JMETP

Journal for the Mathematics Education and Teaching Practices, 1(2), 87-93, Dec 2020
e-ISSN: 2717-8587
dergipark.org.tr/jmetp

Young Wise Publishing
youngwisepub.com

Research Article

The effect of cognitive styles on reasoning and problem solving ability

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Article Info

Received: 29 October 2020
Revised: 16 November 2020
Accepted: 03 December 2020
Available online: 15 Dec 2020

Keywords:
Cognitive Style
Problem Solving
Reasoning

Abstract

The purpose of this study was to determine the effect of cognitive style field dependent and field independent on the ability of problem solving and mathematical reasoning. This study is a comparative causal study. The sample of this study amounted to 176 junior high school students taken from three schools in Mesuji regency using the cluster random sampling technique. The instruments used were tests of problem solving abitity and mathematical reasoning on geometry material and cognitive style tests using the Group Embedded Figure Test (GEFT). The data analysis used Multivariate Analysis of Variance (MANOVA). The findings of this study indicate that cognitive style has a significant effect on reasoning and problem solving abilities. Other findings indicate that field independent cognitive style is better than field dependent on students' reasoning and problem solving abilities in geometry.

To cite this article

Setiwan, A., Wawan, Koderi & Pratiwi, W. (2020). Game based learning in mathematics: future teachers' viewpoint. *Journal for the Mathematics Education and Teaching Practices, 1*(2), 87-93.

Introduction

The goal of mathematics learning at every level of education is to develop students' ability to think mathematically. NCTM (2000) emphasizes the importance of problem solving and mathematical reasoning as a result of learning. In Principles and Standard for School Mathematics, it was the 2000 revealed that one of the five abilities students should know and be able to do, namely: problem solving, reasoning, communication, connection and representation (NCTM, 2000). Based on the "21st Century Partnership Learning Framework", there are several competencies or expertise that must be possessed including problem solving and reasoning skills (Badan Standar Nasional Pendidikan, 2010; Alismail & McGuire, 2015; Motallebzadeh, 2014; P21, 2015). This ability is needed to be able to solve complex problems, acquire new skills and information independently, and adapt to rapidly changing conditions for current global competition (Tindowen, Bassig, & Cagurangan, 2017). The statement shows that the problem solving abilities and mathematical reasoning of students which are considered to be only a small part of the learning objectives, and scattered in a variety of teaching materials, are seen as an important process to develop students' mathematical thinking skills and are in line with other abilities .

There are three aspects of ability that students must possess, namely cognitive, affective, and psychomotor abilities. Each student must have different cognitive abilities. Besides being different in the level of problem solving, intelligence level, or creative thinking ability, students can also be different in how to obtain, store and apply knowledge. The same opinion with Wolfe & Johnson (1995)states that someone has a different way of obtaining and processing information,

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and seeing and interpreting it. According to Keefe (1991)the difference in the way a person processes information is better known as cognitive style. The cognitive styles discussed in this study are the cognitive styles Field Dependent (FD) and Field Independent (FI)(Witkin, Moore, Goodenough, & Cox, 1977).

According to Witkin (1973), cognitive style is a form of functioning in a typical way based on a person's intellectual abilities displayed in perceptual activities and intellectual activities. Cognitive style is a way or habit of someone who is relatively fixed in choosing and remembering information to solve problems (Messick, 1976; Keefe, 1991). Furthermore Messick (1976) defined cognitive style as a stable, preference or strategic attitude that determines the way an individual absorbs, remembers thinking and resolves problems. According to Degeng (2013) cognitive style is defined as the desire to achieve achievements in accordance with established standards.

Some studies conclude that cognitive style influences chemistry learning outcomes (Sellah, 2017), statistics (Rufi'i, 2010), nursing clinics (Yudiernawati, Setyosari, Degeng, & Rudianto, 2015), the results of learning to solve mathematical problems (Sudarman, Setyosari, Kuswandi, & Dwiyogo, 2016). The results of the study Nisa, Sa'dijah, & Qohar (2016) showed that the cognitive style of FI effect on the ability to solve mathematical problems. Other research shows that there are differences in academic learning outcomes between cognitive styles of FI and FD (Sirin & Güzel, 2006; Yudiernawati et al., 2015).

According to Slavin (2015) problem solving is the application of knowledge and skills to achieve the goals correctly. Problem solving is an attempt to find a way out of a difficulty and achieve goals that cannot be achieved immediately (Polya, 1973). Mathematical problem solving involves the integration of several cognitive abilities and metacognitive processes (Jitendra et al., 2015). According to Utami, Djatmika, & Sa'dijah (2017) mathematical problem solving ability is an ability to solve mathematical problems that are non-routine or problems that cannot be solved by routine procedures. Indicators of problem solving in this study, namely: 1) understand the problem. 2) devising a plan. 3) carry out a plan. 4) looking back at the completed solution. Hedjazi, Shakiba, & Monavvarifard (2012) found a positive relationship between problem solving ability and academic achievement, whereas, Udeani & Adeyemo (2011)showed that teacher problem solving abilities and student learning styles influence student achievement in biology. Priya (2017), found that female students' mathematical problem solving abilities were significantly higher than boys.

The term reasoning comes from the word reasoning which is defined as the process of achieving logical conclusions based on relevant facts and sources (Suriasumantri, 2001). Reasoning is defined as the way (things) that use reason; things that develop or control something with reason and not with feelings (Lailiyah, Nusantara, Sa'dijah, & Irawan, 2015). According to Suherman & Winataputra (1993) reasoning is the thought process carried out in a way to draw conclusions. Some literature (Brodie, 2010; Litner, 2000; Fischbein, 1999) states that mathematical reasoning is reasoning about and with mathematical objects. Mathematical reasoning ability helps students to conclude and prove a statement, build new ideas, to solve problems in mathematics.

In short, previous studies related to the three variable variables (cognitive style, reasoning ability and problem solving abilities) revealed that cognitive style and cognitive abilities seemed to have a significant effect, however, not many studies have used cognitive style together in reasoning and solving abilities. problem. Study Previous research has determined that all three variables (cognitive style, reasoning ability and problem solving abilities) are related to academic achievement and other cognitive variables. However, not much is known about the shared influence of cognitive style in relation to reasoning and problem solving abilities. In the current study, researchers sought to fill the gaps that exist in the literature by directly examining cognitive style in the context of reasoning and problem solving abilities.

Problem of Study

STEM is collaborative problem-solving which requires any student to apply an integrated knowledge. STEM is claimed to affect students' achievement but yet is not declared "why" and "how" its effect in higher thinking skills (Shanta & Wells, 2020). Some previous research report that the developed students' worksheets effective in increasing literacy based on STEM (Sulistiyowati, Abdurrahman, & Jalmo, 2018), can improving of in critical and creative thinking (Yulianti, Rusilowati, & Nugroho, 2020), and effective to increasing problem solving (Taub, Azevedo, Bradbury, Millar, & Lester, 2018). Based on the previous study, it can be underlined that there is an existing gap, namely to find the effect of student math-worksheets with a picture-based approach on STEM. This study aims to determine the effectiveness of the use of Student Math-worksheets with a picture-based STEM approach.

Method

Research Model and Data Analysis

This research is a quantitative study with a comparative causal method. The data analysis used was Multivariate Analysis of Variance (MANOVA), which was used to investigate the comparison of reasoning abilities and problem solving with different cognitive styles.

Participants

The sample of this study amounted to 176 junior high school students taken from three schools in Mesuji district (Indonesia) using the cluster random sampling technique.

Data Collection Tools

Tests used in this study are written tests in essay form with the five questions. Content validity was evaluated through experts. The item has a different power index greater than or equal to 0.3. This study uses an interpretation of the level of difficulty of the item that is sufficient (moderate) that is $0.3 \leq P \leq 0.7$ in order to get the quality of the item about the good. Test reliability was calculated through the Cronbach Alpha Coefficient above 0.70.

Students' cognitive style data are collected using the Group Embedded Figure Test (GEFT) instrument. The developer of this cognitive style measurement tool is (Witkin, 1973). Test questions are done with a specified time, all participants' answers are checked and given a score according to GEFT provisions, where for the correct answer get a score of 1 and the answer gets the wrong score 0. Maximum score is 18, minimum score is 0. If the total score is in the range 0-9 the students are categorized in the field dependence (FD) group and if the total score is in the range of 10-18, the student is categorized in the field independence (FI) group.

Results

To find out the significance of the difference between the average score of learning styles on student reasoning and problem-solving abilities, multivariate variance analysis (MANOVA) was used to describe dependencies directed from reasoning and problem-solving ability to students' cognitive styles. The use of assessment is based on the assumption that learning styles promote thinking skills and problem solving. With multivariate analysis, two dependent variables (reasoning and problem solving abilities) were examined on the independent variable (learning style). Thus, one-way MANOVA is used, to measure how students' reasoning and problem solving abilities (in combination) differ with respect to cognitive style (multivariate effects). MANOVA can be used when both dependent variables are moderately correlated (0.4-0.7).

Table 1.

Correlation between Reasoning and Problem-solving Ability

Dependent Variables	R	R Square
Reasoning and problem solving ability	.647	.419

From Table 1, the correlation between the ability of reasoning and problem solving is (0.419) which is within acceptable limits for the results of MANOVA for correlation not too high from the dependent variable.

In addition, it is necessary to examine the covariate homogeneity test using Box's Test of Equality of Covariance Matrices. The Box's test was used to examine the assumption of homogeneity of covariance in all groups using p <.01 as a criterion. The results are shown in table 2.

Table 2.

Box's Test of Equality of Covariance Matrices and Wilk's Lambda Test

Dependent Variables	Box's M	F	p	Wilks Lambda	F	p
Reasoning and problem solving ability	5.632	1.854	.135	.202	341.290	.000

Discussion on Table. 2. obtained F value of Box's M = 1.854, (p> 0.01) therefore, no significant difference in the covariance matrix. Therefore, Wilk Lambda is a test that can be used.

This table also displays the results of a one-way MANOVA test, using the Wilks Lambda test by taking alpha 0.01. Values (F = 341,290, p <0.01) indicate that the test is significant at the 0.01 level. The results of this test indicate that there is a significant difference between the independent variables on bound variables. Therefore, it was concluded that there was a significant multivariate difference between cognitive style and counterfeiting and problem solving abilities.

Table 3.
Mean Differences and Univariate Analysis of Reasoning and Problem Solving Abilities according to Differences in Cognitive Styles of Students

Dependent Variable	Cognitive Style	N	Means	F	p
Reasoning Ability	Field Independent	91	80.52		
	Field Dependent	85	62.88	357.628	.000
Problem Solving Ability	Field Independent	91	79.67		
	Field Dependent	85	62.19	310.538	.000

Discussion of table 3 shows that students with FI cognitive style have better reasoning abilities with an average value of 80.52 than students with cognitive style FD with an average value of 62.88. Likewise in students' problem-solving abilities with FI cognitive style is better with an average value of 79.67 than students with cognitive style FD with an average value of 62.19.

To find out whether differences in reasoning and problem solving abilities in terms of their cognitive style are actual or just accidental, we can see using univariate analysis. According to univariate analysis, students' reasoning abilities and problem solving were significantly different in terms of their cognitive style, because the F values (357,628; 310,538; $p<0.01$) were significant at the 0.01 level.

To find out whether the differences in reasoning and problem solving abilities in terms of their cognitive style are actual or just accidental, use a post hoc test using the Scheffe test.

Table 4.
Multiple Comparisons Using Scheffe's Post Hoc Test

Dependent Variable	(I)Cognitive Style	(J)Cognitive Style	Mean Difference (I-J)	p
Problem Solving Ability	Field Independent	Field Dependent	17.634	.000
	Field Dependent	Field Independent	-17.634	.000
Reasoning Ability	Field Independent	Field Dependent	17.482	.000
	Field Dependent	Field Independent	-17.482	.000

Table 4 reveals that in problem solving abilities there is a significant difference between the cognitive style FI and the cognitive style of FD. Likewise the significant difference between the cognitive style of FI and the cognitive style FD on the students' reasoning abilities on geometry material.

Discussion and Conclusion

Theoretically, individuals who have cognitive style FD and FI have differences in receiving or responding to stimuli originating from the Witkin environment (Witkin, 1973). In fact, the cognitive style individual FI is more detailed in receiving and describing information or stimuli from the environment compared to the cognitive style FD. Individuals who are cognitively styled FI are superior to mastering natural sciences and mathematics rather than social sciences (Saracho, 1988). In line with the findings of Prastiti (2006), it was explained that the student group with cognitive style FI was superior in achieving mathematical communication skills and solving story problems compared to groups of students who had the FD cognitive style. Hamid's research (2015), there is a significant effect of cognitive style with learning outcomes, students who have the FI cognitive style have an average score of intellectual skills increased higher than students who have the FD style cognitive. The results of the previous study Degeng (1991), concluded that students had the FI cognitive style superior to FD in learning acquisition, as well as subject retention can also be maintained by many FI students than FD. This study also supports the results of research by Okwa & Otubah (2007) and Adeyemi (1992) who found that students with cognitive FI style were better than FD students in the fields of physics and biology.

Recommendations

From the results of the study, it has been found that different cognitive styles of students show variations in reasoning and problem solving abilities. In addition, students who have a field independent cognitive style have better results than cognitive field dependent styles of reasoning and problem solving abilities. Identifying students' cognitive styles helps students to become efficient problem solvers. The more successful individuals are in solving problems, the more control someone will have over their lives. Students must be given the opportunity to receive education in fields that suit their cognitive style. Someone who is educated in an area that does not have a relationship with his cognitive style may lack confidence, and can result in delayed success.

Therefore, emphasizing that teachers and students must be accustomed to learning with their cognitive style. Thus, recognizing students' cognitive styles can enable teachers to organize learning according to individual student needs and facilitate their learning. In addition, teaching according to students' cognitive styles of each student can help students become more enthusiastic about studying the subject, investigating and understanding the facts and basically practicing what they have learned. Teachers can use cognitive style instruments to determine the cognitive style of students at the beginning of the academic year. Thus, the teacher can set learning strategies according to the cognitive style preferences of students. Also, teacher training programs can be held to renew the teacher's abilities about students 'cognitive styles and teaching methods based on students' cognitive styles.

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