Research in Phyiscs Education (2023), **2(2)**, 138–153

ARTICLE

Inquiry ability of students to develop cognitive ability in learning hydrostatic pressure

Pramita Sylvia Dewi,[*,1] Eka Cahya Prima,[*,2] Ari Widodo,[*,2] and Diana Rochintaniawati[2]

[1]Faculty of Teacher Training and Education, University of Lampung
[2]Department of Science Education, Universitas Pendidikan Indonesia
[*]Corresponding author. Email: pramita.sylvia@fkip.unila.ac.id; ekacahyaprima@upi.edu; widodo@upi.edu

(Received 5 October2023; revised 4 November 2023; accepted 10 November 2023; published 26 December 2023)

Abstract

This research aims to implement questions through problem stimuli regarding hydro static pressure based on inquiry investigations. This research is limited to conducting experiments because the focus of the study is analyzing the cognitive abilities of the questions tested on 106 junior high school students. This study uses a quantitative exploratory method that aims to improve the understanding that students go through for their initial inquiry and perspective abilities during the science learning process. Data collection was carried out using a test instrument in the form of description questions whose inquiry indicators had been developed referring to the National Research Council (NRC) indicators, plus a questionnaire to identify students' perceptions as a secondary data source. The results showed that all stages of inquiry activities had a low percentage of 50.0%. The involvement of students has yet to be able to ask investigative questions in formulating problems to be a significant start, as well as predicting in hypothesising. So it affects the activities of designing experiments and analysing data. This causes scientific reasoning to be challenging to communicate. In comparison, student interest in science learning is only around 51.2%. This proves that the inquiry process aspects are tied to one another, and the role of students must be maximally fully involved in every stage. Teacher and technology support needs to be harmonised to optimise further research.

Keywords: Inquiry ability, science learning perspective, teacher support

1. Introduction

Many inquiry-based learning models have been developed (Chai et al. 2017; Donnelly, Linn, and Ludvigsen 2014; García-Carmona 2019; Hong et al. 2019). Inquiry learning directs investigations by carrying out scientific activities characterised by thinking processes and operations based on the goals achieved between students and teachers (Kidman and Casinader 2017). For this reason, the implementation of inquiry learning shows the process passed by open experimentation and reflects the inquiry process (Mieg 2019). Inquiry learning that has been applied so far in the teaching and learning process in schools is guided inquiry. The inquiry stage starts with formulating problems, making hypotheses, designing experiments, conducting experiments, collecting data, analysing data, and communicating the results (Bretz et al. 2013; Constantinou, Tsivitanidou, and Rybska 2018; NRC 1996). Based on these scientific studies, students should acquire scientific knowledge and the skills to investigate how a person seeks curiosity about the problem he wants to know.

Like inquiry in school implementation, science learning focuses on process skills to analyse and understand concepts through direct inquiry activities (McNew-Birren and Kieboom 2017). Science learning which emphasises the need for inquiry-based learning is directed at facilitating students to solve authentic problems (Lehman et al. 2006). Often students are faced with science problems in everyday life, so they try to find ways to solve problems through inquiry learning (Elvan, Güven, and Aydoğdu 2010). Therefore, students' thoughts explored from solving abstract problems become real, but displaying scientific relationships through explanations of scientific phenomena is challenging. This should be balanced with how a teacher can build a complete understanding of science concepts to be taught to students through the inquiry process. Thus, the abilities possessed by students are used as provisions for teachers to carry out their professional duties, which is one of the standards for the professional development of science teachers (NRC 1996).

Based on the research of Ješková et al. (2018), it was found that the level of development of inquiry skills was not satisfactory because it did not reach an average value of 40%. The best results were achieved in designing experiments and identifying variables. Furthermore, there were differences in inquiry abilities between male students. Male and female students it turns out that male students are superior in identifying variables. Tests diagnosed this level of inquiry skill development, which showed that students were less likely to engage in inquiry activities. This signals teachers to change their attitudes towards teaching students to adopt more inquiry-based strategies. Anticipating these results requires social interaction and good scientific understanding from teachers and students, so knowledge development through learning principles will be better if practised (Bell et al. 2010).

The implementation of science learning found in the field also has many obstacles, and this further strengthens that the conditions of science learning through guided inquiry conducted by teachers in the classroom are often not optimal (Ayurachmawati and Widodo 2016) because science learning is still taught only in lectures and discussions. These indications indicate that the transmission of knowledge is only between students and teachers without any reciprocal relationship, whereas the student learning process tends to emphasise memorising factual information only (Huffman 2002). This research is based on a study that further implements the cognitive abilities of junior high school students in measuring their knowledge through inquiry questions developed based on the discourse stimulus providing problems from several concepts of fluid pressure. This will later be correlated with the science learning factors that involve students in the inquiry process.

The reason for choosing the hydro static pressure material used in this research is because it contains a conceptual understanding of scientific concepts such as buoyancy, which is very important to understand from the nature of science and the way environmental aspects interact (Subramaniam et al. 2019). Accommodation problems are described from the questions that lead to this research through the students' inquiry ability in conceptualising the material of hydro-static pressure. In addition, providing a point of view on student interest through science learning because the urgency of this study requires teachers to continue to carry out dynamic science learning because variations in each phase of inquiry are significant for science teachers to understand, especially students' cognitive mastery in answering questions in this study. This makes students have to have high curiosity because abstract science material cannot be separated from investigative activities, b. Besides,e reciprocal relationship between teachers and students in the science learning process is expected to support students in finding concepts independently.

2. Research methodology

This study uses an exploratory quantitative that emphasises identifying problems, making hypotheses, and prospectively providing the results of a study (Creswell 2020). The following is a thought diagram for analysing students' inquiry abilities in science learning on the fluid pressure material presented in Figure 1.

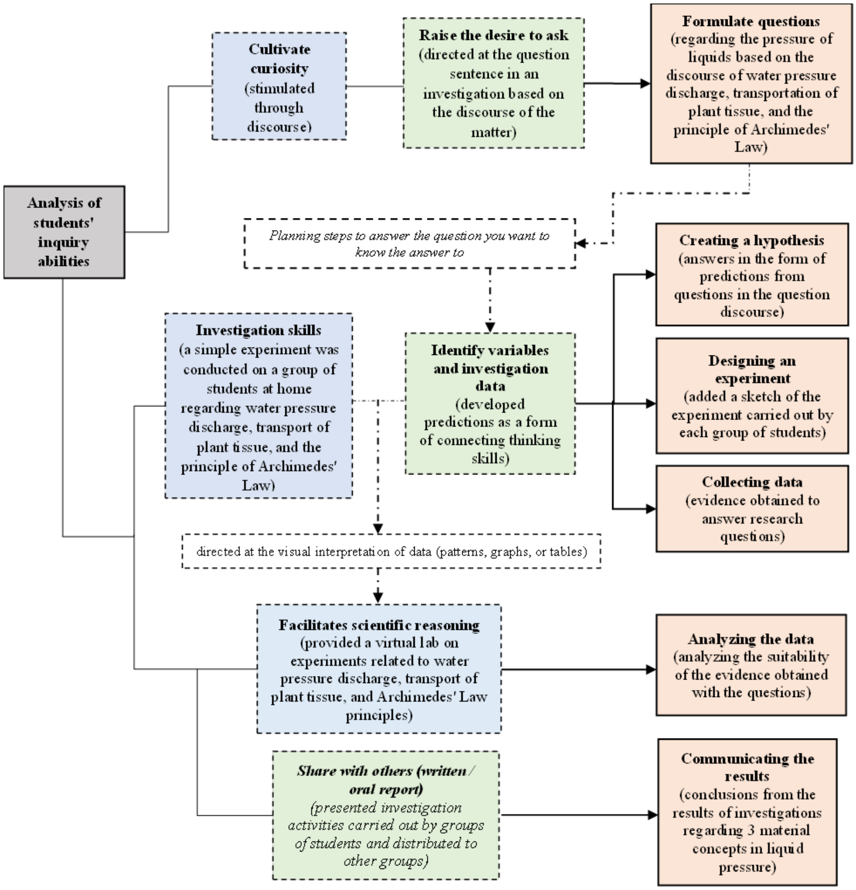

Figure 1. Research Paradigm

Based on the research paradigm, Figure 1 explains the ability analysis by students taking 6 inquiry competencies involving cognitive processes. The ultimate goal of these competencies is carried out through the conception of hydro-static pressure. So that the impact provides students' perspectives on science learning that have been applied in schools. Of the six scientific processes, the competence to carry out investigations is not contained in the research paradigm explicitly, the reason being that the analysis involves more motor skills, while the inquiry abilities studied in this study are only based on students' cognitive skills in answering questions based on the discourse stimulus provided. Related to the theme of fluid pressure. This research begins with the development of an instrument of inquiry, the indications of this question will provide information about the process of developing students' inquiry abilities. Furthermore, students' views on science learning that they have gone through so far by identifying the most influential factors in the science learning process.

2.1 Development of indicators of inquiry ability

The development of previously made inquiry questions using indicators (National Research Council, 2000) contains material content of hydro static pressure. This material was chosen because it covers scientific aspects such as water pressure discharge, plant tissue transportation, and Archimedes' law principles. This theme is a science problem that students often encounter in everyday life. The students who participated in this research had never previously received the material on hydro static pressure. The mechanism was chosen because a thorough fundamental analysis of students' abilities related to existing competencies in inquiry learning is needed to provide a complete picture. The test results have been through a testing process by 2 raters and calculated through the SPSS statistical application.

Table 1. Statistical data

Statistical measurement	Grade	
	A	B
Mean score	39.6	39.9
St. deviation	11.3	10.3
Minimum score	26	26
Maximum score	71	73
Test of normality	0.3	0.4
Test of homogeneity	0.7	0.7

This test was conducted by the assessor twice at different times. When viewed from the acquisition of the rater assessment, which was carried out 2 times, the coefficient in class A was 0.98. At the same time, the coefficient results in class B is 0.99. Based on the research (Landis and Koch 1977), which is used as a reference, the two coefficients indicate that the level of inter-rater reliability of the two raters on the pretest in both classes is "AlmosIfeans that if the reliability degree is very high, the test results can be selected as one of the data from the two raters in both classes to be analysed for hypothesis testing. As shown in Table 1, the total number of students in this study was 106 students, with details of students in class A for boys as many as 21 students and for girls as many as 32 students. Meanwhile, there are 25 male and 28 female students in class B.

The selection of the two classes, A and B, was based on the recommendation of the science teacher who taught in the two classes, considering that the science test scores of the two last term were almost equal. Based on Table 1, the average score is between 39.6 and 39.9, meaning that the science learning carried out by teachers in class A and class B has the same teaching method so that students form almost the same mindset. This is also in line with statistical analysis, which shows that all samples are normally distributed and homogeneous in the SPSS 25 statistical test, using Kolmogorov Smirnov (KS) through the exact method. This method was chosen based on the number of samples, 50 following the number of students in each class, which amounted to 53 students, so the reference uses KS (Hahs-Vaughn and Lomax 2020). Type of method Exact Sig. (2-tailed) was chosen because the sample data was relatively small, only using a scale of 1-4 for 26 essay questions that were tested to measure students' abilities based on inquiry competence. The following provision shows that the exact method has the lowest scores starting from 20 points. Although the two previous classes had never experienced testing on the material of hydro static pressure, the students' inquiry abilities in initial processing knowledge were still minimal. This influence cannot be ignored because it affects the results of evaluating the ability of inquiry. This challenge requires students to actively participate in providing relevant arguments without skipping reasoning at all. Although the nature of the questions tested on 106 students is a type of description, students are expected to be able to explore a more scientific answer to a problem in the question posed.

2.2 Indicators of students' perspectives on science learning

Perspectives regarding students' perspectives on science learning that have been carried out so far are summarised in 6 indicators that outline the science learning experience. The intended indicator describes students' interests, expectations, learning difficulties in science, understanding, and the importance of science practicum facilities. This assumption was obtained during direct visits to several schools. Indicators that produce secondary data are expected to provide an overview of the extent to which science learning teachers have applied guided inquiry can be realised for students. In contrast to the inquiry ability in the testing process, this student's perspective is more about their opinion of the science learning that has been passed, which covers all levels of levels in several junior high schools. The reason for taking prospective data is needed to see how far the implementation of science learning can be carried out and provide maximum student results.

2.3 Data collection and analysis

The primary data used in this study were questions of inquiry, totalling 26 questions, and student perceptions, summing 14 statements. The acquisition of data sources is summarised in a google form and distributed to students according to research needs. Meanwhile, the question rubric is adjusted to the answers that are considered correct and can be answered by students. Furthermore, the data were analysed and assessed using an assessment rubric on a scale of 1-4 and for the student questionnaire scale. The reason for the scale range is that students can minimise answering statements by being trapped in safe answers. The evaluation results are intended to avoid choosing secure solutions that students often do. Data collected from instruments such as scales can describe the quality of analysis (Isaac and Michael 1995). The study is presented in a document that provides an overview of student development regarding the ability of inquiry in answering questions on the pressure of hydro static and provides students' views on their point of view in science learning so far.

3. Result

3.1 Student inquiry processability

A total of 106 students were involved in taking the inquiry ability test on the material of hydro static pressure. The hydro static pressure used as a topic in this study includes three themes, the first regarding water pressure discharge. Water discharge is the volume of hydro static flowing in a cross-section that can be accommodated per unit of time. Mathematically, the discharge is expressed by the symbol Q. From its understanding, and it means that the discharge is influenced by the volume of a hydro static and the time it takes for the substance to flow. By knowing the water discharge, students can obtain information such as calculating the amount of water used for watering plants and calculating the time it takes to fill the bathtub fully. Second, regarding the transportation of plant tissue, plants absorb water and nutrients (mineral salts) from the soil. Water and mineral salts enter the roots through the root epidermis by osmosis. Water and mineral salts can enter the plant stem because of the compressing force of the sources. The groundwater pressure is greater than the water pressure in the branches so that theatre can enter the plant cells through the roots. In addition, the influence of the sunlight's intensity can accelerate the evaporation of water into the stem.

The three principles of Archimedes' Law, learning buoyancy requires students to have accurate concepts about mass, volume, and density to fully develop and calculate formula values. These terms are interrelated and dependent on each other (Subramaniam et al. 2019). Buoyancy is the upward force acting on an object in a fluid and determines whether the thing will rise, sink or remain static in the liquid (Serway and Faughn 1999). Buoyancy is defined as a dimension to understanding why objects float and sink. Although considered a single concept, buoyancy relies on a conceptual understanding of related physical science concepts. For example, the concept of Archimedes' principle is summarised in the formula $F_B = \rho_{fluid} V_{Object}(g)$, where this formula relates the buoyant force and density of the fluid, the buoyant force and volume of the object, and the buoyant force and gravity (Dijksterhuis 2014). Based on the students' inquiry abilities results, the percentage value produced is at most 50%, as shown in Figure 2. In general, it can be concluded that the results of the students' inquiry abilities studied are still low in accommodating all abilities in inquiry competence. This can be a trigger that the topic used as a matter of discourse containing a stimulus is broad enough to be interpreted. So students find it challenging to decide which ones they can answer in experimental planning, collecting, analysing data, and making conclusions (Everest and Vargason 2013).

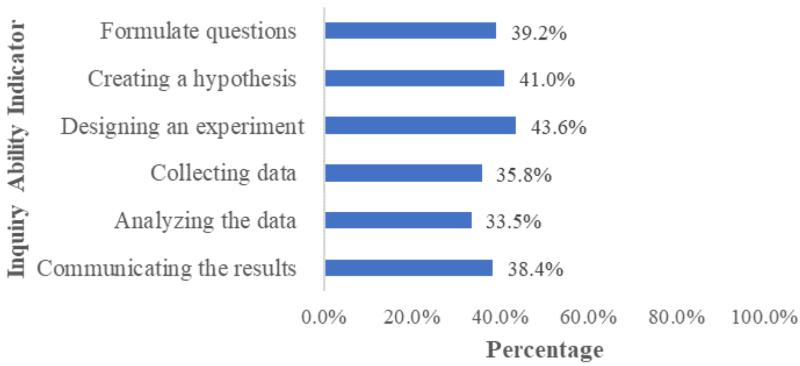

Figure 2. The results of students' cognitive abilities in the inquiry process

Figure 2 explains the inquiry ability section, which starts with formulating problems. This section further emphasises that students cannot ask questions that can be investigated through investigation activities. The indicator is only around 39.2%. In terms of making research questions, most students do not start with a question sentence but are immediately accompanied by an answer to the problem stimulus given. For example, when students are given a problem stimulus regarding plant tissue transportation events, such as the following "Dita wants to investigate the speed of transportation in plants. Dita prepared two water henna plants with stems of the same size and length and then washed the roots. Each plant was placed in a measuring cup containing 200 ml of coloured liquid and labelled A and B. Measuring cup A was placed in a place exposed to direct sunlight, and measuring cup B was placed in a place not exposed to sunlight, then both were observed. For 15 minutes". Based on the discourse, if it is described, the problem stimulus created by several groups of students is shown in Figure 3 below.

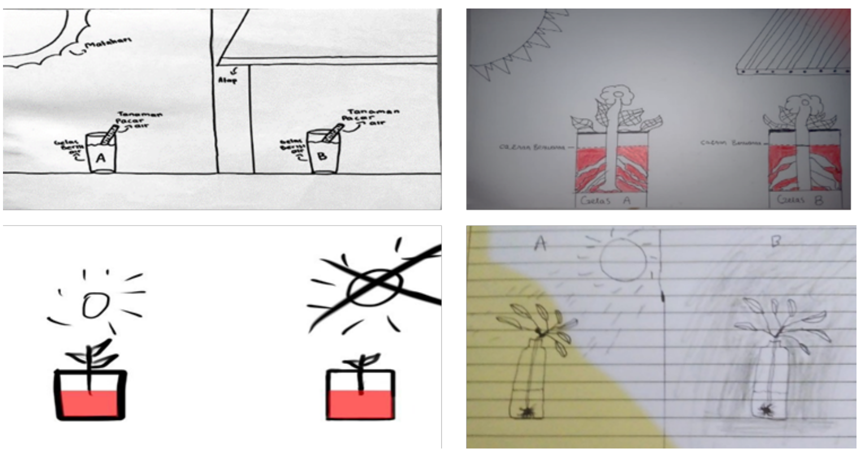

Figure 3. Illustration of the problem of investigating plant tissue transport

Figure 3 explains that the average student in answering does not ask about the height of the colour of the liquid or the effect of sunlight on the two plants. However, the answers raised were questions that were not for investigation. For example, students commented more with the question, "why are these two plants? Some assert they will become infertile due to plants lacking or excess sunlight." This assumption is based on students with a low literacy level in reading questions. It affects their thinking skills when they raise research questions that formulate problems in further investigation activities.

In the second part of inquiry competence, which is making hypotheses, students are directed to the indicators of proposing theories based on the phenomena presented and using knowledge to develop an idea through investigation. The percentage of values obtained around 41.0% indicates that the students in the hypothesis views till low. The results of the answers show that students' assumptions about the scientific phenomenon do not indicate mean problem. The third inquiry competency, designing experiments, has the most extensive engagement age index reaching 43.6% of all existing inquiry aspects. However, it does not exceed 50%. of designing experiments; students are seen to be able to answer questions by recognising the attitude of involvement in investigation activities, appropriate laboratory skills, and independence through making experimental procedures, analytical methods, communication, and maintaining results (Bruck and Towns 2009). This is indicated because students prefer to be involved in actual activities, such as practicum activities, and get less direction from teachers or instructors to be free to conduct investigations (Movahedzadeh et al. 2012). The indicators in designing the experiment include answering the problem formulation through a sketch of the image that comes to mind for the discourse stimulus from the question received. This result can be said to be good because most students can express the overall sketch of the meaning according to the problem stimulus given.

An example of a problem stimulus in the first discourse is "Andi occupies a room on the ground floor of his house. Every morning when taking a shower, Andi complains that the faucet in the bathroom has very little flow, so it takes longer to fill the tub. Meanwhile, at the same time, the faucet of the bathroom upstairs occupied by his sister was very fast-flowing. Andi wondered what caused this to happen. After observing it, it turned out that there was only one pipe from the torn, dividing its flow into two bathrooms. Andi plans to change the water supply pipe from the torn to the bathroom and then compare the water flow." An example of a sketch made by a group of students is shown in Figure 4.

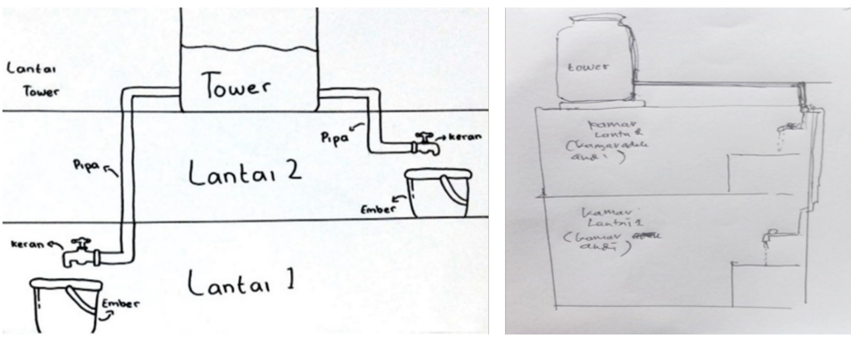

Figure 4. Water pressure discharge sketch

The sketch in Figure 4. made by the students is analogous to a water torn inserted by a pipe, placed on the 2nd-floor position as the sister's room, and the 1st-floor position as Andi's room. The line is installed and adjusted to drain water in the upper and lower bathrooms. In addition, in the design phase of the experiment, the indicators assessed include identifying variables and planning systematic observations. Students' answers show promising results, and they can answer which components are made the same so that the swift flow of water can be compared and then what is measured, observed and what part does not affect the investigation results. An example of a problem stimulus in the second discourse is:

> "Rina and her family every semester goes on vacation to grandmother's house in Jakarta. They use car transportation from Bandar Lampung to Jakarta. The journey they took, apart from the land route, also crossed the Sunda Strait. When boarding a ship, Rina often finds the ship overcrowded with a large number of passengers and the number of vehicles that are also heavily parked. Rina is curious about what causes this ship to remain strong to sail, then Rina plans to investigate using the plasticine material at home". Examples of sketches made by students are shown in Figure 5.

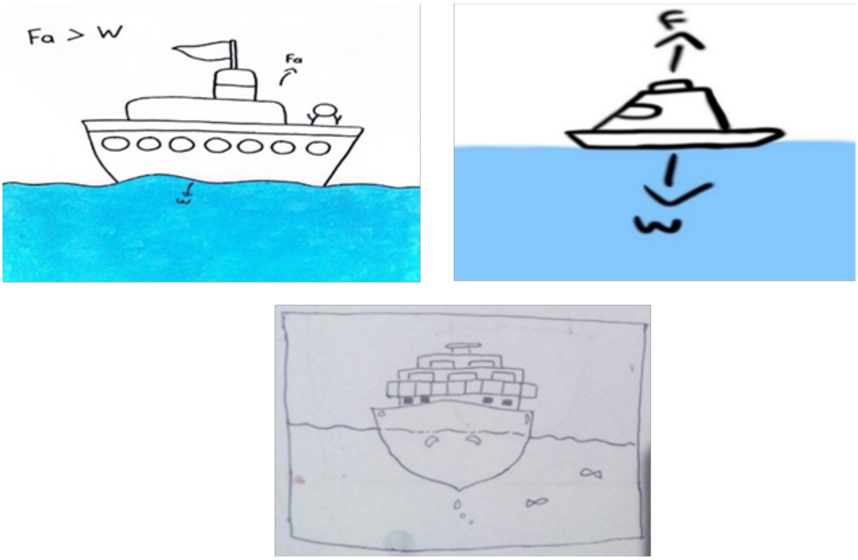

Figure 5. Archimedes' principle representation

The sketch in Figure 5 shows the relationship that the ship remains strong in sailing because the boat is in the form of a container whose volume is enormous so that when pushed into the sea, the importance of water that is made is significant and causes the upward force of water to balance the weight of the ship.

The fourth competency tested is collecting data; about 35.8% of the scores were obtained for this competency. Students are still considered low in terms of collecting data because students need to be more decisive in making tables and graphs from the experimental results stimulated in questions. The weak thinking of students towards the notion of the phenomena displayed makes it challenging to compare subsequent measurements. So students need more material to be presented as necessary information. The intended indicator is to build a strong understanding of the data collection process, which can be seen in the following question

> An experiment to determine the density of the four data, then he carried out the data collection process. How to choose the position of the four data. A solid P (7,900 kg/m3) is placed in a liquid S (7,900 kg/m3). A solid Q (2700 kg/m3) is placed in a liquid R (13,600 kg/m3). A solid R (19,300 kg/m3) is placed in a liquid P (1,000 kg/m3). A solid S (8,400 kg/m3) is placed in a liquid Q (800 kg/m3).

Based on students' answers, the positioning of answered students was not directly proven by the investigation results. Still, based on the lowest to the highest data, students only guessed which part of the object was heavier. At the same time, the four data must consider the positioning of the comparison of the two masses of objects where Data 1, the position of the object will float, because ρP is the same as ρS. Data on 2 positions of objects will float because Q is smaller than ρR. Data on the 3 positions of objects will sink, because ρR is greater than ρS. Data on the position of objects will sink, because ρS is greater than ρQ.

Next is the lowest inquiry competency of all existing aspects, namely analysing data. This aspect gets a percentage of 33.5%, meaning in answering questions. Likewise, with the explanations students give, this inquiry ability is closely related to scientific reasoning, which becomes a problem for middle-level students in building scientific reasoning (Wu Hsieh, 2006). Students try to solve problems to translate the narrative of scientific phenomena and provide descriptions of scientific explanations. This goal leads to data analysis skills that can provide answers with evidence to support them, meaning that students need related understanding knowledge to develop their scientific reasoning (Glasson, 1989). One example of a question in the indicator of analysing data is contained in the following problem stimulus:

> "Based on the observations made, there is a difference between the mass and volume of an object. The differences between the three objects are presented in Table 2. It is known that the density of mercury is 13.6 g/cm3. Determine the correct position of the three objects if they are placed in one vessel?"

Table 2. The difference in mass and volume of the three objects

Object name	Massa (g)	Volume (cm3)
Object 1	96.5	5
Object 2	272	20
Object 3	118.5	15

The average student's answer only rewrites the text of the question and does not even examine the meaning of the question. Besides, students need help writing down proof of the problem in Table 2. However, some students seem to be able to present the analytical relationship from Table 2; here are examples of student answers:

Known: $\rho = \frac{m}{V}$
Object 1: $\rho = \frac{96.5}{5} = 19.3gcm^3$
Object 2: $\rho = \frac{272}{20} = 13.6gcm^3$
Object 3: $\rho = \frac{118.5}{15} = 7.9gcm^3$

Based on the results of the investigation, object 1 sinks because the density of object 1 is greater than the density of mercury. Object 2 floats because object 2's density equals the density of mercury. Object 3 flows because the thickness of object 3 is less than the density of mercury, as shown in Figure 6.

While the last inquiry competence is communicating the results, this indicator is more about conveying scientific arguments against the investigation results and evaluating other opinions that differ logically. The results of the acquisition of students get a value of 38.4%; although it is still far from 50.0%, this competence is quite well answered by students. Students can reveal the factors that cause hypertension in indicators of the delivery of the investigation results, such as "The circulatory system receives pressure from the heart pump so that blood flows in the human body. This is what Ali tried to do to observe the blood pressure of his five friends. The following are the results of Ali's observations.

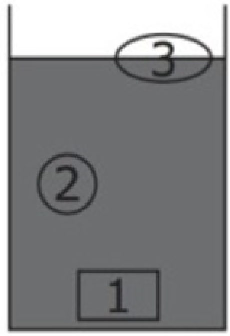

Figure 6. Position of the three objects

Table 3 shows an increase in blood pressure measurements when Ali's five friends sat relaxed and then ran. This factor is caused by each individual's activity habit (exercise). If they are rarely active, it causes the heart to pump blood faster to meet oxygen needs. The factor of weight and body also allows for an increase in blood pressure because it is not balanced with activity (exercise) if it is rarely done. Likewise, by evaluating opinions, students are judged to be able to provide logical reasoning regarding their views on investigations regarding the way blood circulates in the body, such as:

> "Blood circulates throughout the body apart from being pumped by the heart, blood also flows in blood vessels scattered throughout the body, both through the major and minor circulatory systems. Proof of blood flowing throughout the body is also marked when we are injured in certain parts, and it bleeds."

Table 3. Frequency of blood pressure for 15 minutes of activities

No	Ali's friend	Gender	Weight	Blood pressure (mmHg)	
				Sit and relax	Run up and down stairs
1	Ana	F	40 kg	110/80 mmHg	115/85 mmHg
2	Banu	M	46 kg	100/70 mmHg	110/80 mmHg
3	Hasna	F	48 kg	110/80 mmHg	120/90 mmHg
4	Budi	M	45 kg	105/75 mmHg	110/80 mmHg
5	Rudi	M	49 kg	100/70 mmHg	135/90 mmHg

3.2 Science learning needs to be based on students' perspectives

Analysis of science learning needs experienced by students in the learning process has collected data related to factors related to students' perspectives. The information is more about the interests, expectations, and difficulties in learning science. The rest is how vital the practicum, practical experience, and science practicum facilities have been to students. All of these are presented in Table 4.

Based on the data collection results in Table 4, interest or curiosity (inquisitive) in science lessons implies investigating or questioning problems. This curiosity means that there is new information, but the achievement of the agreement indicator gets the highest percentage, with an average of 51.2%. This means that there are challenging problems in science learning that involve how to stimulate students' thinking to find out, discover or explore. Students are curious about newly

Table 4. The results of students' perspectives on science learning

No	Indicators	Percentage (%)			
		Strongly disagree	Disagree	Agree	Strongly agree
1	Interest in science lessons	3.6	9.9	35.3	51.2
2	Students' expectations in learning science	4.1	14.6	39.9	41.4
3	Difficulty learning science	15.8	25	26.3	32.9
4	The importance of science practicum	7.5	13	29.3	50.2
5	Science practical experience	24.2	21.6	28.8	25.4
6	Science practicum facilities	5	13.8	34.1	47.1
Total		60.2	97.9	193.7	248.2
Mean		10	16.3	32.3	41.4

obtained information, which is very likely to satisfy students' curiosity. Because the percentage strongly agrees that students' interest in learning science is very high. Inquiry activities that raise continuous productive questions with science practicum experience involve both inquiry activities, namely collecting and analysing data. However, the results of the lowest percentage of students' perspectives on practicum experience indicators stating agreement were only 24.2%. Then the science practicum facilities that are not optimal are also a problem so that students cannot carry out investigative activities. The percentage stating the agreement is very high, reaching 47.1%.

The practicum experience is shallow since students need to fully follow the impressive process of what they get during the science practicum. Students need to gain the practice to complete assignments and work together in groups, let alone understand the subjects they plan to contribute to their groups. However, the process does not provide meaning that can be obtained as a valuable experience to be used as a provider of knowledge. Therefore, students do not get the benefits and have limitations that still need to be completed. The teacher's role as a facilitator can arouse students' motivation to explore simple practicums. The results of interviews limited to the three science teachers showed that in the learning process, the teacher had tried to carry out his role in facilitating student learning. The teacher provides intervention by opening up to discuss scientific problems with students in a friendly and non-threatening way. The teacher tries to help link the prior knowledge that students already have with the new information they will learn. Teachers provide additional support, such as pre-lab training outside class hours. However, this will not work if students intend to practice their thinking skills in investigation activities.

4. Discussion

Inquiry learning trains students to work scientifically in understanding natural phenomena because students make observations, experiments and empirical and analytical activities (Chang, Sung, and Lee 2003). Students are allowed to develop skills, and thinking skills, increase interest and motivation (Bretz et al. 2013), and expand their knowledge, insight, and scientific literacy. Practising the same activities as scientists also help students gain a deeper understanding of scientific inquiry. Students can also learn not only from successes achieved but also from "failure" experiments (e.g. experiments that did not give the results they expected) to be more instructive than experiments that showed the desired results. This failure might make students more daring to design and try new experiments (Lamanna and Eason 2011).

Inquiry learning carried out in this study involves the ability of the inquiry process itself. The first aspect is formulating a problem. This activity is expected to trigger students to have curiosity, so it raises the desire to ask questions, which are marked by the words "what if", "why," and "how". This questioning activity leads to research questions, which should teach students to research by finding them themselves (**<empty citation>**). However, this was not achieved in the activity of formulating problems. Instead, non-productive questions emerged from students, such as "why did this happen?" Although using interrogative sentences "why, how and whether", the question element does not show the core problem of thinking about the investigation of a discourse stimulus read by students. Therefore, students have appropriate unpreparedness when answering inquiry questions that provide various incentives for science problems. The following is an example of data regarding the answers of groups of students in making research questions on 3 concepts of liquid pressure material contained in Table 5.

Table 5. Research questions for groups of students regarding hydro static pressure

Group	Discharge Water Pressure (D)	Plant Tissue Transport (T)	Archimedes' Law Principle (A)
1	What should the torn pipe position be to drain a heavy water flow? D1 (correct)	Does the intensity of sunlight affect the height of the coloured liquid between class A and class B? T1 (correct)	Why didn't Rina's ship sink? A1 (correct)
2	How is the upper and lower bathroom water positioned, so the flow is the same? D2 (correct)	What effect does sunlight have on plant transportation? T2 (correct)	How could the ship that Rina was on didn't sink? A2 (correct)
3	How do you get the same amount of water from Andi and his sister's room simultaneously, even though there are different positions? D3 (correct)	Is there a difference in the height of the colour liquid in the plants in glasses A and B? T3 (correct)	Why can ships float strong even though they hold much weight? A3 (correct)
4	How do I change the water distribution pipe from the torn to the bathroom so that the water flow has the same flow rate in both bathrooms? D4 (almost correct)	How does Dita compare her speed? T4 (false)	Why did Rina and her family's ship not sink? A4 (correct)
5	Why is the water discharge in the upper and lower bathrooms different? D5 (false)	What is observed in measuring cups A and B after being kept for 10 minutes? T5 (false)	Why can a ship sail even when there is a heavy load? A5 (almost correct)
6	Why is the flow of water in the lower bathroom less flowing than the flow of water in the upper bathroom? D6 (false)	What causes the difference in the growth of the water henna plant? T6 (false)	Why don't ships sink while sailing? A6 (almost correct)
7	What causes the flow of water in the sister's bathroom upstairs the water flow is hefty. D7 (false)	Why do water henna plants have the same size and length as the stems? T7 (false)	Why does Rina's ship keep sailing? A7 (false)
8	How does Andi compare the water flow from his room to his sister's room? D8 (false)	How does light intensity affect glass A and B water henna plants? T8 (almost correct)	How can ships keep sailing? A8 (false)

Based on the description in Table 5, for the first material, only 4 groups of students (D1, D2, D3, and D4) had appropriate answers in the form of research questions based on the discourse given by the teacher as a problem stimulus. Likewise, with the second material, only 4 groups of students were correct (T1, T2, T3, and T8). In the third material, only 2 groups of students (A7 and A8) needed to be more precise in providing research question sentences according to the discourse of the question. This indicates that the ability to think with various answers can stagnate because of habits in answering or not daring to be different (Hu et al. 2013). This understanding is then explained by Loewenstein (1994), who interprets curiosity as a form of lack of knowledge. Cause the emergence of perceptions due to gaps in understanding. Someone who feels an information gap will be disturbed to ask questions, or when someone learns about the sequence of events without knowing the conclusion, curiosity will arise in that person. This is due to a shift in attention from what is known and not when constructing an action plan to solve a problem (Setiawan et al. 2018).

The second aspect is making hypotheses, directing students to make predictions on the questions students ask, and involving inquiry skills as a response to improve thinking skills. These things must be chosen to make it easier for students to direct their guesses before designing an experiment. The third aspect is designing an experiment. This activity is carried out by identifying and describing the variables to be studied as appropriate clues to several independent, dependent, and control variables in an experiment. The selection and use of objects for research purposes must be prepared before use because designing experiments in inquiry learning takes into account the needs needed during the activation process. The following is a discourse about the transportation of plant tissue, "students should be able to understand that the height of the colour fluid in the two plants is an indicator of the dependent variable, which is influenced by the intensity of sunlight. However, students need to make appropriate predictions. Most of the students only focused on the effect of daylight and the sun's explanation of predictions on experimental variables in plant tissue transportation materials made by groups of students in Table 6.

Table 6. Predictive variables in designing plant tissue transport experiments

Group	Student Group Prediction Variable Answers	Decision
1	The plants in glass A and B will have their stems changing colour due to absorbing the coloured liquid, but the plants in glass A have a higher height of coloured stems than those in glass B because sunlight helps increase the water in the plants.	(correct)
2	There are differences in the two plants in both glasses because glass A is exposed to sunlight, so the coloured liquid that rises is relatively high. In contrast, while B is not exposed to the sun's light, it is likely a coloured liquid that rises slightly.	(correct)
3	Because it is affected by sunlight, a glass labelled A in a place exposed to direct light, and a glass labelled B is in s dark place. It is possible that the plants in the glass label were marked higher in coloured liquid than the hosts in the glass labelled B.	(correct)
4	You may see the transportation difference between glasses A and B.	(almost correct)
5	There is a difference between glasses A and B, where glass A will rise in colour while glass B is not due to the absence of sunlight.	(false)
6	There is the influence of sunlight that helps the process of plant photosynthesis.	(false)
7	Water girlfriend plants are the same size as the stem and the same length.	(false)
8	Yes, the influence of sunlight helps the evaporation process in both plants.	(false)

Table 6 describes the predictive variables from 8 groups, but from the 8 answers given, only 3 groups met (groups 1, 2, and 3). Inquiry activities to design experiments are closely related to formulating hypotheses because students already have predictions about how to design experiments to be followed up. But in fact, students need help to distinguish which variables are real l. actual difficulty distinguishing these variables makes students' predictions often wrong in providing explanations, as seen in the group answers (4, 5, 6, 7, and 8). This activity will affect the fourth aspect of collecting data, and students must recognise in a brief description that connects questions with data. This allows students to submit the results of processing the collected data. Students also provide explanations in making decisions for data explanations because this will affect activities in the data analysis process. This fifth aspect is done by clearly representing the visual relationship. So far, students need help relating graphs or tables with evidence that leads to scientific explanations. This is evident in the use of virtual labs taught by teachers. Therefore, this difficulty indicates that scientific reasoning involve activating on changing knowledge (Hand, Lawrence, and Yore 1999; Kuhlthau 2010).

The last aspect of communicating the results is the result of experimental data support. Students engage in interactive discussions to criticise discuss theories from various sources and defend conclusions based on evidence. Based on students' answers, they are better off writing their opinions using their knowledge base, but more evidence must be added to add explanations. To minimise, the teacher's role as a facilitator helps students construct the concepts they want to build in their cognitive structure (Criswell 2012). Furthermore, the results of students' perspectives on the importance of science practicum, which most students are aware of, but the existing facilities at the school need to support the investigation process; this results in a minimal student experience. Inquiry practicum activities train students to become scientists by applying the scientific method in investigating authentic problems (Domin 1999; Lunetta, Hofstein, and Clough 2013). The research experience that students rarely do should be balanced with the willingness to carry out simple experiments at home so that the development of inquiry is honed. These activities increase creativity and contribute to stimulating increased learning and improving reasoning and innovative thinking skills (Lamanna and Eason 2011).

Individual experience using a laboratory can stimulate an increase in liking, knowledge, and confidence in performing scientific procedures (Movahedzadeh et al. 2012)(Movahedzadeh et al., 2012). Inquiry practicum equips students with prudence in achieving the objectives of inquiry activities, trains skills in determining the problems they explore, reduces the cognitive load when involved in activities, and enhances the inquiry learning experience (Criswell 2012). This is in line with the opinion of Laal and Ghodsi (2012). Students are more likely to give up when they are stuck in difficulties, but if they are in a group, the investigation will find a way to move forward. The explanation of Peterson and Swing (1985) reinforces the previous answer that students actively involved in groups seek to develop problem-solving skills by discussing them and giving each other feedback on questions and comments. Thus, students' communication skills can be seen in developing ideas and conveying them openly to each other. The results of this study indicate the importance of the teacher's role in motivating students to build intrinsic motivation. Motivation is based on developing students' interests, keeping them engaged, and encouraging confidence in their ability to perform specific tasks. The opinion of other researchers supports this (Ivankova and Stick 2007)(2007). Then Hart's research (2012) views motivation as having an effect as an effective teaching tool where students feel that learning is fun.

5. Conclusion

Inquiry activities are connected to each activetrainingone activity cannot be adequately accommodated; it will affect the next move. When students cannot ask research questions based on problem stimulation, predicting students' hypotheses will be problematic, so collecting data to analyse data does not provide appropriate reasoning. As a result, student investigations' results are insufficient evidence and explanations. Based on the results of this research data, it can be seen that from all aspects of inquiry learning, the overall ability of students is below 50%, which means it is still low.

Teachers find it difficult to train students to inquire about science learning, especially to make students curious about the problems of every science phenomenon that occurs in everyday life. In addition, most science questions do not require students to think like scientists. Science questions are only limited to common knowledge, which is conventionally still done by teachers in moving students' thinking stimuli, moreover not many useful learning sites to describe the science process, such as the presentation of interesting virtual labs. . The results of students' perspectives on science learning are still low to provide meaningful experiences for students, especially in practicum. This makes students' curiosity to analyse science problems less optimal. If this is allowed, students lose motivation to learn for better improvement.

Acknowledgement

The authors wish to express our gratitude to anonymous reviewers in this journal whose critical and helpful comments have greatly improved this paper.

References

Ayurachmawati, Puji, and Ari Widodo. 2016. Analisis kemampuan inkuiri siswa di sekolah dasar. *EduHumaniora| Jurnal Pendidikan Dasar Kampus Cibiru* 8 (2): 217–227.

Bell, Thorsten, Detlef Urhahne, Sascha Schanze, and Rolf Ploetzner. 2010. Collaborative inquiry learning: models, tools, and challenges. *International journal of science education* 32 (3): 349–377.

Bretz, Stacey Lowery, Michael Fay, Laura B Bruck, and Marcy H Towns. 2013. What faculty interviews reveal about meaningful learning in the undergraduate chemistry laboratory. *Journal of Chemical Education* 90 (3): 281–288.

Bruck, Laura B, and Marcy H Towns. 2009. Preparing students to benefit from inquiry-based activities in the chemistry laboratory: guidelines and suggestions. *Journal of Chemical Education* 86 (7): 820.

Chai, Ching Sing, Lynde Tan, Feng Deng, and Joyce Hwee Ling Koh. 2017. Examining pre-service teachers' design capacities for web-based 21st century new culture of learning. *Australasian Journal of Educational Technology* 33 (2).

Chang, K-E, Y-T Sung, and C-L Lee. 2003. Web-based collaborative inquiry learning. *Journal of computer assisted learning* 19 (1): 56–69.

Constantinou, Costas P, Olia E Tsivitanidou, and Eliza Rybska. 2018. What is inquiry-based science teaching and learning? *Professional development for inquiry-based science teaching and learning,* 1–23.

Creswell, John W. 2020. *Educational research: planning, conducting, and evaluating quantitative and qualitative research.* Pearson Higher Ed.

Criswell, Brett. 2012. Framing inquiry in high school chemistry: helping students see the bigger picture. *Journal of Chemical Education* 89 (2): 199–205.

Dijksterhuis, Eduard Jan. 2014. *Archimedes.* Vol. 784. Princeton University Press.

Domin, Daniel S. 1999. A review of laboratory instruction styles. *Journal of chemical education* 76 (4): 543.

Donnelly, Dermot F, Marcia C Linn, and Sten Ludvigsen. 2014. Impacts and characteristics of computer-based science inquiry learning environments for precollege students. *Review of Educational Research* 84 (4): 572–608.

Elvan, İNCE, Ezgi Güven, and Mustafa Aydoğdu. 2010. Effect of problem solving method on science process skills and academic achievement. *Journal of Turkish Science Education* 7 (4): 13–25.

Everest, Michael A, and Jeffrey M Vargason. 2013. How does atomic structure affect electron clouds? a guided-inquiry nmr laboratory for general chemistry. *Journal of Chemical Education* 90 (7): 926–929.

García-Carmona, Antonio. 2019. Pre-service primary science teachers' abilities for solving a measurement problem through inquiry. *International Journal of Science and Mathematics Education* 17:1–21.

Hahs-Vaughn, Debbie L, and Richard G Lomax. 2020. *An introduction to statistical concepts.* Routledge.

Hand, Brian, Chris Lawrence, and Larry D Yore. 1999. A writing in science framework designed to enhance science literacy. *International journal of science education* 21 (10): 1021–1035.

Hong, Jon-Chao, Chi-Ruei Tsai, Hsien-Sheng Hsiao, Po-Hsi Chen, Kuan-Cheng Chu, Jianjun Gu, and Jirarat Sitthiworachart. 2019. The effect of the "prediction-observation-quiz-explanation" inquiry-based e-learning model on flow experience in green energy learning. *Computers & Education* 133:127–138.

Hu, Weiping, Baojun Wu, Xiaojuan Jia, Xinfa Yi, Chunyan Duan, Winter Meyer, and James C Kaufman. 2013. Increasing students' scientific creativity: the "learn to think" intervention program. *The journal of creative behavior* 47 (1): 3–21.

Huffman, Douglas. 2002. Evaluating science inquiry: a mixed-method approach. In *Evaluation of science and technology education at the dawn of a new millennium,* 219–242. Springer.

Isaac, Stephen, and William B Michael. 1995. *Handbook in research and evaluation: a collection of principles, methods, and strategies useful in the planning, design, and evaluation of studies in education and the behavioral sciences.* Edits publishers.

Ivankova, Nataliya V, and Sheldon L Stick. 2007. Students' persistence in a distributed doctoral program in educational leadership in higher education: a mixed methods study. *Research in Higher Education* 48:93–135.

Ješková, Zuzana, Brigita Balogová, and Marián Kireš. 2018. Assessing inquiry skills of upper secondary school students. In *Journal of physics: conference series,* 1076:012022. 1. IOP Publishing.

Kidman, Gillian, and Niranjan Casinader. 2017. Inquiry-based teaching and learning across disciplines. *London: Palgrave Pivot* 10:978–1.

Kuhlthau, Carol. 2010. Guided inquiry: school libraries in the 21st century. *School libraries worldwide,* 1–12.

Laal, Marjan, and Seyed Mohammad Ghodsi. 2012. Benefits of collaborative learning. *Procedia-social and behavioral sciences* 31:486–490.

Lamanna, Justin R, and Perri K Eason. 2011. Building creative scientists in the classroom laboratory: applications for animal behavior experiments. *The american biology Teacher* 73 (4): 228–231.

Landis, J Richard, and Gary G Koch. 1977. The measurement of observer agreement for categorical data. *biometrics,* 159–174.

Lehman, James D, Melissa George, Peggy Buchanan, and Michael Rush. 2006. Preparing teachers to use problem-centered, inquiry-based science: lessons from a four-year professional development project. *Interdisciplinary Journal of Problem-Based Learning* 1 (1): 7.

Loewenstein, George. 1994. The psychology of curiosity: a review and reinterpretation. *Psychological bulletin* 116 (1): 75.

Lunetta, Vincent N, Avi Hofstein, and Michael P Clough. 2013. Learning and teaching in the school science laboratory: an analysis of research, theory, and practice. In *Handbook of research on science education,* 393–441. Routledge.

McNew-Birren, Jill, and Leigh A van den Kieboom. 2017. Exploring the development of core teaching practices in the context of inquiry-based science instruction: an interpretive case study. *Teaching and Teacher Education* 66:74–87.

Mieg, Harald A. 2019. *Inquiry-based learning-undergraduate research: the german multidisciplinary experience.* Springer Nature.

Movahedzadeh, Farahnaz, Ryan Patwell, Jenna E Rieker, Trinidad Gonzalez, et al. 2012. Project-based learning to promote effective learning in biotechnology courses. *Education Research International* 2012.

NRC. 1996. *National science education standards.* National Academies Press.

Peterson, Penelope L, and Susan R Swing. 1985. Students' cognitions as mediators of the effectiveness of small-group learning. *Journal of Educational Psychology* 77 (3): 299.

Serway, Raymond A, and Jerry S Faughn. 1999. *College physics.* Pearson Educación.

Setiawan, A, A Malik, A Suhandi, and A Permanasari. 2018. Effect of higher order thinking laboratory on the improvement of critical and creative thinking skills. In *Iop conference series: materials science and engineering,* 306:012008. 1. IOP Publishing.

Subramaniam, Karthigeyan, Pamela Harrell, Christopher Long, and Benjamin Kirby. 2019. Using concept maps to reveal prospective elementary teachers' knowledge of buoyancy. *The Electronic Journal for Research in Science & Mathematics Education* 23 (2).