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The cells at work animation improves students' analytical skills in learning the circulatory system

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ABSTRACT

Analytical skills are one of the essential skills that high school students must possess and are listed in the curriculum. Analytical skills are included in category C4 in Bloom's taxonomy. However, many students still lack this ability. This is influenced by several factors, one of which is the type of learning media. Learning media is one of the crucial elements that can determine how successful students are in mastering learning concepts, especially in biology education. Cells at Work is one of the animation media that presents biological concepts through representations of cell life in the human body. This study aims to evaluate the effectiveness of the Cells at Work animation as a learning medium for biology, with a focus on the material related to the circulatory system. The method used is a pre-experimental design with a one-group pre-test-post-test model, conducted on class XI-MIPA 5 students at SMA Pasundan 2, Bandung. The results of the study showed that this animation media makes it easier for students to understand the material due to its attractive visual and audio displays. This can be seen from the increase in the average student score, namely from 56 at the pre-test to 83 at the post-test, with the percentage of mastery of all indicators reaching 83%. Thus, the Cells at Work animation is effective for use as a learning medium in biology, especially for material related to the circulatory system. This study provides empirical evidence that animated media with contextual content, such as Cells at Work, can significantly enhance analytical thinking skills in science learning, particularly for complex topics like the circulatory system.

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INTRODUCTION

Critical thinking skills are among the primary competencies that students must possess in the 21st century (Hizqiyah et al., 2022). The development of these abilities is the responsibility of educational institutions because critical thinking is not only born from understanding concepts, but also from the habit of conducting analysis (Fitriani et al., 2019). However, in Indonesia, students' analytical skills are still relatively low, especially in understanding complex concepts such as biology. Based on the report from the Ministry of Education, Culture, Research, and Technology (Kemendikbud Ristek, 2023), Indonesia's declining score on the Programme for International Student Assessment (PISA) highlights the need to enhance critical thinking and analytical skills in the learning process. One field of study that requires high analytical skills is biology, especially in

complex material such as the blood circulation system (O'Connor et al., 2022). According to Ningrum et al. (2022), this material poses a challenge for students because it requires a deep understanding of concepts, including organ functions, blood circulation mechanisms, and the relationships between complex physiological structures. SMA Pasundan 2 Bandung is one of the high schools in Bandung City that actively implements biology learning. However, there are still 11th-grade students who struggle to understand the material on the circulatory system. This is indicated by the results of daily assessments and mid-semester exams, which are not yet fully optimal in alignment with the desired curriculum (Alimuddin, 2023).

The development of analytical skills in students aligns with the objectives of the independent curriculum, which emphasizes active learning and mastery of critical thinking skills (Wang et al., 2023). In a study conducted by Kamha and Chookhampaeng (2023), this curriculum emphasizes that students are expected not only to master concepts but also to develop attitudes during learning and the ability to review concepts, as these aspects require improvement. One approach proposed to support this goal is the use of educational technology, especially animation-based learning media (Rosamsi et al., 2019). Animation media can help visualize abstract concepts that are difficult to understand only through text or static images, such as the blood circulation system. One of the most popular learning theories is the multimedia learning theory, proposed by Richard Mayer in his book (Mayer, 2020), which suggests that students will find it easier to grasp concepts if supported by multimedia that is visually engaging and has interesting audio. The learning media with great potential is Cells at Work, an animation from Japan that depicts the life of blood cells in the human body engagingly and educationally (Hanselmann & Welter, 2022).

Cells at Work is a Japanese animation series by Akane Shimizu, adapted from a comic of the same title (Campos & Cruz, 2020). Initially, the creator wanted to create a simple story about the life of cells in the body to help his nephew master biology material that is notoriously difficult, such as bacteria, viruses, the circulatory system, and the respiratory system (Wardani et al., 2021). Then this comic received a positive response from all fans in the world and was adapted into an animated show under David Production with the same title (Hataraku Saibou in Japanese). In several studies conducted by (Hardjana, 2021) and (Cintya et al., 2021), it was explained that the storyline and characters of the Cells at Work animation can represent biology material well in terms of quality.

The Cells at Work animation media not only serve as entertainment but also offer a unique and interesting visual approach to conveying complex biological concepts. This animation presents the personification of cells in the human body, such as red blood cells, white blood cells, and platelets, which are displayed like characters in an action story. This uniqueness makes it easier for students to understand the functions and interactions between components in the circulatory system. According to Kurniawan Salamoon (2021), the use of Cells at Work as a learning medium enables the bridging of understanding between theory and biological reality through concrete visual representations. This not only increases the appeal of learning but also encourages students' analytical abilities about the material being taught. Thus, this animation has the potential to be a practical educational innovation in strengthening conceptual understanding and fostering students' interest in the world of biology (Kurniawan & Kurniah, 2021).

Similar research was also conducted by (Fadlah, Angki, 2022), who used narrative-based animation media in science learning at the junior high school level. They found that interactive visual media significantly improved students' conceptual understanding and critical thinking skills.

METHOD

The method used in this study is a quantitative pre-experimental design with a one-group approach (Creswell & Creswell, 2018). This study involved only one sample as an experimental class, without a control sample. The sample consisted of 29 students from Class 11 MIPA-5. This research process involved watching an intervention where participants watched the "Cells at Work" animation for 13 minutes and then working on Student Worksheets (LKPD) and recreating a presentation.

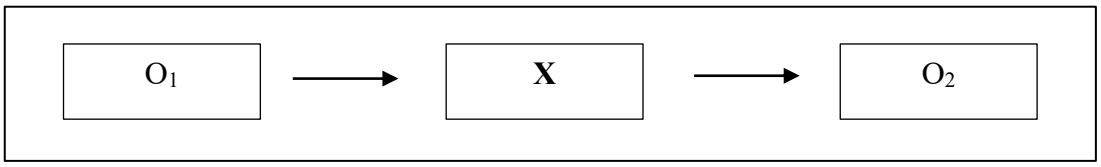


Figure 1. One group pre-test and post-test design research model
Source: (Creswell & Creswell, 2018)

Description
O1 : Pre-test
X : Intervention
O2 : Post-test

The final step is to work on the post-test, which will be compared with the N-Gain test.

$$\text{N} - Gain = \frac{posttest\ score - pretest\ score}{\text{maximum score} - \text{pre} - \text{test score}}$$

Source: (Yaniawati, 2020)

Description
Post-test score : The value obtained by students after learning
Pre-test score : The value obtained by students before learning
Maximum score : The maximum value achieved in the test

The instruments used in this study were pre-test and post-test questions, totaling 20 questions given to 29 students. These questions were designed to measure the extent to which students' analytical abilities had improved before and after being treated through certain learning media. Before being given to students, these 20 questions underwent validity, reliability, difficulty, and discrimination tests, yielding the following results.

Table 1. Instrument Test Results

Validity			Reliability		Difficulty Index	
Average Index	Status	Criteria	Index	Status	Average Index	Status
0,63	Valid	High	0,94	Very high	0.35	Difficult

RESULTS AND DISCUSSION

In line with the research design, which employs a one-group pre-test post-test design model, students are required to complete a pre-test before learning and a post-test after learning is complete

(Sugiyono, 2017). The following is a comparison of the score results from the pre-test and post-test completed by students of Class XI-MIPA 5. Improvement in student learning outcomes is a crucial indicator of the effectiveness of an intervention or treatment in the learning process. The pre-test was administered to students before they began learning with the Cells at Work animation learning media, consisting of 20 multiple-choice questions in total. After the pre-test was conducted, students watched and analyzed the "Cells at Work" animation for 13 minutes on their respective devices.

Table 2. Improving Students' Analytical Skills based on Pre-test and Post-test Results

Student Analytical Skills Indicators	Question Number	Pre-test		Pos-ttest	
		Correct Answer	Percentage	Correct Answer	Percentage
Analyzing organs in the circulatory system	1	24	57%	29	95%
	2	16		24	
	3	14		29	
	4	13		29	
Creating illustrations, the flow of the circulatory system	5	11	54%	15	77%
	6	16		22	
	7	16		27	
	8	20		26	
Detailing the components found in blood	9	8	41%	27	69%
	10	8		26	
	11	19		12	
	12	13		16	
Characterizing blood based on ABO/rhesus blood type	13	17	55%	21	79%
	14	15		24	
	15	16		24	
	16	17		23	
Diagnosing disorders of the circulatory system	17	19	66%	29	97%
	18	20		28	
	19	17		28	
	20	21		28	

Based on Table 3, there is a significant increase in students' analytical skills in all measured indicators. The highest indicator mastered by students during learning is the ability to diagnose disorders in the blood circulation system, with a pre-test percentage of 66%, then increasing to 97% in the post-test.

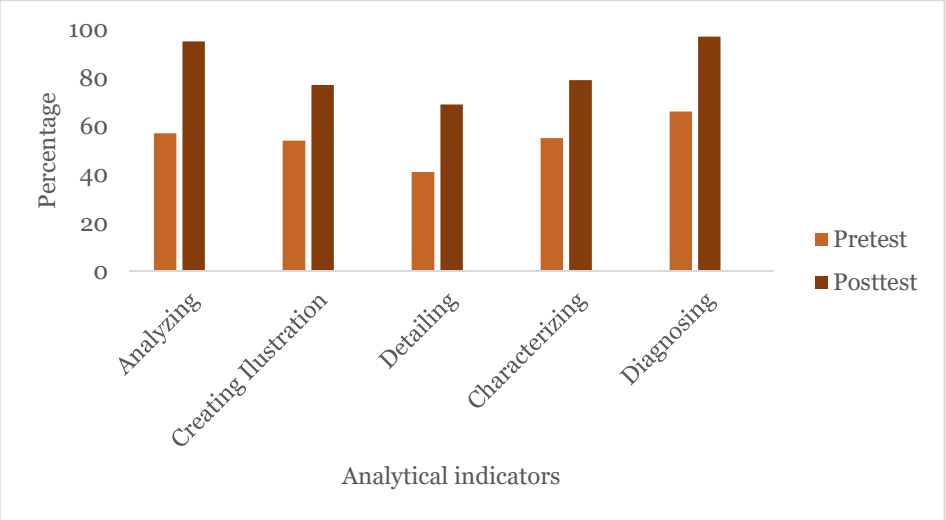


Figure 2. Comparison Graph of Students' Pre-test and Post-test Scores

The figure above shows a comparison of pre-test and post-test scores from 29 participants. It can be observed that most participants experienced an increase in scores after receiving treatment or intervention. Pre-test scores were generally in the range of 30 to 80. In contrast, post-test scores experienced a significant increase, with most participants scoring above 80 and some even reaching a maximum score of 100.

Table 3. Interpretation of Pre-test and Post-test Data Analysis of Students

Test Type	Normality *Saphiro-Wilk*		Parametric *Paired t-Test*			Gain
	Sig.	Status	Mean	Sig.	Status	Mean
Pre-test	0.366	Normal	55.69	<0,001	H1 accept	27,59
Post-test	0.070	Normal	83.28	<0,001		

The indicator with the highest increase is "Diagnosing disorders of the blood circulation system", with an average increase from 66% in the pre-test to 97% in the post-test. This indicates that students are increasingly proficient in diagnosing problems related to disorders of the circulatory system. This increase can be attributed to the unique characteristics of the Cells at Work animation media, which presents concrete visualizations and narratives of blood cell figures within the human body. In episodes that demonstrate the body's response to infection or injury (for example, the role of white blood cells in combating bacteria), students can observe directly the process by which the body responds to disorders of the blood circulation system. This provides a realistic and in-depth picture of various diseases or disorders, making it easier to understand than just through text or static images.



Figure 3. Representation of Circulation Blood in Cells at Work Media
(a): Red Blood Cell; (b): White Blood Cells; (c): Platelet Cells; (d): Human Circulation Blood; (e): Bacteria; (f): Human Heart

According to Istiqomah et al. (2023), the sub-material of blood circulation system disorders is a highly successful material because students are oriented to problems that often occur in real life, and some of them have even experienced them, such as anemia or a lack of hemoglobin in the blood. The selection of a problem-oriented learning model is considered suitable for material content related to real life (Pawlak et al., 2020). This animation encourages emotional and imaginative engagement in students because each cell is depicted as a "living" character with a distinct purpose. Thus, understanding becomes more contextual, and the concept of circulatory system disorders is no longer

abstract but is depicted dynamically (Arje Cerullo Djamen & Johan Reimon Batmetan, 2023). This supports students' analytical abilities in linking symptoms, physiological processes, and diagnosis of disorders more systematically.

Cells at Work is a Japanese animation series by Akane Shimizu, adapted from a comic of the same title (Campos & Cruz, 2020). Initially, the creator wanted to create a simple story about the life of cells in the body to help his nephew master biology material that is notoriously difficult, such as bacteria, viruses, the circulatory system, and the respiratory system (Wardani et al., 2021). Then this comic received a positive response from all fans in the world and was adapted into an animated show under David Production with the same title (Hataraku Saibou in Japanese), in several studies conducted by (Hardjana, 2021) and (Cintya et al., 2021) explained that the storyline and characters of the Cells at Work animation can represent biology material well in terms of quality.

During the learning process using the Cells at Work animation media, students exhibit a level of learning motivation that also increases, as indicated by the response questionnaire completed by students at the end of the learning process. Students assess the knowledge that is packaged in a bright character with a simple storyline, allowing the learning flow, especially in the material related to the circulatory system, to be conveyed effectively and enabling students to understand it (Aprianingsih et al., 2022).

The Cells at Work! An animation that improves students' analytical skills incorporates concrete biological visualization and a contextual narrative. Through the approach of personifying body cells—such as erythrocytes, leukocytes, and platelets—this animation not only presents factual information but also connects it with a logical and easy-to-understand storyline (Schmidt et al., 2019). The visualization of how cells work to fight pathogens, for example, forms a mental model in students' minds about how the immune system works dynamically. The narrative helps them analyze cause-and-effect relationships, such as the immune response to infection or the wound-healing process (Mahler & Mayer, 2024).

The use of Cells at Work animation media is highly suitable when combined with the Problem-Based Learning (PBL) learning model, as both emphasize the development of students' critical and analytical thinking skills (Arifin, 2021). According to (Widowati et al., 2021), Cells at Work, as an educational animation media, presents an interesting and informative visual depiction of the role and mechanism of body cells in the circulatory system. When used in PBL, this animation can trigger relevant contextual problems, such as blood circulation disorders or the body's immune response to infection, which are then analyzed together by students (Kawuri et al., 2019). In this process, students not only gain a deep understanding of the concept through concrete visualization but are also encouraged to collaboratively find solutions to the presented problems. This aligns with the characteristics of PBL, which prioritizes real-world problem-based learning, group discussions, and active investigations, making the learning process more meaningful and significantly improving students' analytical skills (Smith et al., 2022).

In addition, one of the most notable aspects during the learning process was the students' attitude, particularly in the activity of "creating detailed and structured illustrations of the blood circulation system", which received the highest response at 93%. This indicates that students were not

only actively engaged cognitively, but also showed a strong positive attitude and high levels of affective and social involvement throughout the lesson.

This level of engagement aligns well with the highest scores achieved in the LKPD, specifically in the indicators of "detailing the components of blood and their physiological processes," "classifying blood based on ABO/Rhesus types," and "diagnosing disorders in the circulatory system"—all of which earned perfect scores 100 across all groups. These results suggest that students were able to grasp the material deeply and apply it effectively in analytical tasks.

The alignment between students' positive attitudes and strong academic performance highlights the effectiveness of the Cells *at Work* animation as a learning tool. Its engaging narrative, vivid visuals, and character-driven storytelling helped students understand complex physiological concepts more clearly. This, in turn, enabled them to express their understanding through structured illustrations and in-depth analysis in their assignments, demonstrating both comprehension and creativity.

CONCLUSION

Based on the study's results, the use of Cells at Work animation media in biology learning, specifically on the concept of the blood circulation system, has been proven to improve students' analytical skills, with an average percentage of scores showing a significant increase. Students responded positively, showing greater motivation and interest in learning because the media used was engaging, easy to understand, and closely related to real-life contexts. This suggests that a narrative-based visual approach is highly effective in enhancing student engagement, particularly in complex biology topics. Furthermore, students were able to represent and solve problems related to the blood circulation system creatively and collaboratively across five aspects of analytical skills. The contribution of this research to education lies in demonstrating that integrating contextual and animated media into science learning not only enhances cognitive abilities, such as analysis, but also fosters active learning, creativity, and collaboration—key competencies in 21st-century education.

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