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The Use of the Anime Film Cells at Work Combined with Writing is Thinking to Influence Students' Cognitive Load and Mastery of Concepts in Immune System Material

Fitriani Nurpratiwi Susanto[1*], Adi Rahmat[1], Didik Priyandoko[1]

[1] Postgraduate Study Program in Biology Education, Faculty of Mathematics and Natural Sciences Education, Indonesian University of Education, Indonesia.

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Corresponding Author:
Fitriani Nurpratiwi Susanto
fitrianinurpratiwi@upi.edu

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Abstract: After the pandemic, people have become more concerned about the immune system. Immune system material is also studied in class XI in Biology. Unfortunately, immune system material is material that is difficult for students to learn because its abstract concepts with high complexity cause an increase in cognitive load on the ICL and ECL components which results in students' ability to master the Immune System concept being low. This research aims to obtain information regarding the influence of the anime film Cells at Work and Writing Thinking on students' cognitive load and mastery of concepts in the immune system material. This research uses descriptive research. The research method used was a quasi-experiment with a pre-test and post-test design. The research population is class XI students at SMAN 4 Cimahi for the 2022/2023 academic year. Sampling was conducted using Purposive Sampling so that class X1 MIPA-2 was obtained as the experimental class and class X MIPA-6 as the control class. The subjective rating scale instrument is used to measure cognitive load, while to measure concept mastery, reasoned multiple choice (two-tier multiple choice) is used to obtain data on concept mastery. Based on the results of research on the cognitive load aspect, it shows that with the use of the anime film Cells at Work combined with Writing is Thinking, there is a significant difference in scores on the lower ECL component and there is an increase in learning outcomes (GCL) compared to the control class. In line with the increase in GCL, there was a significant increase in mastery of concepts in the cognitive domains C2 (understanding), C3 (applying), and C4 (analyzing).

Keywords: Anime cells at work; Concept mastery; Reasoned multiple choice; Writing is thinking

Introduction

During the pandemic, the resilience of the human immune system throughout the world is being tested by the coronavirus. This encourages humans to understand how their immune system works to maintain and increase their body's resistance. Material regarding the immune system in humans is also studied in the Biology subject in class XI in the even semester. The immune system is one of the materials that is considered difficult for students to understand because it is an abstract concept with high complexity (Fakhriah et al., 2022; Nisa et al., 2015; Takuro, 2023).

The concept of material with quite high complexity without being able to be accompanied by a proper learning process means that Biology always becomes a rote lesson. The incompatibility of learning strategies and media used by teachers in the learning process creates a cognitive burden for students in receiving and processing the information obtained during limited learning. So students' ability to master Biology concepts is quite low (Aisyiyah et al., 2020; Rahmadani et al., 2017; Suryanti et al., 2019).

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Gathercole (2009) explains that human cognitive structure is related to working memory, where each person has a different and limited memory capacity. This causes each student's ability to understand information during learning to be different. A person who has limited working memory capacity, when receiving information, will feel difficult and burdened if there is a lot of information to be received with increasing information complexity. In this condition, a person has a cognitive load. There are 3 components of cognitive load, namely: Intrinsic Cognitive Load (ICL), Extraneous Cognitive Load (ECL), and Germane Cognitive Load (GCL).

ICL is a person's ability to receive and process the information given. Kalyuga (2011) explains that the ICL level cannot be eliminated because it is related to learning material. As long as people think there must be ICL, it's just that what is attempted in learning is to ensure that the ICL value does not increase or is within the medium criteria. ECL is a mental effort to get good learning results. ECL is influenced by learning strategies developed by teachers. This ECL can arise as a result of learning design or teaching materials. ICL and ECL are closely related to GCL. In GCL there is a self-effort to learn and remember the information learned, this GCL can be measured using a reasoning test. GCL is the effective load generated to construct cognitive schemes. Cognitive schema construction involves several cognitive processes that occur when students process information during teaching (Rahmat et al., 2015). Meissner et al. (2012) explain that good learning design is learning that is able to provide tasks that can reach a sufficient or moderate ICL level, can reduce ECL, and increase students' GCL.

The processing results of students' cognitive thinking that originate from the learning process produce the ability to master the concepts they have learned. Students' mastery of concepts must be able to be used to solve a problem related to the concept they have (Aini et al., 2018; Sumiadi et al., 2016). Mastery of concepts is the most important and fundamental thing before developing students' critical thinking abilities as a current educational demand (Ramdani et al., 2020).

To increase students' mastery of concepts, teachers continue to innovate using learning strategies and media that can control students' cognitive load by increasing students' interest and understanding of concepts. One of the interests of Indonesian teenagers that is quite high is Japanese cartoons/anime (Aprianingsih et al., 2022). Until now, anime has developed a lot with more varied titles and genres and there are also many anime films made based on scientific concepts, including the anime film Hataraku Saibou known as Cells at Work. The anime story Cells at Work is based on science and provides a study related to the performance of red blood cells and white blood cells in the body. Therefore, the anime film Cells AT Work can be used as an alternative learning media (Wardani et al., 2021).

Apart from using learning media. Choosing a learning method is also important to control students' cognitive load and increase students' ability to master concepts. This process can be helped by the writing is thinking methods. Writing is thinking is an activity of writing about concepts and material that have been studied using simple language. As a result of students' thinking, the writing thinking method can describe the extent to which students construct the knowledge they gain after learning (Ambion et al., 2020; Reyes et al., 2021). This research aims to obtain information regarding the influence of animated videos from the anime films Cells at Work and Writing Thinking on students' mastery of concepts in the immune system material.

Method

This research uses descriptive research. The research method used was a quasi-experiment with a pre-test and post-test design. The population of this study was class XI students at SMAN 4 Cimahi. The research sample was selected using a purpose sampling technique consisting of 2 classes, namely XI MIPA 2 and XI MIPA 6 as the experimental group and control group. The number of students in each class is 28 students.

Table 1. Concept Mastery Criteria (Stiggins, 1994)

Level 1	Level 2	Score	Clarification of answer
Correct	Complete reasons	5	Master the concept
Correct	The reasons are incomplete	4	Lack of mastery of concepts
Incorrect	Correct reason		
Correct	Wrong Reason	3	
Correct	No reason	2	Not mastering the concept
Incorrect	Wrong Reason	1	
Incorrect	No reason	0	

To measure the level of cognitive load on the three components, namely ICL, ECL, and GCL, the Subjective Rating Scale is used on a scale from 1 (Strongly disagree) to 8 (Strongly agree). The questionnaire used is an adaptation of the naïve rating questionnaire 2nd version. The Subjective Rating Scale is given after the learning activities are completed. Meanwhile, for the level of student mastery of concepts in the immune system material, a reasoned multiple choice test (two-tier multiple choice) was used which was developed referring to the cognitive domain indicators of Bloom's Taxonomy, including: remembering (C1), understanding (C2), applying (C3), analyzing (C4), and

evaluating (C5). The two-tier test aims to measure the extent of concepts students have acquired, reveal students' conceptual errors, and analyze concepts that students have not yet understood. Criteria for student mastery of concepts are presented in Table 1.

Result and Discussion

Cognitive Load

In each component and overall the experimental class and control class showed different results at each meeting. At the 1st meeting both classes studied material on non-specific (innate) immunity, while at the 2nd meeting studied material on specific (adaptive) immunity, and at the 3rd meeting studied material on immune disorders. The results of the overall percentage of cognitive load from the three components of ICL, ECL, and GCL at meeting 1 to meeting 3 showed that the ICL level in the control class was slightly higher than the experimental class. But both values are in the medium criteria so they do not show a significant difference. Significant differences exist in the ECL and GCL components.

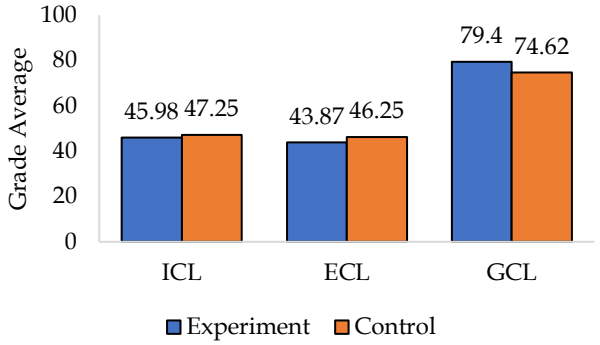

Figure 1. Differences in total cognitive load for each component

In more detail, based on the results of the average scores for each component of cognitive load, it was found that the overall ICL component in Figure 1 shows that there is no difference between the experimental class and the control class. Students' intrinsic cognitive load is in the medium category in both classes. This means that students in both classes have a cognitive process to understand the material provided but do not provide excessive cognitive load during learning. High Intrinsic Cognitive Load (ICL) does not only occur because of the large amount of material provided but many other factors cause intrinsic cognitive load so that it is difficult to make the Intrinsic Cognitive Load (ICL) low, but at least during learning you can control the Intrinsic Cognitive Load (ICL) so that it remains within the medium category. This is by the explanation Meissner et al. (2012) that a learning strategy is said to be good if it can create a moderate level of Intrinsic Cognitive Load (ICL).

Meanwhile, the ECL and GCL components as a whole show a significant difference between the experimental class and the control class which is supported by the results of statistical tests of the average differences. In the ECL average difference test the two classes obtained 0.020, while in the GCL the two classes obtained 0.012 which was significant <0.05. This shows that the use of the anime film Cells at work combined with writing is thinking can influence the ECL and GCL results. These differences can result from how the material is presented. Even though both classes use animated videos, the presentation of the storyline of the anime film Cells at Work is more interesting, there are elements of entertainment, and discussions about each immune cell character are repeated and present various kinds of problems, examples of infections that occur in the body. Repetition of discussion of material also continues because the writing is a thinking activity so it can improve student learning outcomes.

The results of the analysis of the relationship between the three components of cognitive load based on the correlation test show the results shown in Table 2.

Table 2. Correlation Test Results for Each Cognitive Load

Component		Class	r	Sig.	Information
ICL	ECL	Experiment	0.472	0.011	(+) significant
		Control	0.683	0.000	(+) significant
ICL	GCL	Experiment	-0.248	0.022	(-) significant
		Control	-0.143	0.467	Not significant
ECL	GCL	Experiment	-0.306	0.014	(-) significant
		Control	-0.290	0.134	No significant

Based on Table 2, the results of the ICL–ECL correlation test in the experimental and control classes overall show significant positive results. These results show that the higher the ICL score a student has, the more ECL the student has. This means that an increasing ICL value causes students' ability to receive and process information to decrease or become more difficult, which can cause an increase in students' mental effort.

The correlation between the ICL–GCL components was only in the experimental class (XI MIPA 2) which showed a significant negative correlation. Meanwhile, the control class did not show any correlation. This shows that an increasing ICL causes the GCL to decrease or vice versa, if the ICL decreases then the GCL increases but the effect is very small. This means that an ICL value that decreases to moderate results in students' ability to receive and process information getting better, resulting

in GCL in the form of good learning outcomes. However, this did not happen in the control class.

The correlation between the last cognitive load component between ECL–GCL is only in the experimental class which has a correlation in the negative direction and with a strong correlation level. Meanwhile, the control class shows an insignificant value. These results show that the lower the ECL score a student has, the greater the increase in the student's GCL which occurs in the student's learning results. On the other hand, if the ECL value, namely mental effort, is higher, it will cause the GCL in the form of student learning outcomes to be lower. The relationship between the components of cognitive load is by what Rahmat et al. (2015) explains, that the correlation between Intrinsic Cognitive Load (ICL) and Extraneous Cognitive Load (ECL) is significantly positive, which means that students' ability to process information has suppressed the emergence of mental effort. The correlation between Intrinsic Cognitive Load (ICL) and German Cognitive Load (GCL) is significantly negative, which means that students' ability to process information has improved learning outcomes. Meanwhile, the correlation between Extraneous Cognitive Load (ECL) and German Cognitive Load (GCL) is significantly negative, which means that a decrease in mental effort encourages better results. Reducing mental effort can increase space in cognitive memory to form new cognitive schemes.

This shows that the use of the anime film Cells at work combined with writing is thinking can influence the ECL and GCL results. These differences can result from how the material is presented. Even though both classes use video media, the presentation of the storyline of the anime film Cells at Work is more interesting, there are elements of entertainment and repeated discussions about each immune cell character. The anime film Cells at Work presents a story about the physiological mechanisms of cells in the body which is packaged simply and interestingly without losing its scientific essence (Aprianingsih et al., 2022; Takuro, 2023; Wardani et al., 2021). Repetition of material discussion also continues because the writing is a thinking activity. With the writing thinking method, students must write down the concept of knowledge obtained based on their understanding. To be able to write down their knowledge concepts well, students are encouraged to focus more on learning (Menary, 2007).

Mastery of Concepts

The results of the test for mastery of biological concepts before being given treatment for the experimental and control groups, each obtained an average pre-test score of 20.37 and 20.43. Based on the average difference test in the pre-test, it shows a score of 0.881 with a significance of >0.05 so there is no difference in students' initial knowledge.

Meanwhile, the average post-test score for the experimental group that was treated with learning using the anime film Cells at Work combined with Writing is Thinking was 80.20 and the average post-test score for the control group that was treated with learning using PowerPoint and Student Worksheets was 74.97.

The material presented on the immune system is divided into 3 sub-materials, namely: Non-specific immune mechanisms, Specific immune mechanisms, and Immunity, and Disorders of the immune system. Each sub-material is presented in 1 meeting. The results of mastering the concepts in each material can be seen in Figure 2.

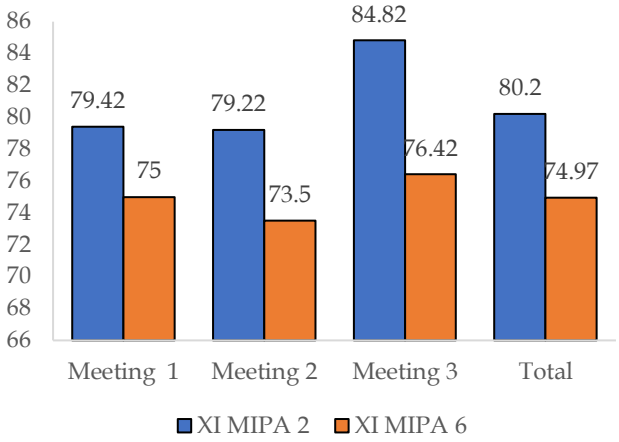

Figure 2. Average concept mastery score for each meeting

The data in Figure 2 on the immune system material, shows that the level of mastery of the material for classes XI MIPA 2 and XI MIPA is different. The percentage of students who mastered concepts in class XI MIPA 2 as the experimental group was a higher percentage than in class XI MIPA 6 which was the control class. Based on the test, the difference in the average post-test score for mastery of the overall concept between the experimental class and the control class obtained a score of 0.000 with a significance of <0.05, meaning that there was a difference in the average score between the two classes at each meeting. The experimental class has a greater average score. Thus, the experimental class students' mastery of concepts was better than the control class. The levels of mastery of the concept of the Immune System in each cognitive domain are shown in Table 3.

Based on Table 3, shows the percentage of student's mastery of concepts in each cognitive domain. Students who fall into the understanding category can be seen from explanation answers that are by the concept, meaning that the correct answer they get is not just

guessing but is by the concept. The percentage of the number of experimental class students towards the level of concept understanding in each cognitive domain of the Understanding criteria shows results of more than 50% or more than half of the experimental class students were able to master concepts in cognitive domains C1 to C5. Meanwhile, in the control class, concept mastery that can reach the understanding criteria with a percentage of students of more than 50% is only found in the cognitive domains C2 (understanding), C3 (applying), and C5 (evaluating). However, the number of students who mastered the concept was still higher in the experimental class than in the control class. The results of this research are similar to previous research by Puspitasari carried out in 2022 and Takuro's research in 2023. However, the previous research did not explain in detail the mastery of concepts in each cognitive domain.

Table 3. Percentage of the Number of Students in the Concept Mastery Criteria for Each Question Domain

Question realm	Understand		Not understand		Do not understand	
	Experimental	Control	Experimental	Control	Experimental	Control
C1	53.6%	50%	32.1%	35.71%	14.3%	14.3%
C2	64.3%	53.6%	28.6%	32.1%	7.1%	14.3%
C3	46.4%	32.1%	32.1%	42.9%	21.5%	25%
C4	57.1 %	50%	25%	25%	17.9%	25%
C5	53.6%	57.1%	35.7%	14.3%	10.7%	28.6%

Based on the research that has been carried out, there are striking differences in the results of the cognitive domain of concept mastery between the experimental class and the control class. Learning using the anime film Cells at Work combined with Writing is Thinking can improve mastery of concepts in the cognitive domains C2 (understanding), C3 (applying), and C4 (analyzing). Apart from that, learning using the anime film Cells at Work combined with Writing is thinking can reduce the number of students who have difficulty understanding the immune system material compared to learning carried out using PowerPoint. However, learning using the anime film Cells at Work combined with Writing is thinking has not been able to improve student's abilities in the C5 cognitive domain.

Anime films present stories about the immune system, blood circulation, physiological concepts of the body, and various kinds of problems that occur in the body which are related to each other, and are presented with a storyline that is easy to understand and attractive visuals (Wardani et al., 2021). This results in students easily connecting the knowledge they have received between sub-materials (Aprianingsih et al., 2022; Takuro, 2023; Wardani et al., 2021).

When using PowerPoint some scientific animated videos and images support the immune system material. However, most animated videos about immune mechanisms are not connected, or the immune mechanisms presented are only available in a few conditions. So it cannot describe the working mechanism of immunity more broadly with the various problems that occur. This is what makes mastery of concepts with conventional learning only reach the C2 cognitive realm, namely understanding concepts. However, applying concepts and analyzing concepts to real problems is still very low.

Meanwhile, the Writing-is-thinking method encourages students to first understand in depth the concepts being studied and then write down students' thoughts about the concepts that students understand simply using their own words (Ambion et al., 2020; Reyes et al., 2021). At the first meeting, the Writing is thinking results were slightly lower than using Worksheets. This is because students have never studied Writing is Thinking and students are used to doing assignments via Student Worksheets. However, most of the student worksheets used so far are only able to make students answer questions based on what is stated in the learning resource without first understanding the written answers (Susanto et al., 2020). Abilities began to improve at the next meeting. Students explore more of the concepts they have learned and write down these concepts according to their understanding. This is in line with what has been stated by Alloway (2009) that the writing method can help construct the knowledge obtained by oneself to understand the content being studied and improve memory.

The results of concept mastery are closely related to high-level thinking abilities and critical thinking (Aini et al., 2018). This is by existing findings, learning using the anime films Cell at Work and Writing is Thinking can increase concept mastery, indicated by the number of students who can answer questions in the cognitive domains C2 (understanding), C3 (applying), and C4 (analyzing). This ability to apply and analyze is an indicator of high-level thinking and critical thinking abilities.

Even though anime is used less frequently in learning than other visual media, anime has rich potential as a learning resource that can illustrate scientific concepts. For a long time, many animated films contain life values, and currently, many Japanese anime

are made based on scientific knowledge (Bachmann et al., 2017; Ryu et al., 2020; Takuro, 2023). However, in its application during learning, the right strategy is needed so that it is easy to apply and the information received is correct. This is because some of the story concepts do not correspond to existing reality. After all, the aim is for the audience to easily understand and be entertained, so a simple analogy is made, so further explanation is needed to avoid misunderstandings such as the way white blood cells fight pathogens using weapons, viruses that infects cells by eating the heads of the cells, and other things.

Correlation of Cognitive Load and Concept Mastery

The cognitive load that arises during the learning process is believed to be one of the factors that influence student learning outcomes. Therefore, it is important to know the relationship between the components of cognitive load and the results of concept mastery as shown in Table 4.

Table 4. Percentage of the Number of Students in the Concept Mastery Criteria for Each Question Domain

Component		Class	r	Value Sig.	Interpretation	Information
ECL	Concept	Experimental	-0.474	0.011	Sig.>α	Significant Negative
	Mastery	Control	-0.128	0.053	Sig.>α	Not significant
GCL	Concept	Experimental	0.480	0.010	Sig.<α	Significant Positive
	Mastery	Control	0.279	0.036	Sig<α	Significant Positive

Based on Table 4, shows the results of extraneous cognitive load with concept mastery in the experimental class as a whole with a significance value of 0.011 which is smaller than 0.05, and an r-value of -0.474, meaning it has a strong negative correlation. Meanwhile, the control class with a value of 0.053 is more than 0.05 and an r value of -0.128 does not correlate. With negative correlation results, it means that the lower the mental effort, the easier it is for students to understand and master the concepts being studied. On the other hand, if the student's mental effort is high, it means that the student has difficulty understanding the concept being conveyed. The r value shows how strong the correlation is, the experimental class has a higher r value than the control class. This shows that the use of media and methods given to the experimental class had a better effect than the control class.

The correlation between Germane's cognitive load and mastery of concepts in the experimental class as a whole with a significance value of 0.010 is smaller than 0.05 and an r value of 0.480, meaning it has a strong positive correlation. Meanwhile, the control class with a value of 0.036 is more than 0.05 and an r value of -0.128 has a weak positive correlation. Germane's cognitive load results are obtained from a statement regarding how confident students are in mastering the concept after learning is carried out and the GCL results are then linked to the results of mastering the concept that has been achieved. In the experimental class, it was shown that students who filled out the GCL questionnaire with high scores or were confident in what they had understood were proven to have high concept mastery results as well. On the other hand, students who get a low GCL will also have low concept mastery scores. This also happened in the control class but the correlation between GCL and concept mastery was weak. This is because several respondents have low GCL scores but their concept mastery scores are quite good or vice versa. According to Juanengsih et al. (2018), this condition can occur because students who feel they do not understand the material being studied will look for other learning resources to get good grades or the students' knowledge during the learning process is only basic knowledge and cannot apply their knowledge more deeply.

The use of the anime film Cells at Work combined with writing is thinking which is used in learning the immune system is one of the factors that causes the cognitive load to be sufficiently resolved in the overall ECL and GCL components so that students are at a high level of cognitive thinking. This is by previous research which states that the most important thing in choosing learning strategies in class is being able to control students' ICL, reducing ECL, and increasing GCL (Hidayat, 2022). The cognitive load that occurs on students can be said to be resolved if students can organize and manage themselves in participating in learning. This ability can influence students' mastery of concepts. Based on previous research, Latifah et al. (2020) emphasized that students control themselves in a class by maintaining a sense of comfort during learning. Thus, this research shows that the use of the anime films Cells at Work and Writing is Thinking can overcome Extraneous Cognitive Load (ECL) and German Cognitive Load (GCL) as well as increase students' mastery of concepts in the human immune system material.

Conclusion

Based on the research results, it was concluded that learning using the anime Cell at Work combined with Writing is Thinking can reduce extraneous cognitive load (ECL) and increase germane cognitive load (GCL) better than conventional learning. Controlling cognitive

load is very important and influences students' mastery of concepts. Apart from that, learning using the anime Cell at Work combined with Writing is Thinking can improve students' mastery of concepts in each cognitive domain, especially C2 (understanding), C3 (applying), and C4 (analyzing). However, it has not been possible to improve the ability to evaluate (C5) because the storyline analogy in the anime film Cells at Work is too simple and the limited material presented is only about the working mechanisms of cells.

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The authors in this research are divided into executor and advisor.

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Conflicts of Interest
The author declares no conflict of interest in this research.

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