



## An Exploration of the Biological Cognitive Competencies of 10th Grade Science Pupils in the City of Makassar

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### Abstract

This research is survey research, to determine biology cognitive abilities students in grade X students in the public high schools in Makassar City. The study population was all students of class X science from 23 public high schools in Makassar City in the 2022/2023 academic year. Sample withdrawal was carried out using cluster random sampling and simple random sampling techniques. The total number of research samples was 254 students taken from 8 schools, namely: SMAN 4 Makassar, SMAN 5 Makassar, SMAN 6 Makassar, SMAN 9 Makassar, SMAN 14 Makassar, SMAN 16 Makassar, SMAN 20 Makassar, and SMAN 21 Makassar. The instrument used was 25 items of multiple-choice questions. Data collection was done by distributing tests to students. Data analysis was done descriptively. The results showed that the biology cognitive competencies of class X science pupils at public high school in Makassar City in the low category as of many as 81 people (31.89%), medium category as many as 127 people (50%), high category as many as 31 people (12.2%) and very high category as many as 15 people (5.91%). Based on these results, the cognitive ability of biology class X science students of public senior high school in Makassar City is classified in the medium category.

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## INTRODUCTION

Cognitive ability is a process that takes place in humans internally in the brain that causes a person to think. Cognitive ability is closely related to the ability to think. All human activities related to the acquisition of knowledge, developing a simple idea, and considering various events to solve complex problems cannot be separated from a person's cognitive abilities (Ghafoor & Rabaia, 2022). Gagne suggested that cognitive ability is an internal process that occurs in the central nervous system when humans think. Thinking is generally defined as a mental process that can produce knowledge through the combination of perception and elements that exist in the mind (Riyadi, 2008).

Cognitive ability is the ability possessed by a person to think and process information. Cognitive abilities include the ability to think and understand information obtained from the surrounding environment. Cognitive ability can also be defined as the ability possessed by a person to solve problems and make decisions appropriately. Thinking is processing information mentally or cognitively. More formally, thinking is the rearrangement or cognitive manipulation of both information from the environment and symbols stored in long-term memory. Thus, thinking is a symbolic representation of some event (Urban, 2004).

Karli (2012) explained that the thinking process is gradual from low order thinking to high order thinking. Basic thinking processes are finding relationships, connecting cause and effect, transforming, classifying, and qualifying. Complex thinking processes known as higher order thinking processes can be categorized into four groups, namely: problem-solving, decision-making, critical thinking, and creative thinking. In education, cognitive level, abbreviated as "C" is a term often used in formulating learning objectives and determining the cognitive level of questions. The term is taken from the taxonomy of learning objectives proposed by Bloom (Widodo, 2006).

21st-century learning can simply be defined as learning that provides 21st-century skills to students, namely the 4Cs which include: (1) Communication, (2) Collaboration, (3) Critical Thinking and Problem-Solving, and (4) Creativity and Innovation. Based on Bloom's Taxonomy which has been revised by Krathwohl and Anderson, the abilities that students need to achieve are not only LOTS (Lower Order Thinking Skills), namely C1 (knowing) and C2 (understanding), MOTS (Middle Order Thinking Skills), namely C3 (applying) but also HOTS (Higher Order Thinking Skills), namely C-4 (analyzing), C5 (evaluating), and C6 (creating) (Susanti *et al.*, 2020).

Learning implementation is generally evaluated based on three main domains, namely the cognitive, affective and psychomotor domains. Recently, these three domains have become the target of learning outcomes that will be achieved simultaneously as a result of the learning experience of students. In this study, the assessment of learning outcomes is limited to the cognitive domain only. Based on the taxonomy of educational objectives, the cognitive ability of learners can be interpreted based on their ability to answer questions that categorized into the cognitive levels proposed by Bloom. Retention requires students to be able to remember, while transfer requires students not only to be able to remember but also to understand and apply the knowledge that has gained. The 21st century is a century that provides great challenges and opportunities for students, teachers and education providers. The quality of education can be improved in many ways, one alternative is through the application of innovative learning with student-centered learning methods. Through this method, it is expected that students' involvement in learning takes place better and more meaningful. In addition, students' thinking skills are more trained through learning experiences that can stimulate students' higher-level thinking skills.

The cognitive dimension includes critical thinking skills such as analysis, explanation, interpretation, induction, deduction, assumption, and inference (Barta *et al.*, 2022). There are six general cognitive skills, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. Davies and Barnett (2015) in Barta *et al.*, (2022) classify critical thinking cognitive skills into four groups. Low-level thinking skills include interpretation, explanation, and recognition of assumptions, high-level thinking skills include analysis and synthesis, and complex skills include induction, deduction, inference, and metacognitive skills at the highest level.

Cognitive skill is one of the important factors in a person's ability to process and make decisions based on available information. This ability is also very important to improve a person's quality of life and help him in achieving goals and solving problems in everyday life. In addition, cognitive abilities can also help a person in learning and developing new abilities. The cognitive ability of biology of high school students is still in the spotlight of observers and practitioners of education both at the national and international levels. World Education Ranking published by the Organization for Economic Cooperation and Development (OECD) place Indonesia ranks 57th out of a total of 65 countries. Indonesia earned a natural science score of 383. The world education ranking is related to the Program for International Student Assessment (PISA) (Edupost.ID, 2017). In 2018, Indonesia ranked 71st out of 79 countries with a score of 396; Meanwhile, in 2021, PISA was not held due to the pandemic and was held in 2022. Indonesia's PISA science literacy results, which are held every three years, have slightly improved from the results obtained in previous years, but are still in the low category because the scores obtained are not much different from the PISA results in previous years.

Research on students' cognitive competencies is considered important because it can help teachers and decision-makers in developing educational programs that suit students' needs. Cognitive ability is one of the important factors that can affect students' success in learning. By knowing students' cognitive skills, teachers can adjust learning materials and methods so that students can learn more effectively. Research related to cognitive abilities can also help identify students who have below-average and above-average cognitive abilities, so that special assistance and attention can be given to help these students reach their maximum potential. In addition, students' cognitive competencies need to be studied because they can provide important information about how students learn and understand the subject matter. High cognitive abilities can help students achieve higher achievement in learning, while low cognitive abilities can be an obstacle to student learning achievement. By knowing the level of students' cognitive abilities, teachers can develop more effective learning strategies and customize subject matter according to students' abilities.

Some research results related to students' cognitive abilities have been conducted among others. The research showed on the biological science literacy skills of junior high school students in South Sulawesi are still relatively low and most students fail to solve science literacy-based problems (Adnan, Mulbar, *et al.*, 2021). Other finding exposed that the cognitive abilities of biology students of SMAN 5 Makassar are classified in the medium category (Adnan *et al.*, 2022). Another study on the profile of higher order thinking skills of students majoring in biology FMIPA UNM on average are in a fairly good or medium category (Adnan, Faisal, *et al.*, 2021). The investigation on the cognitive abilities of students in SMAN 14 Makassar using student worksheets are still classified as medium (Aldi *et al.*, 2022). Based on these findings, research was conducted to determine the cognitive abilities of senior high school students in the field of biology studies.

## RESEARCH METHOD

This research is survey research. The study population was students of class X Science (X IPA) in the public senior high school (SMAN) in Makassar. The sampling technique used cluster random sampling and simple random sampling. This research was conducted at SMAN 4 Makassar, SMAN 5 Makassar, SMAN 6 Makassar, SMAN 9 Makassar, SMAN 14 Makassar, SMAN 16 Makassar, SMAN 20 Makassar, and SMAN 21 Makassar in the academic year 2022/2023. The number of samples was 254 students. The research instrument used was a cognitive ability test instrument consisting of 25 multiple-choice questions. Data collection was done by giving test questions to the research sample students directly. Cognitive ability data obtained were then analyzed descriptively using categorization as shown in Table 1.

**Table 1.** Categorization of students' biology cognitive abilities

Criteria	Interval Nilai
Very Low	$X < M - 1,5(SD)$
Low	$M - 1,5(SD) < X < M - 0,5(SD)$
Medium	$M - 0,5(SD) < X < M + 0,5(SD)$
High	$M + 0,5(SD) < X < M + 1,5(SD)$
Very High	$M + 1,5(SD) < X$

Source: (Azwar, 2012)

Description:

M: *Mean*

SD: Standard Deviation

## RESULTS AND DISCUSSION

### a. Descriptive Analysis of Cognitive Ability

Statistical data on the value of biology cognitive abilities of students in class X IPA SMAN in Makassar can be seen in Table 2.:

**Table 2.** Descriptive statistical analysis of students' biology cognitive abilities

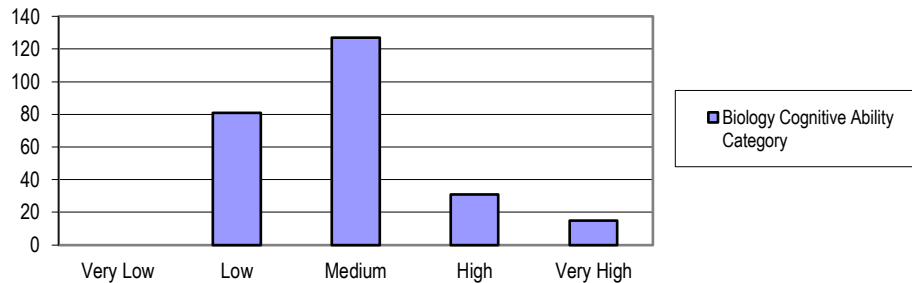
	N	Minimum Value	Maximum Value	Mean	Standard Deviation
Total Value	254	16	88	31,54	11,18
Valid N (listwise)	254				

Based on Table 2, it is known that the average score of biology cognitive abilities of students at SMAN in Makassar is  $31.54 \pm 11.18$ . The minimum value for cognitive ability is 16, and the maximum value is 88.

**Table 3.** Category of cognitive ability of biology of students of SMAN Makassar

Category	Value Interval	Sum	Percentage (%)
Very Low	$X \leq 15$	0	0,00
Low	$15 < X \leq 26$	81	31,89
Medium	$26 < X \leq 37$	127	50,00
High	$37 < X \leq 48$	31	12,20
Very High	$48 < X$	15	5,91
Total		254	100,00

Based on Table 3, it is obtained that the cognitive ability of biology of high school students in Makassar City is in the medium category, with a total of 127 people and a percentage of 50%.

**Gambar 1.** Diagram of cognitive ability of biology students at class X SMAN in Makassar

The results of the cognitive ability of biology of students of class X IPA SMAN in Makassar City in the low category of as many as 81 (31.89%) people, medium category as many of as 127 (50%) people, high category as many of as 31 (12.2%) people, very high category as many as 15 (5.91%) people. These results indicate that the cognitive ability of biology of high school students of class X IPA in Makassar City is generally still in the medium category with a total of 127 people and a percentage of 50%. These results indicate that the cognitive abilities of biology class X IPA students of SMAN in Makassar City still need to get serious attention from all parties, especially the teachers of biology subjects, principals, supervisors and education agencies.

A total of 81 (31.89%) students in this low category need to be pursued seriously so that their cognitive abilities can be improved at a higher level. These results indicate that students are still accustomed to working on problems that show low-level thinking skills. Therefore, student's must be introduced to work on problems related to higher-level thinking skills to improve student's cognitive abilities. Students who are familiarized to solving problems that require higher-level thinking skills are expected to be able to solve various life problems they face better (Widarta & Artika, 2021). Student's cognitive abilities can be influenced by various factors, one of which is the learning method used. With the right learning method, students can more easily understand the subject matter and improve their cognitive abilities. For example, by using the demonstration method, students can observe the process directly and understand the material better. Meanwhile, by using the group discussion method, students can interact with their friends and develop critical and creative thinking skills. Thus, choosing the right instructional method can help students improve their cognitive abilities.

The results also show that there are still more students in the low and medium categories than the number of students in the high and very high categories. One of the high-level thinking skills is critical thinking skills. High-level thinking skills are the ability to think and learn by going beyond the limits of the process of memorizing facts or telling something back to someone just as it was told before. High-level thinking skills need to be possessed by students, because of the needs of students in the future will be related to the ability to think, find problems, find alternative solutions, and be able to solve them (Angraini & Sriyati, 2019).

Improving students' thinking skills can be done in various ways, such as: (1) Provide challenges to students. Students need challenges to think critically and use strategies to solve them, (2) Teaching students thinking strategies such as grouping information, looking for patterns, comparing and contrasting, and grouping into categories, (3) Using fun learning methods such as games, projects, or group discussions that can help students learn more effectively, (4) Providing useful feedback to students understand the mistakes they make and provide direction to improve their understanding, (5) Providing opportunities to discuss and exchange ideas with their peers. This can help students think critically and develop their own opinions, (6)

Teach students to ask questions about what they are learning. This will help them understand the material better and develop better thinking skills, (7) Train the ability to solve real problems that they face at school or in their environment. This can help them learn how to think critically and use strategies to solve problems, and (8) Encourage students to read. Reading can help students develop their critical and analytical thinking skills. Provide students with challenging reading materials and opportunities to discuss what they have read.

The results of (Rahmatullah *et al.*, 2020) are in line with the research data obtained that the cognitive ability profile of X-grade high school students in Sukabumi City with levels C1 to C6 is 53.15. This study concludes that the cognitive abilities of grade X students in high school in Sukabumi city are included in the "low" category. The low cognitive ability of students is also in line with the results of research by Ashari *et al.*, (2021) that (1) The initial cognitive ability of students is still lacking. (2) The value of the cognitive domain is as follows: C4 (analyze) level with a percentage of 60.1%, C5 (evaluate) with a percentage of 57.9%, and C6 (prove) with a percentage of 63.2%. The same thing is also obtained in the results of Ibrahim's research (2021) that the average student's high-level thinking ability of 63.83 is classified as medium, the distribution of cognitive dimensions of students in the X MIPA class of SMAN 1 Tarakan is in the low category of 37 (C4), low category of 21 (C5) and very low category of 5.2 (C6). This is different from the results of research obtained by Lestari *et al.*, (2020) that (1) students cognitive level reached the level of analysis. (2) The highest percentage is the level of remembering (87.9%) that classified into very good and the lowest percentage is evaluating (58.1%) which was categorized into not good.

## b. Descriptive Analysis based on Each Cognitive Level

Statistical data on the value of biology cognitive abilities of students of class X IPA SMAN in Makassar City based on each cognitive level, can be seen in Table 4:

**Table 4.** Category of cognitive ability of biology of students of SMAN Makassar class X IPA each cognitive level

Cognitive Level	Category	Score Interval	Sum	Percentage (%)	Average Score
C1	Very Low	$X \leq (-20)$	0	0	29,92
	Low	$(-20) < X \leq 13$	127	50	
	Medium	$13 < X \leq 46$	0	0	
	High	$46 < X \leq 80$	102	40,16	
	Very High	$80 < X$	25	9,84	
C2	Very Low	$X \leq 5$	15	5,91	34,78
	Low	$5 < X \leq 25$	73	28,74	
	Medium	$25 < X \leq 45$	86	33,86	
	High	$45 < X \leq 65$	44	17,32	
	Very High	$65 < X$	36	14,17	
C3	Very Low	$X \leq (-17)$	0	0	32,09
	Low	$(-17) < X \leq 16$	115	45,28	
	Medium	$16 < X \leq 48$	0	0	
	High	$48 < X \leq 81$	115	45,28	
	Very High	$81 < X$	24	9,84	
C4	Very Low	$X \leq 6$	4	1,57	35,26
	Low	$6 < X \leq 26$	68	26,77	
	Medium	$26 < X \leq 45$	129	50,79	
	High	$45 < X \leq 64$	34	13,39	
	Very High	$64 < X$	19	7,48	
C5	Very Low	$X \leq (-4)$	0	0	24,02
	Low	$(-4) < X \leq 16$	43	16,93	
	Medium	$16 < X \leq 32$	101	39,76	
	High	$32 < X \leq 52$	103	40,55	
	Very High	$52 < X$	7	2,76	
C6	Very Low	$X \leq (-16)$	0	0	32,5
	Low	$(-16) < X \leq 16$	113	44,49	
	Medium	$16 < X \leq 49$	0	0	
	High	$49 < X \leq 81$	117	46,06	
	Very High	$81 < X$	24	9,45	

Table 4 shows that the average score of students' cognitive abilities is in the moderate or medium category for each cognitive level. For cognitive levels C1, C3, and C6, the majority of students are in two

categories, namely low and high. A different pattern is shown for the C5 cognitive level where most students categorized into the medium and high categories. Meanwhile, the distribution is almost even in each category, which can be observed at cognitive levels C2 and C4.

In the C1 cognitive level there were still 127 (50%) students in the low cognitive level category and 127 (50%) students in the high and very high cognitive level categories. The data shows that there are still 127 (50%) students who have difficulty remembering information. Some things that can be done to improve students' ability to remember information are (1) Teaching effective memory techniques such as repetition, making diagrams, and writing notes, (2) Providing students with exercises. Practice helps students strengthen their memory of the material they have learned. Students can do practice problems or try to teach the material to others to improve their memory, (3) Using diverse learning methods. The use of various learning methods can help students remember information better. For example, using visuals, audio, and demonstrations can help students understand and remember material better, (4) Teaching students to manage time. Organizing study time well can help students manage the material to be learned and strengthen their memory of the material, and (5) Provide students with sufficient motivation. Sufficient motivation can help students be eager to learn and remember the information learned.

C2 cognitive level is still found in as many as 87 (34.16%) students in the category of very low and low cognitive level, 86 (33.86%) in the category of medium cognitive level, and 86 (33.86%) at a high and very high cognitive level. To improve student understanding, several ways can be done, including, (1) Reading and understanding the text or subject matter carefully. This is an effective way to understand the subject matter in-depth, (2) Trying to ask questions and find the answers themselves. This will help students to better understand the material and develop critical thinking skills, (3) Discussing with friends or teachers about the material studied. Discussions can help students to better understand the material and explore ideas that have not been thought of before, (4) Trying to teach the material learned to others. This will help students to better understand the material and improve communication skills, (5) Try to solve practice problems and evaluate the progress that has been achieved. This will help students to know their strengths, weaknesses and develop effective learning strategies, (6) Search for additional learning resources, such as video tutorials, articles, or books related to the material studied. This will help students to deepen their understanding and develop insights.

In the C3 cognitive level there were still 115 (45.28%) students in the low cognitive level category and 139 (55.12%) students in the high and very high cognitive level categories. Improve students' application skills, several ways can be done, including (1) Providing relevant exercises and examples: Providing relevant exercises and examples can help students understand how the theory learned can be applied in real situations, (2) Providing sufficient time to learn and practice: Students need sufficient time to understand the subject matter and practice applying it. By providing sufficient time, students can be more focused and encouraged to understand the material better, (3) Using varied learning methods: Using a variety of learning methods, such as group discussions, presentations, or role plays, can help students more easily understand the material and apply it, (4) Provide guidance and support: Students may need help and support from teachers or others to understand and apply the subject matter. By providing appropriate guidance and support, students can more easily improve their application skills, and (5) Using appropriate evaluation: Appropriate evaluation can help students know their progress and provide useful feedback to improve their application skills.

In the C4 cognitive level there were still 72 (28.34%) students in the category of very low and low cognitive levels, 129 (50.79%) in the category of medium cognitive levels, and 53 (20.87%) at high and very high cognitive levels. To improve students' ability to analyze, several ways can be done (1) Provide structured exercises: By providing structured analyzing exercises, students can understand how to analyze better. These structured exercises can be in the form of questions that help students understand how to analyze a text or situation, (2) Provide good examples of analysis: Providing good examples of analysis can help students understand how to analyze a text or situation correctly. These can be examples of analysis made by the teacher or other sources that students can refer to, (3) Encourage students to express their own opinions and ideas: Encouraging students to express their own opinions and ideas can help them learn to analyze a text or situation better. This can be done through group or class discussions that focus on analyzing a text or situation, (4) Using analysis-focused learning methods: Analysis-focused learning methods such as problem-based learning (PBL) or inquiry-based learning (IBL) can help students learn to analyze a text or situation better. These methods place students as researchers who must seek answers to the questions posed through a process of analysis, and (5) Providing quality feedback: Providing quality feedback can help students understand how to better analyze a text or situation. The feedback can be in the form of comments that help students improve their analysis.

Cognitive level C5 found as many as 43 (16.93%) students are in the category of low cognitive level, 101 (39.76%) in the category of medium cognitive level, and 110 (43.31%) at high cognitive level and very high. To improve student's evaluation skills, several steps can be taken (1) Make clear evaluation objectives:

Make sure that your evaluation objectives are clear and match what you want to see from students, (2) Use the right evaluation method: Choose an evaluation method that suits your objectives and is appropriate for the students' abilities. For example, if you want to evaluate students' ability to solve problems, use problem tests or projects, (3) Provide useful feedback: Provide useful feedback to students after the evaluation, including suggestions for development and how to improve future achievements, (4) Provide opportunities for relearning: Provide opportunities for students to relearn the evaluated material if needed. This can help students correct deficiencies and improve future performance, and (5) Provide guidance and support: Appropriate guidance and support can help students understand what is expected and how to achieve it so that they can improve their achievement.

The C6 cognitive level, 113 (44.49%) students were found to be in the low cognitive level category and 141 (55.51%) at the high and very high cognitive levels. To improve students' ability to create, several steps can be taken: (1) Give clear directions: Make sure that students understand what is expected of them in creating. Providing clear examples and giving precise directions will help students to understand what is expected of them, (2) Provide space to explore: Give students space to explore and develop their ideas. This will help them to develop better creating skills, (3) Provide support: Provide enough support for students while they are creating. This could be technical assistance, advice or even just listening to their ideas, (4) Teach inventing strategies: Give students some strategies they can use to create, such as brainstorming, breaking down problems, or using the "beans and chocolate" technique to combine different ideas, and (5) Give praise for progress: Give students praise for the progress they have made in creating. This will boost their confidence and encourage them to continue learning and creating.

This is in line with the results of Hardianti, (2018) which shows that: 1) The cognitive abilities of students are still low, only 30% get scores above the minimum completeness criteria. 2) The cognitive level possessed by students is still at the low order thinking level. The research data obtained is different from the results of research conducted by Lestari *et al.*, (2020) that the cognitive level at the level of remembering (87.9%) is very good, understanding (76.8%) is good, applying (79.4%) is good, analyzing (60.9%) is quite good, evaluating (58.1%) is not good, and creating (59.1%) is not good.

## CONCLUSION

The results showed that the study of cognitive abilities of biology class X IPA students of SMAN in Makassar City was in very low category of 0% with a total of 0 people. In the low category of 31.89% with a total of 81 people. In the medium category of 50% with a total of 127 people. In the high category of 12.2% with a total of 31 people. In the very high category of 5.91% with a total of 15 people. Based on these results, the cognitive ability of biology class X IPA students of SMAN in Makassar City is classified in the medium category.

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