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STUDENTS' COVARIATIONAL REASONING REVIEWED FROM COGNITIVE STYLES

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Abstract

Covariational reasoning is important for students because it is a basic ability to master mathematical concepts. However, in reality many students have difficulty in working on covariational reasoning. One of the factors that influence covariational reasoning is cognitive style. Therefore, it is necessary to analyze covariational reasoning based on cognitive style. The research method used in this study is a qualitative research on prospective mathematics teacher students as many as 4 people taken from 31 people. The research instrument used in this study was GEFT to determine cognitive style, covariational reasoning worksheets, and interviews. The results showed that subjects with FIK and FIL cognitive styles only met MA 3, but FIL had erroneous thoughts. Meanwhile, FDK only met MA 2 and FDL met MA 1. In general, subjects with FI cognitive style had better covariational reasoning abilities than subjects with FD cognitive style.

Keywords: Covariational reasoning; cognitive styles; field independent; field dependent

Abstrak

Penalaran kovariasonal penting dimiliki oleh siswa karena merupakan kemampuan dasar untuk menguasai konsep matematika. Namun, pada kenyataannya banyak siswa yang mengalami kesulitan dalam mengerjakan penalaran kovariasional. Salah satu factor yang mempengaruhi penalaran kovariasional adalah gaya kognitif. Oleh karena itu perlu dilakukan analisis penalaran kovariasional berdasarkan gaya kognitif. Adapun metode penelitian yang digunakan pada penelitian ini adalah penelitian kualitatif pada mahasiswa calon guru matematika sebanyak 4 orang yang diambil dari 31 orang. Instrumen penelitian yang digunakan pada penelitian ini adalah GEFT untuk mengetahui gaya kognitif, lembar kerja penalaran kovariasional, dan wawancara. Hasil penelitian menunjukkan bahwa subjek dengan gaya kognitif FIK dan FIL hanya memenuhi MA 3, namun FIL memiliki pemikiran yang keliru. Sedangkan FDK hanya memenuhi MA 2 dan FDL memenuhi MA 1. Secara umum subjek dengan gaya kognitif FI memiliki kemampuan penalaran kovariasional lebih baik daripada subjek dengan gaya kognitif FD.

***Kata kunci**: field independent; field dependent; gaya kognitif; penalaran kovariasional*

INTRODUCTION

Covariational reasoning is a form of mathematical reasoning (Hidayanto, Zulkarnain, Kamaliyah, & Ismail, 2020). Covariational reasoning is the basic ability to understand many mathematical concepts such as change, variation, and covariation of quantities (Kertil, 2020). This is indicated by several studies which state that one of the main reasons students and teachers have difficulty with the concepts of ratio, proportion, function, rate of change, derivative, and integration may be related to the lack of covariation reasoning (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Kertil, 2020). The covariational reasoning abilities are

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formally defined by (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Thompson & Carlson, 2017) as cognitive activity involving coordinating two kinds of quantities related to the ways these two quantities change one against the other. According to (Subanji & Supratman, 2015), the coordination of these two quantities is closely related to the concept of function, i.e., one quantity can be viewed as an input (independent variable) and the other quantity can be viewed as an output (dependent variable).

Covariational reasoning has been studied by several researchers. One of the most studied topics in covariational reasoning is dynamic event modeling (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Subanji & Supratman, 2015; Karpuzcu, Ulusoy, & Isiksal, 2017; Sandie, Purwanto, Subanji, & Hidayanto, 2019). Dynamic events have been proven by researchers as an important foundation for students to think on further calculus concepts (Umah & Vitantri, 2019). Covariational reasoning is closely related to dynamic events, namely when students model dynamic situations into function graphs. Pre-servise mathematics teacher needs to have the covariational reasoning ability (Sandie & Susiaty, 2020).

Reality, the result of observation shows that the ability of students in interpreting graph of function which is still very low. It has also been found that in learning Calculus, students have difficulties in interpreting and representing the concavity and turning points of a graph. Although the student is able to draw a change of images for the adjacent intervals of the function domain, students still have difficulties in drawing continuous value changes and cannot accurately represent and interpret the rate of the increasing or decreasing of dynamic function. High performing students have difficulties in modeling dynamic function situations (Santoso, Budiarto, & Sulaiman, 2018). The observation results are in line with the results of (Sandie, Purwanto, Subanji, & Hidayanto, 2019) research which states that students are still having trouble in reasoning covariational.

When students are making reasoning, students use representations to rearrange issues in their mental representations, in this rearrangement can be attributed to the specific cognitive style of the subject, the way in which their cognitive systems operated and how information is obtained and processed (Yusuf & Sukestiyarno, 2022). This is stated by (Bendal, Galpin, Marrow, & Cassidy, 2016), that individuals have a habit of approaching tasks and situations related to certain patterns in cognitive processes including decision making, problem solving, perception, and attention. Furthermore (Santoso, Budiarto, & Sulaiman, 2018) mention that one of the factors that need to be considered in covariational reasoning is cognitive style.

The cognitive style means the preferred method of obtaining information, organizing, processing, and storing information in memory to use as needed (Witkin, Moore, Goodenough, & Cox, 1977). Faiola & Matei (Yusuf & Sukestiyarno, 2022) mentioned cognitive style is a strategy owned by someone to filter and receive and process information from the environment. There are many dimensions of cognitive style developed by experts that can distinguish individuals. In the research of (Santoso, Budiarto, & Sulaiman, 2018), the dimensions of cognitive style used are

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verbal and visual cognitive style. This study differentiates Field Dependent (FI) and Field Independent (FI). Son et al. (Kholid & Jayanti, 2022) Subject with Field Independent kognitif cognitive style tend to be more independent and trustself, while the subject with style Cognitive Field Dependent tends relying on external conditions.

From the above findings, individual differences including cognitive styles can affect learning achievement. So, the author believes that cognitive style will have an impact on the ability of covariational reasoning. Based on the description above, this study has the objective to analyze the students' covariational reasoning STKIP Sebelas April Sumedang in constructing graph of dynamic event function reviewed from their cognitive style. The benefit of this research is as a reference to develop students' learning that can improve students' reasoning skills, especially covariational reasoning reviewed from students' cognitive styles.

METHOD

This research uses descriptive method with qualitative approach. The Subject of this research were pre-service teachers from the fourth semester of mathematics major of STKIP Sebelas April, consisting of 1 class with 31 students. The data collection techniques used were carried out in three stages. This research begins with the determination of students' cognitive styles using Group Embedded Test (GEFT) instrument. And the secondly, they work of dynamic event graphics action sheet to examine the characteristics of his thinking in solving the covariate problem based on the covariational reasoning framework. Covariational reasoning can be seen from the behaviour of students in completing tasks that can describe his mental actions. The last from each cognitive style, two students were chosen with the lowest and highest scores of subjects studied. The subject of FD with the lowest score is called Low FD (FDL), while the subject of FD with the highest score is called Strong FD (FDK). The same condition is also applied to subjects with FI cognitive style, the subject of FI who got the lowest score called Low FI (FIL) and who got the highest score called Strong FI (FIK). After four subjects were selected, each student was interviewed about solving the given sheet.

The instrument in this study is the researcher directed by a dynamic event graphics action sheet to collect data on covariational reasoning and the Group Embedded Figure Test (GEFT) instrument for its cognitive style. In addition, researchers are also guided by a worksheet and interview guidelines.

(Carlson, Jacobs, Coe, Larsen, & Hsu, 2002)have developed a framework for measuring students' covariational reasoning in constructing graphs of dynamic event functions by identifying the levels of covariational reasoning. These levels of covariational reasoning are based on their mental action in solving the problem. There are five mental actions composed by Carlson et al. Each mental action describes a mental action consisting of Mental Action 1 (MA 1), Mental Action 2 (MA 2), Mental Action 3 (MA 3), Mental Action 4 (MA 4), and Mental Action 5 (MA 5). This can be seen in the Table 1.

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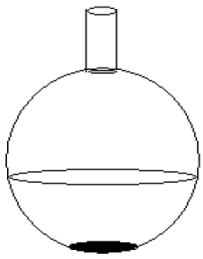
Table 1. Mental Actions of the Covariation Framework

Mental Action	Description of mental action	Behaviors
Mental Action 1 (MA1)	Coordinating the value of one variable with changes in the oer.	• Labelling the axes with verbal indications of coordinating the two variables (e.g., *y* changes with changes in *x*).
Mental Action 2 (MA2)	Coordinating the direction of change of one variable with changes in the other variable.	• Constructing an increasing straight line. • Verbalizing an awareness of the direction of the change in the output while considering changes in the input.
Mental Action 3 (MA3)	Coordinating the amount of change of one variable with changes in the other.	• Plotting points/constructing secant lines. • Verbalizing an awareness of the variable amount of change of the output while considering changes in the input.
Mental Action 4 (MA4)	Coordinating the average rate-of-change of the function with uniform increments of change in the input variable.	• Constructing contiguous secant lines for the domain. • Verbalizing an awareness of the rate of change of the output (with respect input) while considering uniform increments of the input.
Mental Action 5 (MA5)	Coordinating the instantaneous rate of change of the function with continuous changes in the independent variable for the entire domain of the function.	• Constructing a smooth curve with clear indications of concavity changes. • Verbalizing an awareness of the instantaneous changes in the rate of change for the entire domain of the function (direction of concavities and inflection points are correct).

As for the worksheet to be used in this research is the development of the covariate worksheet from (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002). Figure 1 shows one of the questions in the covariational reasoning sheet.



Imagine the bottle above is filled with water. Draw a function graph between the height of the water in the bottle and the amount of water put into the bottle. Give reasons for your answer.

Figure 1. Worksheet of Covariational Reasoning

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Data analysis technique used is the descriptive qualitative and interpretative analysis. The processes were done since the data collection started. Data is a construct of meaning derived from data sources. Data analysis should be inductive, generative, constructive, and subjective, so that it contains the interpretation of the reality of the subject itself. Test the validity of the data done by triangulation technique. Qualitative data is expressed as an activity that takes place continuously; therefore data collection and data analysis are done jointly throughout the study.

RESULT AND DISCUSSION

Before the covariational reasoning worksheets were given, students are grouped by cognitive styles using psychiatric tests developed by (Witkin, Moore, Goodenough, & Cox, 1977), it is the GEFT instrument. According to Witkin, Moore, Goodenough, & Cox (1977) GEFT is defined as a valid and reliable test instrument, requiring the subject to place the next geometric field in a more complex form within 20 minutes. In completing the GEFT test which consists of spatial problems that require mental images in analyzing images (Matlin, 2009). Spatial ability is the ability that involves a person's cognitive ability to process and manipulate 2D or 3D objects both in changing their position, perception, being able to imagine how objects look when viewed from various positions and imagining abstract objects (Rahmatulwahidah & Zubainur, 2017). (Matlin, 2009) states that differences in cognitive style are caused by spatial abilities.

Of 31 students of fourth semester STKIP Sebelas April Sumedang, 12 students are classified as FI cognitive style and 19 students are classified as FD cognitive style. These results are in line with research conducted by (Khodadady & Tafaghodi, 2013; Jantan, 2014; Ariawan & Zetriuslita, 2021; Yuliyani & Setyaningsih, 2022; Kholid & Jayanti, 2022) which shows that the cognitive style that is more likely to be possessed is the Field Dependent cognitive style than the Field Independent. The sample used in this study were pre-service mathematics teacher where they should have high abilities. In theory, the FI learning style is superior in mathematics or science (Snowman, McCown, & Biehler, 2012). However, the results of this study indicate the opposite, where there are more research subjects with FD learning styles. The results of this study are in line with the results of research by (Umah & Vitantri, 2019) that did not show consistent results between students with high and medium abilities. However, this is different from the results of (Yusuf & Sukestiyarno, 2022) research which shows that pre-service mathematics teachers generally have an FI cognitive style. The subjects used in the research of (Yusuf & Sukestiyarno, 2022) were sixth semester students while the subjects used in this study were also fourth semester students where students still received a lot of general course learning, so that their cognitive style had not been formed by their new environment. This is as stated by (Zhang & Sternberg, 2009; Snowman, McCown, & Biehler, 2012) that cognitive style is very possible to be formed and not something rigid.

Based on Figure 2a and Figure 2b, it can be seen that both subjects have the same abilities. Where both can construct the graph of the dynamic function correctly. Both subjects can determine the effect of the variable the

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amount of water that enters the bottle will affect the other variable, namely the water level. So based on the results of working on the worksheet, it can be concluded that the subject of FIL is also the same as the FIK subject is only able to meet up to level 3 (MA 3) that is able to coordinate the magnitude of change from one variable to the change of other variables by constructing the slope of the line and expressing verbally with an awareness of the magnitude of output change when considering changes Input. The subject has also understood that the speed of the water level is also influenced by the diameter of the bottle, where in the bottle with a smaller diameter the velocity of the water level will be greater. However, the subject has not been able to model changes in detail and according to the context. The results of this study are in accordance with the research results of (Sandie, Purwanto, Subanji, & Hidayanto, 2019; Hidayanto, Zulkarnain, Kamaliyah, & Ismail, 2020; Sandie & Susiaty, 2020) that students still have difficulty in solving covariational problems. Moreover, the results of the interview show that the FIL subject has the wrong idea where FIL thinks that the shape of the graph is also influenced by the rate of water filling. This condition according to (Subanji & Supratman, 2015) is called Pseudo covariational reasoning, namely they seem unable to do covariational reasoning even though their construction and knowledge are qualified.

The results of interviews with FIK subject for covariational reasoning sheet are as follows.

Interviewer : *Please explain how you sketch the graph?*

FIK subject : *When the water has not been poured into the bottle, the height of the water is still zero or in the graph is at the point (0,0). As the water is poured into the bottle slowly the height of the water increases, but the speed decreases as the altitude begins to reach the point of bottle diameter, at the time the water is close to the point of the diameter, the speed slows down and it increases again after leaving the diameter and getting faster again when the water is in the bottle neck. The height of the water increases faster until the water is in the mouth of the bottle [MA 3].*

Interviewer : *Please look carefully at the neck of the bottle, whether the speed increases or constant during the neck bottle?*

FIK subject *At the neck of the bottle, the water speed increases, because it has a small diameter. (The subject doesn't reach MA 4 yet).*

The results of interviews with FIL subject for covariational reasoning sheet are as follows.

Interviewer : *Please explain how you sketch the graph?*

FIL subject : *When the water is not poured in the bottle, the height of the water will be at (0,0), as the amount of water entered. After half bottle it will increase*

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constantly. But when approaching the neck of the bottle up to the top of the bottle the height of the water will have a drastic rate. The rate of the increasing in water depends on the rate of water filling speed that poured into the bottle, so that the rate of water filling will affect the shape of the graph.

Interviewer : *Please look carefully at the neck of the bottle, whether the speed increases or constant during the neck bottle?*

FIL subject *At the bottle neck, the height of the water will have a drastic rate (up to MA 3)a small diameter. (The subject doesn't reach MA 4 yet).*

Based on the results of the interview, it can be said that the subject of the FI has been able to explain the answers he received even though it is not complete. The subject has an FI cognitive style where FI cognitive style is able to identify problems by writing detailed information, clearly describing the problem, and understanding the purpose of the problem well (Yekti, Kusmayadi, & Riyadi, 2016; Mardiyah & Suhito, 2018). Furthermore, (Haryanti & Masriyah, 2018) say that the FI cognitive style is able to prepare plans and make assumptions, can implement plans, can provide arguments before giving conclusions, and can provide logical conclusions.

The result of the covariational reasoning sheet of FD subject can be seen in Figure 3.

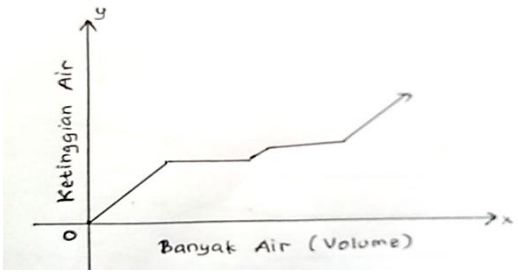

Figure 3a. The Construction Result of FDK subject

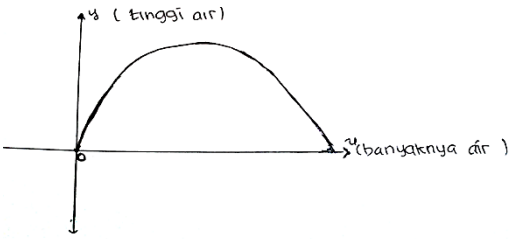

Figure 3b. Construction Result of FDK subject

Based on Figure 3, subject of FDK is only able to meet up to level 2 (MA 2) that is able to coordinate the direction of variable change to other variables by drawing points that direction up or down and able to express it verbally with an awareness of the direction of change of output when considering input changes. The subject of FDK also has the wrong idea, where the speed of water filling poured into the bottle will affect the shape of the graph. While the subject of FDL only able to meet up to level 1 (MA 1) is labelling the axis with verbal indication of coordinating two variables (*y* changes as the changing of *x*).

The results of interviews with FDK subject are as follows.

Interviewer : *Please explain how you sketch the graph?*

FDK subject : *The height of the water increases rapidly when the bottle is filled at the bottom, but when the center is filled with*

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water the height only increases slightly because the diameter of the middle is larger. When it is next to the top of the bottle increases again faster. But it all depends on the speed of filling the water poured into the bottle and I have not been able to determine the exact shape of the chart because it cannot calculate the volume. (Up to MA 2).

The results of interviews with FDL subject are as follows.

Interviewer : Please explain how you sketch the graph?

FDL subject : The more water poured into the bottle the higher the water in the bottle. But when the bottle is almost full with water then the amount of water entered will be less and finally back to zero, so the graph intersects again with the x axis. (Only up to MA 1).

In addition, based on the results of the interview, it is known that the subject of FDL is also preoccupied with finding the formula of the volume of the bottle, although in the end in the graph making, they do not use the formula. This is in accordance with the opinion of (Novalina & Kamid, 2022) which states that subjects who are less able to express mathematical ideas in graphic form are less able to identify early mathematical ideas in writing in their own language. As it is known that the covariational reasoning worksheet is a question that asks the subject to construct a graph of the given problem. In addition, FD subject is slow in finding solutions to problems and requires scaffolding to find that. As Stated by (Zaini, 2021) that students with the cognitive type of FD needed a long time to create connection to the problem thinking and they needed direction as a stimulus to stimulate their thinking. Further, (Husna, Nuraziza, & Angelina, 2018), states that individuals who have a Field Dependent cognitive style have difficulty in distinguishing between stimuli through the information they have. In addition, subjects with Field Dependent cognitive style are also less able to filter the existing and correct information in the problem so they are unable to find solutions to existing problems (Sudirman, Son, Rosyadi, & Fitriani, 2020; Kholid, Hamida, Pradana, & Maharani, 2020).

Based on the results of data analysis, it is shown that subjects with FI cognitive style have a higher level than those with FD cognitive style. The results of this study are in line with the results of research by (Yusuf & Sukestiyarno, 2022; Kholid & Jayanti, 2022; Maswar, Tohir, Pradita, Asyari, Sardjono, & Selviyanti, 2022) which states that learning outcomes individuals with FI is better than individuals with FD. In contrast to the results of (Inayah, 2017) which shows that FI and FD are not different. This happens because FI has good analytical skills. This is because understanding of stylish individuals Field Independent cognitive is much better (Sakina, Dewi, & Putri, 2017) (Son, Darhim, & Fatimah, 2020). Furthermore, (Taufik, Nurhayati, Prayitno, Tresnawati, & Syafari, 2020; Ngilawajan, 2013) that individuals with FI cognitive style tends to be more analytical in solving a problem or received material.

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CONCLUSSION AND SUGGESTION

From the results and discussion above it can be concluded that the subject of FIK is only able to meet up to level 3 (MA 3). The subject of FIL is the same as the FIK subject, they are only able to meet up to level 3 (MA 3), but the FIL subject has the wrong idea. The subject of FDK is only able to meet up to level 2 (MA 2). While the subject of FDL only able to meet up to level 1 (MA 1). From the above discussion and conclusion, all subjects have not been able to meet up to level 4 and 5 perfectly. In general, subjects with FI cognitive style had better covariational reasoning abilities than subjects with FD cognitive style.

Covariational issues such as constructing the function of dynamic events are rarely given in our colleges. So to understand more deeply and more meaningfully related to learning function, need to be given problem related to dynamic incident. It is also necessary to develop learning model that enhances covariational reasoning abilities, as well as other mathematical abilities that may affect the ability of covariational reasoning, such as: creative thinking ability and mathematical problem solving. Moreover, the results research shows that students who fail to do covariational reasoning is necessary pay more attention by deepening it more continue to find out the cause and solutions to overcome them.

REFERENCE

Ariawan, R., & Zetriuslita. (2021). Kemampuan Berpikir Kritis Matematis Mahasiswa ditinjau dari Gaya Kognitif (Studi Kasus pada Mata Kuliah Persamaan Differensial). *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(2), 1410-1426.

Bendal, R. C., Galpin, A., Marrow, L. P., & Cassidy, S. (2016, November 15). Cognitive Style: Time to Experiment. *Frontiers in Psychology*, *7*, 1-4.

Carlson, M., Jacobs, S., Coe, E., Larsen, S., & Hsu, E. (2002). Applying Covariational Reasoning While Modeling Dynamic Events. *Journal for Research in Mathematics Education*, *33*(5), 352-378.

Haryanti, C. F., & Masriyah. (2018). Profil Penalaran Matematika Siswa SMP Dalam Memecahkan Masalah Open Ended Ditinjau Dari Gaya Kognitif Field Dependent dan Field Independent. *MATHEdunesa Jurnal Ilmiah Pendidikan Matematika*, *7*(2), 197-204.

Hidayanto, T., Zulkarnain, I., Kamaliyah, & Ismail. (2020). Penalaran Kovariasional Mahasiswa Dalam Memodelkan Grafik Hubungan Antara Waktu dan Kecepatan. *Jurnal Penelitian Pembelajaran Matematika*, *13*(2), 298-312.

Husna, U., Nuraziza, & Angelina, C. M. (2018). Studi Pendahuluan Tentang Profil Berpikir Geometri Siswa SMP Ditinjau dari Perbedaan Gaya Kognitif Field Independent (Fi) dan Field Dependent (Fd). *Journal of Research In Education* , *1*(1), 33-39.

Inayah, N. (2017). The Influence Of Mathematical Reasoning And Cognitive Style Toward Student's Comunication And Connection Ability To The Statistical Topic In Class Xi Exact of Public Senior High School Palu. *Jurnal Daya Matematis*, *5*(1), 120-128.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v11i3.5854

Jantan, R. B. (2014). Relationship between Students' Cognitive Style (FieldDependent and Field–Independent Cognitive Styles) with their Mathematic Achievement in Primary School. *International Journal of Humanities Social Sciences and Education (IJHSSE), 1*(10), 88-93.

Karpuzcu, S. Y., Ulusoy, F., & Isiksal, M. (2017). Prospective Middle School Mathematics Teachers' Covariational Reasoning for Interpreting Dynamic Events During Peer Interactions. *International Journal of Science and Mathematics Education, 15*(1), 89-108.

Kertil, M. (2020). Covariational Reasoning of Prospective Mathematics Teachers: How Do Dynamic Animations Affect? *Turkish Journal of Computer and Mathematics Education, 11*(2), 312-342.

Khodadady, E., & Tafaghodi, A. (2013). Cognitive Styles and Fluid Intelligence: Are They Related? *Journal of Studies in Social Sciences, 3*(2), 138-150.

Kholid, M. N., & Jayanti, I. T. (2022). Truth-Seeking Mahasiswa Dalam Memecahkan Masalah Non-Rutin Ditinjau Dari Gaya Kognitif. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11*(2), 1241-1254.

Kholid, M. N., Hamida, P. S., Pradana, L. N., & Maharani, S. (2020). Students' Critical Thinking Depends On Their Cognitive Style. *International Journal of Scientific & Technology Research, 9*(1), 1045-1049.

Mardiyah, I., & Suhito, S. M. (2018). Analysis of mathematical reasoning ability of junior high school students of grade VII viewed from cognitive style on problem based learning with mind mapping. *Unnes Journal of Mathematics Education, 7*(2), 122-128.

Maswar, Tohir, M., Pradita, D. A., Asyari, D. N., Sardjono, W., & Selviyanti, E. (2022). Mathematics Problem Solving Based on Cognitive Style to Determine of Student Reasoning Abilities in The Covid-19 Pandemic Era. . *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika, 4*(1), 37-51.

Matlin, M. W. (2009). *Cognition Seventh Edition.* New York: John Wiley and Sons, Inc.

Ngilawajan, D. A. (2013). Proses Berpikir Siswa SMA dalam Memecahkan Masalah Matematika Materi Turunan Ditinjau dari Gaya Kognitif Field Independent dan Field Dependent. *Pedagogia: JUrnal Pendidikan, 2*(1), 71-83.

Ngilawajan, D. A. (2013). Proses Berpikir Siswa SMA dalam Memecahkan Masalah Matematika Materi Turunan Ditinjau dari Gaya Kognitif Field Independent dan Field Dependent. *Pedagogia: JUrnal Pendidikan, 2*(1), 71-83.

Novalina, D., & Kamid, H. (2022). Analisis Kesulitan Siswa Dalam Menyelesaikan Soal Matematika Berdasarkan Teori Pemrosesan Informasi Ditinjau Dari Gaya Kognitif. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11*(1), 752-761.

Rahmatulwahidah, N., & Zubainur, C. M. (2017). The analysis of

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v11i3.5854

students' spatial ability at senior high school in banda aceh. *TThe 7th Annual International Conference (AIC) Syiah Kuala University and The 6th International Conference on Multidisciplinary Research (ICMR) in conjunction with the International Conference on Electrical Engineering and Informatics (ICELTICs)* (pp. 745-752). Banda Acah: Universitas Siyah Kuala.

Sakina, P. N., Dewi, D. S., & Putri, A. (2017). The Correlation between Cognitive Styles and Student's Reading Comprehension . *Journal Anglo-Saxon , 8*(1), 68-74.

Sandie, & Susiaty, U. D. (2020). Student's Covariational Reasoning In Solving Covariational Problems Of Dynamic Events. *Journal of Education, Teaching, and Learning, 5*(2), 375-382.

Sandie, Purwanto, Subanji, & Hidayanto, E. (2019). Process Thinking Of Students In Translating Representation Of Covariational Dynamic Events Problems. *International Journal of Scientific & Technology Research, 8*(10), 1405-1408.

Santoso, K. F., Budiarto, M. T., & Sulaiman, R. (2018). Argumentation in Covariational Reasoning: Middle School Student's Solving Covariation Problem with Different Cognitive Style. *International Conference on Science, Technology, Education, Arts, Culture and Humanity (STEACH 2018) . 227*, pp. 27-31. Advances in Social Science, Education and Humanities Research.

Snowman, J., McCown, R., & Biehler, R. (2012). *Social Cognitive Theory. Psychology Applied to Teaching* (13 ed.). Belmont,: Wadsworth, Cengage Learning.

Son, A. L., Darhim, & Fatimah, S. (2020). Students' Mathematical Problem-Solving Ability Based on Teaching Models Intervention and Cognitive Style. *Journal on Mathematics Education, 11*(2), 209-222.

Subanji, R., & Supratman, A. M. (2015). The Pseudo-Covariational Reasoning Thought Processes in Constructing Graph Function of Reversible Event Dynamics Based on Assimilation and Accommodation Frameworks. *Research in Mathematics Education, 19*(1), 61-79.

Sudirman, Son, A. L., Rosyadi, & Fitriani, R. N. (2020). Uncovering the Students' Mathematical Concept Understanding Ability: A Based Study of Both Students' Cognitive Styles Dependent and Independent Field in Overcoming the Problem of 3D Geometry. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 10*(1), 1-12.

Taufik, A., Nurhayati, N., Prayitno, A. T., Tresnawati, B., & Syafari, R. (2020). Analysis of Mathematical Proportional Reasoning Ability Based on Field Dependent and Field Independent Cognitive Style. *UNISET 2020*. Kuningan.

Thompson, P., & Carlson, M. (2017). Variation, covariation, and functions: Foundational ways of

ISSN 2089-8703 (Print)
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thinking mathematically. In J. Cai, *Compendium for research in mathematics education* (pp. 421-456). Reston: NCTM.

Umah, U., & Vitantri, C. A. (2019). Representasi Visual Matematis Mahasiswa Dalam Memodelkan Kejadian Dinamis Ditinjau dari Perbedaan Gaya Kognitif dan Jenis Kelamin. *FIBONACCI: Jurnal Pendidikan Matematika danMatematik, 5*(1), 87-96.

Umah, U., Asari, A. R., & Sulandra, I. M. (2016). STRUKTUR Argumentasi Penalaran Kovariasional Siswa Kelas VIIIB MTsN 1 Kediri. *JMPM: Jurnal Matematika dan Pendidikan Matematika, 1*(1), 1-12.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive style and their educational implications. *Review of educatioanl Reaserch, 47*(1), 1-64.

Yekti, S. M., Kusmayadi, T. A., & Riyadi. (2016). Penalaran Matematis Siswa Dalam Pemecahan Masalah Aljabar Ditinjau Dari Gaya Kognitif Field Dependent - Field Independent. *Journal of Mathematics and Mathematics Education (JMME), 6*(2), 178-192.

Yuliyani, D. R., & Setyaningsih, N. (2022). Kemampuan Literasi Matematika dalam Menyelesaikan Soal Berbasis PISA Konten Change and Relationship Ditinjau dari Gaya Kognitif Siswa. *Edukatif : Jurnal Ilmu Pendidikan, 4*(2), 1836 - 1849.

Yusuf, Y., & Sukestiyarno, Y. (2022). Pre-service Teachers' Statistical Reasoning based on Cognitive Style. *Jurnal Didaktik Matematika, 9*(1), 136-150.

Zaini. (2021). Mathematical Reasoning Abilities Of Students in Terms of Field Dependence (FD) Cognitive Style in Problem-Solving. *Multica Science And Technology (MST), 1*(1), 1-5.

Zhang, L.-F., & Sternberg, R. J. (2009). *Perspectives on the nature of intellectual styles.* New York: Springer.