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Exploration of the Eleventh Graders Difficulties in Understanding Procedural and Declarative Knowledge in the Laboratory Experiment of Heat Transfer

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Abstract: The purpose of this study was to describe the factors that caused class XI students to have difficulty mastering procedural knowledge and declarative knowledge in heat experiments at Senior High School 1 Gowa. Pseudo-experiment with a population of 5 (five) class XI with a randomly selected sample of one class XI consisting of 50 students. The tests used procedural knowledge, declarative knowledge and valid and reliable questionnaires. Processing data using descriptive statistics. The findings of this study include that physics teachers do not practice declarative indicators, physics teachers do not practice procedural, the average score of declarative and procedural knowledge is medium and low respectively. The reason students have difficulty mastering procedural knowledge and declarative knowledge is because physics teachers rarely train and teach procedural knowledge and declarative knowledge, and students are rarely given the opportunity to develop their potential in the domains of low-level thinking and high-order thinking.

Keywords: declarative knowledge, procedural knowledge, physics learning.

Abstrak: *Tujuan penelitian ini untuk mendeskripsikan faktor-faktor yang menyebabkan siswa kelas XI kesulitan menguasai pengetahuan prosedural dan pengetahuan deklaratif pada percobaan kalor di sekolah menengah Atas 1 Gowa. Ekperimen semu dengan jumlah populasi 5 (lima) kelas XI dengan sampel satu kelas XI yang dipilih secara acak terdiri 50 siswa. Tes yang digunakan pengetahuan prosedural, pengetahuan deklaratif dan angket yang valid dan reliabel. Pengolahan data menggunakan statistik deskriptif. Temuan penelitian ini diantaranya adalah guru fisika kurang melatihkan indikator deklaratif, guru fisika kurang melatihkan prosedural, rata-rata skor pengetahuan deklaratif dan prosedural masing-masing kategori sedang dan rendah. Penyebab siswa mengalami kesulitan menguasai pengetahuan prosedural dan pengetahuan deklaratif karena guru fisika jarang melatihkan dan mengajarkan pengetahuan prosedural dan pengetahuan deklaratif, dan siswa jarang diberikan kesempatan untuk mengembangkan potensinya pada domain berpikir tingkat rendah dan berpikir tingkat tinggi.*

Kata kunci: *pengetahuan deklaratif, pengetahuan procedural, pembelajaran fisika.*

▪ INTRODUCTION

In the current era of 21st century globalization, human resources are urgently needed who have high-level thinking skills in overcoming various problems of daily life, on the other hand the results of a survey conducted by the Program for International Student Assessment (PISA) in 2018 shows that the critical thinking ability of Indonesian children has decreased in all fields, including science. For example, in science, 40% of Indonesian students have just reached level-2 with an average score of 396, while the average for the Organization for Economic Co-operation and Development is 489 (OECD, 2019).

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The government expects students to achieve various competencies by applying Higher Order Thinking Skills (HOTs). One of these competencies in the knowledge dimension is procedural knowledge in Anderson's taxonomy and declarative knowledge as the basis for developing these dimensions (Yoki et al., 2018). Learning development oriented to higher order thinking skills is a program developed as an effort of the Ministry of Education and Culture through the Directorate General of Teachers and Education Personnel in an effort to improve the quality of learning and improve the quality of graduates (Yoki, et al., 2018). This program was developed following the policy direction of the Ministry of Education and Culture which in 2018 has integrated

Strengthening Character Education and learning oriented to Higher-Level Thinking Skills.

One of the higher order thinking skills is complex thinking processes in describing material, making conclusions, building representations, analyzing, and building relationships involving the most basic mental activities (Arends, 2012). Anderson and Krathwoll through the revised taxonomy have a series of processes that show cognitive complexity by adding knowledge dimensions, such as: 1) metacognitive knowledge, 2) factual knowledge, 3) conceptual knowledge, and 4) procedural knowledge (Anderson, et al., 2001). Procedural knowledge is related to "knowledge of how" to do something. This can range from completing fairly routine exercises to solving new problems. Procedural knowledge often takes the form of a series of steps to be followed. This includes declarative knowledge , knowledge of skills, algorithms, techniques, and methods are collectively referred to as procedures which include: 1) knowledge of subject-specific skills and algorithms; 2) procedural knowledge can be expressed as a series of steps , which are collectively known as procedures. Sometimes the steps are followed by definite orders; other times decisions have to be made about which step to take next. In the same way, sometimes the end result is definite; in other cases the result is not certain, although the process can be certain or more open, the final result is generally assumed to be certain in terms of the type of knowledge, technical knowledge and method specific of a subject.

Knowledge of subject-specific techniques and methods includes knowledge that is broadly the result of consensus, agreement, or disciplinary norms rather than knowledge that is more directly the result of observation, experimentation, or discovery. This type of knowledge generally describes how experts in the field or discipline think and solve problems rather than the results of thinking or solving these problems, including: knowledge of criteria for determining when to use appropriate procedures. Before engaging in an investigation, students can be expected to know the methods and techniques that have been used in similar investigations. At some later stage in the investigation, they can be expected to demonstrate the relationships between the methods and techniques they actually use and the methods employed by other students.

Declarative knowledge is knowledge about something in fact which is usually declared in the form of words or also known as conceptual knowledge or knowledge about something (about something) which can be declared in words, both orally and in writing (Clark & Mayer, 2007; Zainuddin, 2010). Based on this opinion, it can be interpreted that declarative knowledge is knowledge of concepts and facts which are declared/described in words (sentences) orally and/or in writing.. In relation to the notion of declarative knowledge, Anderson, et al., (2001), describes declarative knowledge on two types of knowledge, namely factual knowledge and conceptual knowledge. Factual knowledge is knowledge about the basic elements of a material topic. While conceptual knowledge is knowledge about the relationship between the basic elements of a material topic and its relation to classifications, categories, principles, generalizations, theories, models, and structures.

Declarative knowledge is needed by science educators as the basis and substance to meaningfully teach science concepts and facts. As for students, declarative knowledge is needed as a basis for understanding the facts and scientific concepts being studied as well as for understanding and studying science facts and concepts in the next lesson. This description is in accordance with one of the explanations in the Australian Curriculum Assessment and Reporting Authority (Aini, et al., 2021) that mastery of declarative knowledge for science and mathematics teachers is the key to success in teaching science and mathematics concepts. Although declarative knowledge is important in science learning, the problem is that declarative knowledge is often ignored by teachers because it is considered as knowledge that is merely memorizing, uninteresting, and unimportant (Aini, et al., 2021).

Problems that occur in the world of science education and learning today are often associated with conceptual knowledge and teacher factual knowledge. This means that the teacher's declarative knowledge in teaching science is still low. One of the results of a study on the low level of teacher declarative knowledge in science learning in Indonesia is a study conducted by (Gustirah,2013) which explains that most science teachers in junior high schools only teach science in a procedural manner without explaining why the procedure is used and why the procedure is used. Based on the observations of science teachers at high school I Gowa in the 2019-2020 school year, it was found that, in describing examples of temperature and heat problems, the teacher only wrote a description of the completion of the sample questions on the blackboard as stated in the student handbook and read it aloud without being given an explanation. This phenomenon is an indication of the teacher's low level of declarative knowledge in teaching temperature and heat material science.

The low declarative knowledge of a teacher in teaching science can cause the teacher to misdeclare the delivery of the science concepts being taught. Ashlock (2006) explains that, two things related to conceptual understanding of declarative knowledge that often cause errors (misconceptions) in science learning are overgeneralizing and overspecializing. One example of over-generalizing, for example, is naming pictures of science practicum tools and their functions. While examples of overspecializing include believing that, the size of a solid volume can only be found by measuring using a measuring cup, always having to equate the denominator when solving mathematical operations problems (addition and subtraction of fractions), in learning science without teaching science concepts.

Marzano (2009) suggests that there are four categories of common errors in declarative knowledge, namely misrepresenting conflicting information, incorrect because they cannot interpret the argument against exceptions based on rules, wrong due to confusing temporal (time) sequence of events with causality or oversimplifying the reasons behind some incident or event, and wrongly asking a question and then making a claim arguing using only the statement equivalent to the statement of claim.Procedural and conceptual knowledge is the basic knowledge in practicing comprehensive science experiments on all science and mathematics materials. and is a cognitive load perspective; learning and teaching (Miller & Hudson, 2007; Slava, 2009; Madalina, 2011).

From some of the results of these studies, no one has investigated the difficulties of students in carrying out declarative and procedural activities in heat practicum. On this basis, an investigation or investigation related to this variable is carried out. The students' difficulties discussed in this paper are focused on the difficulty of recognizing the names of physics measuring instruments, the functions of physics measuring instruments, the limits of measuring physics tools, understanding work procedures in investigating the relationship between manipulation, response and control variables in heat praktimum.

▪ METHOD

Participants

The research population is all class XI students in the even semester of 2021/2022 SMA 1 Gowa. The number of samples for one class XI is 50 students. Random sampling technique (Creswell, 2015) states that total sampling is asampling technique if all members of the population are used as samples.

Research Design and Procedures

The type of research used in this research is experimental research. The research design used in this study includes the pre-experimental design. This selection is based on the many external variables that influence the formation of independent variables. This can happen because there is no control variable. The design of the research plan to be carried out is to use the One Group Posttest Design with the following scheme:

Table 1. One group pretest-posttest design

Treatment	Posttest
X	O

Remark: X and O are the treatment with practicum and posttest, respectively.

The research procedure went through several stages, i.e: 1) development of research instruments: creating procedural and declarative test questions, validated by scientific experts, analyzed and revised according to the validator's suggestions; 2) classroom learning: indicators of competence attainment related to indicators of procedural and declarative knowledge are attached, practical work on temperature and heat is carried out in the laboratory in 6 (six) meetings; 3) given a procedural and declarative posttest in 2 (two) meetings; 3) posttest score analysis with descriptive statistics. Procedures states that quantitative research methods can be interpreted as research methods based on the philosophy of positivism Kerlinger (2014).

Validity and Reliability

The instruments used were tests, namely: 1) 4 items of procedural knowledge test, 18 items of declarative knowledge and 2) a questionnaire of 7 closed questions, in the form of multiple choice with a score given if the correct answer is given. score 1 and if wrong is given a score of 0. The instrument was validated by 2 science education experts. Validation analysis using Gregory analysis (Husnur, et al., 2017; Tawil, 2019). To calculate the value of the coefficient of internal consistency (internal validation) as shown in Table 2. To calculate the internal consistency coefficient value (internal validation) using (1), and to determine the category in Table 3. The validation results show that the creativity test, and questionnaire responses, each of which the internal validation value is greater than 0,8 including the high category, this is eligible for use in the study.

Table 2. Gregory's validation analysis tabulation

	Expert assessment	
	Weak relevance (Score 1 or 2)	Strong relevance (Score 3 or 4)
Assessment	A	B
Assessment	C	D

Internal consistency coefficient (Internal validation) = $\frac{D}{A + B + C + D}$

Remarks: A: both experts give weak relevance, B: the first expert gives strong relevance, the second expert gives weak relevance, C: the first expert gives weak relevance, the second expert gives strong relevance, D: both experts give strong relevance

Table 3. Validation category (Arlini et al., 2017)

Interval	**Category**
> .8	high
0.4-0.8	medium
<.4	low

Reliability analysis of procedural knowledge test, declarative knowledge and response questionnaires To calculate the percentage of agreements between the two raters whose data is only “yes” or “no”, formula (2) is used (Grinnell, as citied in Fuadi et al., 2015). The results of the instrument analysis, namely the content consistency coefficient values are .98, .99 and .96 respectively in the high validity category, meaning that all instruments are valid, and the percentage of agreement (Reliability) is 100 %, 99 % and 98 % greater than 70 %, means a reliable instrument. The focus of this research is on declarative variables whose indications are: the name of the physics measuring instrument, the function of the physics measuring instrument, and the measuring limit of the physics measuring instrument, meaning that all research instruments are reliable.

$$\text{Percentage of Agrrement} = \frac{\text{Agreement (A)}}{\text{Disagreement(D)} - \text{Agreement (A)}} \text{x}100\%$$

Procedural variables whose indicators are: the relationship between heat and changes in object temperature, the relationship between heat and changes in the state of matter, the effect of salt on the melting point of ice, and the effect of salt on the boiling point of water, while the student response questionnaire is in the form of closed questions that require "yes" and "yes" answers. "no", the indicator is related to the implementation of physics learning in class on the delivery of declarative knowledge and procedural knowledge. Develop research instruments, collect data. At the data collection stage, tests of declarative knowledge and procedural knowledge and response questionnaires were given to high school students XI online. Data analysis was carried out by scoring and tabulating the number of questionnaire responses, filtering appropriate data and obtaining research findings.

Data analysis

The data analysis technique in this study is to describe the factors that cause students in class XI to have difficulty mastering procedural knowledge and declarative knowledge in heat experiments at High School 1 Gowa, so the statistics used are descriptive statistics. Descriptive statistics are statistics used to analyze data by describing the data collected as they are without intending to make general conclusions or generalizations. Quantitative data analysis, you analyze the data using statistics Creswell, 2015).

▪ RESULT AND DISSCUSSION

The results of the research and discussion of three variables, namely the results of the analysis of student responses, declarative knowledge, and procedural knowledge are as follows.

Student Responses

The results of the analysis of the responses of class XI students of High School 1 Gowa to the implementation of classroom learning related to the delivery of declarative knowledge and procedural knowledge, i.e: 6% answered "yes" and 94% “No” to the question does your teacher teach name recognition of physics measuring instruments. 8% answered "yes" and 92% “No” to the question does your teacher teach Introduction to the function of physics measuring instruments. 4% answered "yes" to the question does your teacher teach the introduction of measuring limits on physics measuring instruments. 6% answered "yes" and 94% “No” to the question does your teacher teach experimental procedural The relationship between heat and the change in temperature of an object. 4% answered "yes" and 96% “No” to the question does your teacher teach procedural experiments on the relationship between heat and changes in state of matter?. 2% answered "yes" and 98% “No”to the question does your teacher teach procedural experiments on the effect of salt on the melting point of ice. 6% answered "yes" and 94% “No” to the question does your teacher teach procedural experiments on the effect of salt on the boiling point of water.

Based on the results of the descriptive analysis, it shows that the responses of students in class XI of State Senior high school 1 Gowa vary greatly on each question with closed answers. In the results of this analysis, it was found that in general students stated that physics teachers rarely trained and taught procedural knowledge and declarative knowledge when teaching heat subject matter. This means that this is one of the causes so that students' procedural and declarative knowledge are underdeveloped which can result in low level thinking skills and ultimately low learning outcomes

The results of the analysis of the responses of class XI students at SMA Negeri 1 Gowa to the implementation of classroom learning related to the delivery of declarative knowledge and procedural knowledge found that on average above 90% of student responses stated that the teacher had never trained declarative and procedural knowledge when studying physics at school. classroom and in the laboratory. In the results of this analysis, it was found that in general students stated that physics teachers rarely trained and taught procedural knowledge and declarative knowledge when teaching heat subject matter. This means that this is one of the causes so that students' procedural and declarative knowledge are underdeveloped which can result in low level thinking skills and ultimately low learning outcomes. This finding is supported by the theory put forward by (Macias, 2019; Eyina, 2019; Saks, et al., 2021; Wuryaningrum et al., 2020) that students will give a positive response if they are given continuous practice of declarative and procedural knowledge in doing practicum.

Procedural and Declarative Knowledge Analysis

The results of the distribution of answers of students in class XI high school 1 Gowa to the procedural knowledge test, i.e: Percentage of proportion of correct answers on the problem the relationship between heat and the change in temperature of an object was 40%; on the problem the relationship between heat and changes in the state of matter was 30%; on the problem effect of salt on the melting point of ice was 18%; on the problem effect of salt on the boiling point of water was 46%. The percentage of the proportion of correct answers for procedural knowledge is shown in Figure 1.

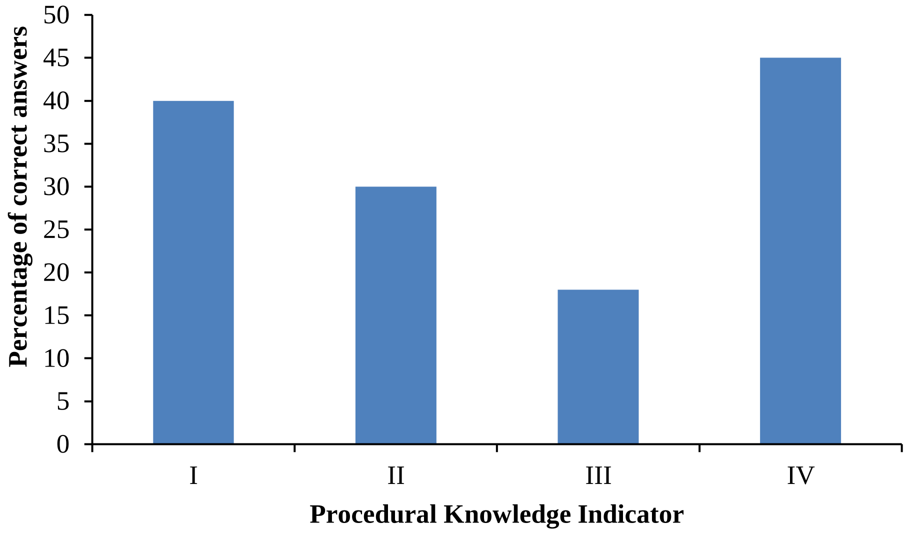

Figure 1. Percentage of correct answers in procedural knowledge. I is an indicator of the relationship between heat and changes in object temperature, II is an indicator of the relationship between heat and changes in the state of matter, III is the effect of salt on the melting point of ice, and IV is the effect of salt on the boiling point of water.

The results of the above analysis show that the highest average scores for procedural knowledge indicators are the effect of salt on the boiling point of water, the relationship of heat to changes in body temperature, the relationship of heat to changes in the state of matter, and the effect of salt on the melting point of ice. This shows that some problems still require continuous and continuous practice so that students can practice higher-order thinking questions. Theoretically in Anderson's taxonomy, it is reported that the level of procedural knowledge is included in the category of high-order thinking that can be trained continuously.

The results of the distribution of answers of students in class XI high school 1 Gowa to the declarative knowledge test, i.e: percentage of correct answers on the problem introduction to the name of physics measuring instrument, respectively, with the question numbers 1,2,3,4, and 5, i.e: 92%; 78%; 94%; 96%; and 92%. the problem introduction to the function of physics measuring instruments respectively, with the question numbers 1,2,3,4, 6,7, and 8, i.e: 62%; 60%; 22%; 84%; 20%; 82%; 56%; and 76%.

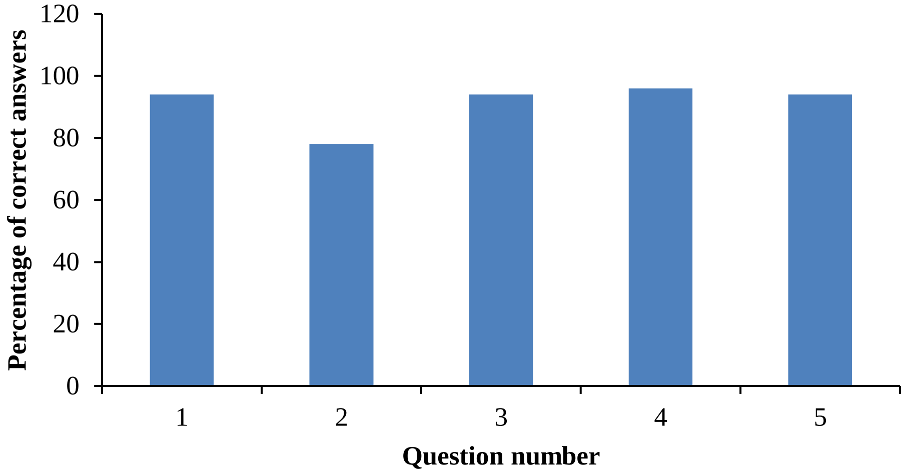

Figure 2. Percentage of correct answers on introduction to the name of physics measuring instrument

The results of the above analysis show that the highest average scores for declarative knowledge indicators are the that the proportion of correct answers from the highest to the lowest indicator of the introduction of the name of the physics measuring instrument, respectively, with the question numbers 4, 3, 1, 5, and 2. This means that students are a little familiar with the name of the digital thermometer compared to the manual thermometer measuring instrument, students are also less familiar with the name of the beaker measuring instrument compared to the bunsen and time measuring instrument. This finding shows that in general students never use digital measuring instruments in the laboratory, even though they get the information in the learning process in class. According to Piaget's theory, concrete knowledge and skills are easier for students to learn and understand than abstract (Chua, 2014; Abdulrahman, 2015; Bengi, 2015; Agustin, et al., 2017; Anna., & Elena, 2017)

The average score of students' declarative and procedural knowledge test results is 40 which is low from all indicators. The highest average score for the indicator of procedural knowledge is successively the effect of salt on the boiling point of water, the relationship between heat and changes in object temperature, the relationship between heat and changes in the state of matter, and the influence of salt on the melting point of ice. The proportion of correct answers from the highest to the lowest indicator of the introduction of the name of the physics measuring instrument, respectively, with the question numbers 4,3,1,5, and 2. This means that students are a little familiar with the name of the digital thermometer compared to the manual thermometer measuring instrument, students are also less familiar with the name of the beaker measuring instrument compared to the bunsen and time measuring instrument. This finding shows that in general students never use digital measuring instruments in the laboratory, even though they get the information in the learning process in class. This finding is supported by the theory put forward by (Çiğdem., Aylin., & Hasan, 2014;Vallance,. 2017; Untu, et al., 2020; Pushenko., & Aksenova, 2021; Giorgioa, 2020) that declarative and procedural knowledge of heat and temperature experiments requires continuous practice to improve students' abilities in practicum.

This finding can be proven by the results of the analysis, the average score of class XI students in declarative knowledge is in the medium category, this shows that class XI students have difficulty in declarative knowledge, even though this declarative knowledge is included in the low-level thinking domain. In the theory of Anderson et al (2001), this variable is included in the domain of factual knowledge and conceptual knowledge. The results of the analysis of the average procedural and declarative ability scores of students in class XI senior high school 1 Gowa are, i.e: 1.92 low category, and 12.32 medium category. This means that students who have a high mastery of declarative knowledge will not guarantee a high mastery of procedural knowledge. The mastery of procedural knowledge has a higher cognitive domain level than the declarative knowledge domain level, so it requires a lot of higher-order thinking practice. showing that all indicators of declarative knowledge are in the medium category. This shows that class XI students have difficulty in recognizing the names of physics tools, the functions of physics tools, the limits of measuring physics tools related to heat material. This variable is one of the causes so that students have difficulty carrying out investigative activities in proving the truth of concepts, principles, and theories in the heat subject matter they have learned.

The results of the analysis of the average scores of students in class XI of senior high school I Gowa on each indicator of procedural knowledge, i.e: the relationship between heat and the change in temperature of an object 0.60; the relationship between heat and changes in the state of matter 0.60; effect of salt on the melting point of ice 0.20; and effect of salt on the boiling point of water 0.50 All procedural knowledge indicators are in the low category. It means that physics teachers should develop and practice this variable more often. This is in accordance with several research results which report that the procedural knowledge variable is included in the level of high-order thinking which is difficult for students to do, especially making practicum procedures in the laboratory (Ghulam, et al.,2012; Doosuur., & Sandra, 2013; Esen., & Neş'e, 2014; Rebecca, et al., 2014; Hakan., & Mehmet, 2015; Massyrova, et al.,2015; Sayyed, et al., 2015; Rula, 2017)

The results of the analysis of the average scores of students in class XI of senior high school I Gowa on each indicator of declarative knowledge, i.e: introduction to the name of physics measuring instrument 4.56 medium category; introduction to the function of physics measuring instruments 4.64 medium category; introduction to measuring limits on physical measuring instruments 1.34 low category. This finding shows that the eleventh grade students of Gowa high school I have difficulty in the domains of low-level thinking and higher-order thinking. This can result in students' creative potential having difficulty developing, so that their creativity will also be hampered. On the other hand, in all sectors of industry, government, and education in the 21st century today, it is very necessary for humans who have high creativity to produce new products (Shridevi, et al., 2013; Sitthichai., Panita, 2014). This finding is supported by the theory which states that mastery of declarative knowledge is dominated by mastery of names and symbols (symbols), circulation, and language (Hari, 2010; Tabrani, et al., 2011; Dewanto., Agustianto., & Sari, 2018;Nida, 2019).

▪ CONCLUSION

Based on the results of descriptive analysis, it can be concluded that the causes of class XI High School 1 Gowa students having difficulty mastering procedural knowledge and declarative knowledge are 1) physics teachers rarely train and teach procedural knowledge and declarative knowledge, 2) students are not familiar with the names of tools, the function of the tool, and the measuring limit of the tool, 3) students are less accustomed to carrying out experimental activities in the laboratory that require procedural knowledge, and 4) students are rarely given the opportunity to develop their potential in the domains of low-level thinking and higher-order thinking.

Implications of the research results, provide an overview of students' declarative and procedural knowledge as a guide for physics teachers in improving higher-order thinking skills, and students' skills in conducting practical work in the laboratory. However, further research is still needed to conduct research by implementing a learning model in a larger sample size. Limitations: there are several limitations, namely the number of participants in this study is relatively small (only 50 students), using google classroom and zoom applications, and procedural and declarative knowledge instruments.

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