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The Impact of Cognitive Style-based Learning Models on Students' Problem-Solving Abilities

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Abstract: Every student must possess problem-solving abilities. Solving students' problems is varied; several factors influence the difference between cognitive styles and learning models. This study aimed to determine differences in problem-solving abilities based on students' cognitive styles in the Concept Attention (CA) and Group Investigation (GI) learning model. This study was a quantitative study with the tenth-grade students of SMA Negeri 16 Semarang as the 2018/2019 academic year population. The sample was selected using cluster random sampling. The research data had been collected through documentation and tests and then were analyzed using nonparametric tests, specifically the Hildebrand test, since the data were not normally distributed. The results showed that students with Field Independent (FI) cognitive style's problem-solving ability were better than students with Field Dependent (FD) cognitive style, either in general, CA, or GI learning models. The CA learning model produced better problem-solving abilities than the GI learning model, both in general and in terms of the type of students' cognitive style.

INTRODUCTION

Mathematics is the subject that students must obtain from Elementary School to Senior High School. Learning mathematics in schools has a purpose, one of which is to have an attitude of appreciating the usefulness of mathematics in life, namely having curiosity, attention, and interest in learning mathematics, as well as being tenacious and confident in problem-solving (Hasratuddin, 2013; Purwasih et al., 2020; Samad et al., 2020). These goals are what enable mathematics was required to apply to a variety of learning in schools. However, in reality, mathematics is a difficult subject and is not easily mastered by students (Liberna, 2012). One effort to make students understand mathematics is to familiarise students with solving mathematical problems.

Problem-solving is a process for overcoming difficulties encountered to achieve the expected goals (Sumartini, 2015). Solving problems is essential for students because it is learning mathematics (Hidayat & Sariningsih, 2018; Li & Schoenfeld, 2019; Rahayu & Afriansyah, 2015). However, each student has a different level of problem-solving ability with other students.

Based on the PISA worldwide ranking in 2018, students' mathematical abilities in Indonesia are still below international standards, 71 out of 77 countries (FactsMaps, 2019). However, in other championship events, Indonesian students can win the championship. In the 59th International Mathematical

Olympiad (IMO) event in Cluj-Napoca, Romania on July 4-14, 2018, the Indonesian Mathematical Olympiad Team won one gold medal and five silver medals in the competition (Harususilo, 2018). This means that students have different problem-solving abilities between individuals.

Problem-solving abilities in students are using in every field in mathematics, one of which is trigonometry. Trigonometry is one of the competencies complained by students because of the many formulas that are not only memorized but also require a high understanding of their application (Perangin-Angin & Banjarnahor, 2017; Purba & Sirait, 2017; Rahmadani et al., 2018). Thus, efforts are needed to improve the problem-solving ability of trigonometry material.

Cognitive style is thought to be one of the causes of students' problem-solving abilities. Purnomo et al. (2017), Syamsuddin (2020), and Wulandari (2017) suggest that cognitive style shows the consistency and inclination of individual characters in feeling, remembering, organizing, processing, thinking, and solving problems. When solving a problem, each student must have a different thought process, and the difference in thought processes is possible because of differences in each student's cognitive style (Ngilawajan, 2013; Panjaitan, 2013; Yahya, 2015). Mathematical problem-solving strategies are influenced by how students process, store, and use the information to respond to a problem. In education, this is called cognitive style (Akbar et al., 2020; Panjaitan, 2013; Purnomo et al., 2017). Ngilawajan (2013) and Wulandari (2017) also argue that there are many kinds of cognitive styles, including the Field Independent (FI) and Field Dependent (FD) cognitive styles.

This statement is in line with Udiyono & Yuwono (2018), which states that there are two cognitive styles: FI and FD. There are differences between students with FI and FD cognitive styles. FD students tend to depend on their environmental perceptions, have difficulty focusing, find main ideas, use prominent instruction, find it challenging to provide ambiguous information structures. While students with FI can see shadows separate from their forms, separate relevant things from irrelevant forms, provide information structures separate from those provided, rearrange information from the context of prior knowledge, and tend to be more appropriate in taking part in memory. Based on Fadliilah's research results, it is concluding that students with the FI cognitive style perform complete problem-solving compared to the FD cognitive style (Fadliilah et al., 2017).

Besides cognitive style, learning models are also thought to be one of the causes of problem-solving (Sutrisno et al., 2020). In learning mathematics, there are many learning models, one of which is the cooperative learning model. The cooperative learning model is a learning model expected by the teacher to form cooperative groups to maximize their learning and peers (Huda, 2017).

The Concept Attention (CA) learning model is a type of cooperative learning model that is essential to classifying, thinking, and listening to students (Bhargava, 2016; Putri, 2017; Sijabat et al., 2019). Sumartini (2015) states that this learning model has a syntax of data presentation and concept identification, testing the achievement of concepts, and analyzing thinking strategies. The research conducted by Wiyono (2013) states that the CA learning model produces better problem-solving abilities than conventional models.

In addition to the CA learning model, Group Investigation (GI) is also a type of cooperative learning consisting of several members responsible for mastering subject matter supported by other group members (Bundu et al., 2018). Richardo (2015) states six steps in this learning model: topic selection, cooperative planning, implementation, analysis and synthesis, presentation of final results, and evaluation. Research conducted by Fadila et al., (2019) shows that the class using the GI model has better problem-solving abilities than the class using the conventional model. Therefore, it is hoping that both models could improve the problem-solving ability of trigonometry material.

The use of different learning models and viewpoints of different cognitive styles will also affect students' problem-solving abilities. Thus, research needs to be carried out to determine CA and GI learning models' impact on students' cognitive styles on problem-solving abilities.

METHOD

This study discussed the differences in problem-solving based on the Concept Attention (CA) and Group Investigation (GI) learning models' cognitive style. The CA and GI learning models' syntax is presented in Figure 1 and Figure 2, respectively.

Figure 1. The Syntax of CA Learning Model

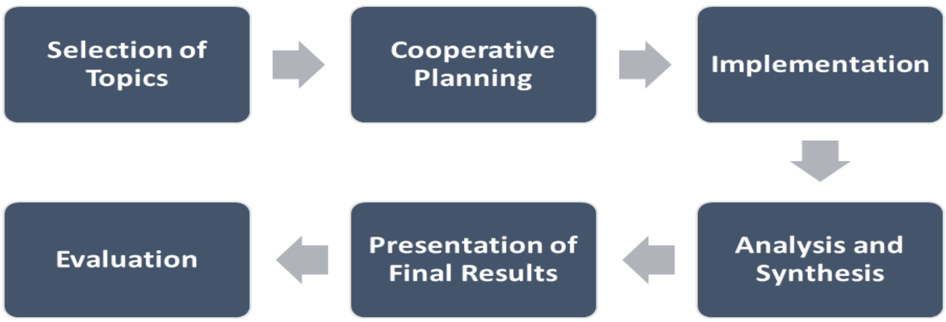

Figure 2. The Syntax of GI Learning Model

The design used was a factorial experimental design, a modification of the true experimental design, by considering a moderator variable that affects a treatment (Lestari & Yudhanegara, 2017). The research sample consisted of two classes.

Table 1. Research Design

Problem-solving Abilities on Learning Models	**Problem-solving Abilities on Cognitive Styles**	
	Problem-solving abilities on FI ($X_{.1}$)	Problem-solving abilities on FD ($X_{.2}$)
Problem-solving abilities on CA ($X_{1.}$)	Problem-solving abilities on CA with FI (X_{11})	Problem-solving abilities on CA with FD (X_{12})
Problem-solving abilities on GI ($X_{2.}$)	Problem-solving abilities on GI with FI (X_{21})	Problem-solving abilities on GI with FD (X_{22})

The experimental class was taught using the CA and GI learning models. Each experimental class had been previously tested for the average equilibrium using the t-test. Before conducting the average test, a distribution normality test was performed using the Lilliefors test, and the similarity in variance was done using the Bartlett test. Then in the middle of the learning meeting, the GEFT test was held, and at the final session, a final evaluation was having.

The final stage was analyzing the tests' calculation results, both the GEFT test and the final evaluation. The final analysis is used to see whether there are differences in problem-solving abilities between each group of students. In the final analysis, the distribution stage's normality is done first, namely, by using the Lilliefors test. Due to the non-normal distribution, a nonparametric test was performed using the Hildebrand test (Lestari, 2009). The Hildebrand test was developed from a factorial experimental design and derived from the existing formulas in two-way ANOVA with the same objective, namely knowing the difference in row factors, column factors, and interaction factors (Huhn & Leon, 1995).

RESULT AND DISCUSSION

This study's sample consisted of two tenth-grade classes subjected to the Concept Attention (CA) and Group Investigation (GI) learning models. It then examined each student's cognitive style and problem-solving abilities. The integration of indicators of problem-solving abilities with learning models is presented in Table 2. Before the CA and GI learning models were applied, the average balance test was conducted beforehand with the distribution normality and homogeneity variance tests.

Table 2. Integration of Indicators of Problem-solving Abilities with Learning Models

Indicators of Problem-solving Abilities	Integration in the Learning Model	
	Concept Attention (CA)	**Group Investigation (GI)**
Understand the problem	Data Presentation	Selection of Topics
Make a problem plan	Concept Identification	Cooperative Planning
Implement a problem-solving plan	Concept Achievement Testing	Implementation
Re-check answers	Analysis of Thinking Strategies	Analysis and Synthesis
		Presentation of Final Results
		Evaluation

Table 3. Distribution Normality Test of Initial Data

Sample	n_i	L_{obs}	L_α	Test Decision
Experiment 1	35	.127	.15	Accepted H_0
Experiment 2	33	.144	.15	Accepted H_0

From Table 3, it can be seen that Lilliefors value (L_{obs}) is less than the critical value (L_α) for significance level (α) = 5 % with n_1 = 35 and n_2 = 33, respectively. This test means that the samples from both classes are normally distributed. Next, the variance homogeneity test is performed to determine the similarity of each experimental class variance. The homogeneity variance test results are presented in Table 4.

Table 4. Homogeneity of Variance of Initial Data

Sample	n_i	s_i^2	b	b_α	Test Decision
Experi-ment 1	35	42.081	.997	.940	Accepted H_0
Experi-ment 2	33	36.218			

From the calculation the initial data in Table 4, obtained the Bartlett value (b) = .997 and the critical value (b_α) = .940 for significance level (α) = 5 % with n_1 = 35 and n_2 = 33. Because b exceeds b_α can be concluding H_0 is accepted, the two groups' variance is the same (homogeneous). After that, the average similarity test is done using the t-test. The t-test results are presented in Table 5.

Table 5. The Balance Test with t-Test

Sample	n_i	$\bar{X}_i$	t	t_α	Test Decision
Experiment 1	35	80.00	1.66	1.96	Accepted H_0
Experiment 2	33	77.97			

Based on the calculation in Table 5, t-statistic (t_{obs}) = 1.66 and the critical value (t_α) = 1.96 for significance level (α) = 5 % with the degree of freedom (df) = 66. Because t_{obs} less than t_α, accepted H_0. Therefore, the average problem-solving ability of students between the two classes did not differ significantly, so that the problem-solving abilities of students of both classes were the same.

After both classes received treatment as the design of this study, the final analysis was carried out based on tests of problem-solving abilities and cognitive styles. The first analysis is doing by testing the distribution normality. Similar to the initial data analysis, the final data analysis of the distribution normality test uses the Lilliefors test. The results of the distribution normality test are presented in Table 6.

Table 6. Distribution Normality Test of Final Data

Independent Variable	Group	L_{obs}	L_α	Test Decision
Learning model	CA	.129	.167	Accepted H_0
	GI	.160	.170	Accepted H_0
Cognitive style	FD	.199	.159	Rejected H_0
	FI	.115	.189	Accepted H_0

Based on Table 6, it is known that there are groups that are not normally distributed, so the final analysis uses nonparametric statistics, namely the Hildebrand test (Lestari, 2009).

The Differences in Problem-Solving Abilities Based on Cognitive Style

There are differences in students' problem-solving abilities with the FI and FD cognitive styles in this study. These results are obtained through calculations using the Hildebrand factor column test. The results are shown in Table 7.

Table 7. Hildebrand Test of Column Factors

Cognitive Style	Marginal Average $\bar{R}_{.j\cdot}$	χ^2_{obs}	χ^2_α	Test Decision
FI	33,32	6,67	3,84	Rejected H_0
FD	22,52			

From the calculation in Table 7, χ^2-statistic (χ^2_{obs}) exceeds the critical value χ^2_α for significance level (α) = 5 %, which is 6.669 > 3.841. Because of $\chi^2_{obs} > \chi^2_\alpha$, rejected H_0, which means there are significant row differences. Because of the Average Marginal Ranking FI ($\bar{R}_{1.}$) = 33.32 and FD ($\bar{R}_{2.}$) = 22.52. In other words, students with FI cognitive styles are better than students with Filed Dependent cognitive style.

Students with the FD cognitive style believe their surroundings, difficult to focus, find the main points, and use prominent instructions, difficult to provide ambiguous information, challenging to compile new information and relate it to the previous one, difficult to retrieve information from memories (Udiyono & Yuwono, 2018). Students with FI cognitive style can imagine the original form of a part, separate related matters from unrelated forms, provide information separate from the others, rearrange information from the context of prior knowledge, and tend to be more appropriate in remembering things (Udiyono & Yuwono, 2018). Students with a FI cognitive style have characteristics that tend to be more confident with themselves than students with an FD cognitive style who are more confident with shared decisions or the results of group discussions.

Those factors caused students with the FI cognitive style to solve problem-solving problems better than students with the FD cognitive style. In line with Fadliilah et al. (2017), Prabawa & Zaenuri (2017), Purnomo et al. (2017), and Sari et al. (2019) researches, students with FI cognitive styles are better at solving problems than students with FD cognitive styles.

The Differences in Problem-Solving Abilities in the CA and GI Learning Models

In this study, there are also differences in students' problem-solving abilities with the CA and GI learning models. These results were obtained through calculations using the Hildebrand row factor test (Lestari, 2009). The results are presenting in Table 8.

Table 8. Hildebrand Test of Row Factors

Learning Model	Marginal Average $\bar{R}_{i..}$	χ^2_{obs}	χ^2_{α}	Test Decision
CA	32,89	8.01	3.84	Rejected H_0
GI	20,88			

From the calculation in Table 8, χ^2-statistic (χ^2_{obs}) exceeds the critical value χ^2_{α} for significance level (α) = 5 %, which is 8.01 > 3.84. Because of $\chi^2_{obs} > \chi^2_{\alpha}$, rejected H_0, which means there are significant row differences. Because of CA's Marginal Ranking Average ($\bar{R}_{1..}$) = 32.89 and GI ($\bar{R}_{2..}$) = 20.88. In other words, the students' problem-solving ability with the CA learning model is superior to the GI. That is reversing by the results of the analysis conducted by Noor (2011). His research found that GI's learning model had better learning achievement than the CA learning model in Economics subjects.

There are differences in problem-solving ability from the classroom with the CA and GI learning models in this study. That is in line with Noor (2011), which states that there are differences in learning opportunities between the CA learning model and the GI learning model. The difference is causing by the different treatment of each class. The CA learning model is a learning model that is very important to learn how to classify, think, and listen to students (Bhargava, 2016). In contrast, the GI learning model is a model that emphasizes students' participation and activities to search for material lessons to be learned through available materials (Richardo, 2015).

Students who are giving the CA and GI learning models were active during learning. The CA learning model, which emphasizes the concept's achievement, is considered better in problem-solving than the GI learning model, which focuses more on discussing a problem. The learning objectives of individual students are more achieving by using the CA learning model. The concepts already reached at each meeting are considered more easily understood by students to be reapplying during the final evaluation in the form of a problem-solving ability test. Therefore, the CA learning model's problem-solving ability is better than the GI learning model.

The Difference in Problem-Solving Abilities in the CA and GI Learning Models based on the Cognitive Styles

There is no interaction between cognitive style and learning models on students' problem-solving abilities in this study. These results are obtained through calculations using the Hildebrand test of interactions between row and column factors. The results are presented in Table 9.

Table 9. Hildebrand Test Interactions between Row Factors and Column Factors

Learning Model	Cognitive style		χ^2_{obs}	χ^2_{α}	Test Decision
	FI	FD			
CA	30.09	32.00	.372	3.841	Accepted H_0
GI	24.45	21.27			

From the calculation in Table 9, χ^2-statistic (χ^2_{obs}) less than the critical value χ^2_{α} for significance level (α) = 5 %, which is .372 < 3.841. Because $\chi^2_{obs} < \chi^2_{\alpha}$, accepted H_0, there is no significant interaction between a row and column factors. It can be concluded that both the CA and GI learning models, students with the FI cognitive style, have better problem-solving abilities than the FD cognitive style. Students with a FI cognitive style are more focused on working on a problem than students with an FD cognitive style who tend to be more interested in the surrounding environment. Ulya (2015) also believes that the higher the level of students' cognitive style, the higher their mathematical problem-solving abilities. As a result, both in CA and GI learning models, students' problem-solving abilities with the FI cognitive style is better than the FD, as is the case with

Khafid (2010), which states that cognitive style carries an effect on any learning outcomes regardless of learning models. High and low learning outcomes of students also affect the level of problem-solving abilities of students. As in the case of Winardi (2016), where the problem-solving abilities of students studied were high, at the same time, students' learning outcomes were also high. Based on Khafid's (2010) research, it is possible that in the CA learning model, students with the FI cognitive style have better problem-solving abilities compared to students with FD cognitive style. That also happened in the GI learning model. In line with this, Khafid (2010) states that the FI cognitive style has better learning outcomes in the GI learning model than the FD cognitive style. As a result, in the GI learning model, students with the FI cognitive style are better at solving problems than the FD cognitive style. Besides, students with the CA learning model will always be better at solving problems than the GI learning model. Based on the discussion, some of the learning goals are not all achieved in the learning process.

This study provides insights for teachers in choosing the right learning model in their learning practices. Besides, students' cognitive style also needs to get more attention from teachers because it influences students' problem-solving abilities.

CONCLUSION

This study showed that the students' problem-solving abilities with the FI cognitive style were better than the FD. Furthermore, the CA learning model produced better problem-solving abilities than the GI learning model. Besides, it can also be shown that in the CA and GI learning models, students' problem-solving abilities with FI cognitive styles were better than students with FD cognitive styles. For students with FI and FD cognitive styles, the CA learning model produced better problem-solving abilities than the GI learning model.

Based on the analysis, it is suggested that teachers use the CA learning model to improve problem-solving abilities, and teachers should pay attention to students' cognitive styles in learning. Students with FD cognitive styles need to get more attention when studying.

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