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# The Relationship of Student's Algrebraic Thinking and Cognitive Learning Style

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## ABSTRACT

This study aimed at investigating the relationship between student's algebraic thinking and cognitive style of Field Independent (FI) and Field Dependent (FD). The method implemented in the study is Group Embedded Figure Test (GEFT) which was intended to categorize students into the FI and FD styles. Afterward, to collect the data of students' algebra thinking ability, a test was administered. The result of the test was compared to the result of GEFT test by integrating a computer program to find out the relationship between the students' algebraic thinking and their cognitive styles, both FD and FI. The subjects of this research were the eighth-grade students totaling at 24 students. The findings of this study indicate that there is no relationship between manipulating symbols and students' cognitive style.. There is a relationship between generalizing and formalizing and stundents' cognitive styles. There is a relationship between using algebra as a tool and FD. There is a relationship between reasoning and representation and student's cognitive style.

Keywords: Algebraic Thinking, Cognitive styles, Field dependent, Field Independent

## ABSTRAK

Penelitian ini bertujuan untuk mengetahui hubungan antara berpikir aljabar siswa dengan gaya kognitif Field Independent (FI) dan Field Dependent (FD). Metode yang dilakukan dalam penelitian ini adalah dengan melakukan tes GEFT (Group Embedded Figure Test) untuk mengkategorikan siswa kedalam gaya kognitif FI dan Field FD Kemudian siswa diberikan tes untuk mengetahui kemampuan berpikir aljabar siswa. Kemudian nilai tes berpikir aljabar akan dibandingkan dengan nilai tes GEFT FD dan FI menggunakan bantuan program computer untuk mengetahui hubungan antara gaya kognitif siswa dengan FD dan FI Subjek penelitian ini adalah siswa kelas sebanyak 24 siswa. Tidak ada hubungan antara manipulasi simbol dengan gaya kognitif siswa. Ada hubungan antara generalisasi dan formalisasi dengan gaya kognitif siswa, ada hubungan antara menggunakan aljabar sebagai alat dengan FD. Ada hubungan antara penelaran dan representasi dengan gaya kognitif siswa

Kata Kunci: Berpikir Aljabar, Gaya Kognitif, Field Dependent, Field Independent.

## INTRODUCTION

Mathematics is a lesson taught in all levels of education. It is because math is useful for daily life, especially for the development of technology. Math has a pivotal role in accommodating daily needs moreover in facilitating the development of science and technology (Nugraha & Sundayana, 2014). Nearly all human activities especially those related to technology involves math. Sciences and knowledge derivated from learning math can be used to solve problems (As'ari, 2016). Uno (2007) stated that math is a branch of science which is a means for thinking, communicating, and solving practical problems, and it has types such as arithmetic, algebra, and analysis.

Algebra is known as a type of mathematics that learns about structure, relationship, and calculation. Algebra becomes a powerful tool for expressing and relating structures in math. Functional relationships are represented in the form of symbolic therefore complex ideas of math can be easily analyzed (Hodgen, 2014). Algebra has long been considered a gatekeeper in high school because students' understanding of algebra will determine whether students are ready to understand more difficult mathematical concepts (Julius et. al, 2018; Dougherty et al., 2015)

Most activities in math can be identified in different situations where thinking skills like algebraic thinking and those which involve mathematical symbols are used to solve a problem. Cai & Knuth (2005) stated that algebraic thinking can be regarded as a thinking skill about fundamental mathematical structure. Meanwhile, (Kieran, 2015) defined it as a thinking process which involves the developing of a way of thinking using algebraic symbols as tools but still attached to algebra, and way of thinking which is not employing algebraic symbols such as analyzing the relationship between quantitative, observing structures, investigating changes, generalizing, solving problems, modeling, making a conclusion, and predicting. Radford (2001) argued that algebraic thinking occurred as it is initiated by one's sensitivity towards an indefinite object, followed by analyzing it and ended by modeling it into a symbol.

Algebraic thinking is an integral element in mathematical thinking skills and reasoning. Being skilled in algebraic thinking, a student can accommodate activities such as analyzing, representing, and making generalizations of symbols, patterns, and numbers (Wang, 2015; Rahardi, 2015; Irfan et al., 2019; Paridjo, 2018). Magiera, et.al. (2013) interpreted algebraic thinking as a habit of quantitative thinking by drawing a relationship between variables to make it more clearly defined. Moreover, algebraic thinking is a thinking activity required in learning mathematics and helpful for developing students' ability in mastering algebra. Additionally, Kilpatrick et al. (2001) expressed that algebraic thinking is a kind of thinking which tends to be developed by students in traditional arithmetic program and that required for learning algebra.

Lew (2004) classified algebraic thinking framework into several thinking activities, as follows: 1) *Generalization*, that is a process of finding a pattern or shape, started with a patterned identified from a given object; 2) *Abstraction*, that is a process of extracting a mathematical object and relationship obtained from generalization; 3) *Analytic Thinking*, a process of which related to finding an unknown value; 4) *Dynamic Thinking*, that is a process of thinking linked to manipulating mathematical objects; 5) *Modeling,* which is a process of representing a complex situation using mathematical shapes to analyze the situation using the model, and to depict the relationship of

activities involved; and 6) *Organization*, that is combinational thinking used to find all independent variables required for solving problems by sorting and organizing the data which describe the situation and condition of a problem. Whereas Walkoe (2014) defined the framework involving the following: 1) manipulating symbols and procedures, 2) exploring relationship; 3) generalizing and formalizing; 4) using algebra as a tool; 5) reasoning and representing; 6) relating representations.

The indicator that uses in this study is adopted by Walkoe (2004) that is 1) Manipulating symbols and procedures; 2) Generalizing and formalizing; 3) Using algebra as a tool; 5) reasoning and representation because of these four indicators are closely related to algebra so it needs to be focused to see students' algebraic thinking ability from those four indicators

Every student as his or her own way of learning and processing received information. It is also influenced by their different cognitive learning styles. Cognitive style is one's way of receiving and organizing received information from the surrounding environment (Schmittau, 2011; Fitriyah, Indrawatiningsih, & Khoiri, 2019). Cognitive styles are one's characteristic in receiving, analyzing, responding to a given cognitive act (Kozhevnikov, 2007; Silma, Sujadi, & Nurhasanah, 2019). Pitta-pantazi & Christou (2009) stated that such style is, in fact, a preferred approach of individuals and their habits in organizing and representing information, which later may affect their way of looking at and acknowledging certain phenomena and ideas.

The present study focused on two cognitive learning styles, such as *field-depend*ent (FD) and *field independent* (FI). FD style is thinking globally, accepting available structure and information, socially-oriented, tends to prefer profession which requires social skills, tends to follow existing objectives and information, and prioritizing external motivation (Witkin & Moore, 1977; Munawaroh, 2020; Naraghipour & Baghestani, 2018). On the other hand, one with FI cognitive style tends to be capable of analyzing an object detached from its context, organizing objects, impersonally oriented, tends to choose profession requiring individual capability, and prioritizing internal motivation. Furthermore, one with FI style is likely to analyze and dissociate elements from their context more analytically, while the counterpart tends to process information globally, thus their perception may be easily affected by changes in the environment. Meng, et.al. (2009) concluded that cognitive learning styles (i.e. FD and FI) can impact the processing of conflict using the "cognitive control" system because of their different capabilities in mobilizing or allocating resources. Based on the aforementioned explanation, the objective of the present study is formulated to investigate the relationship between student's algebraic thinking and cognitive learning style of Field Independent (FI) and Field Dependent (FD).

## RESEARCH METHOD

This study employed a descriptive quantitative design (Lestari et al., 2019). The study aimed to describe the relationship between students' algebraic thinking and cognitive learning style of Field Independent (FI) and Field Dependent (FD). The study took place in one of the private secondary schools in Malang and conducted during the 2018/2019 academic year to 24 students in the eighth grade. Initially, the researchers administered a test using *Group Embedded Figure Test (GEFT)* aiming to classify students into FD and FI categories. The test was adopted from Witkin (Ulya, 2015).

This test is in the form of images where students must find and mark hidden patterns in a figure. GEFT is comprised of three sections; the first is introduction and exercises which consist of 7 items. Students were given three minutes to finish this part. The second and third sections consist of 9 items with 10 minutes provided to finish them. All items in the first section are not scored because they are meant for practices. While the second and third ones are scored with the range of 0-18. Students who finished earlier ought to wait until the next section starts. All students started doing every section together. Every correct answer was scored 1 and incorrect 0. The maximum score is 18 points and 0 for the minimum score. The cognitive learning styles were categorized by employing the statistical method as shown in Table 1.

Table 1. Categories of Cognitive Learning Styles

| Interval | Category |
|---|---|
| $skor\ GEFT > 10$ | FI |
| $skor\ GEFT\ < 11$ | FD |

To analyze the student's algebraic thinking, the researchers administered another test using test specialized for algebraic thinking which was developed by Walkoe (2014); this test aimed to identify student's algebraic thinking skills. Test questions used to identify algebraic thinking skills were different and unrelated to GEFT test. This test is in form question of number. The test was scored based on indicators of algebraic thinking, such as 1) manipulating symbols and procedures; 2) generalizing and formalizing; 3) using algebra as a tool; and 4) reasoning and representing.

## RESULT AND DISCUSSION

According to the result of GEFT, 17 of 24 students have FD learning style, while their counterparts have FI learning styles. This result was further analyzed to investigate the relationship of each cognitive learning style and indicators of algebraic thinking, that is 1) manipulating symbols and procedures($X_1$), 2) generalizing and formalizing($X_2$), 3) using algebra as a tool($X_3$), and 4) reasoning and representing($X_4$). The result of the computerized analysis is displayed in Table 2 below.

Tabel 2. Pearson Correlation Table

| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $n$ |
|---|---|---|---|---|---|
| FD ($Y_1$) | $a$ | 0,645 | 0,635 | 0,574 | 17 |
| FI ($Y_2$) | $a$ | 0,768 | 0,600 | 0,766 | 7 |

Descriptors: $a$ = Not able to analyze because one of the variables is constant

Based on Table 2, it can be seen that the correlation between $Y_1$and $X_1$from Pearson Correlationtablecould not be computerized because the $X_1$ variable was constant (not changing) therefore no relationship was shown between $Y_1$and $X_1$. In other words, FD learning style does not affect students' ability in manipulating symbols or procedures.

Next, the correlation of $Y_1$ and $X_2$, obtained the score of $r_{xy}$ = 0,645, this score was then compared to that in the $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 17 thus obtained $r_{tabel}$ = 0.4124; therefore ,$r_{xy} > r_{tabel}$ means there is a relationship between $Y_1$ and $X_2$. As $r_{xy}$ showed positive value, so the higher the FD score the higher the generalization score. Then, the correlation of $Y_1$ and $X_3$ obtained the score of $r_{xy}$ = 0,635. This score was compared to that of $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 17, and thus $r_{tabel}$ = 0.4124 was obtained; therefore, $r_{xy} > r_{tabel}$ meaning that there is a relationship between $Y_1$ and $X_3$. Due to the positive value of $r_{xy}$, so the higher the FD score the higher the tool score. Finally, the correlation between $Y_1$ and $X_4$ obtained the value of $r_{xy}$ = 0,645 which was then compared to that of $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 17 and resulted $r_{tabel}$ = 0.4124; therefore, $r_{xy} > r_{tabel}$ or there is a relationship between $Y_1$ and $X_4$. Due to the positive value of $r_{xy}$, so the higher the FD score the higher the representation score.

Then, the correlation of $Y_2$ and that of $Y_2$ and $X_1$ from the Pearson Correlationtable could not be computerized due to the constant nature of $X_1$ variable, thus there is no relationship between $Y_2$ and $X_1$. In other words, the FI learning style does not affect the student's ability in manipulating symbols and procedures. Furthermore, the correlation of $Y_2$ and $X_2$ obtained the value of $r_{xy}$ = 0,768; this value was compared to that of $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 7 thus obtained $r_{tabel}$ = 0.6694 and $r_{xy} > r_{tabel}$ meaning that there is a relationship between $Y_2$ and $X_2$. As $r_{xy}$ showed positive value, so the higher the FI score the higher the generalization score. Then, the correlation of $Y_2$ and $X_3$ obtained the score of $r_{xy}$ = 0,600. This score was compared to that of $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 7, and thus $r_{tabel}$ = 0.6694 was obtained; therefore, $r_{xy} > r_{tabel}$ meaning that there is no relationship between $Y_2$ and $X_3$. In other words, the FI learning style does not affect students' ability in making a relationship between two or more representations when solving a problem. At last, the correlation between $Y_2$ and $X_4$ obtained the value of $r_{xy}$ = 0,766 which was compared to the value of $r_{tabel}$ at $\alpha = 0{,}05$ and $n$ = 7 thus $r_{tabel}$ = 0.6694 and $r_{xy} > r_{tabel}$ meaning that there is a relationship between $Y_2$ and $X_4$. Due to the positive value of $r_{xy}$, so the higher the FI score the higher the representation score.

The correlation between the cognitive learning style and algebraic thinking is explained as in the following: first, there is no relationship between symbolizing mathematical problems with either FI or FD cognitive learning style. Second, students with FI cognitive learning styles performed better than those with FD in learning previous and incoming patterns, generalizing patterns, and representing algebra-related problems. It is in line with Sukmawati (2018) stating that students with Field Independent (FI) learning style are able to represent problems in their own language, likely to draw a conclusion based on observation or given facts, and performing analytical thinking by collecting relevant information. Pitta-pantazi & Christou(2009)stated that one with Field Independent (FI) learning style is more likely to re-organize available data or information and change them to match their own understanding, than their counterparts who have FD learning style.

The indicator stages of algebraic thinking in students with FI learning style are as follows; 1) generalizing and formalizing patterns, 2) reasoning and representing, and 3) administering algebra as a tool. On the other hand, the indicator stages of algebraic thinking in students with FD learning style are as follows; 1) generalizing and formalizing patterns, 2) administering algebra as a tool, and 3) reasoning and representing.

The higher the level of students' cognitive style, the higher the students' ability to solve mathematical problems. The sentence has that meaning the more students you have cognitive style FI, the higher achievement of problem-solving abilities students on mathematics. The meaning of "high" in this cognitive style reflects the unique abilities of students in studying mathematical material in more detail to certain parts and resilient to complete a problem or solving mathematics problem. The cognitive style which is characterized as this is style cognitive FI (Sukmawati, 2018; Ulya, 2015; Hodgen, 2014).

What is new in this research with previous research is that previous research does not reveal the relationship between algebraic thinking ability and cognitive style FD (Field Dependent) and FI (Field Independent). Previous research discusses the description of students' algebraic thinking skills in terms of the workmanship of each student based on the type of cognitive style FD (Field Dependent) and FI (Field Independent) (Agoestanto et. al, 2019; Bander, 2018; Rosita 2018). So this study is the only one that discusses the relationship between algebraic thinking ability and cognitive style FD (Field Dependent) and FI (Field Independent).

## CONCLUSION

Based on the result and discussion presented above, some conclusions of the present study can be withdrawn as follows: first, there is no relationship between students' cognitive style either FI or FD in symbolizing mathematical problems. Second, FI expresses better results than FD in terms of learning patterns and relating them to the previous ones. Third, FI is better than FD in generalizing patterns. Fourth, FD outperforms FI in terms of using algebra as a tool. Finally, FI is better than FD in reasoning and representing.

Suggestions that can recommended in this study is that teachers should design, develop, and manage learning varies according to the characteristics of students and the subject matter presented in order to be able to reach three types of student cognitive styles namely FI and FD. In addition, teachers and schools need to do an assessment / identification of the type of cognitive style of students as a whole. It is expected that the teacher can adapt his teaching style to the cognitive style of students so that optimal problem solving abilities are achieved. The results of this study can be used as one of the information materials to conduct further research on the use of certain learning strategies in teaching students with the cognitive style of FD and FI.

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