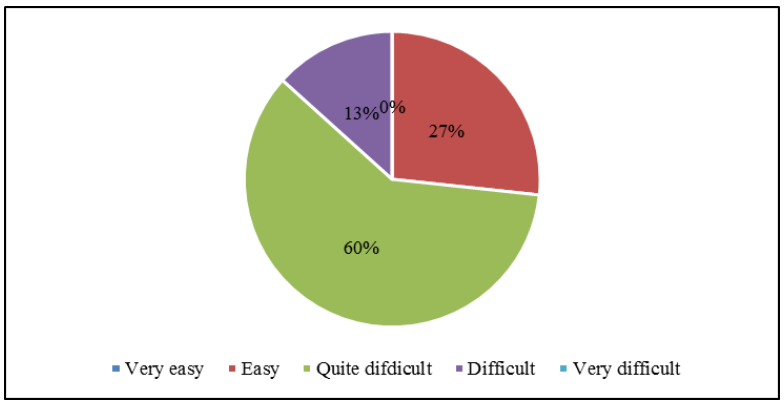


Fig. 2. Perception of students' difficulty level on immune system learning

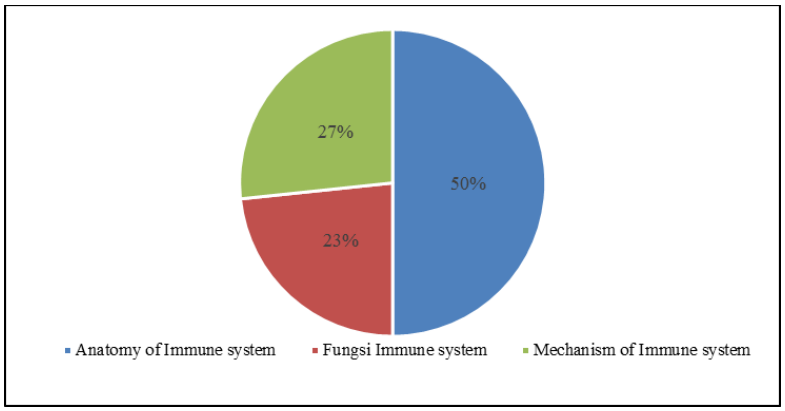


Fig. 3. Perception of students' difficulty based on topic in immune system learning.

Based on Figure 2. The students' perception on immunology was that the content is a quite difficult content to study. Topics in immune system are a high level learning [58]. This learning contains obligation of analyzing the immune system structures, functions and work mechanism to strengthen body immunity [14], [35]. The analysis results on perception of students' difficulty on immunology content topic in Figure 3, suggest that students encountered difficulties in learning the immune system anatomy topic. The immune system anatomy consists of key components including macrophages, neutrophils, and other cellular components, as well as T γδ cells, innate lymphoid cells (ILC), and regulatory T cells (Treg)[69]. The survey results also found that most students had understood the general concept of immune system, but difficulties occurred when they were asked to explain in complete sentences. Another finding on students' learning difficulty perception on immunology was related to the many complicated terms and memorization concept. It is similar to various research results in biology learning that state that biology is difficult since it contains many terms and memorized [11], [45], [70].

Misconception was also found in the result survey on immune system definition understanding. There were students who had difficulty to define immune system basic concept. The students understand immune system as an immunization. Immune system is a body immune system responsible for immunity, which is a defense against organisms to protect body from external biological influences by recognizing and killing pathogens [69], [71]. Immunization is a process to make someone immune to a disease [16], [72]. The following is one example of student response when they were asked to explain basic concept of immune system.

"Immunization is a process to give vaccine into the body using a needle as a formation of antibody against a disease"

The survey results to students suggested that the implementation of biology learning had used several learning media, such as PowerPoint, props or torso, and website. The research finding indicates that students' perception on the use of learning media as helpful in understanding biology content. The students, however, also stated that PowerPoint media was a less interesting and boring medium in biology learning. PowerPoint in the current biology learning process was considered as a conventional learning medium [36], [73]. The results of biology learning media needs analysis by students found that learning media needed was media that have various features, such as pictures, animation, and video and could present an interesting visual display. Interesting visualization media content could provide good attraction to learning [33]. In biology learning, the students also need the content to be directly related to daily life and easy to access at any time [74]. Another survey result suggest that e-book learning media had been used by 80% (n=30) students. Moreover, 76.7% (n=30) students did not know about flipbook learning media. It indicated that digital flipbook media were not commonly used in learning process. The students preferred immune system learning media that contained information with interesting pictures, animation, and video. The survey results in media development aspect showed that 96.7% (n=30) students agreed with digital flipbook-aided immune system learning media.

Teachers' needs analysis: The distribution of needs analysis to biology teachers was directed to biology teachers who taught in Grade 11 of science class in a senior

high school of Cibinong, Indonesia. There was one biology teacher who taught in the class; therefore, in this research stage, teacher's needs analysis was limited to one respondent. The point of view and the role of the teacher is very important in the implemented learning innovation. The teacher's experience and knowledge will influence planning in designing and applying it to learning [75]. The result of needs analysis on immune system learning is summarized in Table 4.

Table 4. Biology Learning Tools and Media.

No	Tool	Media
1	Projector	PowerPoint
2	Internet Fiber	Torso
3	Laboratory	Compact disc
4	White board	

Media-aided biology learning aims to facilitate biology learning process [2], [33]. The interview results found that learning media are vital to be used in biology learning process. Obstacles in the biology learning process are related to students who have different understanding and learning type [76]. Students with visual characteristics could understand media with visual characteristics well; likewise, for audio type or other type of student who are accustomed to reading books. Another finding in the needs analysis on biology teacher was that the learning process never used digital flipbook. It was due to teachers who did not have flipbook media.

3.2 Design

The design stage produced content analysis and storyboard. The content analysis results were in the form of content adjustment based on basic competence and needs analysis results on teachers and students. Concept produced in the design stage was an immune system learning topic hierarchy as illustrated in Figure 4.

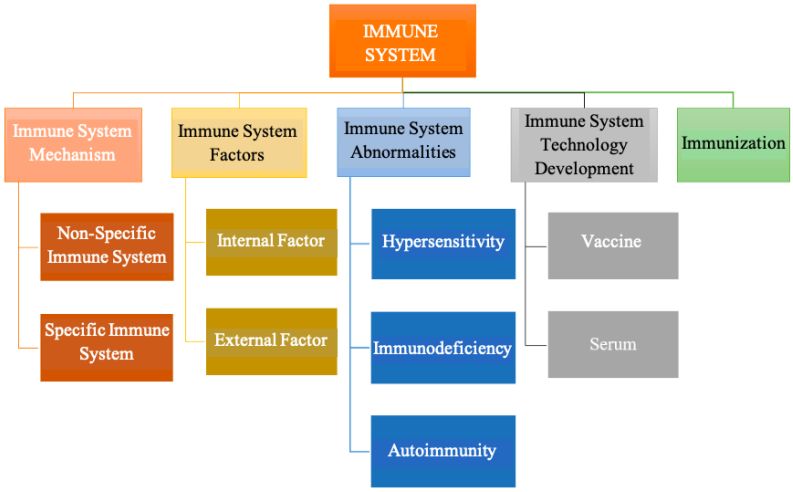


Fig. 4. Immune System Learning Topic Hierarchy in DFI Media.

The immune system content in Figure 4 was arranged in order and interesting as a reference to create story board. The story board was created using Microsoft PowerPoint 2010 Application. The application was selected since it has various features that support DFI model concept creation. The storyboard creation became an important thing as a basis in developing a learning medium.

3.3 Develop

Several activities conducted in the development stage included DFI development, media validation by three biology education experts, and small group trial to ten students. The DFI development was started with creating supporting media, such as teaching content text, model pictures, and animation videos. The media supporting creation was done using Microsoft PowerPoint 2010 and Movavi Video Editor 14 applications. Next, all supporting media were compiled into a Digital Flipbook using Flip PDF Professional application. The Flipbook Imunopedia displays are indicated in Figure 5.

Fig. 5. Flipbook Imunopedia Display

Once the media were completed, validation was conducted to assess the media feasibility in learning process. Media validation was assessed in three main aspects, namely: content aspect, media aspect, and language aspect. The media validation carried out by three biology education experts. The assessment results of the three validators were divided into three aspects: content, media, and language aspects.

Content Aspect: The content aspect assessment referred to basic competences, learning objectives, and learning indicators in accordance with the Indonesian national education standard containing in the DFI. The assessment results in the content aspect are presented in Table 5.

Table 5. Validation Results in DFI Immune System Content Aspect by Experts.

No	Statements	Expert 1	Expert 2	Expert 3	Average
1	Suitability of the Flipbook Imunopedia content to content competences, basic competences and the current curriculum.	3.00	3.00	3.00	3.00
2	Clearly outlines the basic competences content of the immune system.	3.00	4.00	3.00	3.33
3	Suitability of the Flipbook Imunopedia content to immune system learning objectives.	3.00	4.00	3.00	3.33
4	The Flipbook Imunopedia contains skill aspect in the core competences and basic competences.	3.00	3.00	3.00	3.00
5	The Flipbook Imunopedia indicates examples of immune system application in accordance with the basic competences.	3.00	4.00	3.00	3.33
6	Accuracy of picture and video illustration in the	3.00	4.00	3.00	3.33

	Flipbook Imunopedia to the immune system concepts.				
7	Suitability of exercise questions to the immune system concepts containing in the Flipbook Imunopedia.	3.00	2.00	3.00	2.67
8	The use of standard words in the Flipbook Imunopedia.	3.00	3.00	3.00	3.00
9	Suitability to thinking development level of senior high school students in Grade 11.	3.00	4.00	3.00	3.33
10	Accuracy of structure and grammar (no typo).	3.00	3.00	3.00	3.00
11	Accuracy in using biology terms.	3.00	4.00	3.00	3.33
12	The immune system content elaboration is in accordance with the current immunology development.	2.00	3.00	3.00	2.67
13	Question exercises include all core competences and basic competences.	3.00	2.00	3.00	2.67
14	Effectiveness of picture illustration in the immune system concept visualization.	2.00	4.00	3.00	3.00
15	Suitability of videos in the immune system concept mechanism visualization.	3.00	3.00	3.00	3.00
16	Diversity of concept presentation in various interesting features.	3.00	4.00	3.00	3.33
17	Diversity of scientific facts related to the immune system content.	3.00	3.00	3.00	3.00
18	Diversity of exercise question types on the Flipbook Imunopedia.	3.00	2.00	3.00	2.67
19	Picture and video model are in accordance with thinking development skills of senior high school students in Grade 11.	3.00	4.00	3.00	3.33
20	It encourages students' activeness in learning.	2.00	3.00	3.00	2.67
Average		2.85	3.30	3.00	3.05
Category		Valid	Valid	Valid	Valid

Based on the above figure, the DFI media according to the content aspect were valid with a little revision based on validator inputs. The average result of the immune system content aspect in the DFI was 3.05. Based on the category [67] the content aspect in the DFI media was in valid category. The DFI revision was conducted by referring to comments and suggestion from website address expert, supporting journals of immune system content and improvement in question exercise features. There were two inputs and comments from the immune system contents on the DFI, as follows.

It needs to add current issues on abnormalities, disorders, and diseases on immune system. For example, lupus, etc. (Expert 1).

Cognitive, affective, and psychomotor aspects have been empowered in the media, although the cognitive aspect is more dominant (Expert 2)

Based on the experts' assessment and inputs, the DFI learning media improvement carried out on disorders, abnormalities, and diseases in the immune system that were included in the end part of the media content. Students needed to study disorders, abnormalities, and diseases in human anatomy and physiology system learning to be a wise and grateful person and able to maintain their health well [10]. Learning packed

in media should consider three aspects, namely: knowledge, attitude, and skills [7], [77].

Media Aspect: The media feasibility assessment was performed to learn the quality of composition and features on the DFI. The media feasibility assessment results could be seen in Table 6.

Table 6. DFI Media Validation Test Results in Language Aspect by the Experts.

No	Statements	Expert 1	Expert 2	Expert 3	Average
1	Background and feature layout selection of the Flipbook Imunopedia in general.	2.00	3.00	3.00	2.67
2	Appropriateness of color composition on the Flipbook Imunopedia.	2.00	3.00	3.00	2.67
3	Diversity of picture illustration supporting the content concept visualization.	3.00	4.00	3.00	3.33
4	Diversity of pictures supporting the immune system content in the Flipbook Imunopedia.	3.00	4.00	3.00	3.33
5	Diversity of videos in the Flipbook Imunopedia.	3.00	4.00	3.00	3.33
6	Diversity of presentation of website addresses on immune system additional content material.	3.00	3.00	3.00	3.00
7	Uniqueness of each page display on the Flipbook Imunopedia.	2.00	3.00	3.00	2.67
8	Diversity of features that trigger students' curiosity.	3.00	3.00	3.00	3.00
9	Appropriateness of font type and size selection thus it has good readability.	2.00	3.00	3.00	2.67
10	Use of sentences is in accordance with Bahasa Indonesia general guidance.	3.00	3.00	3.00	3.00
11	Accuracy of words or sentences writing (no typo).	3.00	3.00	3.00	3.00
12	Picture quality does not broken when it enlarged.	3.00	3.00	3.00	3.00
13	Correctness of picture and video layout on the flipbook imunopedia.	3.00	3.00	3.00	3.00
14	Video and sound quality is not broken and smooth when it displays.	2.00	3.00	3.00	2.67
15	Accuracy in presenting website addresses with the destination website .	3.00	3.00	3.00	3.00
Average		2.67	3.20	3.00	2.96
Category		Valid	Valid	Valid	Valid

The media feasibility test results by the three experts indicated an average score of 2.96. Based on the category [67], the media aspect of the DFI media was in valid category. The expert assessment also provided inputs and comments. Several examples of important inputs related to DFI media is as follows.

On the front page should provide information or guide related to DFI direction for use to optimize application in the biology learning. Direction for use should also be provided on how to open the book, how to play video, books could be move forward or backward, and other technical information (Expert 2).

Color selection is still dominated by one color, light blue. It makes the DFI monotonous. Stronger color combination or color based on sub-topic in the immune system content should be applied (Expert 1).

Videos presented on the media should include the source (Expert 2)

Language Aspect: The language aspect was assessed based on the use of sentences and biology terms written on the DFI learning media. The language aspect validation results are indicated in Table 7.

Table 7. DFI Media Validation Test Results in Language Aspect by the Experts.

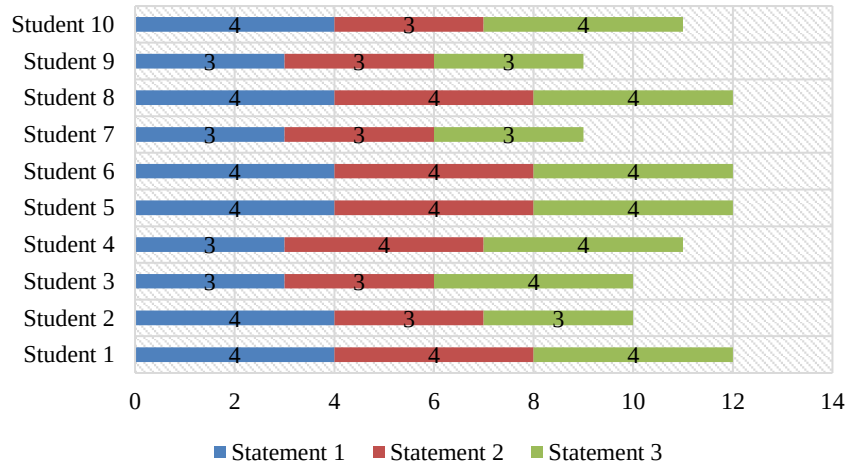
No	Statements	Expert 1	Expert 2	Expert 3	Average
1	Sentences used do not have a double meaning.	3.00	3.00	3.00	3.00
2	The use of sentences is in accordance with thinking level of senior high school students in Grade 11.	3.00	3.00	3.00	3.00
3	There is diversity of inductive and deductive paragraphs.	3.00	3.00	3.00	3.00
4	The correctness of font size and type selection.	2.00	3.00	3.00	2.67
5	The correctness of font size and type selection in source writing.	3.00	3.00	3.00	3.00
6	The correctness of font size and type selection in pictures and videos explanation.	3.00	3.00	3.00	3.00
7	The use of clear sentences without double meaning.	3.00	3.00	3.00	3.00
8	The suitable of sentence writing to the correct and appropriate Bahasa Indonesia.	3.00	3.00	3.00	3.00
9	The appropriateness of biology terms utilization.	3.00	3.00	3.00	3.00
10	The use o clear and understandable roman symbols.	3.00	3.00	3.00	3.00
11	Consistent use of terms and sentences.	3.00	3.00	3.00	3.00
12	Consistent use of symbols in sentences.	3.00	3.00	3.00	3.00
13	The use of sentences that trigger students' curiosity.	2.00	3.00	3.00	2.67
Average		2.85	3.00	3.00	2.95
Category		Valid	Valid	Valid	Valid

The assessment of DFI media language aspect from the three experts had average of 2.95. According to feasibility category [67], the DFI media feasibility in the language aspect was valid. Some inputs and suggestions from the biology education experts on the DFI media are as follows.

"There are several parts with smaller font size and the use of sentences that trigger students' curiosity" (Expert 1).

Referring to the comment, the media was enhanced by considering font size and type and improving sentences that could encourage students' curiosity. Good learning media content could assist students to develop their cognitive skills through curiosity enhancement [78]. Students' curiosity provide good contribution to the attainment of learning achievement [79].

Once the media was improved by referring to the biology education experts' assessment and inputs, the next stage would be trial to limited students. The DFI media trial was done to 10 students of Grade 11 of science class in a senior high school of Cibinong, Indonesia. Aspects assessed by the students include content, display, and benefits of the DFI learning media in immune system learning. The trial results and statements question are presented in Figure 6 and Table 8.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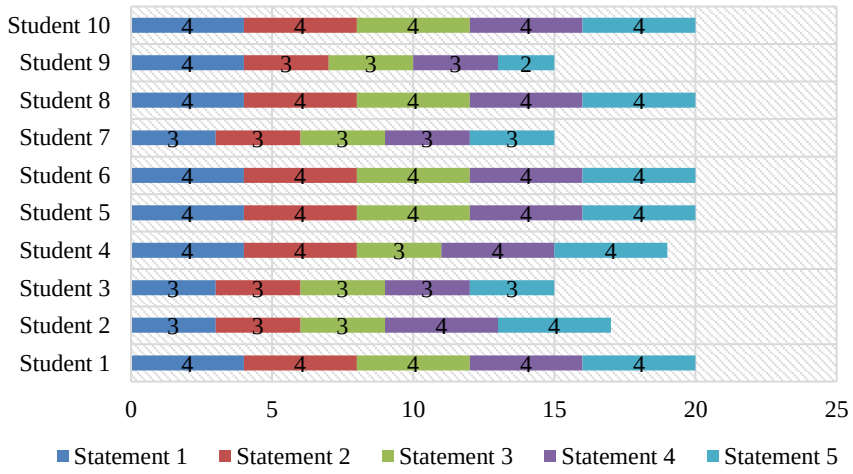
(a)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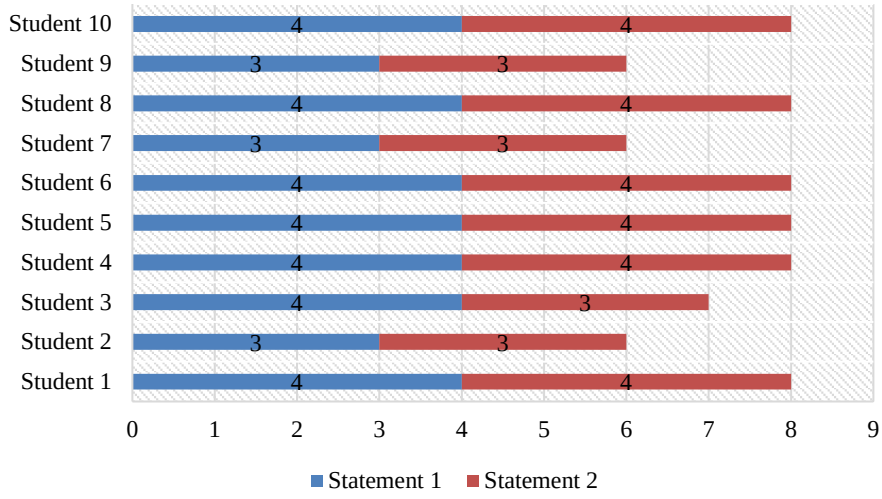
Statement 5

(b)



(c)

Fig. 6. Results of small group trial (n=10), (a) content, (b) display, and (c) DFI benefits.

Table 8. List of statements on the small group test.

No	Statement
	Content of DFI
1	Material on DFI presented systematically.
2	The content on DFI is following the concept.
3	DFI media is easy to use.
	Display of DFI
1	Display DFI media according to layout, color, shape, and size.
2	Attractive DFI media display.
3	DFI media can be read properly.
4	Language on DFI media is easy to understand.
5	The DFI media is easy to use.
	Benefits of DFI
1	The DFI media can increase motivation in learning the immune system.
2	The DFI media can increase knowledge of the concept of the immune system

The results of DFI media trial on 10 students obtained an average of content aspect (3.60), display (3.62), and media benefits (3.65). Based on the category [67], the small group trial was categorized as very valid in the three aspects. Students also provided arguments that diversity in content presentation in the DFI media that strengthened by pictures and videos and questions facilitated respondents in mastering the immune system concept.

4 Conclusion

The DFI learning media development was valid. The average of validation results by experts obtained content aspect (3.05) in feasible category, media aspect (2.96) in feasible category, and language aspect (2.95) in feasible aspect. The results of DFI learning media trial on small group that involved 10 students resulted in a very valid category in the three aspects, namely content (3.60), display (3.62), and media benefits (3.65). Flipbook learning media on biology and science learning have been developed [50], [51], [63]. This learning media contributes to the solution to the availability of learning media for the immune system that is not currently available. Good distribution of the immune system content in the learning media will facilitate students to master the immune system concept. The DFI learning media development had met the feasibility aspects of a learning medium. Learning biology related to physiological processes such as the body's defense response mechanism against pathogens cannot be directly observed by students (Wulandari, Herlita, & Nurmiyati, 2020). This DFI learning media helps students to be able to analyze the body's mechanisms through pictures and videos equipped with explanations in the form of sound and text. Several things to be considered in the DF development with Flip PDF Professional application were related to the necessity to prepare many picture models and more varied written content. Therefore, the media could be well arranged so that functions of each DFI feature could run maximally. At the stage of analysis, students found fundamental misconceptions about the definition of the immune system. Misconceptions that occur in students can result in students' cognitive development being constrained in studying biology further [80], [81]. A trial to larger student group should be done to find out the effectiveness of the DFI learning media.

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6 References

[1] Machali, I. (2014). Kebijakan perubahan kurikulum 2013 dalam menyongsong Indonesia emas tahun 2045. *Jurnal Pendidikan Islam*,*3*(1),71. https://doi.org/10.14421/jpi.2014.31.71-94

[2] Supriyatin, Rahayu, S., Ristanto, R. H., & Ichsan, I. Z. (2019). Improving hots in biology learning: A supplement book of plant growth and development. *Universal Journal of EducationalResearch*,*7*(12),2642–2646. https://doi.org/10.13189/ujer.2019.071211

[3] Miarsyah, M., & Ristanto, R. H. (2019). Memberdayakan keterampilan mengembangkan soal hots pada guru biologi di kabupaten bekasi. *BAKTIMAS : Jurnal Pengabdian Pada Masyarakat*,*1*(4),151–159. Retrieved from https://ojs.serambimekkah.ac.id/index.php/BAKTIMAS/article/view/1718
[4] Ristanto, R. H., & Djamahar, R. (2019). Penguatan keterampilan penilaian autentik guru ipa biologi di kabupaten bogor. *BAKTIMAS : Jurnal Pengabdian Pada Masyarakat*, *1*(1), 61–69. https://doi.org/10.32672/btm.v1i1.1183
[5] Styers, M. L., Van Zandt, P. A., & Hayden, K. L. (2018). Active learning in flipped life science courses promotes development of critical thinking skills. *CBE Life Sciences Education*, *17*(3), 1–13. https://doi.org/10.1187/cbe.16-11-0332
[6] Ören, F. Ş. (2011). An analysis of pre-service teachers' drawings about the digestive system in terms of their gender, grade levels, and opinions about the method and subject. *International Journal of Biology Education*, *1*(1), 1–22.
[7] Sungur, S., Tekkaya, C., & Geban, Ö. (2006). Improving achievement through problem-based learning. *Journal of Biological Education*,*40*(4),155–160. https://doi.org/10.1080/00219266.2006.9656037
[8] Hatina, J., Kripnerova, M., Khazov, N., Krimpeni, M. S., Drbal, K., & Schwarz, S. (2019). Molecules of life and mutations: a new course of advanced pathophysiology combining several modern didactic approaches. *Advances in Physiology Education*, *43*(4), 537–540. https://doi.org/10.1152/advan.00071.2019
[9] Durand, M. de T., Restini, C. B. A., Wolff, A. C. D., Faria Jr., M., Couto, L. B., & Bestetti, R. B. (2019). Students' perception of animal or virtual laboratory in physiology practical classes in PBL medical hybrid curriculum. *Advances in Physiology Education*, *43*(4), 451–457. https://doi.org/10.1152/advan.00005.2019
[10] Rao, S. P., & DiCarlo, S. E. (2017). Active learning of respiratory physiology improves performance on respiratory physiology examinations. *Advances in Physiology Education*, *25*(2),55–61. https://doi.org/10.1152/advances.2001.25.2.55
[11] López-Manjón, A., & Angón, Y. P. (2009). Representations of the human circulatory system. *Journal of Biological Education*,*43*(4),159–163. https://doi.org/10.1080/00219266.2009.9656176
[12] Klymkowsky, M. W., Garvin-Doxas, K., & Zeilik, M. (2003). Bioliteracy and Teaching Efficacy: What Biologists Can Learn from Physicists. *Cell Biology Education*. https://doi.org/10.1187/cbe.03-03-0014
[13] Aydın, S. (2016). To what extent do Turkish high school students know about their body organs and organ systems? *Journal of Human Sciences*, *13*(1), 1094–1106. https://doi.org/10.14687/ijhs.v13i1.3498
[14] Sartono, N., Rusdi, R., & Handayani, R. (2018). Pengaruh pembelajaran process oriented guided inquiry learning (pogil) dan discovery learning terhadap kemampuan berpikir analisis siswa sman27 Jakarta pada materi sistem imun. *Biosfer: Jurnal Pendidikan Biologi*,*10*(1),58–64. https://doi.org/10.21009/biosferjpb.10-1.8
[15] Puspita, A., Kurniawan, A. D., & Rahayu, H. M. (2017). Pengembangan media pembelajaran booklet pada materi sistem imun terhadap hasil belajar siswa kelas xi sman 8 Pontianak.*JurnalBioeducation*,*4*(1),64–73. https://doi.org/10.29406/524
[16] Rosandali, F., Aziz, R., & Suharti, N. (2016). Hubungan antara Pembentukan Scar Vaksin BCG dan Kejadian Infeksi Tuberkulosis. *Jurnal Kesehatan Andalas*, *5*(2), 381–384. https://doi.org/10.25077/jka.v5i2.526
[17] Aripin, I. (2019). Pendidikan nilai pada materi konsep sistem imun. *Jurnal Bio Educatio*, *4*(1),1–11. Retrieved from https://www.jurnal.unma.ac.id/index.php/BE/article/viewFile/1297/1207
[18] Lazarowitz, R., & Penso, S. (1992). High school students' difficulties in learning biology concepts.*JournalofBiologicalEducation*,*26*(3),215–223. https://doi.org/10.1080/00219266.1992.9655276

[19] Kholifah, A. N., Rinanto, Y., & Ramli, M. (2015). Kajian penerapan model guided discovery learning disertai concept map terhadap pemahaman konsep siswa sma kelas xi pada materi sistem imun. *Bio-Pedagogi*,*4*(1),12–18. https://doi.org/10.31849/bl.v2i2.322
[20] Raved, L., & Yarden, A. (2014). Developing seventh grade students systems thinking skills in the context of the human circulatory system. *Frontiers in Public Health*, *2*(December), 1–11. https://doi.org/10.3389/fpubh.2014.00260
[21] Chavan, R. (2018). Perception of biological concepts among higher secondary teachers : a study. *Aarhat Multidisciplinary International Education Research Journal*, *7*(23), 144–153.
[22] Crowe, A., Dirks, C., & Wenderoth, M. P. (2008). Biology in bloom: Implementing Bloom's taxonomy to enhance student learning in biology. *CBE Life Sciences Education*, *7*, 368–381. https://doi.org/10.1187/cbe.08-05-0024
[23] Lestari, P., Ristanto, R., & Miarsyah, M. (2019). Analysis of conceptual understanding of botany and metacognitive skill in pre-service biology teacher in Jakarta, Indonesia. *Journal fortheEducationofGiftedYoungScientists*,*7*(2),199–214. https://doi.org/10.17478/jegys.515978
[24] Kristiani, E., Ristanto, R. H., & Lisanti, E. (2020). Exploring gender-based biological concepts: an analysis of bilingual secondary school students. *Biosfer : Jurnal Pendidikan Biologi*,*13*(1),1–13. https://doi.org/10.21009/biosferjpb.v13n1.1-13
[25] Papadakis, S., & Kalogiannakis, M. (2018). Using gamification for supporting an introductory programming course. The case of classcraft in a secondary education classroom. In Interactivity, game creation, design, learning, and innovation. In *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST* (pp. 366–375). https://doi.org/10.1007/978-3-319-76908-0_35
[26] Ristanto, R. H., Miarsyah, M., Luthfi, I. A., Kristiani, E., & Hasanah, R. (2020). Invertebrate-interactive dichotomous key media: Enhance students learning motivation in lower secondary school. *International Journal of Information and Education Technology*, *10*(9),669–673. https://doi.org/10.18178/ijiet.2020.10.9.1441
[27] Dahri, A. S., Al-Athwari, A., & Hussain, A. (2019). Usability evaluation of mobile health application from AI perspective in rural areas of Pakistan. *International Journal of InteractiveMobileTechnologies*,*13*(11),213–225. https://doi.org/10.3991/ijim.v13i11.11513
[28] Djamahar, R., Ristanto, R. H., Sartono, N., Ichsan, I. Z., Darmawan, E., & Muhlisin, A. (2019). Empowering Student's Metacognitive Skill Through Cirsa Learning. *Journal of Physics:ConferenceSeries*,*1227*(1),012034. https://doi.org/10.1088/17426596/1227/1/012034
[29] El-Sofany, H. F., & El-Haggar, N. (2020). The effectiveness of using mobile learning techniques to improve learning outcomes in higher education. *International Journal of Interactive Mobile Technologies*,*14*(8),4–18. https://doi.org/10.3991/IJIM.V14I08.13125
[30] Pratama, A. T. (2019). Improving metacognitive skills using problem based learning (pbl) at natural science of primary school in deli serdang, indonesia. *Biosfer : Jurnal Pendidikan Biologi*,*12*(2),238–248. https://doi.org/10.21009/biosferjpb.v12n2.238248.10.21009/biosferjpb.v12n2.238-248 https://doi.org/10.21009/biosferjpb.v11n2.101-107
[31] Akyol, G., Sungur, S., & Tekkaya, C. (2010). The contribution of cognitive and metacognitive strategy use to students' science achievement. *Educational Research and Evaluation*,*16*(1),1–21. https://doi.org/10.1080/13803611003672348
[32] Widiansyah, A. T., Indriwati, S. E., Munzil, M., & Fauzi, A. (2018). I-invertebrata as an android-based learning media for molluscs, arthropods, and echinoderms identification and its influence on students' motivation. *Jurnal Pendidikan Biologi Indonesia*, *4*(1), 43. https://doi.org/10.22219/jpbi.v4i1.5476

[33] Miarsyah, M., Ristanto, R. H., Nurhayati, Mufida, S. N., Suparini, & Zharroh, A. E. (2020). Development of adobe flash media integrated into HOTS on circulation system (AF-HOTS bicycle media). *International Journal of Advanced Trends in Computer Science and Engineering*,*9*(1),896–903. https://doi.org/10.30534/ijatcse/2020/128912020

[34] Azer, S. A. (2015). Is wikipedia a reliable learning resource for medical students? evaluating respiratory topics. *Advances in Physiology Education*,*39*(1),5–14. https://doi.org/10.1152/advan.00110.2014

[35] Azka, S. H. M., Indriyanti, D. R., & Widianti, T. (2016). Keefektifan media pembelajaran "si imut" berbasis masalah materi sistem imun terhadap sikap peka dan peduli keselamatan diri dan lingkungan siswa. *Journal of Biology & Biology Education*, *5*(024), 3–4.

[36] Rosamsi, S., Miarsyah, M., & Ristanto, R. H. (2019). Interactive multimedia effectiveness in improving cell concept mastery. *Journal of Biology Education*, *8*(1), 56–61. Retrieved from https://journal.unnes.ac.id/sju/index.php/ujbe/article/view/28154/13099

[37] Ristanto, R. H., Miarsyah, M., Muharomah, D. R., Astuti, T. A., Aini, S., & Prihatin, A. I. (2020). Light-board: Simple media to learn photosynthesis concepts. *International Journal of Advanced Trends in Computer Science and Engineering*, *9*(1), 299–303. https://doi.org/10.30534/ijatcse/2020/45912020

[38] Sharma, N., Colucci-Gray, L., Siddharthan, A., Comont, R., & Van Der Wal, R. (2019). Designing online species identification tools for biological recording: The impact on data quality and citizen science learning. *PeerJ*, *2019*(1), 1–24. https://doi.org/10.7717/peerj.5965

[39] Inayah, A. D., Ristanto, R. H., Sigit, D. V., & Miarsyah, M. (2020). Analysis of science process skills in senior high school students. *Universal Journal of Educational Research*, *8*(4A),15–22. https://doi.org/10.13189/ujer.2020.081803

[40] Wahyuni, S., Erman, Sudikan, S. Y., & Jatmiko, B. (2020). Edmodo-based interactive teaching materials as an alternative media for science learning to improve critical thinking skills of junior high school students. *International Journal of Interactive Mobile Technologies*,*14*(9),166–181. https://doi.org/10.3991/ijim.v14i09.13041

[41] Stewart, J. H. (2012). Difficulties experienced by high school students when learning basic mendeliangenetics.*TheAmericanBiologyTeacher*,*44*(2),80–89. https://doi.org/10.2307/4447413

[42] Lee, Y. H., & Wu, J. Y. (2012). The effect of individual differences in the inner and outer states of ICT on engagement in online reading activities and PISA 2009 reading literacy: Exploring the relationship between the old and new reading literacy. *Learning and Individual Differences*. https://doi.org/10.1016/j.lindif.2012.01.007

[43] Permana, F. H., & Chamisijatin, L. (2018). Project-based learning through edmodo: improving critical thinking and histology concepts. *Biosfer : Jurnal Pendidikan Biologi*, *11*(1),58–69. https://doi.org/10.21009/biosferjpb.v11n2.90-100 https://doi.org/10.21009/biosferjpb.v12n1.58-69

[44] Kostova, Z., & Radoynovska, B. (2010). Motivating students' learning using word association test and concept maps. *Bulgarian Journal of Science & Education Policy*, *4*(1), 62–98. Retrieved from http://proxy.libraries.smu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=51301136&site=ehost-live&scope=site

[45] Cosme, L., Turchen, L. M., & Guedes, R. N. C. (2020). Insect world: game-based learning as a strategy for teaching entomology. *The American Biology Teacher*, *82*(4), 210–215. https://doi.org/10.1525/abt.2020.82.4.210

[46] Jenkinson, J., & McGill, G. (2012). Visualizing protein interactions and dynamics: evolving a visual language for molecular animation. *CBE Life Sciences Education*, *11*(1), 103–110. https://doi.org/10.1187/cbe.11-08-0071

[47] Ismirawati, N., Corebima, A. D., Zubaidah, S., Ristanto, R. H., & Nuddin, A. (2020). Implementing ERCoRe in learning : will metacognitive skills correlate to cognitive

learning result? *Universal Journal of Educational Research*, *8*(4A), 51–58. https://doi.org/10.13189/ujer.2020.081808

[48] Vidakis, N., Barianos, A. K., Trampas, A. M., Papadakis, S., Kalogiannakis, M., & Vassilakis, K. (2019). Generating education in-game data: The case of an ancient theatre serious game. In *CSEDU 2019 - Proceedings of the 11th International Conference on Computer Supported Education*(pp.36–43). https://doi.org/10.5220/0007810800360043

[49] Papadakis, S. (2020). Evaluating a game-development approach to teach introductory programming concepts in secondary education. *International Journal of Technology Enhanced Learning*,*12*(2),127–145. https://doi.org/10.1504/IJTEL.2020.106282

[50] Amiyanti, R., Ningsih, K., & Yokhebed. (2018). Pengaruh model kooperatif berbantuan media flipbook terhadap hasil belajar siswa kelas x SMAN 3 materi bakteri. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, *7*(8), 1–9. Retrieved from http://jurnal.untan.ac.id/index.php/jpdpb/article/view/27062/75676577671 https://doi.org/10.23887/jipp.v2i2.15607

[51] Maf'ula, A., Hastuti, U. S., & Rohman, F. (2017). Pengembangan media flipbook pada materi daya antibakteria tanaman berkhasiat obat. *Jurnal Teori, Penelitian, Dan Pengembangan*, *2*(11), 1450–1455.

[52] Kalogiannakis, M., & Papadakis, S. (2019). Evaluating pre-service kindergarten teachers' intention to adopt and use tablets into teaching practice for natural sciences. *International Journal of Mobile Learning and Organisation*, *13*(1), 113–127. https://doi.org/10.1504/IJMLO.2019.096479 https://doi.org/10.1504/ijmlo.2019.10016617

[53] Qian, K., Owen, N., & Bax, S. (2018). Researching mobile-assisted Chinese-character learning strategies among adult distance learners. *Innovation in Language Learning and Teaching*,*12*(1),56–71. https://doi.org/10.1080/17501229.2018.1418633

[54] Chaiyo, Y., & Nokham, R. (2017). The effect of Kahoot, Quizizz and Google Forms on the student's perception in the classrooms response system. In *2nd Joint International Conference on Digital Arts, Media and Technology 2017: Digital Economy for Sustainable Growth,ICDAMT2017*(pp.178–182). https://doi.org/10.1109/ICDAMT.2017.7904957

[55] Al-Kinani, M. N. H., Adetunmbi, S. B., & Hussain, A. (2020). Usability testing of mobile flipboard application on both non-users and novice users. *International Journal of Interactive Mobile Technologies*,*14*(5),47–56. https://doi.org/10.3991/IJIM.V14I05.13341

[56] Papadakis, S. (2018). Evaluating pre-service teachers' acceptance of mobile devices with regards to their age and gender: A case study in Greece. *International Journal of Mobile Learning and Organisation*, *12*(4), 336–352. https://doi.org/10.1504/IJMLO.2018.095130 https://doi.org/10.1504/ijmlo.2018.10013372

[57] Papadakis, S., Kalogiannakis, M., Sifaki, E., & Vidakis, N. (2018a). Access moodle using smart mobile phones. A case study in a greek university. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, *229*,376–385. https://doi.org/10.1007/978-3-319-76908-0_36

[58] Septiyana, K., Prasetyo, A. P., & Chrisjanti, W. (2013). Jurnal belajar sebagai strategi berpikir metakognitif pada pembelajaran sistem imunitas. *Unnes Journal of Biology Education*,*2*(1),1–9. Retrievedfrom http://journal.unnes.ac.id/sju/index.php/ujeb

[59] Wulandari, R. I., Herlita, & Nurmiyati. (2020). Pengembangan media pembelajaran laboratorium virtual berbasis discovery learning materi sistem imun kelas XI MIPA. *Media Penelitian Pendidikan: Jurnal Penelitian Dalam Bidang Pendidikan Dan Pengajaran*, *14*(1),61–70.Retrievedfrom http://103.98.176.9/index.php/mediapenelitianpendidikan/article/view/5640/3221 https://doi.org/10.26877/mpp.v14i1.5640

[60] Mulyadi, D., Wahyuni, S., & Handayani, R. (2016). Pengembangan media flash Flipbook Untuk Meningkatkan Keterampilan Berfikir Kreatif Siswa Dalam Pembelajaran Ipa Di Smp.*JurnalPembelajaranFisika*,*4*(4),296–301.Retrievedfrom

https://jurnal.unej.ac.id/index.php/JPF/article/view/2728 https://doi.org/10.33394/j-lkf.v3i1.348
[61] Bray Speth, E., Long, T. M., Pennock, R. T., & Ebert-May, D. (2009). Erratum to:Using Avida-ED for Teaching and Learning About Evolution in Undergraduate Introductory Biology Courses. *Evolution: Education and Outreach*,*2*(4),742–742. https://doi.org/10.1007/s12052-009-0169-5
[62] Rizki, G. H., Budiharto, I., & Sukarni. (2013). Hubungan pemberian air susu ibu (ASI) dengan kejadian diare diare pada bayi 0-6 bulan di Puskesmas Kampung Dalam Pontianak Timur. *Jurnal Proners*,*3*(1),1–10. https://doi.org/10.26630/jk.v7i3.217
[63] Hayati, S., Budi, A. S., & Handoko, E. (2015). Pengembangan Media Pembelajaran Flipbook Fisika untuk Meningkatkan Hasil Belajar Peserta Didik. *Prosiding Seminar NasionalFisika(e-Jurnal)SNF2015*,*IV*,49–54. https://doi.org/10.21009/03.snf2019.01.pe.24
[64] Darmawan, M., Surya, M., & Jamilah. (2018). Adaptation of ADDIE instructional model in developing educational website for language learning. *Global Journal Al-Thaqafah*, *8*(2), 7–16.
[65] Roth, C. E. (2008). Paul F-Brandwein lecture 2006: Conservation education for the 21st century and beyond. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-006-9023-5
[66] Papadakis, S., & Kalogiannakis, M. (2019). Evaluating a course for teaching introductory programming with Scratch to pre-service kindergarten teachers. *International Journal of TechnologyEnhancedLearning*,*11*(3),231–246. https://doi.org/10.1504/IJTEL.2019.100478
[67] Ratumanan, T. G., & Laurens, T. (2011). *Evaluasi Hasil Belajar Tingkat Satuan Pendidikan*. Surabaya: UNESA Press.
[68] Papadakis, S., Kalogiannakis, M., Sifaki, E., & Vidakis, N. (2018b). Evaluating Moodle use via Smart Mobile Phones. A case study in a Greek University. *EAI Endorsed Transactions on Creative Technologies*, *5*(16), 1–9. https://doi.org/10.4108/eai.10-4-2018.156382
[69] Spencer, S. J., Galic, M. A., & Pittman, Q. J. (2011). Neonatal programming of innate immune function. *American Journal of Physiology - Endocrinology and Metabolism*, *300*(1). https://doi.org/10.1152/ajpendo.00516.2010
[70] Spicer, J. I., & Stratford, J. (2001). Student perceptions of a virtual field trip to replace a real field trip. *Journal of Computer Assisted Learning*, *17*(4), 345–354. https://doi.org/10.1046/j.0266-4909.2001.00191.x
[71] Yirmiya, R., & Goshen, I. (2011). Immune modulation of learning, memory, neural plasticity and neurogenesis. *Brain, Behavior, and Immunity*, *25*(2), 181–213. https://doi.org/10.1016/j.bbi.2010.10.015
[72] Karina, A. N., & Warsito, B. E. (2012). Pengetahuan Ibu Tentang Imunisasi Dasar Balita. *Diponegoro Journal of Nursing*, *1*(1), 30–35.
[73] Noviyanti, E., Rusdi, R., & Ristanto, R. H. (2019). Guided discovery learning based on internet and self concept: enhancing student's critical thinking in biology. *Indonesian Journal of Biology Education*,*2*(1),7–14. https://doi.org/10.31002/ijobe.v2i1.1196
[74] Ristanto, R. H. (2011). Pembelajaran biologi berbasis inkuiri terbimbing dengan multimedia dan lingkungan riil terhadap prestasi belajar. *Educatio*, *6*(1), 53–68. Retrieved from http://e-journal.hamzanwadi.ac.id/index.php/edc/article/view/23
[75] Kalogiannakis, M., & Papadakis, S. (2007). The dual form of further education of educators in ICT: technological and pedagogical training. In *C. Constantinou, Z. Zacharias & M. Papaevripidou (Eds.) Proceedings of the 8th International Conference On Computer Based Learning in Science, Heraklion* (Vol. 30, pp. 265–276).
[76] Ristanto, R. H., Djamahar, R., Heryanti, E., & Ichsan, I. Z. (2020). Enhancing students ' biology-critical thinking skill through CIRC-Based scientific approach (Cirsa). *Universal Journal of Educational Research*, *8*(4A), 1–8. https://doi.org/10.13189/ujer.2020.081801 https://doi.org/10.13189/ujer.2020.080602

[77] Seage, S. J., & Türegün, M. (2020). The effects of blended learning on STEM achievement of elementary school students. *International Journal of Research in Education and Science*,*6*(1),133–140. https://doi.org/10.46328/ijres.v6i1.728

[78] Utami, D. N., & Subali, B. (2019). 5E learning cycle combined with mind mapping in the excretory system: effectiveness on curiosity. *Biosfer: Jurnal Pendidikan Biologi*, *13*(1), 130–142. https://doi.org/10.21009/biosferjpb.v13n1.130-142

[79] Nehru, N., & Irianti, E. (2019). Analisis hubungan rasa ingin tahu dengan hasil belajar. *JurnalPembangunanDanPendidikan:FondasiDanAplikasi*,*7*(1),53–59. https://doi.org/10.21831/jppfa.v7i1.25234 https://doi.org/10.21831/jppfa.v6i1.20611

[80] Zulfia, F. A., Susilo, H., & Listyorini, D. (2019). Virus-bacteria diagnostic test (vbd-test) in identifying biology teacher's misconception. *Biosfer: Jurnal Pendidikan Biologi*, *12*(2), 144–156. https://doi.org/10.21009/biosferjpb.v12n2.144-156

[81] Yunanda, I., Susilo, H., & Ghofur, A. (2019). Misconceptions identification on biodiversity and protist using multiple choice open reason (mcor). *Biosfer: Jurnal PendidikanBiologi*,*12*(2),170–181. https://doi.org/10.21009/biosferjpb.v12n2.170-181

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