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# Retrieval Practice: Strategy for Reducing Cognitive Anxiety through Students' Concept Mastery and Cognitive Ability

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**Abstract**: Retrieval practice is a well-known additional learning strategy after class to maintain long-term memory. This study investigates its effect on students' concept mastery, cognitive ability, and cognitive anxiety in learning about the immune system. Using purposive sampling, 128 eleventh-grade students from a public school in Bandung were divided into two groups: 67 in the experimental group and 61 in the control group. In both groups, immune system learning was given three times over three weeks, and retrieval practice was given three days after classroom learning through Google Forms. Concept mastery and cognitive ability were assessed with a 30-item multiple-choice test, while cognitive anxiety was measured with a 27-item questionnaire with nine scales. To see the effect of retrieval practice and the relationship between the data, they were analyzed using T-test or Mann-Whitney and Spearman's rank. The results showed that retrieval practice significantly improved concept mastery and cognitive ability, and reduced students' cognitive anxiety. However, there was no correlation between concept mastery and cognitive anxiety. These results suggest that cognitive anxiety is not related to concept mastery. Cognitive anxiety is more directly affected by retrieval practice.

**Keywords:** cognitive ability, cognitive anxiety, concept mastery, immune system learning, retrieval practice

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## INTRODUCTION

The learning paradigm has recently shifted from teacher-centered to student-centered to promote student-driven learning. Student-centered learning emphasizes teachers adapting their teaching to students' needs, whereas student-driven learning empowers students to have greater control over the direction and management of their own learning (Abdigapbarova & Zhiyenbayeva, 2023; Al-Ansi, 2022). In this student-driven learning, the focus of learning is no longer on memory, but rather on the development of student's skills and understanding (Serin, 2018). Students can learn actively and independently when they can use their knowledge to explain a phenomenon or solve a problem (Anggraeni & Listiaji, 2024). For this reason, what needs to be considered in student-centered learning is the effective learning strategy that students implement, not only the strategy of understanding a concept but also the strategy of how the concept that has been understood can enter and be well stored in long-term memory. Unfortunately, effective learning strategies are not yet widely used by students. The majority of students still use ineffective learning strategies, such as rereading, restudying, and/or highlighting (Blasiman et al., 2017; Carpenter et al., 2022; Rovers et al., 2018). These strategies are unable to build long-term memory and therefore harm students' learning performance (Palmer et al., 2019).

Ineffective learning strategies cause several problems in learning. First, memory in the brain is not maximized in retrieving information, so students cannot master certain learning concepts thoroughly

(Moreira et al., 2019). Second, students' cognitive abilities are underdeveloped because they rely only on short-term memorization (van Gog & Sweller, 2015). This makes learning meaningless in students' memories (Palmer et al., 2019). Third, ineffective strategies cause anxiety related to students' lack of confidence in their ability to face exams at school (Hadden & Frisby, 2019). The anxiety felt by students is also referred to as cognitive anxiety.

A learning strategy known as retrieval practice has been introduced and identified as one of the most effective learning strategies (Bertilsson et al., 2021; Karpicke et al., 2016; McDermott, 2021; Van Hoof et al., 2021). Retrieval practice entails engaging in repeated practice questions with feedback outside of the classroom setting. The strategy has been demonstrated to enhance students' learning performance by strengthening their memory and metacognitive systems. This strategy can enhance the quality of learning in two distinct ways, both directly and indirectly. First, the repetition of practice questions facilitates the strengthening of the memory system, thereby optimizing students' capacity to recall a concept (Pastötter & Bäuml, 2014). Furthermore, repeated practice questions assist students in establishing connections between disparate concepts (Kliegl & Bäuml, 2021). In addition, the feedback received through retrieval practice enables students to identify areas requiring further attention for optimal learning (Van Hoof et al., 2021).

With various benefits to improve the quality of learning, the retrieval practice strategy is a solution to the problem of ineffective learning strategies that are often used by students. This is supported by the way retrieval practice encourages students to recall information that they have stored in long-term memory and reprocess it in working memory (Biwer et al., 2020). Through retrieval practice, students consolidate the material that has been learned and store it back in long-term memory (McDermott et al., 2014). The retrieval practice strategy can also improve students' ability to remember the knowledge that has been mastered and apply it in new situations (Fiorella & Mayer, 2016). Compared to other strategies such as summarizing, rereading, or underlining text, retrieval practice is more effective in maintaining students' long-term retention (Agarwal et al., 2021; Biwer et al., 2020). Students' difficulties in mastering certain concepts due to short-term memorization as well as students' underdeveloped cognitive abilities due to poorly trained memory, can be overcome by retrieval practice strategies.

Retrieval practice strategies not only impact concept mastery and cognitive abilities but also help students overcome cognitive anxiety, particularly when facing exams. Repeated practice questions in retrieval practice familiarize students with exam-taking (Agarwal et al., 2014), while the feedback provided by teachers following the implementation of retrieval practice offers students an opportunity to reflect on and improve their understanding of information they may not fully grasp, thus enabling them to relearn it (McDermott, 2021). Moreover, corrections provided by teachers in the feedback are also highly beneficial to students in maximizing learning performance (Hui et al., 2021). The habit of students engaging with practice questions and the presence of feedback reduce anxiety when facing exams because they gain confidence in their abilities (Hadden & Frisby, 2019; Jones et al., 2021). Therefore, the implementation of retrieval practice strategies in learning not only improves learning outcomes and cognitive abilities but also diminishes the cognitive anxiety experienced by students (Abel & Bäuml, 2020; Agarwal et al., 2014; Van Hoof et al., 2021).

Several studies related to retrieval practice were conducted on a laboratory scale and a classroom scale. (Agarwal, 2018) applied retrieval practice in history subjects, while (Dobson et al., 2017) applied retrieval practice in anatomy courses. Both of these studies applied retrieval practice on a classroom scale. According to (Agarwal et al., 2021), there is still a need for more in-depth exploration related to research on the implementation of retrieval practice, especially on learning materials in schools. Retrieval practice can be implemented at various levels of the educational system, particularly at the middle and high school level (Mcdaniel et al., 2013; McDermott et al., 2014). Biology learning, which forms part of the curriculum at the middle and high school levels, lends itself particularly well to the application of retrieval practice strategies (Pan et al., 2016). This is because biology involves many specific topics, requiring retrieval practice to reinforce information related to those topics (Agarwal et al., 2021). However, the implementation of retrieval practice strategies in biology learning in schools is still very limited, especially in improving students' concept mastery of the material, developing students' cognitive abilities, and reducing students' cognitive anxiety.

One of the materials in biology learning that students learn at school is the immune system. Immune system material involves a lot of detailed information that needs to be remembered (as it


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includes both concrete facts and abstract concepts), scientific terms, and various mechanisms that cannot be observed directly (Rahayu & Nurcahyo, 2020), so it is considered complex and complicated. When taught in high school, the immune system concept is difficult for students to imagine (Rawlings, 2019) and it is prone to causing misconceptions (Cahyati et al., 2022; Ristanto et al., 2020). In addition, learning the immune system requires students to be able to solve problems and think critically about immune system problems in real situations (Kustiani et al., 2018). Based on these characteristics, retrieval practice is suitable to be applied to immune system material because it can help high school students understand scientific terms, describe the mechanism of the immune system, and train critical thinking and problem-solving skills by providing repeated practice questions accompanied by feedback containing input and suggestions for improvement. Thus, retrieval practice is expected to improve students' concept mastery of immune system material.

In addition to contributing to the improvement of immune system concept mastery, retrieval practice exercises accustom students to analyzing a concept and practice cognitive processes by strengthening memory and information retrieval, so that their cognitive abilities can develop (van Gog & Sweller, 2015). Retrieval practice is expected to develop students' cognitive abilities towards higher levels of cognitive processes, especially in learning the immune system which is complex and difficult to observe directly (Trisnaningsih et al., 2016). In addition, the feedback given after retrieval practice provides clues for improvement and encourages positive thinking and self-confidence, thus helping to reduce student anxiety (Zhang & Rahimi, 2014). Based on the above description, this study investigates the implementation of retrieval practice as an additional learning strategy outside of classroom immune system learning hours with the following research questions:

1. What are the students' concept mastery, cognitive ability, and cognitive anxiety in learning the immune system with retrieval practice strategy like?
2. What is the relationship between students' concept mastery and their cognitive anxiety in immune system learning that applies retrieval practice strategy?

## METHOD

This study is a quasi-experiment involving an experimental group and a control group. Quasi-experimental research aims to create a more natural setting, rather than manipulating conditions like in a laboratory, so not all variables can be controlled or altered (Cohen et al., 2018). The experimental group received the intervention of retrieval practice learning strategy after learning hours, while the control group was asked to reread the material that the teacher had given in class. The research design was developed based on a non-equivalent pre-test post-test control group design (Figure 1).

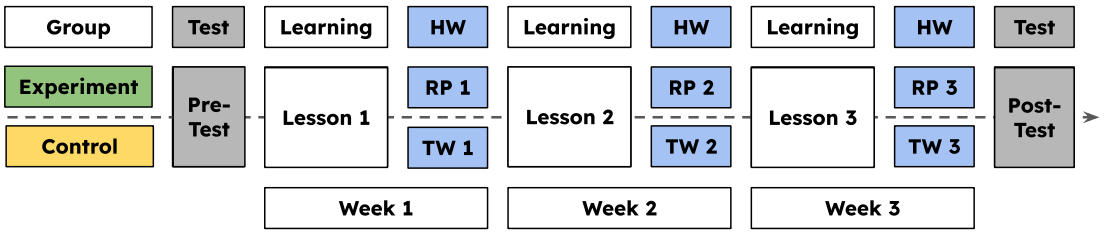


**Figure 1**. Research Design of Retrieval Practice Implementation in Immune System Learning
*"HW" is a homework or session after class hours where the experimental class does retrieval practice (RP 1, RP 2, RP 3) and the control class works on task worksheets (TW 1, TW 2, TW 3).*

This study was conducted from February to June 2023. A total of 128 high school students from 11$^{th}$ grade science class in one of the public high schools in Bandung City, who were studying the immune system were involved in this study. The division of the two groups was done non-randomly, with the number of students in each class being relatively equal. The classes were selected based on specific criteria (purposive sampling technique). The criteria used were balanced student performance between the experimental and control classes. A total of 67 students were in the experimental group and divided into two classes, each consisting of 33 and 34 students. A total of 61 students were in the control group also divided into two classes, each consisting of 30 and 31 students.


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The effect of learning, both in the experimental and control groups, was seen based on three parameters, namely concept mastery, cognitive ability, and cognitive anxiety. Concept mastery was measured using a test on immune system material (pre-test and post-test). The pre-test and post-test questions totaled 30 multiple-choice questions with a reliability value (Cronbach α) of 0.96. The instrument was tested for content validity through expert judgment and construct validity. Initially, there were 40 items, but 10 of these were judged to be of insufficient significance and were therefore excluded. Students' cognitive ability was measured using the same instrument as for concept mastery, but only after the learning had been completed. The questions of concept mastery and cognitive ability were designed based on The New Taxonomy (Marzano & Kendall, 2007a). The instrument grids can be seen in **Table 1**. Cognitive anxiety was measured using a 27-item questionnaire adapted from the Cognitive Test Anxiety Scale (CTAS) (Cassady & Johnson, 2002). The questionnaire was translated into Indonesian and the wording was adapted to be easily understood by high school students in Indonesia. The questionnaire was tested for content validity, including readability ratings by experts and some students. The questionnaire used nine scales ranging from 1 (strongly disagree) to 9 (strongly agree). The cognitive anxiety questionnaire includes five indicators of cognitive anxiety, namely anxiety before the exam, anxiety about the abilities during the exam, anxiety in answering exam questions, anxiety about getting into trouble during the exam, and anxiety about the exam results.

**Table 1.** Pre-test and Post-test Grids based on The New Taxonomy (Marzano & Kendall, 2007a)

| Cognitive Levels | Cognitive Processes | Indicator | Number of Questions |
|---|---|---|---|
| Level 1 - *Retrieval* | Recognizing | • Recognizing the characteristics of the immune system, the cells involved in immune responses, and the components of the nonspecific immune system | 3 |
| | Recalling | • Recalling the types of specific immune systems, the structure of antibodies, and the substances contained in the nonspecific immune system | 3 |
| Level 2 – *Comprehension* | Integrating | • Explaining the relationship between antigens and antibodies, vaccination and immunity; demonstrating the sequence of events that support inflammation, and the characteristics of cells involved in the specific immune system | 4 |
| | Symbolizing | • Representing the sequence of the inflammatory process in a flowchart, the binding of antibodies and antigens in an illustrated diagram, and the immune response during an allergic reaction in an illustrated diagram | 3 |
| Level 3 – *Analysis* | Matching | • Identifying the cells involved in immune responses and illustrating nonspecific defenses | 2 |
| | Classifying | • Categorizing types of immunity and the stages of immune system mechanisms | 2 |
| | Analyzing error | • Analyzing the occurrence of allergies and the decline of human immunity | 2 |
| | Generalizing | • Drawing conclusions related to the types of cells in immune responses and the side effects of vaccines based on phenomena | 2 |
| | Specifying | • Determining the specific stages of humoral and extracellular immune mechanisms | 2 |
| Level 4 – *Knowledge Utilization* | Decision making | • Making the right decisions to minimize allergy symptoms, boost immunity, and avoid viral infections | 4 |
| | Problem-solving | • Determining the appropriate solutions to address immune system disorders | 3 |
| | | **Total Questions** | 30 |

The study began with giving pre-test questions to the experimental group and control group. After the pre-test, students from each group carried out immune system learning for three weeks. Learning activities in both groups used the discovery learning model, following the curriculum implemented in the schools, namely Revised Curriculum 13. The discovery learning model used included several stages in learning: stimulation, problem statement, data collection, data processing, verification, and generalization.

Both the experimental and control groups were taught three times over three consecutive weeks, following the allocated time for studying the immune system at school (Figure 1). Three days after each


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classroom lesson was conducted, both groups of students were required to participate in learning activities after class hours. In the experimental group, students were required to engage in retrieval practice, which involved practicing questions based on the learned material provided through Google Forms. Meanwhile, students in the control class worked on task worksheets. Furthermore, one day after the retrieval practice session, students in the experimental group received feedback on their performance in the retrieval practice activity, whereas the control group was instructed to verify their mastery of the material based on the task worksheets they had completed. After three weeks of implementation, students in the experimental and control groups were asked to complete post-test questions to measure their concept mastery and cognitive abilities and to fill out a cognitive anxiety questionnaire.

Data on concept mastery from both the pre-test and post-test were analyzed using the Mann-Whitney test to determine differences between the two groups. The Mann-Whitney test was used because the assumptions of parametric tests were not met. The results of the N-Gain calculation were used to see the increase in concept mastery of experimental and control group students. N-Gain was grouped and interpreted according to (Hake, 1999) (Table 2). Data on students' cognitive abilities were seen from the post-test results and analyzed using the Mann-Whitney test to determine differences in cognitive abilities between experimental and control group students at each cognitive level (retrieval, comprehension, analysis, and knowledge utilization). Cognitive anxiety data were analyzed using the Independent Sample T-test and Mann-Whitney test to determine differences in cognitive anxiety between experimental and control groups. Cognitive anxiety data were categorized into three groups based on the scores obtained (Cassady & Johnson, 2002). The amount of influence obtained on the three instruments was calculated using effect size. Cognitive anxiety categorization and effect size values can be seen in Table 3 and Table 4. The correlation between concept mastery and cognitive anxiety was analyzed using Spearman's rank correlation coefficient because the data did not meet the assumptions for parametric tests, such as normal distribution or linearity.

**Table 2**. N-gain Categorization (Hake, 1999)

| Score | Interpretation |
|---|---|
| $g < 0.3$ | Low |
| $0.3 < g < 0.7$ | Medium |
| $g > 0.7$ | High |

**Table 3.** Cognitive Anxiety Score Categorization (Cassady & Johnson, 2002)

| Score | Interpretation |
|---|---|
| 0-33% | Low |
| 34-66% | Medium |
| 67-100% | High |

**Table 4.** Effect Size Categorization (Cohen et al., 2018)

| Score | Interpretation |
|---|---|
| 0-0.20 | Very weak |
| 0.21-0.50 | Weak |
| 0.51-1.00 | Medium |
| >1.00 | Strong |

## RESULT AND DISCUSSION

### Concept Mastery

Data on students' concept mastery in both research groups in learning the immune system are presented in Table 5. The pre-test results showed no significant difference in average scores between the experimental and control groups ($p = 0.199$). The insignificant difference in average scores in the pre-test results indicates that both groups of students have the same initial knowledge of the immune system concept. The post-test results showed that there was a significant difference in average scores between the experimental and control groups ($p = 0.000$), where the average score of concept mastery in the experimental group was higher than that in the control group. These results indicate that retrieval practice strategy has a significant effect on students' concept mastery in learning the immune system.


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The effect of retrieval practice strategy on concept mastery is included in a strong effect with an effect size of 1.05.

**Table 5.** Data on Students' Concept Mastery in Both Research Groups

| Test | Research Group | Mean & SD | Sign |
|---|---|---|---|
| Pre-Test | Experimental | 30.49 ± 10.20 | 0.199 |
| | Control | 32.11 ± 9.75 | |
| Post-Test | Experimental | 66.85 ± 12.59 | 0.000** |
| | Control | 54.05 ± 12.13 | |

**very significantly different

The difference in concept mastery between the experimental group and the control group at the end of learning the immune system is also evident from the difference in the improvement of concept mastery (N-gain) between the two groups of students (Figure 2). The experimental group experienced an increase in concept mastery of 0.52, while the control group had a lower increase in concept mastery, which was 0.32. These results strengthen the evidence showing that the retrieval practice strategy helps students in mastering the concept of the immune system. This result is also in line with (Gjerde et al., 2022) who conclude that students with retrieval practice strategy are superior in concept mastery than students without retrieval practice strategy. Retrieval practice requires students to remember and apply knowledge about a concept, thus increasing their ability to master the concept.

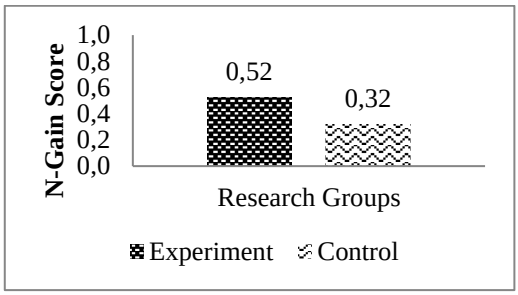


**Figure 2**. Comparison of Concept Mastery Improvement (N-gain)

The findings of this study are in line with the findings of the research by (Carpenter et al., 2016; Kliegl & Bäuml, 2021; Littrell-Baez et al., 2015; Pastötter & Bäuml, 2014). Students can master a concept in learning the immune system because they can store and recall concepts that have been learned. The student's ability to remember the concept is due to the retrieval practice strategy that students use consistently. Retrieval practice allows students to repeat the immune system material that has been learned at school through practice questions every week. The practice questions given in retrieval practice are adjusted to the scope of material presented by the teacher so that students do not feel overwhelmed by repeating the material every week. Through practice questions in retrieval practice, students can sharpen their understanding and improve their learning performance (Carpenter et al., 2016), and can even improve student retention of a concept (Karpicke et al., 2016). Students who participate in retrieval practice activities can maximize their ability to remember a concept (Pastötter & Bäuml, 2014). In addition, students are trained to connect one concept with another (Kliegl & Bäuml, 2021). Thus, retrieval practice activities allow students to strengthen the relationship between existing concepts and new concepts and even make students think more flexibly when working on exam questions (Littrell-Baez et al., 2015).

The findings of this study are consistent with the theory. According to the theory of information processing models (Anderson, 2000; Sternberg & Sternberg, 2016), the process of remembering and mastering certain concepts is related to the work of memory in the brain. There are three memories in the human memory system, namely sensory memory, working memory or short-term memory, and long-term memory. Retrieval practice makes students train working memory to retrieve information that they have stored in long-term memory (Van Hoof et al., 2021). A trained working memory makes retrieving information from long-term memory easier, so students can more easily remember information or a concept they have learned. The retrieval practice strategy is considered more effective for remembering material for a longer time than re-reading or re-studying material (Moreira et al., 2019). Retrieval


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practice makes a specific area in the human brain work actively. These areas are the anterior and posterior parts of the hippocampus, which are parts of the brain involved in memory and information retrieval. Retrieval practice makes students repeatedly recall information from memory that is processed and facilitated by the hippocampus. The activity familiarizes the brain to access information and strengthens connections between synapses on the information being retrieved (Wiklund-Hörnqvist et al., 2021). As a result, it makes it easier for students to remember and master a concept.

In retrieval practice, there is also the provision of feedback. In this study, the feedback provided not only includes students' scores or achievements during practice questions but also contains corrections by the teacher on students' practice question answers. This correction is equipped with a discussion of the question and suggestions on what students should study again if they cannot work on related questions. The components in the feedback make students know what concepts they have not understood and make students think more deeply about a concept. Corrections from the teacher contained in the feedback are also very helpful for students in maximizing learning performance (Hui et al., 2021). In addition, feedback motivates students to learn better in understanding a concept and encourages students to be able to reuse retrieval practice strategies in improving learning performance (Abel & Bäuml, 2020).

The findings of this study confirm that the complexity and difficulty in understanding the immune system material can be overcome by students through the implementation of a retrieval practice strategy. The use of retrieval practice proved effective in improving students' understanding in remembering the concept of the immune system and applying it in real-life situations. Through this strategy, students can be more actively involved in the learning process. Feedback after retrieval practice provides an overview of the strengths and weaknesses possessed by students. With suggestions and improvements, students can better understand the parts that need to be improved in their understanding of the immune system concept. Thus, the retrieval practice strategy is an effective learning strategy to improve students' understanding and application of immune system concepts.

**Cognitive Ability**

In this study, we distinguish concept mastery from students' cognitive ability. The term cognitive ability is used to indicate the level of cognitive process that students achieve after learning the immune system is completed. Following the New Taxonomy, there are four levels in the cognitive system, namely retrieval (Level 1), comprehension (Level 2), analysis (Level 3), and knowledge utilization (Level 4) (Marzano & Kendall, 2007b). The difference in cognitive abilities between the experimental group students and the control group students is presented in Table 6. After learning the immune system with and without retrieval practice, it is known that the cognitive abilities of experimental group students have a higher average score and are significantly different at higher levels of cognitive processes, specifically in comprehension, analysis, and knowledge utilization (Table 6).

The highest cognitive ability in both groups was in the cognitive process of retrieval or at the lowest cognitive process level (Level 1), where students in the experimental group and control group did not show significant differences. There are two cognitive processes measured at this level, including recognizing information (recognizing) and recalling information (recalling). The absence of significant differences between the experimental and control groups on these two cognitive processes indicates that the cognitive process of retrieval (Level 1) is not affected by retrieval practice. In other words, the high average score at Level 1 is not caused by repeated practice questions on retrieval practice. This result is in line with the findings of (Goossens et al., 2016) and (Moreira et al., 2019) who concluded that the retrieval practice strategy does not always help students in recalling information. Several studies have found that one reason students fail to recall information is their lack of awareness of retrieval practice, especially with questions they consider easy and believe can be mastered without optimal practice (Dobson, 2017, 2020). Different findings were found by (Endres et al., 2020) where with retrieval practice students can remember information (recall) specifically.

Cognitive abilities of students, both in the experimental group and the control group decreased in higher cognitive processes (comprehension, analysis, and knowledge utilization). However, in general, students in the experimental group or the group that participated in retrieval practice activities had higher cognitive abilities than control group students. In the cognitive process of comprehension (Level 2), the average score of the experimental group was 69.03, which was very different from that of the control group (44.54) with an effect size of 1.312. These results illustrate that students' ability in the


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cognitive process of comprehension is strongly affected by retrieval practice activities they carried out. There are two cognitive processes measured in comprehension, including integrating information (integrating) and symbolizing or representing information (symbolizing). These two cognitive processes can be trained during retrieval practice activities, thus increasing students' cognitive abilities at the comprehension level (Hinze et al., 2013). In retrieval practice activities, students are allowed to recall previously learned information. This allows them to integrate the information they already have, which will then have an impact on strengthening the information to form an understanding (Roelle et al., 2022). Similar results were also found by (Whiffen et al., 2017) where the implementation of retrieval practice periodically would produce representation skills in a context.

**Table 6.** Data on Students' Cognitive Ability in After Learning the Immune System

| No. | Level of Cognitive System | Experiment | Control | Sign | Effect Size |
|---|---|---|---|---|---|
| 1 | Level 1 - Retrieval | 71.39 ± 19.14 | 72.64 ± 21.04 | 0.611 | - |
| 2 | Level 2 - Comprehension | 69.03 ± 19.18 | 44.54 ± 18.71 | 0.000** | 1.312 |
| 3 | Level 3 - Analysis | 63.13 ± 15.68 | 53.11 ± 18.75 | 0.004** | 0.533 |
| 4 | Level 4 - Knowledge Utilization | 65.69 ± 21.09 | 48.72 ± 19.04 | 0.000** | 0.884 |

**very significantly different

As is the case in the cognitive process of comprehension, students in the experimental group have higher analysis ability (Level 3) (63.13) than control group students (53.11) and are very significantly different. This result illustrates that retrieval practice affects students' analysis ability. However, the effect is not as strong as in comprehension ability (Level 2) because the effect size is 0.533 and falls into the medium category. This is because the analysis ability requires a deeper cognitive process, which requires a more sophisticated level of thinking (Wang et al., 2024). Nevertheless, this result provides evidence that retrieval practice can train students' analytical skills. Through retrieval practice, students are trained in matching, classifying, analyzing errors, generalizing, and specifying. Repeated practice questions in retrieval practice accustom students to analyzing a concept. When students are accustomed to analyzing, slowly they will get used to analyzing problems and being critical. These results strengthen the findings of previous research, where retrieval practice affects students in matching one piece of information with other information (matching) (van Gog & Sweller, 2015). In addition, students also get long-term learning benefits, one of which is in analyzing misinformation during exams (Schuetze et al., 2019).

Furthermore, for the cognitive ability of knowledge utilization (Level 4), the experimental group also got a higher average value (65.69) and was very significantly different compared to the control group (48.72). These results prove that retrieval practice affects students' ability to use their knowledge, even though the effect is in the medium category with an effect size of 0.884. There are two important cognitive processes at the knowledge utilization level, specifically problem-solving and decision-making. The experimental group's better average scores on these two cognitive processes prove that retrieval practice has also trained students to use their knowledge in solving problems and making decisions. When working on retrieval practice questions, students read and try to solve the problems presented in the questions. In the process, students will recall information related to the steps needed to solve the problem presented from their long-term memory. As a result, when faced with a similar problem students can easily determine the solution (Carpenter et al., 2022). In learning the immune system, many examples of cases in everyday life are presented and require using their abilities to solve problems or make decisions. In this case, students will have no difficulty making decisions and solving problems because they have often practiced and faced with various examples of cases through retrieval practice. The information stored in long-term memory is what makes students able to recognize problems and provide solutions (van Gog & Sweller, 2015). This finding seems to break the opinion that complex material demands such as solving problems will not make students feel the effects of retrieval practice (Leahy et al., 2015). Although the cognitive process of knowledge utilization (Level 4) is included in the high cognitive process level, complex, and requires students to use the knowledge they already have in solving problems and making decisions, in reality, through retrieval practice this can be achieved.


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**Cognitive Anxiety**

Cognitive anxiety is related to negative thoughts that students may experience. Giving retrieval practice after learning about the immune system in class appears to reduce students' cognitive anxiety when facing exams (Figure 3). Students from the experimental group mostly had low cognitive anxiety, while students from the control group mostly had high cognitive anxiety. These results illustrate that the group of students who did not get retrieval practice showed higher anxiety than students from the group with retrieval practice when faced with an exam. This proves that the retrieval practice strategy can overcome students' cognitive anxiety in learning the immune system. There are five indicators of cognitive anxiety measured in this study: 1) anxiety before the exam, 2) anxiety about the abilities during the exam, 3) anxiety in answering exam questions, 4) anxiety in getting into trouble during the exam, and 5) anxiety about exam results. Based on the results of the analysis, experimental group students showed lower scores (Figure 3) than control group students, although significant differences only occurred in four indicators, specifically indicators 1 to 4. Only one indicator (Indicator 5) showed a non-significant difference (Table 7).

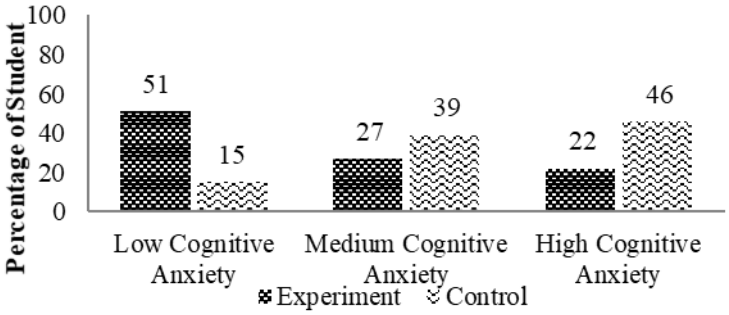


**Figure 3.** Comparison of Cognitive Anxiety between Experimental and Control Group Students

Lower cognitive anxiety in the experimental group was due to students being accustomed to practicing questions during retrieval practice, thereby ensuring that they did not feel unfamiliar when faced with exam questions. This makes students accustomed to taking exams and knowing the subject matter better (Agarwal et al., 2014). Retrieval practice also trains students to remember information, which has an impact on the emergence of student confidence in facing the exam. When students feel confident, the anxiety of failure or not being able to remember the information needed to face the exam will be reduced. In addition to the practice factor that makes students accustomed to working on questions, retrieval practice also facilitates students to improve their understanding through feedback given after retrieval practice. Positive feedback and correction of mistakes in answering questions are very helpful in reducing student anxiety (Zhang & Rahimi, 2014). Feedback on retrieval practice provides positive feedback on students' understanding, provides hints for improvement, encourages positive thinking and self-confidence, and motivates students to learn better. With positive feedback from teachers, students can prevent increased anxiety and feelings of failure after exams, reduced self-confidence, and a decreased sense of competence in learning (Jones et al., 2021). In addition, feedback from teachers also contains emotional support that adds to their confidence in their abilities (Hadden & Frisby, 2019).

**Table 7.** Students' Cognitive Anxiety Score in Facing the Exam After Learning the Immune System

| No. | Indicators of Cognitive Anxiety | Experiment | Control | Sign | Effect Size |
|---|---|---|---|---|---|
| 1 | Anxiety before the exam | 8.26 ± 3.81 | 10.11 ± 3.54 | 0.005** | 0.521 |
| 2 | Anxiety about the abilities during the exam | 56.25 ± 18.72 | 65.16 ± 13.61 | 0.002** | 0.654 |
| 3 | Anxiety in answering exam questions | 27.47 ± 9.34 | 30.50 ± 7.98 | 0.035* | 0.379 |
| 4 | Anxiety about getting into trouble during the exam | 19.28 ± 5.13 | 21.90 ± 4.62 | 0.003** | 0.566 |
| 5 | Anxiety about exam results | 16.61 ± 4.30 | 17.78 ± 3.99 | 0.115 | 0.294 |

**very significantly different, *significantly different


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Based on cognitive anxiety data in Table 7, the implementation of the retrieval practice strategy makes experimental group students more prepared for the exam (Indicator 1) than control group students. The low anxiety of students before the exam is also illustrated by their low anxiety about their abilities during the exam. The confidence in students that already exists before the implementation of the exam makes them build positive feelings during the exam, so they do not feel anxious or doubtful about their abilities (Indicator 2). The implementation of retrieval practice also makes students accustomed to working on questions so that when they see similar questions in the exam they are not too anxious to answer them (Indicator 3). This condition is thought to have something to do with the working memory of students who have been trained to remember information that will be used in answering questions. This is reinforced by the findings of (Pastötter & Bäuml, 2014), which reveal that retrieval practice strategies affect students' ability to remember information to reduce anxiety. In addition, from Table 7 it can also be seen that students who get retrieval practice have a lower sense of anxiety and fear of possible difficulties that will be faced during the exam (Indicator 5). This condition is thought to be related to the amygdala, which is a structure in the brain that plays a role in regulating emotions (Bonnet et al., 2015). The retrieval practice strategy makes the brain more adaptive to exam situations and has an impact on reducing the workload of the amygdala as an emotional center. As a result, students feel calmer in exam situations, and anxiety about having difficulties during the exam is reduced.

Although experimental group students had lower anxiety in the first four cognitive anxiety indicators, experimental group students and control group students had the same anxiety about the exam results (Indicator 5). This test result anxiety tends to lead to anxiety about the consequences of failure and dissatisfaction with what has been done (Lentz, 2017). These results indicate that both experimental group students and control group students still have anxiety when thinking about success in the exam, even though they are confident when carrying out the exam, especially for the group of students who get retrieval practice. Anxiety about success and the fear of failure in exams are natural and can be experienced by all students (Kumari & Vijayavardhini, 2019).

**Correlation between Concept Mastery and Cognitive Anxiety**

Statistically, retrieval practice can improve concept mastery (Table 5), increase the level of cognitive ability (Table 6), and reduce students' cognitive anxiety (Figure 3; Table 7). However, Spearman Rank Correlation analysis showed that the decrease in cognitive anxiety of experimental group students in facing the exam was not related to the increase in concept mastery ($p = 0.935$, $r = 0.01$). This result illustrates that a decrease in cognitive anxiety does not occur due to an increase in concept mastery. The same results were also found in (Lewis, 2019) research, where cognitive anxiety did not correlate with learning performance. In this study, students with good learning performance did not always have low cognitive anxiety. Some factors that make students still have anxiety include student expectations to get high scores, perfectionist nature, trauma with failure in exams, and the nature of not being easily satisfied with exam results (Roick & Ringeisen, 2017). The absence of a significant correlation between concept mastery and cognitive anxiety also illustrates that students with poor learning performance do not always have high cognitive anxiety. Some students with low learning performance also have low cognitive anxiety. This is thought to be because students have realized the limitations of their knowledge, so they do not have high expectations of the exam results. However, this contradicts the findings of (Jones et al., 2021) which state that anxiety and learning performance are significantly negatively correlated. Students with low anxiety have better learning performance. Thus, the implementation of retrieval practice in learning does not always provide the expected relationship between concept mastery and cognitive anxiety. This may be related to students' motivation to learn, their expectations of learning, and their awareness of their abilities. However, this study did not investigate these three things, so this is an opportunity for further research.

## CONCLUSION

The findings of this study indicate that the implementation of a retrieval practice strategy in learning the immune system significantly improves concept mastery, develops cognitive ability, and reduces students' cognitive anxiety. The group of students who used retrieval practice experienced a higher increase in concept mastery than that of those without retrieval practice. Based on their cognitive


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abilities, the group of students who used retrieval practice had higher average scores at higher levels of cognitive processes, such as comprehension, analysis, and knowledge utilization than students without retrieval practice. In addition, students with retrieval practice strategy had a high percentage in the low cognitive anxiety category, while those without retrieval practice had a high percentage in the high cognitive anxiety category. However, there is no relationship between the increase in concept mastery and the decrease in cognitive anxiety of students who use the retrieval practice strategy. This may be related to students' learning motivation, students' expectations of learning, and students' awareness of their abilities. This study did not investigate these three things, so it is an opportunity for future research to explore these factors in more depth. This research also has a limitation in that retrieval practice is done asynchronously using Google Forms, so the teacher cannot see what the students are doing when they do retrieval practice. Nevertheless, the research findings prove that the implementation of retrieval practice strategies can help students master the concept of the immune system, develop students' cognitive abilities towards higher levels of cognitive processes, and reduce students' cognitive anxiety in facing exams. Teachers need to provide complete information about retrieval practice and provide a good approach to motivate students to use retrieval practice strategy, as well as provide positive expectations for students' learning performance.

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