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SETS-PBL based biology learning: Development of multimedia digital quiz on the cardiovascular system

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Abstract

There is a need for learning media that integrates learning approaches and models that can help students understand the concepts contextually and empower critical thinking and metacognitive skills. The study aims to produce a multimedia digital quiz on the cardiovascular system material that is valid. The research method uses the Thiagarajan model but only at the define, design, and develop stages. The research objects were three lecturers and 30 students. The research instruments were a needs analysis sheet, a Semester Lecture Plan analysis sheet, a validation sheet from material experts, media experts, practitioners, and a readability test sheet. This research data is in the form of validation scores from experts and readability tests. Research data will be analyzed using quantitative descriptive analysis techniques. The research results show that material experts assessed the multimedia digital quiz at 98.64% (strongly valid), media experts at 97.65% (strongly valid), practitioners at 98.29% (strongly valid), and student readability test results at 87.31% (strongly valid). Furthermore, these findings can be recommended for use by lecturers who teach human anatomy and physiology in universities to empower students' critical and metacognitive thinking skills.

Abstrak

Perlunya media pembelajaran yang mengintegrasikan pendekatan dan model pembelajaran untuk membantu siswa memahami konsep secara kontekstual serta memberdayakan kemampuan berpikir kritis dan metakognitif. Penelitian bertujuan untuk menghasilkan kuis digital multimedia pada materi sistem kardiovaskular yang valid. Metode penelitian menggunakan model Thiagarajan namun hanya pada tahap *define, design*, dan *develop*. Objek penelitian adalah tiga dosen dan 30 mahasiswa. Instrumen penelitian adalah lembar analisis kebutuhan, lembar analisis Rencana Perkuliahan Semester, lembar validasi ahli materi, ahli media, praktisi, dan lembar tes keterbacaan. Data penelitian berupa skor validasi dari para ahli dan tes keterbacaan. Data penelitian akan dianalisis menggunakan teknik analisis deskriptif kuantitatif. Hasil penelitian menunjukkan bahwa ahli materi menilai kuis digital multimedia sebesar 98,64% (sangat valid), ahli media sebesar 97,65% (sangat valid), praktisi sebesar 98,29% (sangat valid), dan hasil tes keterbacaan siswa sebesar 87,31% (sangat valid). Lebih lanjut, temuan ini dapat direkomendasikan untuk digunakan oleh dosen pengajar anatomi dan fisiologi manusia di perguruan tinggi untuk memberdayakan kemampuan berpikir kritis dan metakognitif mahasiswa.

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A. Introduction

Educational activities currently lead to the 4.0 industrial revolution where learning is required not only to hone skills and knowledge but to be able to identify sources of skills and knowledge. The nine components of learning in era 4.0, namely 1) the learning process is carried out flexibly with learning so that it is not limited to space and time. 2) Independent learning with the availability of teaching materials or multimedia. 3) Students choose their own way of learning. 4) More on project-based learning that hones the skills they have. 5) Students practice and gain experience when collaborating. 6) Students are able to expose in applying the theory obtained. 7) The assessment aspect emphasizes the learning process and its application. 8) The curriculum is developed according to student needs. 9) Students have freedom in learning (Hussin, 2018). The essence of education in the industrial era 4.0 is as a guideline to improve pedagogical competence and contribute to the use of technology to improve education (Zabidin et al., 2019). Mastery of skills in learning is more meaningful if students' critical and metacognitive thinking skills are developed optimally because the skills, they have can be used to solve problems (Naimnule & Corebima, 2018).

The results of observations in the human physiology anatomy lecture at IKIP Budi Utomo Malang show 1) finding difficulties in accustoming students to hone critical thinking and metacognition skills as seen from the results of student test scores in the 2018/2019 academic year, criterion A is 14%, criterion B as much as 32%, 51% of the criteria C, and 5% obtained a D. 2) The use of appropriate teaching materials and in accordance with the curriculum still reaches 40% of the total material in 2018 learning. 3) Difficulty measuring high-order thinking skills during the learning process and application of the concepts obtained. 4) The unavailability of both manual and digital assessments to measure critical and metacognitive thinking skills in all human physiology anatomy subject matter.

One of the innovations to improve critical thinking and metacognition skills is to develop a human physiological anatomy assessment in the form of a SETS-based digital multimedia quiz (Science, Environment, Technology, and Society). The components of SETS learning are critical social reconstruction, decision-making, action, and sustainability so that they can sharpen critical thinking and metacognition skills (Nisak et al., 2017).

Previous research by Hidayati & Irmawati (2019) focused on developing multimedia with material on human anatomy and physiology by integrating the STEM learning model which aims to improve critical thinking skills. Likewise, research by Prayitno & Hidayati (2020) only focused on developing multimedia with microbiology material and STEM learning models. Research by Anwari et al. (2015) shows that metacognitive abilities can be improved by implementing authentic learning and assessment through STEM. However, this research will develop a digital multimedia quiz by integrating the SETS (Science, Environment, Technology, and Society) approach and the PBL (Problem-Based Learning) learning model, only focusing on the circulatory system material, and providing quizzes that can be used to train students' thinking and metacognition skills. Thus, the purpose of this research is to develop a digital multimedia quiz on human anatomy and physiology based on SETS-PBL to improve critical thinking and metacognitive skills.

B. Material and Method

This type of research is research and development. The development model used is the Thiagarajan model but only at the define, design, and develop stages (Thiagarajan et al., 1974). Meanwhile, the dissemination stage was not carried out simultaneously but was carried out in the next research using quasi-experimental research methods.

The procedure for this development research is as follows. 1) The define stage, front-end analysis activities are carried out through interviews with practitioner lecturers and distribution of questionnaires to students regarding learning human anatomy and physiology, analysis of student characteristics, analysis of tasks and concepts, analysis of objectives, and identification of teaching materials. 2) The design stage, benchmark test activities, format selection, and media selection are carried out. The benchmark test is carried out by arranging the depth of the material according to the indicators in the task and concept analysis and preparing questions based on the objective analysis. The preparation of questions or evaluations is developed from course indicators in the curriculum which are adjusted to indicators of critical thinking and metacognitive abilities. So that the content of the teaching materials developed is in accordance with the needs at the define stage. Format selection is determined based on needs at the define stage. The formats for the learning media developed in the form of digital multimedia quizzes include overviews, student activity sheets, minilabs, materials, e-books, personal abilities, and

interactive quizzes. Media selection is choosing learning media in the form of multimedia because it is able to accommodate all needs at the define stage and the format required for format selection. Multimedia was developed from Macromedia Adobe Flash software which can be accessed using laptops and smartphones. This makes it easier for students to access multimedia anywhere and anytime. 3) The develop stage, digital multimedia quiz assessment activities are carried out by experts (material experts, and media experts), practitioners, readability tests for students, and revisions.

The research objects were lecturers and students of the 2017 and 2018 biology education study program, where the lecturers were the validation experts for the media being developed and the students were the readability test samples for the media being developed. The research instruments used were a needs analysis sheet, a Semester Lecture Plan analysis sheet, validation sheets from three experts such as material experts, media experts, and practitioners, as well as readability test sheets for 30 students. All instruments used have been validated by experts. The time allocation for this research was carried out from March to October 2021.

This research data is in the form of validation scores from experts and readability tests in the form of quantitative data calculated using a formula (Formula 1) and qualitative data such as suggestions and other information. Next, the score data is matched with the learning media validity criteria table (Table 1). Research data will be analyzed using quantitative descriptive analysis techniques.

$$P=\frac{\sum X}{\sum X1} \times 100\% \text{.....Formula 1}$$

Description:
P = Percentage of validity
$\sum X$ = Score obtained for each item
$\sum X1$ = Maximum score on each item
100% = Constant

Table 1 Validation Criteria of the Validity Results and Trials

Validity Value (%)	Validity Criteria	Description
81-100	Strongly valid	Not revise
61-80	Valid	Not revise
41-60	Fairly valid	Revise
21-40	Less valid	Revise
0-20	Strongly not valid	Revise

(Source: Masrur et al., 2017)

C. Results and Discussion

The results of the define stage are divided into five phases, including front-end analysis, analysis of student characteristics, analysis of assignments and concepts, analysis of objectives, and identification of teaching materials. Front-end analysis was carried out by interviewing a lecturer in the human physiology anatomy subject and filling out a questionnaire by students about learning human physiology anatomy.

Based on the results of interviews and questionnaires by students, the main problems in learning human physiology and anatomy related to learning activities can be found. Not yet using a varied learning model so it needs to be integrated between teaching materials and learning models to be more effective in implementing learning in the classroom. Students' thinking skills are still limited to cognitive and affective abilities so learning activities are needed that are able to develop higher-order thinking skills such as critical and metacognitive thinking skills. In the absence of teaching materials that are compatible with the curriculum used, teaching materials do not accommodate learning activities in class because teaching materials are still limited to the material.

The results of the analysis of student characteristics show that students feel bored with the presentation discussion learning activities and want learning activities with the existence of discussion topics in groups discussing environmental and technology issues related to the material being discussed. Students do not have relevant teaching materials or learning resources to support the learning process in the human physiology anatomy course. Students need a contemporary type of learning media equipped with an interactive form of evaluation and accommodating learning activities in class.

The analysis of tasks and concepts was carried out by examining the curriculum in the biology education study program at IKIP Budi Utomo, especially in the human anatomy course. Curriculum analysis is carried out on the semester implementation plan where in the RPS there are study program learning outcomes that are derived into course learning outcomes, and translated into sub-course learning outcomes. The next activity is the identification of teaching materials. Teaching materials that have been used only contain material without learning and evaluation activities that hone students' thinking skills. So there needs to be teaching materials that accommodate the material as well as teach students in class with the integration of existing learning models in teaching materials.

Table 2 Results of Validation by Material Experts

Item	Validity Value (%)	Criteria
Completeness of the material	100	Strongly valid
Material accuracy	91.67	Strongly valid
Presentation of material	100	Strongly valid
Blood Structure	100	Strongly valid
The structure and function of blood vessels	100	Strongly valid
Heart structure	95	Strongly valid
Cardiac Physiology	100	Strongly valid
Blood group	100	Strongly valid
Disorders and diseases	100	Strongly valid

Table 3 Results of Validation by Media Experts

Item	Validity Value (%)	Criteria
Multimedia visualization	100	Strongly valid
Multimedia design	100	Strongly valid
Multimedia Typography	100	Strongly valid
Multimedia Illustration	87.5	Strongly valid
Multimedia Content Design	95	Strongly valid
Typography of Multimedia Contents	100	Strongly valid
Multimedia content illustration	91.67	Strongly valid
Language Eligibility	100	Strongly valid
Completeness of Serving	100	Strongly valid

Table 4 Results of Validation by Practitioners

Item	Validity Value (%)	Criteria
Multimedia design	100	Strongly valid
Completeness of the material	98.07	Strongly valid
Theory	95	Strongly valid
Types of student activities	100	Strongly valid
Questions or questions	100	Strongly valid
Minilab	87.5	Strongly valid
Suitability with student development	100	Strongly valid

Table 5 Student Readability Results

Item	Validity Value (%)	Criteria
Identity	91.67	Strongly valid
Access buttons on features	88.33	Strongly valid
Completeness of contents	86.67	Strongly valid
The usefulness of concept maps	89.17	Strongly valid
Completeness of the material	85.00	Strongly valid
Clarity of illustration	88.33	Strongly valid
Use of language	88.33	Strongly valid
Completeness of the menu	88.33	Strongly valid
Benefit of worksheet	87.50	Strongly valid
The attractiveness of the contents of the worksheet	86.67	Strongly valid
SETS on worksheet	87.50	Strongly valid
The usefulness of the e-book	83.33	Strongly valid
Useful digital Quiz	85.83	Strongly valid
Question form	87.50	Strongly valid
There is a minilab	80.00	Valid
Minilab content	85.83	Strongly valid
Instructions for working on questions	86.67	Strongly valid
Use of question language	85.83	Strongly valid
Interactive form of multimedia	86.67	Strongly valid
The value is immediately known	91.67	Strongly valid

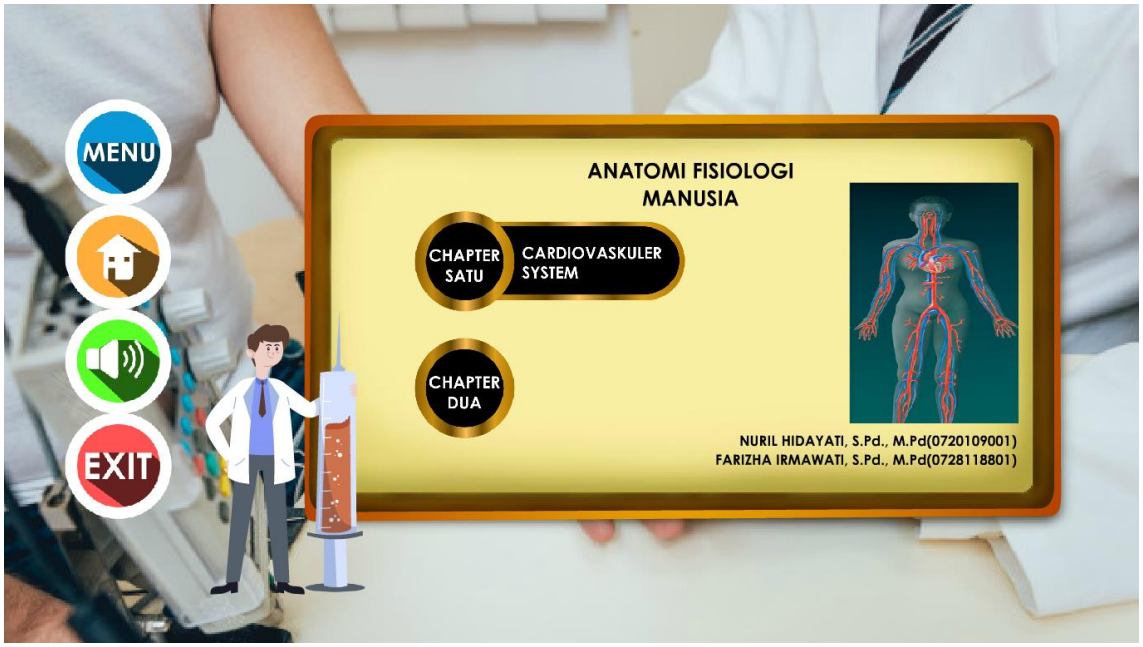

Figure 1 Multimedia Home Screen (in Indonesian and English)

Figure 2 Features in Each Material (in Indonesian and English)

In the define stage, three activities are carried out, namely the benchmark reference test, format selection, and media selection. The benchmark reference test is carried out by compiling the depth of the material according to the indicators in the task and concept analysis and the preparation of questions based on the objective analysis. The preparation of questions or evaluations is developed from indicators of courses in the curriculum that are adjusted to indicators of critical and metacognitive thinking skills. So that the content of the teaching materials developed is in accordance with the needs at the define stage. The results of the preparation of the benchmark reference test are fifteen questions developed from the selected material and indicators of critical and metacognitive thinking skills.

The second activity carried out at the design stage is the format selection. The format is determined based on the needs at the define stage. The format in the learning media developed is the availability of an overview, student activity sheets (LKM), mini-tabs, materials, e-books, self-efficacy, and interactive quizzes. The third activity at the

design stage is media selection. The learning media chosen is in the form of multimedia because it is able to accommodate all the needs at the define stage and the required format in format selection. Multimedia was developed from Macromedia Adobe Flash software which can be accessed using laptops and smartphones.

The next stage is develop which is divided into three parts, namely assessment/multimedia validation by experts (material experts, media experts, and practitioners), legibility testing, and revision. The results of the assessment by material experts, media experts, practitioners, and the legibility test are presented in Table 2, Table 3, Table 4, and Table 5. The form of multimedia developed is presented in Figure 1 and Figure 2.

The implementation of development research is in accordance with the Thiagarajan 4D development model. Define activities are very important to do to get information on the main problems in the human physiology anatomy course. This is in accordance with the opinion of Thiagarajan et al. (1974) that at the define stage, there are findings that reinforce the importance of developing teaching materials. The define stage is very important in development research so that the teaching materials produced are in accordance with the conditions of the user and the curriculum used (Wicaksono, 2018). At the define stage, information will be generated about the advantages and disadvantages of learning (Prayitno & Hidayati, 2017).

Based on the results obtained at the develop stage, shows that the multimedia digital quiz assessment developed meets the very appropriate criteria in accordance with the assessment by material experts, media experts, and practitioners. The results of student responses through the readability test also showed the same thing that the multimedia digital quiz assessment developed received positive responses and met the eligibility criteria as good teaching material. This is in accordance with the opinion of Maria et al. (2019) that multimedia that shows an attractive appearance, the appropriate size, a pleasing menu layout, and appropriate visualization of images and videos will make it easier for users to understand. Good multimedia must be able to combine the right text, images, sound, video, and evaluation so that it can attract the attention of users (Muchlis & Putra, 2017; Andersen, 2015).

The results of the expert's assessment of the multimedia digital quiz assessment are positive and show that multimedia can be used in learning based on existing content in multimedia. This is in accordance with the opinion of Bahri et al. (2016) that the material in a teaching material must have the correctness of the concept. Material content in multimedia must contain concepts that have been tested for credibility and accuracy (Azizah et al., 2018).

The innovative learning approach is one of the important things in developing students' thinking skills. Science, environment, technology, and society is an approach that integrates the concept of knowledge to solve problems related to the environment and society which is supported by the development of technology. The SETS approach aims to teach concepts in a contextual manner. Students are faced with the surrounding situation to apply the concepts learned in the form of technology for the benefit of society. These learning activities are able to stimulate thinking knowledge (Suriyanto & Alinata, 2016).

The module using the SETS approach is able to improve collaborative problem-solving skills in junior high school students in Jember (Tamimiya et al., 2017). Science process skills can be improved through the use of SETS-based modules (Hayati et al., 2019). Learning tools developed in accordance with the SETS approach are able to make students very active and be able to improve student learning outcomes (Minarti et al., 2012). SETS-based science learning using interactive multimedia can improve process skills, student activities, and get a positive response from teachers and students (Yulistiana, 2015; Nurmaulita, 2014; Supahar et al., 2017).

Interactive multimedia affects learning outcomes which include cognitive, affective, and psychomotor aspects of students (Gufron et al., 2018). The use of multimedia in learning makes it easier for students and teachers to carry out learning activities by providing animation, image, video, audio, and text features in one unit that can be studied individually and in groups (Munir, 2013). Interactive multimedia with a valid SETS approach can make learning more effective as proven by increasing students' critical thinking skills (Firdaus et al., 2020).

D. Conclusion

Multimedia digital quizzes on cardiovascular system material were declared valid for use in learning from material aspects (98.64%), media aspects (97.65%), practitioner aspects (98.29%), and student readability test results (87.31%). Furthermore, these findings can be recommended for use by lecturers teaching human anatomy and physiology in universities to train and empower students' critical thinking and metacognitive abilities.

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