E-ISSN: 2829-0844
Vol 8 No (1) April 2025

Validitas Modul Pembelajaran Sistem Peredaran Darah Manusia Berbasis *Constructivist Teaching Sequence* (CTS) Berbantuan *Augmented Reality* (AR)

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Abstrak

Modul pembelajaran sistem peredaran darah manusia berbasis *Constructivist Teaching Sequence* (CTS) berbantuan *Augmented Reality* (AR) dikembangkan untuk meningkatkan pemahaman siswa terhadap konsep sistem peredaran darah manusia. Penelitian ini bertujuan untuk mengetahui validitas dari modul pembelajaran yang dikembangkan. Penelitian ini merupakan *Research and Development* (R&D*)* menggunakan *Generic Design Research Model*. Instrumen yang digunakan dalam penelitian ini yaitu lembar validitas modul yang dinilai oleh ahli materi dan media. Hasil validasi menunjukkan bahwa validasi materi memperoleh nilai rata-rata 93%, sedangkan validasi media memperoleh nilai rata-rata 88%", sehingga modul dinyatakan layak dan dapat digunakan dalam pembelajaran di sekolah.

Kata kunci: *augmented reality, constructivist teaching sequence,* modul pembelajaran, sistem peredaran darah, ,

Abstract

The learning module of human circulatory system based on Constructivist Teaching Sequence (CTS) assisted by Augmented Reality (AR) was developed to improve students' understanding of the concept of human circulatory system. This study aims to determine the validity of the developed learning module. This research is a Research and Development (R&D) using the Generic Design Research Model. The instrument used in this research is a module validity sheet assessed by material and media experts. The validation results showed that material validation obtained an average value of 93%, while media validation obtained an average value of 88%, and the module is declared feasible and can be used in learning at school.

Keywords: *augmented reality, constructivist teaching sequence, learning module, circulatory system,*

INTRODUCTION

Education is a fundamental aspect that cannot be ignored as an effort to develop individual potential in order to enhance human resources. Through this pathway, individuals can hone their ability to think logically, critically, as well as be innovative and act proactively. Education also plays a role in shaping a strong and adaptive character in facing the dynamics and challenges of each stage of life (Kamra, 2019). The rapid development of technology has had a significant impact on various fields of life, including the education sector. In this context, education is required to continuously present innovations in the learning process through the appropriate and effective use of technology. Therefore, learning resources must be designed with content that is future-oriented to support the development of student competencies. In addition, learning resources must also play a positive role in supporting the learning process through the optimal use of the latest technology (Syamsuar and Reflianto, 2019). All learning devices that have been prepared will be implemented in the teaching and learning process to determine the extent to which learning objectives can be achieved (Yusuf et al., 2021), one of which is the learning module.

The use of modules in the learning process allows for encouraging a high level of learning engagement among students (Maritsa et al., 2021). Learning modules are elements that play an important role in the implementation of the learning process in the classroom, as

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they contain the material that must be delivered to students. Their presence not only supports the success of the material delivery process but also provides stimulation so that students can achieve the learning outcomes set. Effective design of learning modules, especially those discussing the topic of the human circulatory system, can present material more systematically and create a more creative and engaging learning experience for students (Magdalena et al., 2020). Learning modules on the concept of the circulatory system have been widely found, but there are also many weaknesses inherent in them, such as the high level of verbatim content without accompanying images and the material in the learning module being less contextual. This situation raises several problems, one of which is the tendency for the learning modules to be monotonous, making them less appealing to students. Therefore, innovative efforts are needed to facilitate a more effective understanding of the material, one of which is through the utilization of appropriate and engaging learning media (Mukhoyyaroh et al., 2023).

The use of appropriate learning media is expected to encourage high motivation and active involvement of students during the learning activities. However, teachers need to be aware that each student has differences in character and learning abilities. Therefore, teachers need to design and provide learning media that can support the learning process comprehensively, so that the material can be accepted by all students, enabling them to achieve learning targets optimally and produce good output (Faradila and Aimah, 2018). The use of digital media in learning has now become commonplace, especially in the current era of globalization. However, in Indonesia, there are still many schools with limited facilities, making the implementation of technology in learning a major challenge. According to a study by Fitri et al (2020), many teachers struggle to integrate digital media into their lessons due to their low mastery of technology.

The results of observations and interviews conducted at SMA Negeri 1 Gorontalo in the biology subject indicate that the students have never used a Constructivist Teaching Sequence (CTS) based learning module assisted by Augmented Reality (AR) in the learning process. Additionally, the students experience difficulties in understanding the relationship between the structure and function of the components in the circulatory system, such as the heart, blood vessels, and blood cells. Limited learning resources and conventional learning models result in a less effective learning process.

One form of technology that is interactive, innovative, and can be utilized in the learning process is Augmented Reality (AR). AR technology presents a new approach in the world of education by offering a more comprehensive learning experience and involving active interaction from students (Yusup et al., 2023). According to Mustaqim (2016), AR technology is an innovation that integrates elements from the virtual world with the real environment, in both two-dimensional and three-dimensional forms. This integration is displayed directly and simultaneously in the real environment, creating an interactive experience between virtual objects and the physical world. AR technology plays an important role in realizing more interactive learning that is in line with the advancement of the times, by displaying three-dimensional objects that appear realistic. This situation not only makes the subject matter more engaging for students but also supports them in preparing to face the challenges of an increasingly advanced digital world.

The use of AR will be maximized if supported by a constructivist-based approach. Constructivism, as a learning theory, focuses on how students develop understanding and knowledge by experiencing directly, reflecting, and actively interacting with their surroundings and other individuals. The Constructivist Teaching Sequence (CTS) model is a learning model based on constructivist learning theory which views that knowledge is not transmitted directly from the teacher to the students, but students engage in the process of constructing their own knowledge. In this context, students do not just receive information, but also process, analyze, and integrate new information into their existing knowledge framework (Hastika et al., 2024).

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The CTS model is very relevant in learning about the human circulatory system, because this model focuses on active learning that encourages students to develop their knowledge independently through experience, exploration, and problem-solving. By using the CTS model, students are able to understand the concepts of the circulatory system in depth, directly engage in activities that connect theory with practice, and build their own concepts based on personal experience and understanding, which has the potential to enhance their engagement and comprehension of the material (Anam et al., 2024). This is in line with the theories of Piaget and Vygotsky, that knowledge is actively constructed by learners through interaction with their environment, rather than passively received. In this view, the teacher does not just play the role of knowledge transmitter, but acts as an active companion in supporting learners to build their own knowledge (Hastika et al., 2024). This study aims to examine the validity of the content, construct, and appearance of the Constructivist Teaching Sequence (CTS) learning module assisted by Augmented Reality (AR) with the hypothesis that the module meets the validity criteria.

METHOD

The research uses a quantitative descriptive approach aimed at knowing the validity of a learning product. The preparation of this learning module refers to the Generic Design Research Model according to Wademan. The steps of GDRM are: 1) problem identification, 2) identification of tentative products and design principles, 3) tentative theory and product, 4) prototyping and assessment of products and initial theory, and 5) problem resolution and theory development (Plomp, 2013).

Data collection was carried out using an instrument in the form of a validation sheet specifically designed and filled out by two categories of validators, namely 1 lecturer as a content expert and 1 lecturer as a media expert. To analyze the data obtained, a validity analysis technique focusing on the quality assessment of the learning module was used. The validity assessment process of the module is referenced against the Likert scale. The results of this validation provide an overview of how well the learning module meets the eligibility criteria based on expert evaluations. The percentage of validation is calculated using the following equivalent formula:

$$Validation\ of\ the\ learning\ module = \frac{\text{The total score of each aspect}}{\sum highest\ score}\ X\ 100\% \ldots\ldots\ldots(1)$$

The Likert scale criteria are presented in Table 1.

Table 1. Likert Scale Criteria

Assessment	Score
Very Valid	86-100
Valid	71-85
Quite Valid	56-70
Less Valid	41-55
Not Valid	<40

(Modified by Yazid (2016))

RESULTS AND DISCUSSION

The purpose of this research is to test the validity level of the biology learning module designed with the Constructivist Teaching Sequence (CTS) model assisted by Augmented Reality (AR). This procedural stage is carried out based on the Generic Design Research Model (GDRM) framework as described by Wademan and is based on the steps put forward

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by Plomp (2013), which include five stages: problem identification, identification of tentative products and design principles, tentative product and theory, prototype development and initial product and theory assessment, as well as problem resolution and theory development.

Step 1: Identify the Problem

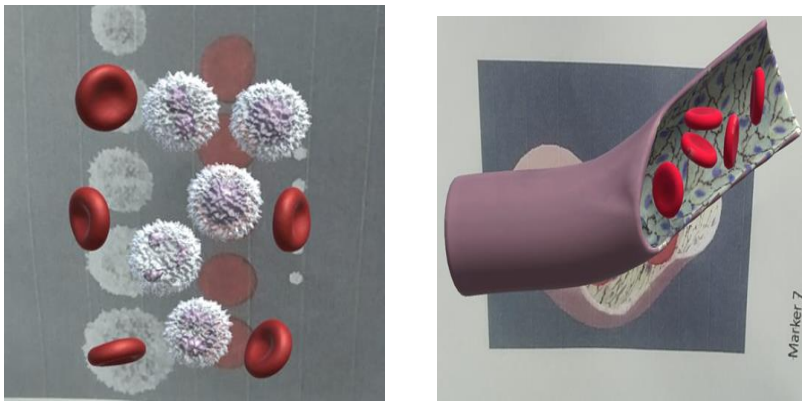
At this stage, a preliminary study is conducted to identify the problems that arise in schools, particularly those related to learning activities, namely the learning model applied and examining issues related to the learning resources used. The results of the preliminary study indicate that students have never used learning modules that integrate the Constructivist Teaching Sequence (CTS) assisted by Augmented Reality (AR). The learning process is still dominated by conventional approaches such as lectures and assignments, and relies on textbooks as the main source of learning. Furthermore, teachers and students express that learners are experiencing difficulties in understanding the relationship between the structure and function of the components of the circulatory system, especially the heart, blood vessels, and blood cells. This is due to the abstract and complex nature of the material, as well as the lack of interactive visualization media that can concretely illustrate the dynamics of blood flow and the role of each organ. The limitations of learning resources and the use of conventional methods are the main factors that make learning feel boring and less effective in helping to understand concepts.

Step 2: Identify Tentative Products and Design Principles

In response to the identified issues, fundamental principles have been established for designing learning modules that support a constructivist approach. The modules are organized following the Constructivist Teaching Sequence (CTS), which consists of:

1. Introduction: This section identifies efforts to prepare students for the topic.
2. Exploring students' prior knowledge (Exploration): Identifying the teacher's efforts to understand the students' foundational knowledge related to the topic.
3. Reconstructing Preconceptions: Identifying efforts to facilitate conceptual change. Students recognize and reflect on their prior understanding of the topic being studied.
4. Applying New Concepts: Identifying efforts to apply concepts that have been understood into other contexts or into real life.
5. Evaluation: Identifying efforts to encourage students to compare the newly acquired concepts with their previous concepts.

AR technology is added as an auxiliary medium to enrich the visual and interactive learning experience, for example through 3D image displays. In accordance with the material being taught, which is the circulatory system, the example of the 3D images visible includes blood cells, the heart, blood vessels, and so on. By using AR technology, these images can be rotated and observed from various angles.



(a) **(b)**

Figure 1 : Displays 3D image of AR technology on (a) Red Blood Cells and White Blood Cells, (b) Blood Vessels.

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Step 3: Products and Tentative Theories

The module is designed to facilitate active and meaningful learning. This module is structured to include a Module Profile containing learning outcomes, objectives, and the CTS learning model. Learning activities are divided into three main parts that cover learning outcomes and objectives, materials such as the definition and function of blood, the structure of the circulatory system organs, and the process of human blood circulation. Each activity is equipped with CTS syntax-based activities emphasizing exploration and problem-solving, as well as practice questions for understanding evaluation. The learning approach focuses on developing creative and critical thinking skills through five CTS stages, supported by visual media such as organ images, barcode videos, and Augmented Reality (AR) applications. Additionally, this module provides an Evaluation section, Glossary, and References to support students' competency achievement.

Step 4: Prototype Development and Evaluation of the Product and Initial Theory

The initial prototype of the module was developed in printed form. The design results of the developed prototype can be seen in the image below.

(a) **(b)**

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(c)

(d)

Figure 2. (a) Design view of the learning module cover, (b) Module cover, (c) Stages of the CTS syntax in the learning module, (d) Instructions for using AR in the CTS learning module

To ascertain the validity of the Constructivist Teaching Sequence (CTS) learning module aided by Augmented Reality (AR), a validity assessment is conducted. The evaluation stage by validators aims to test the legitimacy of the learning module. The results of the validation will be used to conclude that the developed learning module is valid and reliable. The validation process is carried out by two experts in their fields, each serving as a content expert validator and a media expert.

1. Validity of the Human Circulatory System Learning Module Based on Constructivist Teaching Sequence (CTS) Assisted by Augmented Reality (AR)

The developed learning module has undergone a validation process by two expert lecturers, each serving as the material validator and the media validator.

Expert Material Validation

The results of expert validation of the learning module on the human circulatory system based on Constructivist Teaching Sequence (CTS) aided by Augmented Reality (AR) can be seen in the following graph.

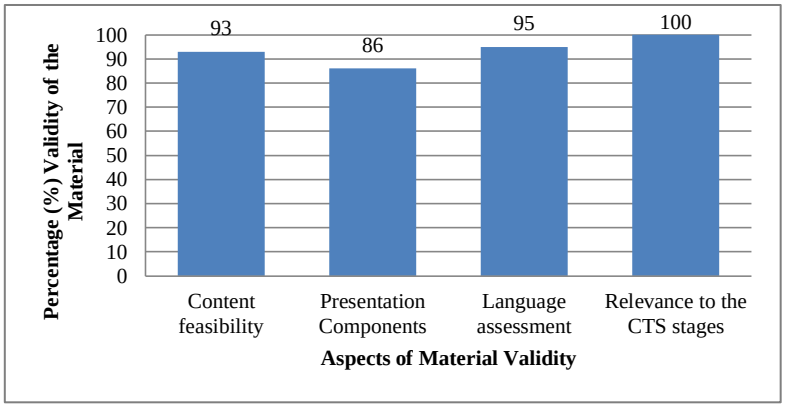

Figure 3. Graph of the percentage of expert material validity

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Based on the validation results by material experts, it is evident that each assessed aspect received varying scores. The content feasibility aspect scored 93%, the presentation component 86%, language assessment 95%, and alignment with CTS stages received 100%. The overall average of these four aspects is 93%, which falls into the 'Very Valid' category. According to Yazid (2016), scores of 86-100% are categorized as 'Very Valid'. This high validation score indicates that the module has excellent quality across various assessment components. One of the outstanding aspects of this module is its strong alignment with the CTS stages, where each learning step is systematically arranged and adheres to the principles of constructivism, thus facilitating the active formation of knowledge by learners. This indicates that the learning module on the human circulatory system based on the Constructivist Teaching Sequence (CTS) assisted by Augmented Reality has met good quality standards in terms of content feasibility, presentation, language use, and learning stages. Therefore, this module is suitable for use in the learning process with some improvements based on feedback from validators.

Here are some suggestions and comments from the validator: (1) The author's name was omitted and the writing of the Constructivist Teaching Sequence (CTS) model was corrected. (2) Add the names of the module compilers in the reviewer section and italicize the Latin names. (3) Revise some learning objectives and structure them well and correctly so they are easy to understand. (4) Add reference sources to the chart and change the chart format. (5) Improve the instructions for using Augmented Reality (AR) to make them more systematic and easier for students to understand. (6) Adjust the introduction to align with the learning objectives. (7) Improve the images in the module by enhancing their resolution and visual clarity.

Media Expert Validation

Media validation is carried out to evaluate whether the learning media used in the Constructivist Teaching Sequence (CTS) module assisted by Augmented Reality (AR) is suitable for use in learning. The results of the validation can be seen in the following graph.

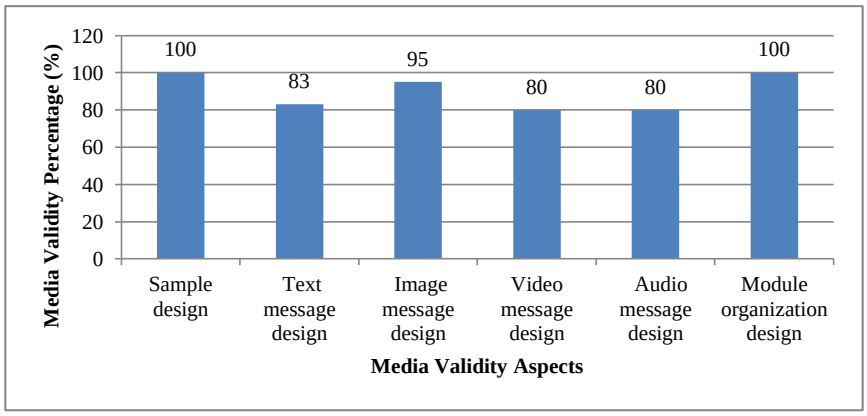

Figure 4. Graph of the percentage of media expert validity

Based on the results of the media validation displayed in the graph above, the validity results by expert media validators showed different average scores. In the aspect of cover design, it received 100%, text message design received a score of 83%, image message design received a score of 95%, video message design received a score of 80%, audio message design received a score of 80%, and module organization design received a score of 100%. The overall average of these six aspects is 88%, which falls into the "Very Valid" category. Hutabri (2022) states that well-designed learning media, from content structure, visualization, to audio-visual delivery, can enhance the effectiveness and participation of students in learning activities. Therefore, the media in this module is suitable for use in learning activities, considering improvements in aspects that can still be enhanced, such as audio narration quality and video synchronization. This is in line with Latifah et al (2023) who

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stated that well-designed video and animation-based learning media can significantly enhance students' understanding.

Step 5. Problem solving and theory development

Based on the assessment of the validity of material experts and media experts, the CTS-based learning module assisted by AR is declared very valid and suitable for use in learning with a few minor revisions according to the validator's suggestions before being used in the classroom. The revisions are focused on the removal of the author's name from the module and the correction of the writing of the term Constructivist Teaching Sequence (CTS) to ensure consistency and adherence to rules. The author's name is added to the reviewer section, and the writing of Latin names is adjusted to follow the rules for italic usage. The learning objectives have been revised and reorganized to be easier for learners to understand. Additionally, reference sources are added to the diagram section, and the form of the diagram is clarified. The instructions for using AR have also been revised to be more systematic and easier for students to follow. According to Agapau et al (2024), an effective text design must consider readability and clarity of information to support students' understanding of the material presented. Meanwhile, revisions to the media design include improvements to the cover design of the learning modules, the selection of images, colors, font types, and layout should be taken into account. The selection of images must be clear and relevant to the material to clarify the concepts being taught, and the color combinations should be appropriate along with the chosen font types. According to Julianto and Cahyadi (2020), visual elements such as illustrations, colors, typography, and layout play a crucial role in supporting the effectiveness of message delivery in learning media. Proper design is not only aesthetically pleasing but also clarifies concepts, facilitates understanding, and enhances the appeal and concentration of students.

CONCLUSION

Based on the results of module validation by content experts, the overall average of the four assessed aspects is 93%, which falls into the category of 'Highly Valid'. Meanwhile, the results of module validation by media experts yield an overall average score of 88% across six assessed aspects, also falling into the category of 'Highly Valid'. Therefore, from both results, the learning module on the human circulatory system based on Constructivist Teaching Sequence (CTS) assisted by Augmented Reality (AR) for class XI-7 at SMA Negeri 1 Gorontalo is deemed suitable and can be used for learning in schools.

The use of a CTS approach that prioritizes the active construction of knowledge by students, combined with AR technology, provides a more contextual, engaging, and interactive learning experience. This can enhance students' motivation and understanding of the abstract concept of the human circulatory system. This module serves as an example of the implementation of modern technology in biology education, which can inspire teachers and other educational media developers to create innovative teaching tools. Furthermore, this module should be tested in more schools or diverse classes to observe its effectiveness consistency and to adapt to the needs of various student characteristics.

THANK YOU

A heartfelt thank you to the Principal, Biology Teacher, and all the students of class XI at SMA Negeri 1 Gorontalo for their active participation and support to the researcher, which enabled the completion of this research on time.

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E-ISSN: 2829-0844
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