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Research Article

The effect of collaborative problem-solving strategies and cognitive style on students' problem-solving abilities

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Abstract

The purpose of this research is to identify the effect of collaborative problem solving (CPS) on students' problem-solving abilities with different cognitive styles, such as field-dependent (FI) and field-independent (FD). This is a quasi-experimental research with a 2x2 factorial design. Data were obtained from 109 students of public junior high school 3 Mesuji, Indonesia, through essay tests and from the Group Embedded Figure Test (GEFT) and analyzed using two-way analysis of variance (ANOVA). The results showed the following, there is a significant difference in problem-solving abilities between students treated with collaborative problem-solving strategies and problem-based learning, there are significant differences in problem-solving abilities between students with field-dependent and field-independent cognitive styles, there is a significant interaction between different instructional strategies (collaborative problem solving and problem-based learning) and cognitive styles (field-dependent and field-independent) on problem-solving abilities.

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Introduction

Problem-solving abilities are critical aspects of students' learning outcome, and it refers to their capability to solve problems in an effective and timely manner without any impediments. It also involves identifying and defining the problem, generating alternative solutions, evaluating, selecting, and implementing the best substitute. Based on the 21st Century Partnership Learning Framework, students need to imbibe several competencies, including problem-solving abilities (Alismail & McGuire, 2015; Motallebzadeh & Kafi, 2014; 2015). These skills are needed to solve complex problems, communicate effectively, independently acquire new abilities and information, and adapt to the rapidly changing conditions due to the current global competition (Tindowen, Bassig, & Cagurangan, 2017). Also, the National Council of Teachers of Mathematics (2000) stated the importance of problem-solving in relation to learning. According to Krulik, Rudnick, & Milou (2003), it aids students to gain the potential to utilize facts, abilities, and information necessary to solve complex problems. The Ministry of Education and Culture (*Permendikbud*) No. 21 of 2016 stipulates that every student needs to apply knowledge, both in mathematics and daily life (Khoirunnisah & Yusmaita, 2019). A question is a problem that requires a solution, although it needs to be solved by routine procedures or specific strategies (Suarsana, Lestari, & Mertasari, 2019; Zevenbergen, Dole, & Wright, 2004).

The Program for International Student Assessment (PISA), organized by the Organization for Economic Cooperation and Development (OECD), assessed the ability of 15-year-old children in Mathematics, Science, and

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Reading skills. The 2015 PISA assessment results showed that Indonesia ranked 63 out of the 69 countries that were evaluated and categorized in the poor mastery group with a mathematical average (M= 386) (OECD, 2016). However, a decline was reported in "2018" with an average value (M= 376) (OECD, 2018). In addition, the results realized from the national examination for junior high school showed that there was no change in the average mathematical value from 2017 to 2019, and it even tended to decline (M = 50.54; M = 44.05; M = 46.19) in Mesuji, Indonesia (*Pusat Penilaian Pendidikan*, 2019).

The poor scores were attributed to a lack of abilities to solve most of the problems (Suarsana, Lestari & Mertasari, 2019). According to Gok & Silay (2010), students often encounter difficulties when solving mathematical concepts related to real-world experiences and daily life. They make certain mistakes when trying to understand these problems, communicate, and test the concept (Saleh, Yuwono, Rahman, & Sa'dijah 2016; Sumaji, Sa'dijah, Susiswo, & Sisworo, 2019). Ineffective implementation of instructional strategies leads to poor problem-solving abilities (Mabilangan, Auxencia, & Belecina, 2011). On the contrary, innovative processes address these issues and improve the capabilities of students.

Problem-based instruction needs to be formulated to fix various challenges, including collaborative problem solving (CPS), which involves developing problem-based learning (PBL). PBL is primarily designed to help students develop cognitive, problem solving, and intellectual skills by organizing lessons related to real-life situations (Arends, 2009), including reflecting on their experiences (Barrows & Tamblyn, 1980). Some of its advantages are improves learning outcomes (Celik, Onder, & Silay, 2011; Wonda, Degeng, Setyosari, & Dasna, 2016) and critical thinking skills (Lohmay, Setyosari, Degeng, & Kuswandi, 2016). Conversely, not all learning materials are applied in PBL, and in certain situations, division of tasks is quite difficult because the students find it difficult working together, however, this is one of its disadvantages (Lobo, 2016). Based on this, CPS encourages students to work together in more intensive groups.

It is a learning strategy that trains individuals to effectively engage in a process where they collaborate to solve problems by sharing ideas, knowledge, and abilities (Luckin et al. 2017; OECD, 2017). Furthermore, studies show that students that engage in collaborative groups realize better learning outcomes (Fawcett & Garton, 2005). In addition, this is also improved by CPS, as reported in previous studies (Harding, Griffin, Awwal, & Scoular, 2017; Harris, 2008; Yin, 2015). It also influences learning outcomes and affects the problem-solving process (Lu & Lin, 2017). The more the collaboration, the higher the ability to demonstrate overall problem-solving performance (Lin, Mills, & Ifenthaler, 2015). It also has the capability to resolve various complex and information problems on a non-routine basis (Greiff, Wüstenberg, Fischer, & Funke, 2013).

In addition to instructional strategies, other factors affect students' learning outcomes. According to Bloom (1982), it is related to two major determinants, namely student characteristics and quality of learning. This is consistent with the research carried out by Reigeluth (1999), which stated that learning outcomes relate to interactions between its strategies and conditions. One student characteristics that influences learning outcomes is cognitive style. Dembo (1981) reported that it is one of the most significant learning variables adopted in cognitive style and process. The growth and activation of cognitive processes are closely related to students' characteristics, which determine the adoption of learning methods or strategies (Sahin & Levent, 2015).

Cognitive style is the difference in intellectual behavior, thinking, and memory, which affects individuals' conduct and activities both directly and indirectly (Allinson & Hayes, 1996). It is perceived as the bridge between intelligence and personality, including the psychological expression in information processing that influences the way a person views and responds to events and ideas (Witkin, Moore, Goodenough, & Cox, 1977). The cognitive style also refers to the manner an individual responds to, processes, stores, thinks and uses the acquired information to resolve various types of environmental situations or tasks (Kozhevnikov, Motes, & Hegarty, 2007). It is a unique way of solving problems, thinking, understanding, and memorizing (Bendall, Galpin, Marrow, & Cassidy, 2016).

This study analyzes the Field Dependent (FD) and Field Independent (FI) cognitive styles (Witkin, Moore, Goodenough & Cox, 1977). The Field Dependent cognitive style is an aspect of one entity that accepts the dominant part or context. On the contrary, the independent Field is defined as the tendency to separate details from the surrounding context. However, several studies have proven that cognitive style influences English and mathematics learning outcomes (Khodadady, Gholami, & Bagheri, 2013; Sudarman, Setyosari, Kuswandi, & Dwiyogo, 2016). It also affects the conceptual understanding and application of ideas (Susilowati, Degeng, Setyosari, & Ulfa, 2019).

Based on these explanations, the CPS strategy effectively improves students' problem-solving abilities, which causes them to benefit differently. Therefore, there is a need to study CPS strategies and cognitive styles, as well as the influence of FI and FD, which are considered relevant. This is due to the fact that it strongly correlates with cognitive processes and aids because of problems. Therefore, it is crucial to investigate the effects of CPS strategies and cognitive styles to improve students' problem-solving abilities.

Problem of Study

The purpose of this study was to identify the effect of CPS (collaborative problem solving) on students' problem-solving abilities using different cognitive styles, namely field-dependent (FI) and field-independent (FD). This study seeks to resolve the following issues:

- The differences detected in students' problem-solving abilities when collaborative problem solving (CPS) strategies are implemented with problem-based learning (PBL)?
- The differences in problem-solving abilities of students with either field-dependent or field-independent cognitive styles?
- Is there an interaction between instructional strategies (CPS and PBL) and cognitive styles (FI and FD) as well as their influence on problem-solving abilities?

Method

Research Method

This quasi-experimental research adopted a 2x2 factorial design. This is due to the failure to control or manipulate all variables presumed to influence the dependent ones (Tuckman, 1999). Furthermore, this research's implementation does not permit the random selection of subjects because they naturally formed intact groups, such as students in a particular class (Cook & Campbell, 1979). Therefore, all the subjects in a class (intact group) were treated. The factorial design was adopted as a research structure in which two or more independent variables were analyzed to examine their interactive effects on the dependent ones (Kerlinger & Lee, 2000).

Table 1.

Design Factorial 2x2 of Quasi-experimental Research

	Type of cognitive style	Instructional strategies	
		CPS	PBL
Cognitive style	Field-independent	Group 1	Group 2
	Field-dependent	Group 3	Group 4

Table 1 describes the influence of the variables used in this study, and its major effects are divided into two, namely (1) the main consequences of instructional strategies without considering the cognitive styles and (2) the primary impact of cognitive styles without considering instructional strategies. The interactional effect provides information in terms of the relationship between instructional strategies and cognitive styles and their influence on the dependent variable.

Participants

This research was carried out at Public Junior High School 3 Mesuji with 109 grade VII students with an average age of 13 to14 years selected using cluster random sampling technique. The distribution of research subjects are shown in Table 2.

Table 2.

Distribution of Research Subjects

Class	Treatment	Total students		
		Male	Female	n
VII B	collaborative problem solving	13	16	29
VII C		11	16	27
VII A	problem-based learning	14	13	27
VII D		11	15	26
Total (N)		49	60	109

Based on Table 2, it is evident that the total number of subjects was 109, and they consist of 49 females and 60 males from four different classes, namely grades VII B (13 females and 16 males) and VII C (11 females and 16 males), which served as the experimental classes handled with collaborative problem-solving procedures. In addition, grades

VII A (14 females and 13 males) and VII D (11 females and 15 males) are the control class handled with problem-based learning approaches.

Data Collection

Two instruments were used in this research, namely (1) problem-solving ability and (2) cognitive style tests. Problem-solving abilities were in the form of essay tests, which involved five items. Conversely, this instrument was used to access 27 students in SMP N 3 Mesuji. The criteria for content validity were authenticated by three experts, and they reported that the essay test for determining problem-solving abilities serves as a minor revision. The feedbacks obtained are as follows: 1) test questions need to use a language that is short and easy to understand, and 2) the indicator of the problem is adjusted to cognitive aspects. The construct validity and reliability indices are Correlation ≥ 0.30 and $\alpha \geq 0.70$, respectively (Fraenkel, Wallen, & Hyun, 2014). The results from the validity test, are shown in Table 3.

Table 3.

The Results from the Validity Test

Correlations	Question				
	Question 1	Question 2	Question 3	Question 4	Question 5
Pearson Correlation	.523	.776	.876	.582	.876
N	27	27	27	27	27

Based on table 3, it was discovered that the correlation scores of questions 1, 2, 3, 4 and 5 was (0.523 > 0.30), (0.776 > 0.30), (0.876 > 0.30), (0.582> 0.30) and (0.876>0.30) respectively. The validity analysis shows that the correlation score is greater than (0.30), which means that the 5 essay tests of problem-solving abilities are valid and tends to be utilized. Conversely, the reliability test was carried out using Cronbach Alpha, and its results are shown in Table 4.

Table 4.

The Results from the Reliability Test

Reliability Statistics	
Cronbach's Alpha	**N of Items**
.823	5

Based on Table 4, it was discovered that Cronbach's Alpha score of (0.823>0.70) shows that the instrument has high reliability.

The instrument adopted for the cognitive styles was the Group Embedded Figure Test (GEFT) developed by Witkin, Oltman, Raskin, & Karp (1971). This test is in the form of a picture consisting of three parts. The first aspect includes seven pictures, while both the second and third encompasses nine pictures. The time allocated for working on part one is two minutes, while two and three are nine minutes each (Davis, 2006). Witkin (1971) used the Spearman-Brown formula to prove that the reliability of the GEFT is 0.82 for men and 0.79 for women (Garton, Dyer, & King, 2000). The test questions were carried out within the allocated time, and participants' answers were checked and rated according to GEFT provisions, in which the correct answer was assigned a score of 1 while the wrong one was assigned 0. Subsequently, the maximum score is 18, while the minimum is 0. Students that scored between 0 to 9 were classified as possessing field-dependent cognitive styles, while those that scored between 10 to 18 have field-independence (Reigeluth, 1999). The distribution of research subjects in cognitive style is shown in Table 5.

Table 5.

Distribution of Subjects in Cognitive Style

Cognitive Style Criteria		Instructional Strategies		
		Collaborative Problem Solving	Problem Based Learning	Total
Cognitive style	Field-dependence	31	29	60
	Field-independence	25	24	49
Total		56	53	109

In accordance with Table 5, it is quite evident that the subjects belonging to FD cognitive style are 60, while 49 of them are categorized as FI.

Procedure

This research examines the effect of CPS and PBL strategies on mathematical problem-solving abilities, and its focus is on social arithmetic material. It was carried out for 8 weeks, with a total of 9 meetings. Furthermore, the adopted steps are shown in Tables 6 and 7.

Table 6.

Learning Activities Involved in Collaborative Problem Solving (Reigeluth, 1999)

Phase	Activities
"Build" readiness	- Overview of collaborative problem solving - Develop scenarios or discover authentic problems
Form a group	- Form small heterogeneous groups
Identification of problems	- Group members need to understand the problem. - The group also needs to be able to identify the required expertise, knowledge, and information
Divide roles and tasks	- Divide tasks related to problem-solving activities among the group members
Planning and problem solving	- Improve and develop problem-solving plans - Collaborate to solve problems - The final draft or solution of problem-solving
Implementation	- Presentation of group works - Evaluation of work results
Evaluation	- Evaluate the solutions made - Evaluate the method or process used
Reflection	- Identifying the benefits of learning - Experience and impressions concerning the process - Reflect on the group and individual learning processes - Closing

The phase that involves building readiness aims to help the students understand all they need to do is develop scenarios or discover authentic problems with an appropriate level of complexity (Wiggins, 2011). The phase that involves forming a group is one of the most important activities associated with CPS's success. The heterogeneous formation of small study groups consists of three to six members (Slavin, 2015). However, the identification of problems implies that all members need to understand the issues. Furthermore, the group that involves identifying skills, knowledge, and information is expected to start working on the initial problem-solving plan (Bransford, Brown, & Cocking, 2000). The subsequent phase implies the division of tasks related to problem-solving sub-activities among the group members. In addition, by assigning a task to each group member, the students are forced to analyze the things that need to be done and those responsible for carrying out certain activities (Bridges & Hallinger, 1996).

The phase which involves planning and problem-solving is the heart of the CPS because it encourages the students to invest most of their time when designing and developing problem-solving solutions through activities such as refining and formulating plans, identifying and assigning tasks, obtaining and disseminating the required information, knowledge, and expertise, engaging in fabricating problem-solving solutions, and collaboration among group members (Reigeluth, 1999). The implementation phase entails that some group members present their work while the others offer their responses, suggestions, or opinions, including solutions (Bridges, 1992). The evaluation phase requires the teachers and students to review the problem-solving processes' results (West, 1992). The final phase is a reflection, which entails the students to identify and discuss their learning outcomes.

Table 7.

Learning Activities Based on Problem Based Learning (Arends, 2009)

Phase	Activities
Student orientation towards problems	The teacher assigns problems for students
The teacher organizes students into groups	The teacher divides students into small groups
The teacher guides individual and group investigations.	The teacher encourages students to gather as much information as possible related to the explanations and solutions to problems
Develop and present the results from problem-solving processes	The teacher helps students organize learning tasks according to problems. Students formulate and present the results from the problem-solving process
Analyze and evaluate the problem-solving process.	The teacher helps students reflect, evaluate, and clarify the discussion results before drawing a certain conclusion on the studied material

The initial phase is the student orientation towards problems. In addition, the teacher assigns problems to them. After which, they are organizing the students into groups. Conversely, in this phase, the teacher divides them into small groups of four to five students (Stinson & Milter, 1996). The subsequent phase entails that the teacher guides individual and group investigations, thereby encouraging them to acquire as much information as possible to obtain explanations and solutions to problems (Slavin, 2015). In the phase to develop and present the results from problem-solving processes, the teacher helps the students organize learning tasks according to the issues. The students acquire knowledge and carry out experiments according to the assigned problem-solving process. In addition, they tend to develop and present their results (Krawec et al. 2012). In the final phase, which is the analysis and evaluation of the problem-solving process, the teacher helps the students clarify the results from their discussion and draw a conclusion from the studied material (Ma, 2010).

Data Analysis

A statistical test was used to interpret the results of this research. In addition, data analysis was carried out based on statistics software. Two types of prerequisite tests were adopted, namely, normality and homogeneity approaches. Furthermore, the normality approach was determined using the Kolmogorov-Smirnov test with a significance value of $p > 0.05$. On the contrary, homogeneity was detected by using the Levene test with a significance value of $p > 0.05$. The different procedures use two-way analysis of variance (ANOVA).

Results

This process involves calculating and describing data based on learning strategies and cognitive styles using descriptive statistics, which include mean and standard deviation. Furthermore, hypothesis testing in accordance with parametric statistics adopted the two way ANOVA, while the prerequisite tests utilized the normality (Kolmogorov-Smirnov) and homogeneity approaches (Levene). The complete data analysis results are shown in Tables 8, 9, 10, and 11.

Table 8.

Description of research data

Learning Strategies	Cognitive Style	Mean	Std. deviation	N
Collaborative Problem Solving	Field-independent	80.64	8.577	25
	Field-dependent	73.23	7.112	31
	Total	76.54	8.575	56
Problem Based Learning	Field-independent	74.75	6.797	24
	Field-dependent	58.28	8.379	29
	Total	65.74	11.259	53

The results in Table 8 shows that certain differences were detected in the learning outcomes of problem-solving abilities, for example, in the total M (Mean) of the experimental and control groups, which was realized as M experiment = 76.54, SD = 8.575, and M control = 65, 74, SD = 11,259 thereby obtaining a difference of 10.8. In addition, certain differences were also detected in each of the cognitive style categories FI and FD in the experimental and the control class. The mean results in the experimental class are M FI = 80.64, SD = 8.577 and M FD = 73.23, SD = 7.112, thereby showing a difference in the value of M = 7.41. Subsequently, the mean in the control class are M FI = 74.75, SD = 6.797 and M FD = 58.28, SD = 8.3379, realizing a difference of M = 16.47 as shown in figure 1.

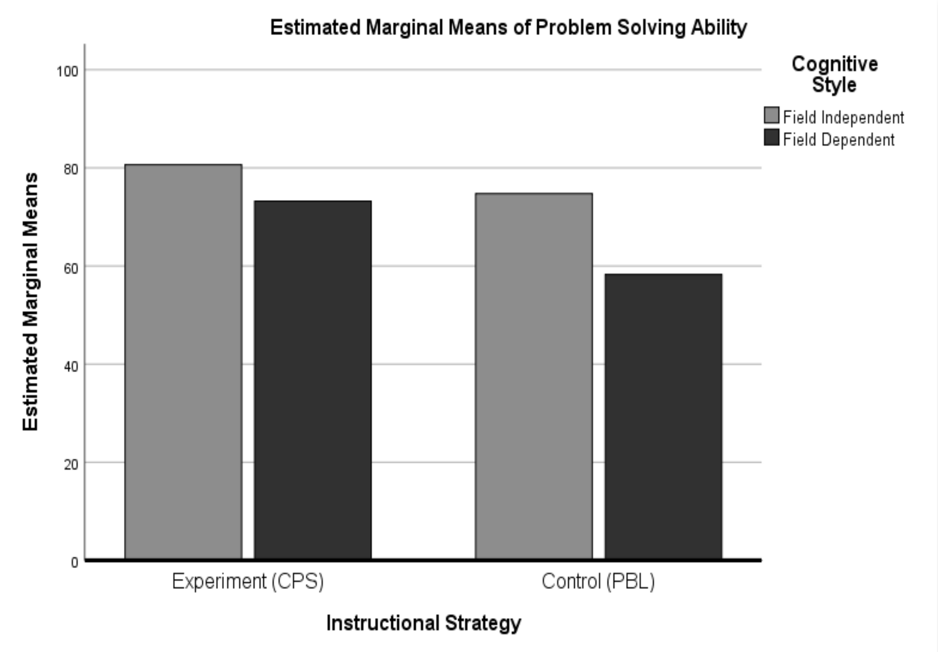

Figure 1.
Comparison of Problem-solving Abilities between the Experimental and Control Classes

The prerequisite test for ANOVA is the normality (Kolmogorov-Smirnov) and homogeneity approaches (Levene). The normality test aims to determine whether the subject is derived from a normally distributed population. The homogeneity test is used to determine whether the variance in each group is homogeneous (evenly distributed). The normality test results are shown in Table 9.

Table 9.
The Results from the Normality Approach Using the Kolmogorov-Smirnov Test

	Mean	Std. deviation	n	Statistic	p
Problem-solving	76.54	8.576	56	.098	.200

Based on Table 9, a significance value of 0.200 (p> 0.05) was obtained, which implies that the data's problem-solving ability was normally distributed. Furthermore, the homogeneity of the data examined using the Levene test is shown in Table 10.

Table 10.
The Results from the Homogeneity Approach Using the Levene Test

Levene statistic	df1	df2	p
.744	3	105	.528

In accordance with Table 10, a significance value of 0.582 (p> 0.05) was realized, it simply means that the data acquired from the problem-solving ability is homogeneous. The output of the ANOVA test results are shown in Table 11.

Table 11.

Results from the Two-way ANOVA Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7500.711a	3	2500.237	41.595	.000
Intercept	554600.240	1	554600.240	9226.536	.000
Instructional Strategy	2926.424	1	2926.424	48.685	.000
Cognitive Style	3845.172	1	3845.172	63.970	.000
Instructional Strategy * Cognitive Style	553.089	1	553.089	9.201	.003
Error	6311.472	105	60.109		
Total	567692.000	109			
Corrected Total	13812.183	108			

a. R Squared = .543 (Adjusted R Squared = .530)

Based on the results from the two-way ANOVA test in Table 11, certain differences were detected in the ability to solve mathematical problems using the CPS and PBL strategies, as indicated by the significant value obtained F = 48,658, p<0.05. Conversely, a difference in the ability to solve mathematical problems by applying the cognitive styles (FI and FD) was also detected, as shown by the significant value F = 63.97, p<0.05. An interaction was discovered between instructional strategies (CPS and PBL) and cognitive styles (FI and FD) when adopted to solve mathematical problems, as shown by the significant value F = 9,201, p<0.05.

Discussion and Conclusion

The first research question's findings showed that students subjected to the CPS and PBL strategies exhibited significant differences. These results indicate that the CPS strategy is more effective than the PBL in improving students' problem-solving abilities. The phases require students to be active and collaborate when solving problems. The mathematical problems solved in this strategy are non-routine (heuristic). They consist of complex knowledge and skills that tend to be combined in various ways in order to successfully complete the tasks (Yin, 2015). Therefore, they need to collaborate in order to find solutions (Wiltshire, Rosch, Fiorella, & Fiore, 2014). Individuals placed in groups tend to work together, are attentive and respectful, and utilize prior knowledge to identify problems (Wiltshire, Rosch, Fiorella, & Fiore, 2014). In addition, this makes it easier to identify their weaknesses.

This research is consistent with previous studies that reported the superiority of the CPS strategy (Reigeluth, 1999). This strategy encourages students to collaborate in more intensive groups. It includes several learning activities, namely building readiness, forming small groups, identifying the skills, knowledge, and information required to start working on the initial plan, dividing tasks related to problem-solving sub-activities among the group members, planning the stages and solving problems together, present work results as well as the responses, suggestions or opinions of others until they finally agree and decided on the solution.

The CPS enables students to invest most of their time when designing and developing problem-solving strategies through activities such as improving and formulating plans, identify and assign tasks, obtaining and disseminating necessary information, knowledge, and abilities obtained from other group members, cooperating with teachers to acquire additional knowledge and skills, getting involved in developing problem-solving strategies, regularly reports on individual contributions and group activities, as well as collaboration among members (Reigeluth, 1999).

Meanwhile, the role of teachers that adopted the CPS strategy is to act as facilitators and collaborate with the students, and they offer explanations and answers just in time whenever questions are asked. In the circumstances when one of the groups encounters difficulties, the teacher directly resolves the issue immediately (Harding et al. 2017; Harris, 2008; Yin, 2015). Therefore, this research's findings are also consistent with the studies carried out by Harding et al. (2017), Harris (2008), and Yin (2015) which stated that CPS improves both learning process and outcomes. According to Susilowati, Degeng, Setyosari & Ulfa (2019), it tends to improve conceptual understanding when assisted by advanced organizers. In other words, supposing students' problem-solving ability is enhanced, learning outcomes and understanding of concepts are also improved.

The second research question shows a significant difference between students with field-independent (FI) cognitive style and those with field-dependent (FD). These results prove that students with FI cognitive styles possess better-solving abilities than their counterparts. This is consistent with the research carried out by Witkin (1978), which stated that individuals with FI have the analytical ability to organize and separate objects from their environment.

They also possess an impersonal orientation and prioritize internal motivation and reinforcement. Similarly, students with FD cognitive styles tend to think about existing structures before accepting them, are oriented towards social skills, and learn according to external motivation.

These results are consistent with previous studies, which reported that cognitive style influences problem-solving abilities (Anderson, 2009). The process of solving a mathematical problem requires certain skills to analyze, interpret, predict, evaluate, and draw conclusions (Anderson, 2009). Cognitive style refers to a person's smartness to describe, understand, think, memorize, consider, and solve problems. Therefore, the differences detected affect the process of solving mathematical problems.

Furthermore, other previous studies also stated that field-independent cognitive styles are superior to field-dependent (Sirin & Güzel, 2006; Sudarman et al. 2016). According to Mancy & Reid (2004), FI students possess analytical, and synthesis abilities to understand problems and tend to convert abstract elements into smaller and more independent parts. This is in line with the results obtained from this study, which reported that students with the FI cognitive style are better at identifying, representing, and solving problems (Mancy & Reid, 2004). Contrastingly, FD students are more inclined to receive unfiltered information, thereby causing them to be extremely dependent on their environment when organizing and processing information. Therefore, students with FD cognitive styles encounter difficulties during the problem-solving process.

The final research question shows an interaction between instructional strategies (CPS and PBL) and cognitive styles (FI and FD), and they both influence problem-solving abilities. The interaction implies that students with FI and FD cognitive styles and adopts CPS learning strategies have better problem-solving abilities than those that utilizes the PBL approaches. Furthermore, in accordance with CPS and PBL strategies, students with FI cognitive styles have better problem-solving abilities than those with FD. These results are consistent with previous studies, which reported that there is an interaction between instructional strategies (CPS with Advanced Organizer) and cognitive style on conceptual understanding (Agboghoroma, 2009), instructional strategies (Instructional Mode and School Setting) and cognitive style on integrated science learning outcomes (Stephen, 2016), instructional strategies (Guided-inquiry and Expository method) and cognitive styles on students' physical abilities (Reigeluth, 1999), learning strategies (Discovery learning and discussion method).

CPS is an effective learning strategy that enhances problem-solving abilities (Reigeluth, 1999). Although, solving mathematical problems involves the integration of several cognitive abilities, such as critical thinking, creativity, and cognitive skills (Armstrong, Cools, & Sadler-smith, 2011; Kheirzadeh & Kassaian, 2011). In fixing these issues, students with FI cognitive styles tend to write known facts and equations that need to be solved. They also explain sketches of the tasks and analyze the model. Furthermore, they are able to review and analytically process information and apply their structure (Vendiagrys, Junaedi, & Masrukan, 2015). In contrast, students with FD cognitive style are unable to effectively separate a part from its unit, accept a more dominant aspect, or expand the problem-solving results obtained (Bloom, 1982).

This study shows there are differences in problem-solving abilities between students with cognitive styles (FI and FD) and those with instructional strategies (CPS and PBL). Based on these results, the following conclusions were drawn 1) the problem-solving ability of students subjected to the CPS and PBL strategies was significantly different. This shows that CPS is more effective than the PBL strategy, 2) the problem-solving ability of students with FI and FD cognitive styles was detected to be significantly different. Conversely, the students with FI cognitive style possess more effective problem-solving abilities than those with FD, and 3) There is an interaction between instructional strategies (CPS and PBL) and cognitive style (FI and FD), which tends to affect the ability to resolve this issues.

Recommendations

The teachers presume that the CPS strategies are superior to the PBL, although this is dependent on the students' cognitive style. The learning outcome is determined by the characteristics of the content of the subject matter, students, and the learning process (Fraenkel et al. 2014). Therefore, in the learning process, the teacher also needs to pay attention to the characteristics of students, such as their cognitive styles (FI and FD). Based on the results of this study, the CPS strategy significantly improves students' problem-solving abilities. Subsequently, there is a need to design and develop instructional strategies in the curriculum by optimizing the CPS syntax.

In accordance with the results from this research, the existence of interactions between the CPS and PBL strategies is dependent on the cognitive style. Educational institutions are expected to implement policies in order to improve the quality and development of instructional strategies that are more student-oriented, particularly in Mathematics subjects, and they are also advised to adopt the CPS strategies.

Subsequent studies need to consider the following;

- The need for teachers to identify cognitive styles at the beginning of the learning process and use it as a basis for determining appropriate strategies in order to achieve academic objectives,
- Given the limited resources, the separation of classes based on FI's and FD's cognitive styles is difficult to realize objectives. Therefore, special methods and intensive guidance for students with FD cognitive styles need to be considered
- There is also the need to analyze other skills, including collaboration and communication abilities as the accompanying impact of the CPS strategy
- Experimental CPS research is carried out in accordance with other dependent and moderator variables which contributes to other related literatures.

Limitations of the Study

The sample used in this research is limited to 109 students in the 7th grade, however, this number is still on a small scale. Therefore, there is a need to monitor other determinants outside the research variables.

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