Implementation of Web Assembly Technology as Visual Learning Media to help High School Students in Human Body System Learning

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Abstract. The aim of this paper is the development of an application learning system for the human body system using Web Assembly technology to help high school students recognize system organs of the human body including general functions and diseases in visual learning. Development of the system using APPED model which consist of five stages development. The first stage is analysis and preliminary research to analyze the system needs and characteristics, second stage is design system to describe the system architecture, flowchart, Screen Design and Storyboard. Third stage is Production to develop the system using authoring tool, fourth stage is Evaluation to test functionality of the system using blackbox testing and test reaction to students using summative evaluation to measure the level of satisfaction program usage. Last stage is dissemination to publish applications in general through social media or the internet. The media visual learning system built based on web applications because it can be used by students anywhere and anytime. The Experimental result it show that applications based on the total score obtained from the questionnaire to 35 respondents obtained a total score of 674 which are based on the attitude categories it show positive attitude the application can help high school students understand the material systems of the human body, with material that has 3D objects, and can recognize the organs of the human body system along with their general functions and diseases and by giving 3D objects as a teaching aid.

1. Introduction
According to Munir, Iwan, and Herman, multimedia learning is a combination of text, images, graphics, sound, video, animation, simulation in an integrated manner and synergistic with the help of certain computer applications to achieve learning goals, in multimedia learning users can control and interact dynamically [1-3]. In the Multimedia Learning Cognitive Theory as described by Richard M, Multimedia learning presented material through words both narrative and written text, images both silent and moving, this is done because human working memory has two sub-components that work in parallel (visual and auditory) and learning can be more successful if both channels are used for processing information at the same time [4]. Multimedia is a combination of text, art, sound, images, animation and video delivered to your computer or manipulated digitally and can be delivered and / or controlled interactively [5]. Interactive is related to two-way communication / something that is mutually take action, active and interconnected with each other and has a reciprocal between one another. Something interactive involves two or more parties are active in it. According Gregory Interactive multimedia is a multimedia equipped with a controller that can be operated by the user, so the user can choose what you want for the next process learning is a change in a relatively permanent behavioral tendencies as a result of practices that reinforced that there are causes of learning and
learning itself occurs between the cause and result of learning [6]. In the process of learning, a relatively permanent change refers to a change in appearance (performance). However, appearances can be observed, but learning (learning) itself cannot be observed. It can be concluded that a person has done to learn if he had been able to do something that previously could not do. But not all learned to produce changes in behavior or appearance. According Douglas there are at least six learned, namely multimedia interactive saying: ease of navigation, content of cognition, presentation of information, integration of media, artistic and aesthetic, and overall functionality [6-7].

Multimedia learning is one way of delivering teaching materials in a study involving visual explanations, a voice that guides the teaching materials and the interactive model of the offered offers to students much more active in the learning process. Previous research conducted by Prawido U [8] showed the development of a learning media in the form of multimedia learning in the learning of human body systems can increase students' motivation and reduce boredom in learning. It's just that in this study visual learning is presented to explain the system part of the human body only in the form of 2 dimensions where the details of the part are not visible, besides the lack of interactivity elements offered makes this learning still emphasize the teaching role in delivering teaching material. Other research conducted by R.D Agustia and I.N Arifin [9] shows that the combination of visual learning in 2-dimensional form with the addition of interactivity in a multimedia learning can improve cognitive abilities of students in understanding numerical learning and learning letters. Both studies only focus on presenting teaching material in the form of 2-dimensional forms where the system implementation environment is limited in the area of the institution. This causes the student cannot access outside the institution. The way that students can access outside the institution is an online system implementation where one application is to use a web platform and teaching material presented in a much more detailed and interactive form of 2 dimensions, namely the presentation of information materials in 3-dimensional form. The obstacle in applying the object in a web platform is the length of the process of displaying 3D objects. Therefore, based on a study conducted by Andreas R [10] showing objects in 3D in the Web environment can be done by applying web Assembly technology.

Based on the above problems a study was conducted to build a visual learning object media teaching material human body system in the form of 3 dimensions on the web environment by taking a case study in one of the high schools in Bandung, while the purpose of this study was to determine how far this visual learning media system can help students in human body system learning. The research methodology refers to research and development research so that the system development model uses the APPED model popularized by Prof. Herman Dwi Surjono.

2. Method
The research methodology refers to research and development research so that the system development model uses the APPED model popularized by Prof. Herman Dwi Surjono. This research has 5 stages. Each step has a systematic and logical method so it can support the Implementation of research. The research methodology used is described in Figure 1 below:

![Figure 1. Research Methodology](image)

1. Analysis and Preliminary Research
At this stage a needs analysis is carried out covering the objectives and conditions desired through this system, gaps that occur in the current conditions and withdrawal of solutions. In this stage data collection is done through observation methods, questionnaires and literature studies. The sampling technique used in this research is Slovin technique.
2. Design
   At this stage, the material outline, material framework, screen design and storyboard are carried out.

3. Production
   At this stage the product is made starting from the prototype Multimedia components (images, sounds, videos, animations) are then combined using authoring tools using C# language, PHP and WebAssembly.

4. Evaluation
   At this stage an evaluation is carried out using ongoing evaluation, alpha testing, and beta testing. On-going evaluation is carried out repeatedly throughout the program. Alpha Testing is done by inviting experts in the field of interfaces and materials. Beta testing is done to the target end users who will use this system which is middle school students.

5. Dissemination
   At this stage the application is deployed by storing it on the web and conducting field trials by applying the system to one of the upper secondary schools. Field trials were conducted by dividing the class into 2 parts, namely the control class and the experimental class.

3. Results and Discussion

3.1. Concept of SITUMAN Multimedia Learning System
   The concept analysis of the system to be built contains a big picture of the system to be built. The system to be built contains eight (8) material systems of the human body, namely the motion system, circulatory system, digestive system, respiratory system, excretory system, reproductive system, nervous system, and immune system. The material of the human body system is modeled using 3D. The system to be built is a web-based learning media using WebAssembly technology called SITUMAN which means “SIstem TUbuh MANusia”. Concept of SITUMAN can be observed in Figure 2.

Figure 2. SITUMAN Multimedia Learning System
3.2. Material Analysis
The following is an analysis of the material that will be discussed in this human body system learning media. Analysis of the material to be discussed in the learning media that will be built can be seen in Table 1.

Table 1. Material Analysis

| Material                      | Sub Material                                                                 |
|-------------------------------|-------------------------------------------------------------------------------|
| Human Motion System           | Body Frame, Axial Frame, Appendicular Order, Skeletal Muscle, Motion System Disorder, Motion System Technology |
| Human Circulation System      | Bloodstream system, Blood, Red Blood Cells, White Blood Cells, Blood Platter, Blood formation mechanism, Blood group, Blood transfusion, Circulatory organs, Human blood circulation mechanism, Lymph system, Circulatory system disorders, Circulatory system technology |
| Human Digestive System        | The organs of the digestive system, Digestive system disorders                |
| Human Respiratory System      | Respiratory, Respiratory mechanism, Transport and gas exchange, Respiratory system disorders, Respiratory system technology |
| Human Excretion System        | Kidney, Heart, Lungs, Skin, Excretion system disorders, Technology of excretion system |
| Human Nervous System          | The nervous system in humans, Neurons, Neuroglia Cell, Synapsis, impulses, nerves, conscious motion and reflexes, Impulse delivery mechanism, Central nerve system, Endocrine system (hormones), Differences in the nervous system and endocrine system, Sensory system |
| Human Reproduction System     | Male reproductive system, Female reproductive system, Reproductive system disorders, Technology for reproductive system |
| Human Immune System           | Body defense system, body defense mechanism, Body defense system disorders     |

3.3. Storyboard
Storyboard is a sketch of a picture arranged sequentially according to the script. Animated storyboard of the digestive system can be seen in Table 2.

Table 2. Digestive System Animation Storyboard

| Scene | Shoot | Link To Scene |
|-------|-------|---------------|
| 1     | Shoot 1: Food goes into the mouth | Scene 1 Shoot 2 |
| 1     | Shoot 2: Food enters the oesophagus | Scene 1 Shoot 3 |
Scene Shoot Link To Scene

1 Shoot 3: Food enters the stomach and is accommodated for 2-5 hours then digested chemically

1 Shoot 4: After passing through the stomach, the food is neutralized by the liver and excreted into the bile content

1 Shoot 5: Food enters the small intestine and the nutrients contained in food are absorbed by the small intestine

1 Shoot 6: Foods that have been absorbed by the small intestine, then enter the large intestine to be absorbed by the water

3.4. **WebAssembly Analysis**

Analysis of the WebAssembly formation process can be observed in Figure 3.

![WebAssembly Process Diagram](image)

**Figure 3.** WebAssembly Process

Before creating an application using Authoring Tools, assets are needed first to support the application that will be created. In the SITUMAN learning media system there are 2 (two) stages for creating 3D object assets, there is:
1. Collecting images to become a reference in modelling 3D objects. The images needed to be a reference in modelling 3D objects are front-looking images and side-view, so that when 3D object modelling is easier.

2. Modelling 3D objects using Blender software. 3D object modelling is needed to create 3D objects needed in SITUMAN learning media. 3D object modelling is then collected into assets.

After having the required assets, then the next stage is the making of learning media using Authoring Tools. C# language used in the process making learning media system. After making the learning media complete, the learning media is built using WebAssembly. In the process carried out by WebAssembly, the C# programming language was first converted into C / C++. Then the C / C++ language is compiled by a tool called Emscripten to become a .wasm file. Because WebAssembly cannot directly access the DOM (Document Object Model), then Emscripten also generates a glue code in the form of a Javascript file (.js). Besides generating wasm and .js files, Emscripten also generates an .html file to display the code results. After the WebAssembly process is complete, the application can be run using a browser.

### 3.5. Functional Software Requirement

The specifications for functional software requirements are software requirements as a result of the analysis process carried out in software development. Analysis of software requirements specifications is needed to make use case descriptions. Analysis of functional software requirements can be seen in Table 3.

| Code  | Specification Requirement                                      |
|-------|-------------------------------------------------------------|
| SKPL-F01 | The system can validate logins                             |
| SKPL-F02 | The system can display objects                            |
| SKPL-F03 | The system can rotate objects                              |
| SKPL-F04 | The system can shift objects                               |
| SKPL-F05 | The system can zoom in and out on objects                  |
| SKPL-F06 | The system can deliver material                           |
| SKPL-F07 | The system can show the results of the practice            |
| SKPL-F08 | The system can provide practice questions                  |
| SKPL-F09 | The system can change the password                        |
| SKPL-F10 | The system can create account                             |
| SKPL-F11 | The system can add practice questions                      |
| SKPL-F12 | The system can edit practice questions                     |
| SKPL-F13 | The system can remove practice questions                   |
| SKPL-F14 | The system can display student grades                      |
| SKPL-F15 | The system can reset the password                         |

### 3.6. Use Case Diagram

Figure 4 describes Use case Diagram of the system to be built.
Figure 4. Use Case Diagrams

Use case diagram is used to describe a number of external actors with use cases contained in the system. Use case diagram can illustrate how the User interacts with any system and behaviour that the system does.

3.7. Implementation System
Implementation of the interface for motion system page can be seen at Figure 5.
3.8. Testing
At this stage the measurement of the level of user satisfaction is carried out on learning media built using the kirkpatrick level 1 evaluation model: Reactions. Testing is done by distributing questionnaires to 35 respondents, then do calculations using a Likert scale. The results obtained show the satisfaction rate at 674 which shows a positive reaction that the learning media can help students to understand and see the shape of the organs of the human body system.

4. Conclusion
The final results of this study to measure the extent of student satisfaction in studying the human body system using visual learning media which shows a positive reaction that the system helps students better understand existing teaching materials. The next research will be testing how effective the learning media are at level 2: Learning.

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