Analysis of Middle School Students' Covariational Reasoning Skills in Modeling Function Charts Based on Self-Efficacy

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Abstract. In covariational reasoning there are five levels, namely, level 1 (L1) Coordination, level 2 (L2) Direction, level 3 (L3) Quantitative coordination, level 4 (L4) Average rate, and level 5 (L5) The momentary rate r. Low reasoning ability is influenced by several factors including self-efficacy. This study aims to describe students' covariational skills in modeling graphs of functions based on self-efficacy. This research is a type of research with qualitative descriptive approach with case study research design. The research subject consisted of 30 students who were grade VIII SMP Negeri 2 KUNINGAN. Data collection techniques used are tests, observations, interviews and documentation. Student writing test results are analyzed based on the framework of Carlson et al and strengthened by observations and interviews. The results showed that subjects with high self-efficacy as many as two students (6,67%), subjects with self-efficacy were quite high as many as 23 students (76,67%), subjects with moderate self-efficacy as many as two students (6,67%), and subjects with self-efficacy quite low as many as three students (10%). The subjects interviewed and observed as many as eight students, with two of each self-efficacy category found in the study. Subjects with high self-efficacy categories were able to achieve the highest level of covariational reasoning ability of level 5 with S_{MFTA} differences linking quantity processes with equation analytics while S_{ZK} connected quantity processes with direct analytics. Subjects with a high self-efficacy category there are students who are able to reach level 4 and there are students who are able to reach level 3. Subjects with moderate self-efficacy categories were only able to achieve level 3 of covariational reasoning ability, and subjects with moderately low self-efficacy categories were only able to achieve level 2 of covariational reasoning abilities.

Keywords: Covariational Reasoning; Graphs of Functions; Self-Efficacy.

1 Preliminary

Mathematics is a solid foundation, because there is no single branch of science that does not involve mathematics. This can be understood because in addition to the knowledge of mathematics itself, mathematics also provides language, processes, and theories that give science into a form and power (Ramdani, 2006). Mathematics is useful for other sciences such as chemistry, physics, architecture, pharmacy, geography and economics. This shows that mathematics is very important, so mathematics must be studied at every level of education.

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The implementation of mathematics education in Indonesia is regulated in the curriculum. The curriculum mandates that one of the important aspects in mathematics learning is the development of students' reasoning abilities. Reasoning ability is considered important, but in fact the reasoning ability of students in Indonesia is still relatively low this is explained by the results of research conducted by TIMSS (Trend in International Mathematics and Science Study) in 2015 that Indonesia is ranked 43 out of 49 countries in reasoning ability (Frey, 2018).

Reasoning is a process of thinking activity to draw a conclusion in the form of knowledge based on information that has the value of truth so as to acquire a new knowledge. Adamura and Susanti (2018) define reasoning as the process of thinking in order to make a new statement true based on some statements whose truth has been proven or assumed before. According to Purbaningrum (2020) Reasoning is one of the mathematical power that must be possessed by students and is a mental process in developing the mind from several facts.

Mathematical reasoning skills are necessary either in understanding mathematics or in everyday life. In understanding mathematics the ability of mathematical reasoning is very important in understanding mathematical concepts or solving mathematical problems. Reasoning is needed to determine whether a mathematical argument is right or wrong to construct a mathematical argument (Kusumawardani et al., 2018). The importance of mathematical reasoning is also contained in Permendiknas Number 22 of 2006 on Standard Content of Mathematics Subjects. Based on research Sofyana & Kusuma (2018) said students who have mathematical reasoning skills will be easy in studying a problem faced with the information obtained.

One of the mathematical reasoning abilities is the ability of covariational reasoning. Covariational reasoning is a cognitive activity that coordinates the change of two different quantities that have a particular relationship or relationship by paying attention to the process of change. Carlson et al (2002) stated that "we define covariational reasoning to be the cognitive activities involved in coordinating two varying quantities while attending to the ways in which they change in relation to each other". Covariational reasoning refers more to the ability to form a picture of two varying quantities and coordinate their changes in relation to each other. Covariational reasoning also emphasizes more on the relationship between two structured quantities that can be expressed algebraically, visually in graphs, or in real situations (Sumarsida, 2018).

This covariational reasoning is very important for students because usually learning about the concept of function uses a correspondence approach that teaches students with the definition of theory only but with this covariational reasoning ability can make students better understand the concept of function so that it is not only pegged by theoretical definitions, so that when students face problems covariation students can solve them well.

The function of mathematics learning is the study that studies the relationship between two sets, namely domains and kodomain, so that members of x domains there is one pair with members of y kodomain. The concept of function is also inseparable from the phenomena that occur in our lives such as the relationship of distance and time, the number and price of goods, and many others (Istiqomah, 2015). The concept of function can be learned from a variety of different points of view. Such views can be influenced by different approaches in function learning (Umah, 2016).

One approach in the learning of function concepts is the correspondence approach and the covariation approach. The correspondence approach is based on the theoretical definition of a set, while the covariation approach refers to the ability to form a picture of two varying quantities and coordinate their changes in relation to each other. The covariation approach

emphasizes the expression of "relationships" between two structured quantities that can be expressed algebraically, visually in graphs, or in real-world situations (Umah, 2016). The covariation approach is not only limited to rules, procedural, but also provides experience of reasoning abilities.

Covariational reasoning ability is a result of learning or learning achievement and according to Januriastuti (2017) states that factors that affect student learning outcomes there are 2, namely internal factors and external factors for internal factors including intelligence level, learning motivation, physical condition and health of students, how to learn and self-efficacy. Self-efficacy is a belief in one's ability to organize, perform and accomplish work. Self-Efficacy is a person's belief in his ability to organize and implement an action to achieve the results set (Bandura, 2010). Self-efficacy is a person's view of his or her ability to organize and determine a job (Hendriana & Kadarisma, 2019).

Based on the above statement can be concluded that covariational reasoning is important for students because in understanding the concept of function is not enough if only through correspondence approach or understanding theoretically but also coupled with the approach of covariation and also considering the relationship between reasoning ability and self-efficacy then this research was conducted aimed to describe the ability of covariational reasoning of junior high school students in the Model function graphs based on self-efficacy.

2 Research Methods

This research is a type of research with a qualitative descriptive approach with case study research design. The data retrieval technique used in this study is using purposive sampling techniques. The subjects of this study were 8 students from 30 participants of SMP Negeri 2 KUNINGAN who represented the criteria for self-efficacy obtained from the 30 participants. The instruments used in this study are self-efficacy tests in the form of questionnaires, tests of covariational reasoning ability in the form of descriptions, interviews, and observations. The data analysis techniques used in this study are in the form of data reduction, presentation of data and withdrawal of conclusions. The test of the validity of the data used is the triangulation of the technique.

Table 1. Criteria for Self-Efficacy

Interval	Criteria
91-100	Very High
78-90	Quite High
65-77	High
52-64	Normal
39-51	Quite Low
26-38	Low
14-25	Very Low

Based on Table 1 explained that in determining the criteria of self-efficacy if the student's grades are at intervals 14-25 then it can be said to have very low self-efficacy, if it is at intervals 26-38 then it can be said to have low self-efficacy, If it is at intervals 65-77 then it can be said to have high self-efficacy, if it is at intervals 78-90 then it can be said to have a high enough self-efficacy, if it is at the interval of 91-100 then it can be said to have very high self-efficacy.

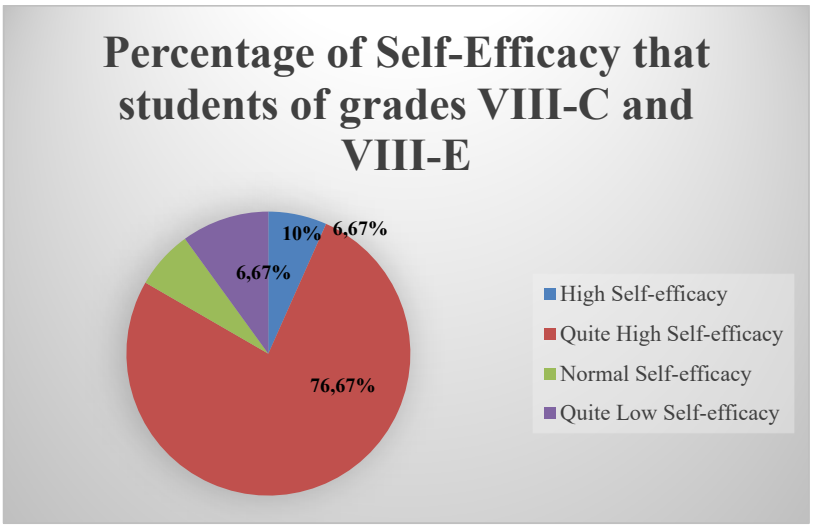
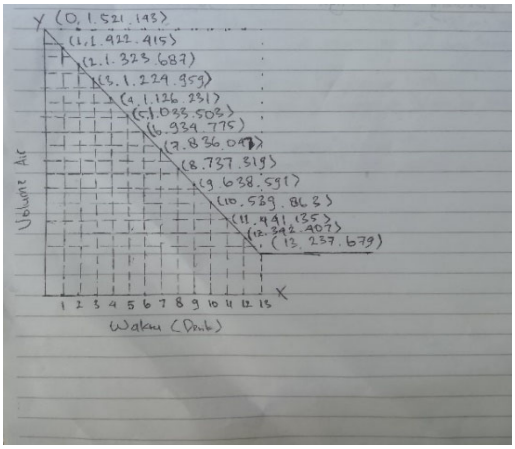


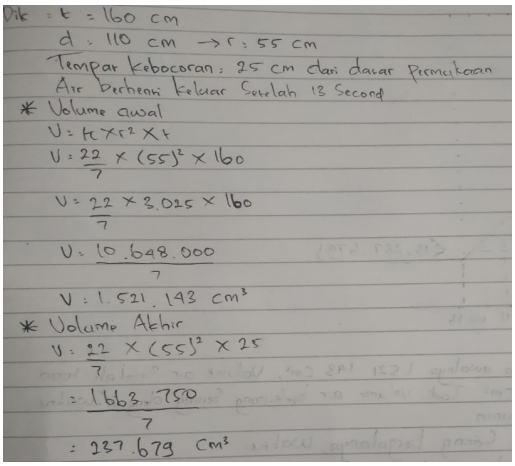
Figure 1 showed that of the 30 subjects studied, 6.67% of students had high self-efficacy, 76.67% of subjects who had high self-efficacy, 6.67% of students who had moderate self-efficacy, and 10% of students who had moderate self-efficacy. The subjects selected for observation and interview were only 8 students because in this study only got four categories of self-efficacy so it was taken 2 students with the highest grades from each category of self-efficacy.

Covariational Reasoning Abilities of Subjects with High Self-Efficacy

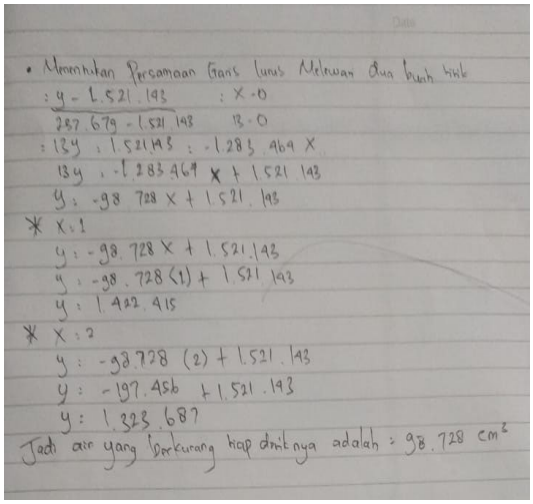
1. **Subject MFTA**



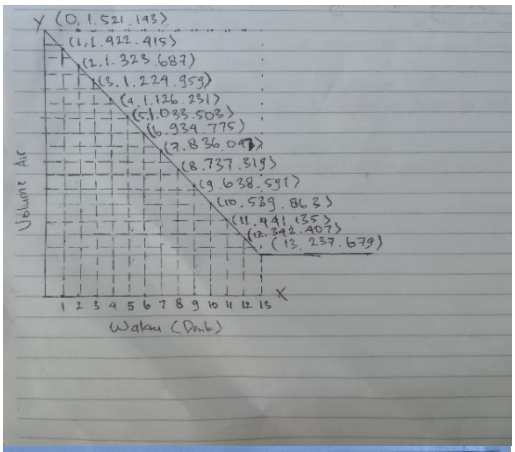
The subject has met levels 1 and level 2 because on the answer sheet MFTA students are able to label the axis then explain the relationship of the two variables and are able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains the direction of the graph down.

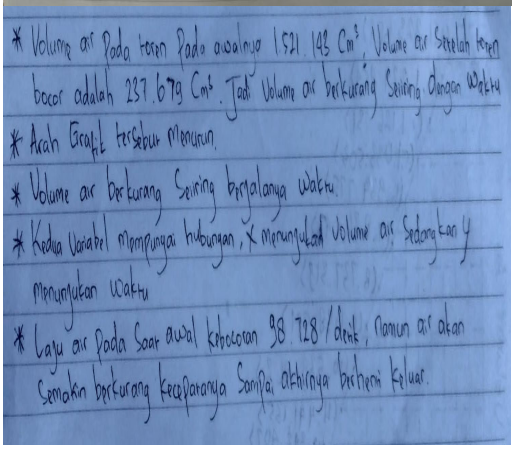

Dik : t = 160 cm
d = 110 cm → r = 55 cm
Tempat kebocoran : 25 cm dari dasar permukaan
Air berhenti keluar setelah 13 second
* Volume awal
V = π × r² × t
V = 22/7 × (55)² × 160
V = 22/7 × 3.025 × 160
V = 10.648.000/7
V = 1.521.143 cm³
* Volume Akhir
V = 22/7 × (55)² × 25
= 1663.750/7
= 237.679 cm³

The subject has met level 3 because on the answer sheet MFTA students can determine the initial volume before the leak and after the leak and place that volume point on the graph then connect it to the line.


• Menentukan Persamaan Garis lurus Melewati dua buah titik
: y - 1.521.143 : x - 0
237.679 - 1.521.143 13 - 0
: 13y : 1.521.143 : -1.283.464 x
13y : -1.283.464 x + 1.521.143
y : -98.728 x + 1.521.143
* x : 1
y : -98.728 x + 1.521.143
y : -98.728 (1) + 1.521.143
y : 1.422.415
* x : 2
y : -98.728 (2) + 1.521.143
y : -197.456 + 1.521.143
y : 1.323.687
Jadi air yang berkurang tiap detiknya adalah : 98.728 cm³

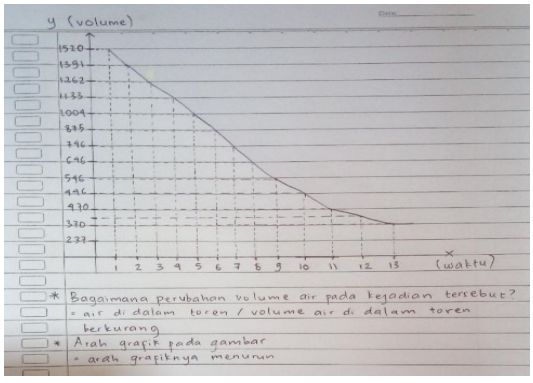
The subject has met level 4 because on the answer sheet MFTA students can determine the water coming out of the toren every second, and students are able to create or plan a coordinate point in detail. Then the subject creates a line segment.



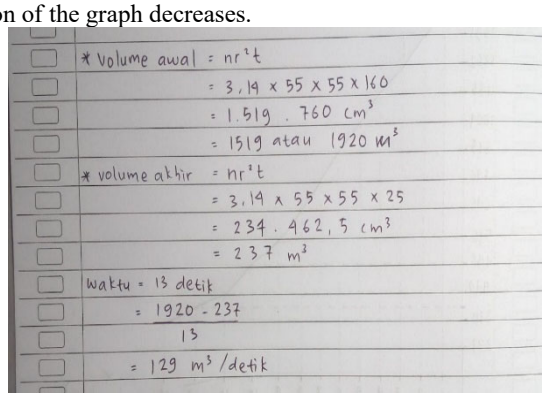


The subject has reached level 5 because on the answer sheet MFTA students realize and explain that the volume of water will decrease until it finally stops coming out, and students make a turn line even though the turn line the subject makes is not smooth.

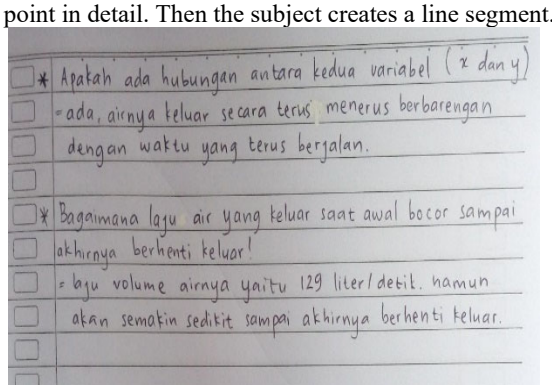
2. Subject ZK



The subject has met levels 1 and 2 because on the answer sheet the subject is able to label the axis then explain the relationship of both variables and the ZK subject is able to construct a descending line and is strengthened in the explanation of the answer point b where the subject explains the direction of the graph decreases.



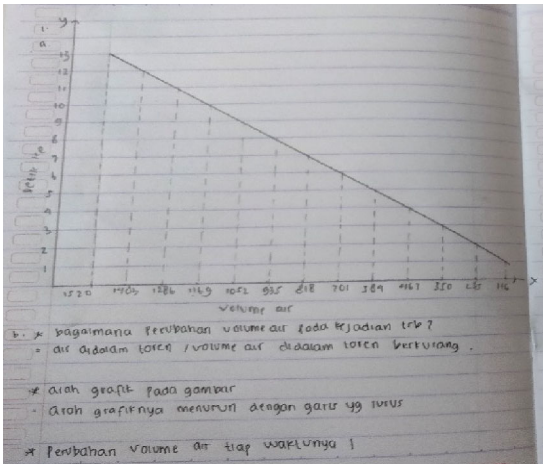
The subject has met levels 3 and 4 because because ZK can know the initial volume before the leak and after the leak then place the volume point on the graph then connect it to the line and ZK can determine the water coming out of the toren every second, and are able to create or plan a coordinate point in detail. Then the subject creates a line segment.



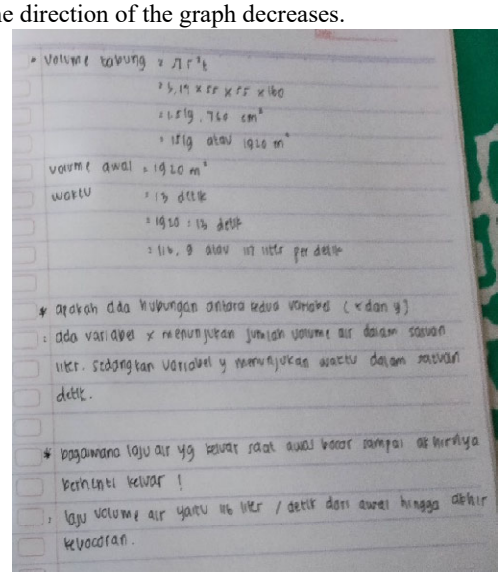
The subject has met level 5 because the subject realizes and explains that the volume of water will decrease until it finally stops coming out, and the subject makes a turn line even though the turn line the subject makes is not smooth.

Covariational Reasoning Abilities of Subjects with Quite High Self-Efficacy

1. **Subject EA**



The subject has met levels 1 and 2 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables then the subject is able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains the direction of the graph decreases.

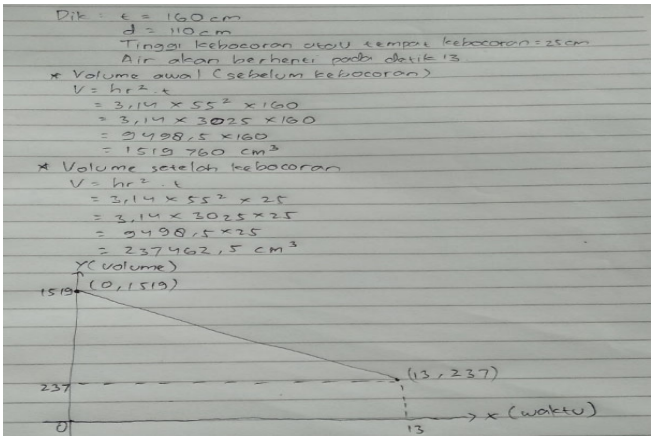


The subject has met levels 3 and 4 because the subject can tell the initial volume before the leak and after the leak then place the volume point on the graph then connect it to the line. The subject can determine the water coming out of the toren every second, and the subject is able to create or plan a coordinate point in detail. Then the subject creates a line segment.

Ea students do not meet on indicator 5 (AM5) because the subject does not make a turn line and the subject explains on the point b answer sheet that the water rate from start to stop

leak is 116 liters per second. This indicates the absence of a change in the speed of water coming out from the beginning to the end of the leak.

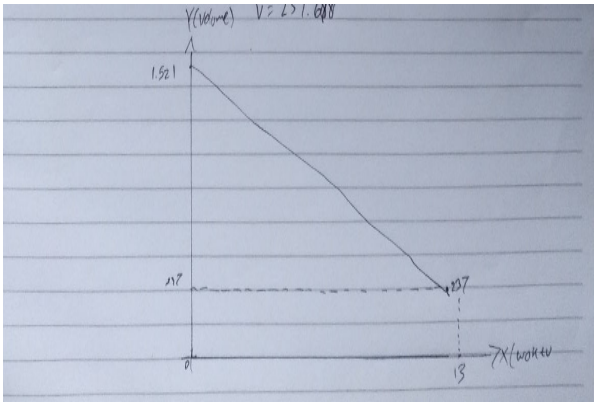
2. **Subject IRM**



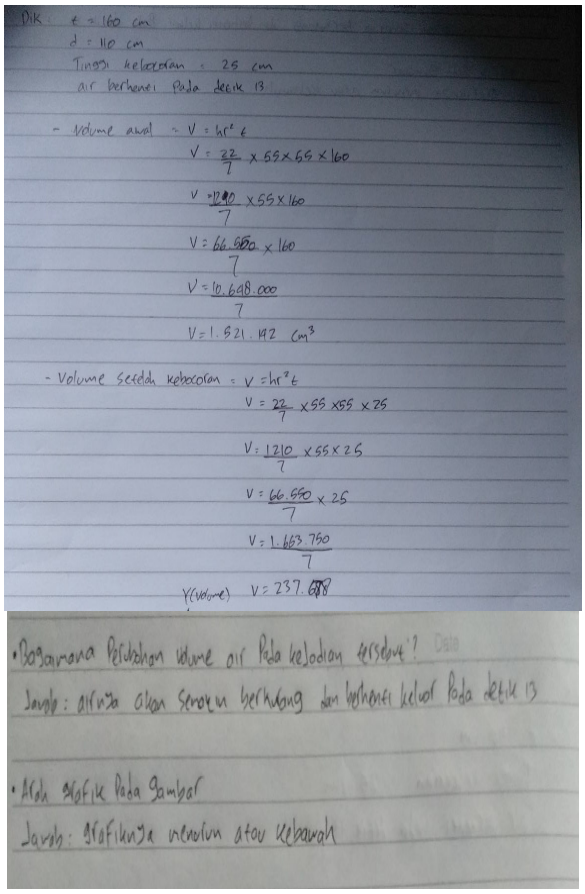
The subject has met level 1 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables. The subject has met level 2 because the subject is able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains the direction of the graph decreases.The subject has met level 3 because the IRM student can tell the initial volume before the leak and after the leak and place that volume point on the graph then connect it to the line. The IRM subject did not meet indicator 4 (AM4) he was unable to calculate the amount of water coming out every second and had no awareness of the change in the speed of water coming out of the toren. so the subject does not meet on the 4th indicator of covariational reasoning ability.

Covariational Reasoning Abilities of Subjects with Normal Self-Efficacy

1. **Subject ABW**

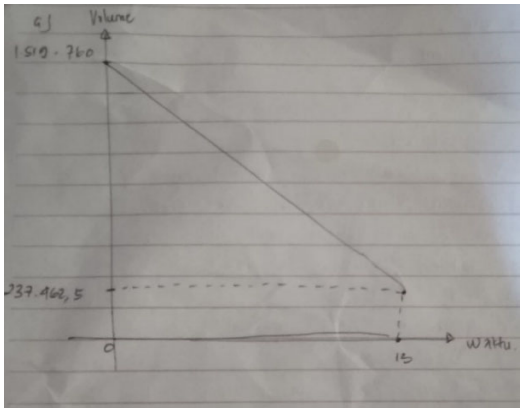


The subject has met levels 1 and 2 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables then the ABW subject is able to construct a straight line that decreases and is strengthened on the explanation of the answer point b where the subject describes the graph down.

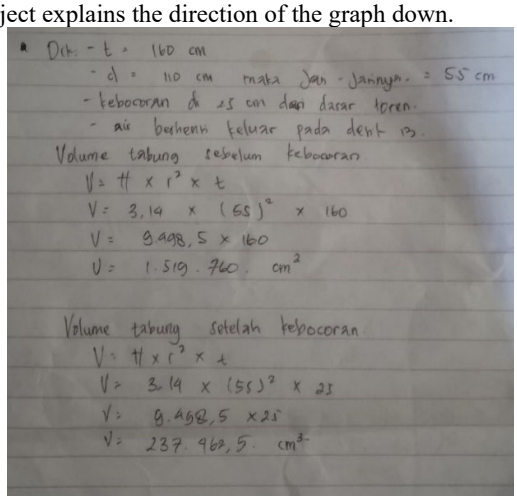


The subject has met level 3 because the subject can tell the initial volume before the leak and after the leak and place that volume point on the graph then connect it to the line. The ABW subject did not meet indicator 4 (AM4) he was unable to calculate the amount of water coming out every second and had no awareness of the change in the speed of water coming out of the toren. so the subject does not meet on the 4th indicator of covariational reasoning ability.

2. Subject ET



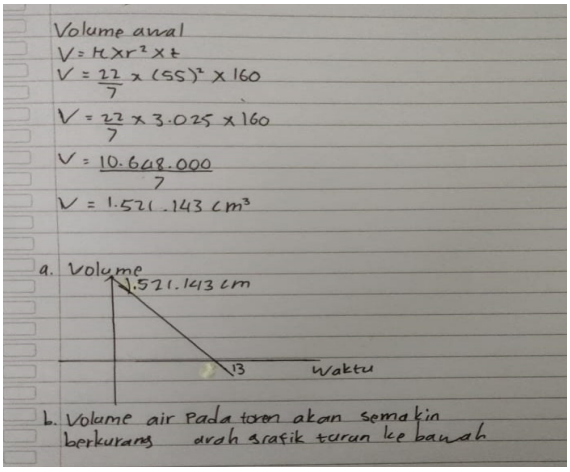
The subject has been able to meet levels 1 and 2 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables then the subject is able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains the direction of the graph down.



The subject has been able to reach level 3 because the subject can tell the initial volume before the leak and after the leak and place that volume point on the graph then connect it to the line. The ET subject did not meet indicator 4 (AM4) he was unable to calculate the amount of water coming out every second and had no awareness of the change in the speed of water coming out of the toren. so the subject does not meet on the 4th indicator of covariasional reasoning ability

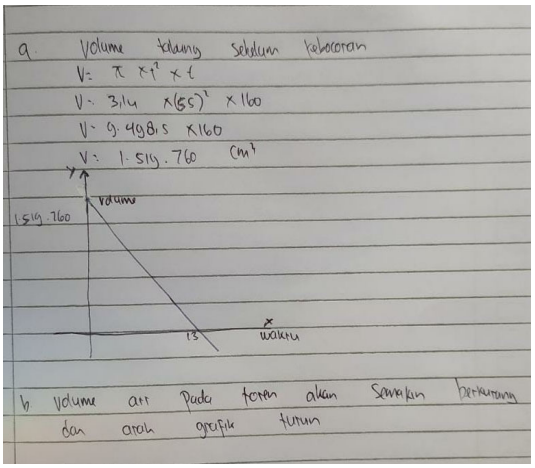
Covariational Reasoning Abilities of Subjects with Quite Low Self-Efficacy

1. **Subject AHN**



The subject has been able to meet levels 1 and level 2 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables then the subject is able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains the volume of water on the toren will decrease so that the direction of the graph drops down. The subject of AHN does not meet the indicator 3 (AM3) he is only able to calculate the initial volume and on the answer sheet he constructs a straight line intersecting with the x-axis this describes the subject assuming the water in the toren will run out, and the subject cannot calculate the water coming out every second.

2. **Subject NTH**



The subject has met levels 1 and level 2 because on the answer sheet the subject is able to label the axis and explain the relationship of the two variables then the subject is able to construct a straight line that decreases and is strengthened in the explanation of the answer point b where the subject explains that the direction of the graph is down. The NTH subject

does not meet the indicator 3 (AM3) he is only able to calculate the initial volume and on the answer sheet the subject yes constructs a straight line intersecting with the x-axis this describes the subject assuming the water in the toren will run out, and the subject cannot calculate the water coming out every second.

3 Discussion

The results of the self-efficacy test that there are 4 categories of self-efficacy include high self-efficacy, high self-efficacy, moderate self-efficacy, and self-efficacy is quite low, students who have high self-efficacy as many as 2 students (6.67%), students who have high self-efficacy as many as 23 students (76.67%), students who have moderate self-efficacy as many as 2 students (6.67%), and students who have low self-efficacy as many as 3 students (10%). Based on these percentages illustrate that students with high self-efficacy are most among other categories.

The results of the covariasional reasoning ability test that there are students with level 5 covariational reasoning skills as many as 2 level 4 students as many as 1 student, level 3 as many as 7 students and level 2 as many as 2 students. Based on the exposure of the results of the test of covariational reasoning ability that there are subjects who are able to meet level 5 of covariasional reasoning, this is in line with previous research conducted by Hidayanto et al. and also research conducted by sandie & Desy Susiaty that there are subjects who are able to reach level 5 covariational reasoning. But unlike the research conducted by Subanji (2006), iffanna fitrotul aadiati and zeytun & cetinkaya, where the subjects studied were only able to reach level 3 covariational reasoning abilities.

From the results of the study illustrates that there is a relationship between self-efficacy and covariational reasoning ability this is in line with the research of Audita Profitasari, Prasetyo Budi Darmono, and Isnaeni Maryam about the relationship of reasoning skills with self-efficacy, and in line with the research of Aprisal &Sartika Arifin that there is a relationship between mathematical covariational reasoning ability with self-efficacy because the reasoning ability of students in accordance with trust. themselves. Here is a discussion of subjects from all categories of self-efficacy found by researchers.

MFTA and ZK students with high self-efficacy are able to meet all indicators of covariasional reasoning ability, both able to determine the initial volume and volume after the leak, then construct the graph downhill by making coordinate points of each change in the volume of water on the toren in detail, although in different ways then connect it to the line and make an inflection point on the graph it makes, MFTA and ZK students are also aware of the changes in water coming out of the toren, MFTA subjects connect the quantity process with analytical equations, it can be seen that the subject determines the water that comes out every second using straight line equations while ZK subjects connect the quantity process with direct analysis, it can be seen the subject in determining the water that comes out every second directly reduces the initial volume by the final volume then divides it by 13.

EA and IRM students with self-efficacy are quite high although in the same category but have different covariational reasoning abilities. Ea student is able to meet 4 of 5 indicators of covariasional reasoning ability, he is able to determine the initial volume and volume after the leak then construct the graph downhill by making a coordinate point of each change in the volume of water on the detailed toren then connecting it with a straight line. But the EA student was unaware of the change in the speed of the water coming out of the toren and did not create a turn line on the graph he made. For IRM students able to meet 3 of the 5

indicators of covariational reasoning ability, he was only able to determine the initial volume and volume after the leak then constructed the graph down by connecting the coordinate point of the initial volume with the volume after the leak. He does not determine the water that comes out every second, because of ignorance of how.

ABW and ET students with moderate self-efficacy are only able to meet 3 of the 5 indicators of covariasional reasoning ability, both are only able to determine the initial volume and after the leak then construct the graph downhill by connecting the coordinate points of the volume. NTH and ANH subjects with low self-efficacy were only able to meet 2 of the 5 indicators of covariational reasoning ability, both of which only determine the initial volume then construct the graph down.

In this case it can be seen the subject linking quantities based on a discrete perspective (Clement, 1989; Johnson, 2012), and there are two thought processes that can be concluded, namely linking quantity processes with direct analytics and with equation analytics (Syarifuddin et al., 2020). In distinguishing the level of covariasioinal reasoning ability, students with higher reasoning abilities were able to demonstrate an understanding of variations in quantity values. For example, students can understand the changes in water that come out continuously due to toren leaks and plan for changes in quantity by making the values of the water volume decrease and then making a turning line. This is in line with Thompson and Carlson (2017) saying that "To distinguish higher levels (e.g., smooth continuous variation) from lower levels (e.g., gross variation) of variational reasoning, students should demonstrate that they could conceive of variation in values of a quantity, rather than just a more general variation in some quantity". This means effective covariational reasoning for understanding function as a representation of relationships in dynamic problem situations where multiple quantities vary simultaneously (Carlson et al., 2002; Carlson, Smith, & Persson, 2003; Saldanha & Thompson, 1998; Thompson, 1994a, 1994b).

4 Conclusion

Based on the problem questions presented and the purpose of the research in Chapter I, the results and discussions in Chapter IV, obtained the following conclusions:

1. **Results of self-efficacy analysis**
   Based on the results of self-efficacy analysis, 30 participants obtained subjects with high self-efficacy as many as 2 students (6.67%), subjects with high self-efficacy as many as 23 students (76.67%), subjects with moderate self-efficacy as many as 2 students (6.67%) and subjects with moderate self-efficacy as much as 3 students (10%).
2. **Analsis results in covariasional reasoning ability**
   Based on an analysis of covariational reasoning abilities from 4 categories of self-efficacy obtained:
   a) Students with high self-efficacy categories are able to meet all indicators of covariational reasoning ability so that it can be said that subjects with high self-efficacy categories have level 5 covariasional reasoning abilities.
   b) Students with a high enough self-efficacy category are able to meet 3 of the 5 indicators of covariasional reasoning ability and there are students able to meet 4 of 5 indicators of covariasional reasoning ability.
   c) Students with the category of self-efficacy are being able to meet 3 of the 5 indicators of covariational reasoning ability so that it can be said that subjects with the category of self-efficacy are having level 3 covariasional reasoning skills.

d) Students with a low enough self-efficacy category are able to meet 2 of the 5 indicators of covariasional reasoning ability so that it can be said that subjects with a low enough self-efficacy category have level 2 covariational reasoning abilities**.**

5 Suggestion

Based on this study some suggestions can be written including the following:

a) For other researchers, if you want to do similar research to further increase the number of participants, doing internal validity this will make the validity more tested.
b) In pandemic conditions, to find research data must be really helped by teachers who work in the school, because the learning facilities of each student are different there are those who can follow online learning activities there are not.
c) For other researchers, if you want to do similar research to conduct covariational reasoning research on different materials.

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