Development of Simulation Scenario for the Circulatory System in Humans Material for Grade XI High School

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Abstract. *This research aims to produce simulation scenarios for biology materials in Grade XI of Senior High School focusing on the mechanism of human blood circulation. The type of research used is R&D research employing the 4D development model (Define, Design, Develop, and Disseminate). The validity and simulation scenarios were assessed by two validated biologist experts from the Faculty of Mathematics and Natural Sciences (FMIPA) at UNM, using simulators and simulation scenario questionnaires. Based on the questionnaire data obtained, the validity of the simulation scenario is Va = 4.12, which falls into the "valid" category (3.5 ≤ Va ≤ 4.5). The practicality of the simulation scenarios was assessed by collecting data through teacher and student assessments based on a practicality assessment questionnaire. The obtained data showed an average percentage of all aspects at 87.41%, indicating a very positive teacher response to the circulation mechanism simulation scenario, while data based on student responses showed an average percentage of all aspects at 82.62%, indicating a positive response from students to the circulatory mechanism simulation scenario. Based on the research conducted, it can be concluded that the simulation scenario for the human circulation mechanism is both valid and practical.*

Keywords: *Simulation scenario, simulation method, 4D, validity, practicality*

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Introduction

The development of supportive methods in learning has been extensively pursued, although not all can be universally applied to all biology topics in classroom instruction. This is because some are tailored for specific subjects, necessitating the exploration of alternative learning methods to complement existing instructional strategies, such as simulation methods as learning resources. Simulation methods play a crucial role in the teaching and learning process in classrooms. Challenges faced by teachers in delivering lessons and students' ability to grasp the material can be aided by the introduction of varied learning methods like simulation, thereby enabling students to absorb the material effectively. Simulation methods should enhance students' insight, learning motivation, and stimulate their memory, thus ensuring a profound learning experience. Research conducted by Nilasari (2008) on challenging biology concepts demonstrated that simulation methods can enhance students' learning activities and outcomes, as evidenced by an increase in students' test scores from 48.83 to 82.64. The topic of the circulatory system in humans involves processes that are not directly observable, necessitating specific tricks and methods to facilitate teachers in delivering the material and ensuring comprehension among students. Arsyad (2012) suggests that retaining information in memory involves utilizing all sensory organs to receive and process information, thereby aiding students in comprehending and internalizing the messages within the presented material. Ikhsania (2015) adds that visual stimuli can help students remember, recognize, and relate facts and concepts within the biology curriculum more easily. Simulation methods are developed in the form of simulation scenarios, which serve as information sources in the learning process, aligning with the basic competencies based on government regulations, namely "Analyzing the relationship between the structure of tissue composing organs in the respiratory system and relating it to its bioprocesses to explain the mechanism of

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the human circulatory system and potential disruptions in human respiratory system function through literature studies, observations, experiments, and simulations."

Based on observations conducted at SMA Negeri 1 Bajeng, it was found that instructional methods in classrooms lacked variation, predominantly relying on lecture-style teaching and student presentations. Observations at MAN 1 Makassar revealed that 5 out of 32 students did not pass the respiratory system subject, accounting for 15.6% failure rate. Teaching methods employed by teachers included information discussions, demonstrations, and experiments. Similarly, observations at SMA 1 Bontonompo showed that learning outcomes in the respiratory system subject for one class were at 50% out of 39 students, with teaching methods encompassing discussions, lectures, and experiments.

The implementation of simulation methods can contribute to effective and active teaching and learning activities, particularly concerning the human circulatory system material in classrooms. The development of the proposed simulation method serves as an appropriate alternative for teachers to impart understanding, especially in challenging subject matters. With this background, the researcher intends to conduct a study on the development of simulation scenario for the mechanism of the human circulatory system material for Grade XI High School..

Problem Formulation

Can the developed simulation scenario for Grade XI biology learning on the concept of the circulatory system mechanism in humans be deemed valid and practical?

Research Focus

The vast coverage of biology learning material often hinders its effective delivery due to limited time allocation. Moreover, the instructional methods utilized often lack variation, with a predominant reliance on lecturing by most teachers. However, abstract biological concepts necessitate creative and contextually appropriate teaching methods. Additionally, certain biology topics involve processes that cannot be directly observed, such as the circulatory system in humans. Teaching these topics through inadequate techniques, such as lecturing, may result in students struggling to comprehend the material effectively, leading to passive learning attitudes.

Therefore, teachers must creatively design classroom learning processes to achieve the intended learning objectives. Essentially, students are more likely to understand and retain lessons or any information received when actively engaged in hands-on activities rather than solely observing and listening. Thus, the appropriate solution lies in employing simulation techniques. Learning through simulation allows the received lesson information to be encoded into long-term memory as students understand and experience the learning process themselves. Through simulation, students enact scenarios and actively participate in the learning process, fostering increased engagement. The simulation method to be developed will consist of simulation scenarios with routes and flows aligned with the mechanism of the human circulatory system. Simulations can be conducted both inside and outside the classroom, providing an enjoyable learning experience. Each student will be assigned a role and tasked with comprehensively exploring the material content relevant to their role, thereby fostering active interaction within each group. The development of simulated scenarios is expected to aid students in better understanding the material and assist teachers in facilitating student learning.

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Research Method

Overview of the Research

Penelitian ini merupakan penelitian pengembangan (*Development Research*), dalam bidang pendidikan, dengan menggunakan model pengembangan 4D (*Define. Design, Develop*). Penelitian dilaksanakan di SMA Negeri 8 Makassar, Kota Makassar, Sulawesi Selatan pada Semester Genap Tahun ajaran 2016/2017.

Research Sample

The sample in this research consists of Class XI MIA 2, each comprising 32 students.

Research Procedure

The developed simulation scenario was further validated by expert validators from the CID-BIO Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar (UNM). The research process comprised three stages: (1) Definition Stage, aimed at establishing and defining the development criteria through the analysis of development needs, (2) Design Stage, involving the design of the initial product of the simulation scenario, and (3) Development Stage, which focused on validating or assessing the feasibility of the product design, namely the simulation scenario and the simulation scenario assessment instrument. This stage involved validation by two expert lecturers, consisting of one simulation expert and one subject matter expert. Subsequently, a trial of the product design was conducted on the actual target subjects. The trial results were utilized to refine the product.

Data Analysis

The validity of the simulation scenarios was assessed by two expert validators, one serving as a simulation validator and the other as a content validator. The validation data provided by the experts for each learning simulation scenario were analyzed. The developed simulation scenario is considered valid if it meets the criteria of more than half (at least 51%) of the validators stating that each aspect of the developed simulation scenario validation is at least categorized as valid.

Table 1. Categories of Validity Levels

Score	Notes
4,5 ≤ Va 5	Very valid
3,5 ≤ Va ≤ 4,5	Valid
2,5 ≤ Va < 3,5	Less valid
1,5 ≤ *Va* ≤ 2,5	Not valid
Va < 1,5	Very not valid

The practicality of the developed learning simulation scenarios in this study is based on the assessment of teacher and student responses to the product. The practicality test of the simulation scenario is evaluated through instruments measuring teacher and student responses to the learning simulation scenario (Hobri, 2009).

1) The percentage of teacher responses is calculated using the formula:

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RG = $\frac{\sum x}{n}$, with:

RG is teacher's response
$\sum x$ is the total sum of the respondents' answer values.
n is the total number of teachers (respondents).

Table 2. Categories of Teacher Responses

Score	Notes
85% ≤ RS	Very positive
70% ≤ RS < 85%	Positive
50% ≤ RS < 70%	Less positive
RS < 50%	Not positive

2) The percentage of student responses is calculated using the formula:

RS = $\frac{f}{n}$ x 100%, with:

RS Student's response
f is the number of students who answered "agree".
n is the total number of students (respondents).

Table 3. Categories of Student Responses

Score	Notes
85% ≤ RS	Very positive
70% ≤ RS < 85%	Positive
50% ≤ RS < 70%	Less positive
RS < 50%	Not positive

Research Result

The researcher obtained product assessments from validators, so the validators not only provided advice to the researcher but also evaluated the resulting products. Subsequently, the researcher made improvements to the work according to the advice from the validators.

The validators provided assessments of the instruments and simulation scenarios for the human circulatory system that had been developed. The assessments obtained from the validators were then analyzed to determine the validity scores of the instruments and simulation scenarios developed. The assessment results are presented as follows.

1. Validation Test of the Scenario

Table 4. Assessment of Simulation Scenario in the First Revision

No.	Criteria	$\overline{A_i}$	R
1.	Display Format	2,83	0,83
2.	Appeal	2,75	0,75
3.	Language	3,5	0,5
4.	Content	3,18	0,81
5.	Time	3	1
6.	Presentation	2,83	0,83
Average (V_a)		**3,01**	
Reliability (R)			**0,78**

Development of Simulation Scenario for the Circulatory System in Humans Material for Grade XI High School
(page 128-134)
p-ISSN 2621-5527
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The analysis results shown in Table 4.4 above indicate that the total average validity score of the simulation scenarios in the first validation, Va = 3.01, falls into the "less valid" category (2.5 ≤ Va ≤ 3.5); and the total average reliability score of the simulation scenarios, R = 0.78, falls into the "reliable" category (≥ 75% or ≥ 0.75).

Table 5. Assessment of Simulation Scenario in the Second Revision

No.	Criteria	$\overline{A_i}$	R
1.	Display Format	4,25	0,75
2.	Appeal	4	1
3.	Language	4	1
4.	Content	4,25	0,75
5.	Time	4	1
6.	Presentation	4,25	0,9
Average (V_a)		**4,12**	
Reliability (R)			**0,90**

The analysis results shown in Table 4.5 above indicate that the total average validity score of the simulation scenarios in the second validation, Va = 4.12, falls into the "valid" category (3.5 ≤ Va ≤ 4.5); and the total average reliability score of the simulation scenarios, R = 0.90, falls into the "reliable" category (≥ 75% or ≥ 0.75). Therefore, after considering all criteria, it can be concluded that the simulation scenarios are suitable for use.

Tabel 6. Assessment of Teacher Responses to the Simulation Scenarios

No	Aspect	Percentage (%)	Notes
1	Clarity of material	83.33	Positive
2	Attractiveness of media	92.22	Very Positive
3	Ease of use	86.67	Very Positive
Average Percentages		**87.41**	**Very Positive**

Based on the analysis results above, it can be observed that the percentage for each aspect falls into the category of positive response. Meanwhile, the overall average percentage for all aspects is 87.41%, indicating that teachers' responses to the simulation scenarios of the circulatory system mechanism are very positive.

Tabel 7. Assessment of Student Responses to the Simulation Scenarios

No	Aspect	Percentage (%)	Notes
1	Clarity of material	85,52	Positive
2	Attractiveness of media	79,06	Positive
3	Ease of use	83,28	Positive
Average Percentages		**82.62**	**Positive**

Based on the analysis results above, it can be seen that the percentage for each aspect falls into the category of very positive response. Meanwhile, the overall average percentage for all aspects is 82.62%, indicating that students' responses to the simulation scenarios of the circulatory system mechanism are positive.

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Discussion

The criteria used to assess the validity of the simulation scenarios consist of 6 evaluation aspects, namely display format, attractiveness, language, content, time, and presentation. Based on the analysis results of the validity of the simulation scenarios in the first validation, the validity scores from the validators for each assessment aspect were as follows: display format 2.81, attractiveness 2.75; language 3.5; content 3.18; time 3, and presentation 2.83. The overall average score for the simulation scenario assessment from expert validators was 2.7, indicating it to be less valid. This is because none of the aspects met the validity criteria, as evidenced by the numerous suggestions provided by the validators regarding the simulation scenarios, indicating the need for improvement to enhance their validity. Based on the feedback obtained from the first validation, subsequent revisions were made.

The analysis results of the validity of the simulation scenarios in the second validation yielded validity scores from the validators for each assessment aspect as follows: (1) display format 4.25; in line with Hall's research (cited in Rahmadana, 2015), regarding the effect of font and background color combinations on readability, retention, aesthetics, and usage intensity. The best color combination in terms of readability and retention is black-white, aesthetically blue-light blue, and motivationally almost the same in all color combinations. (2) attractiveness 4; indicating that the cover, layout, and simulation media are sufficiently attractive, (3) language 4; stating that sentence clarity avoids ambiguity, and the writing adheres to Indonesian language standards, (4) content 4.25; indicating that the content aligns with the concepts and can be understood using the simulation, (5) time 4 and presentation 4.25; meaning that the simulation media and scenario explanations are comprehensible. The overall average score for the assessment of the learning simulation scenarios from expert validators was 4.12, falling into the valid category.

Based on all the results of the simulation scenario validity tests and instrument validity tests, they have been declared valid and can be implemented with research subjects to determine the practicality and effectiveness of the simulation scenarios. The simulation scenario trials were conducted at SMA Negeri 8 Makassar with research subjects in class XI IPA 2 comprising 32 students. Based on the trial results, the analysis of teacher response data yielded an overall average percentage score of 87.41%, indicating very positive teacher responses to the circulatory system mechanism simulation scenarios. This is evidenced by the questionnaire assessing ease of application in the learning process, presentation of material in line with learning objectives, and clear language use. Meanwhile, the analysis of student response data yielded a percentage of 82.62%, falling into the positive category. This was obtained from the questionnaire indicating students' high interest in simulation activities because they could actively engage in the learning process, easily understand the material, communicate effectively, and use the simulation easily. This aligns with Sudjana's research (2000), stating that simulated events or processes facilitate students' understanding of real-life events or processes that cannot be directly observed. Simulation methods involve students extensively and make learning enjoyable. According to Hasibuan (2009), simulations offer added value; firstly, all students can participate and have the opportunity to demonstrate their ability to work together until successful, and understanding is a fun learning experience for children. Both positive responses indicate that simulation methods are highly effective in the learning process, especially for the circulatory system mechanism material. The research was conducted up to the development stage, and the dissemination stage was not implemented due to time constraints. It is hoped that this research will assist students in their learning activities, thus creating enjoyable learning experiences, facilitating teachers in conveying material concepts, and enhancing student learning activities.

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Conclusion

Based on the research findings and discussions, it can be concluded that the developed simulation scenario for Grade XI biology learning on the topic of the human circulatory system mechanism is deemed valid and practical. The simulation scenario is considered valid with a total average validity score of 4.12. Furthermore, the simulation scenario is deemed practical with a total average practicality score of 4.4.

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