



The Effect of Problem-Based Learning Strategies and Cognitive Styles on Junior High School Students' Problem-Solving Abilities

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This study aims to examine the effect of Problem Based Learning learning strategies, cognitive styles, and their interaction on students' problem-solving ability in social studies subjects. The type of this research is a quasi-experiment with nonequivalent control group design. The number of samples used was 120 students consisting of 60 students in the experimental class (2 classes) with the implementation of Problem Based Learning strategies and 60 students in the control class (2 classes) with the Direct Instruction strategy treatment. The research data was collected by the Group Embedded Figures Test (GEFT) instrument and problem-solving tests. The data analysis technique used is the Multivariate Analysis of Variance (MANOVA). This research resulted in several findings. Among them is a significant difference in students' solving abilities based on the application of learning strategies. Second, there is a significant difference in students' Problem-Solving abilities based on cognitive styles. Additionally, there was no correlation between learning strategies and cognitive styles on students' problem-solving abilities.

Keywords: problem based learning, cognitive style, problem-solving ability, learning, learning strategies

INTRODUCTION

Students' ability in understanding concepts is one of the education reform focuses and a key component of 21st-century education (Geller, Son, & Stigler, 2017) that can be used as a basis for obtaining problem-solving ability (Wismath, Orr, & Mackay, 2015).

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According to the observations, the students in the learning process only memorized the material in the form of concepts. The teachers only provide the information by re-conveying the definition of the concept; students are only limited to memorizing and knowing without understanding the purpose of the concept itself. Although students are also expected to utilize the concept in the problem-solving process. Thus, the students' ability is knowledge-oriented and limited to only face the test and achievement of test scores.

Learning is not only memorizing concepts or adding vocabulary, but students are expected to be able to understand concepts and their critical attributes (Arends, 2008). The teacher must also consider whether students use concepts in problem-solving and connect with real-life (Gultepe, Celik, & Kilic, 2013). Besides, teachers are also expected to be skilled in identifying tasks and activities that will challenge student knowledge, and facilitate students to arrive at understanding concepts as a basis for problem-solving (Lopez, 2017).

Understanding concepts is an integration of cognitive processes (Loyens, Jones, Mikkers, & van Gog, 2015) consisting of correlation, comparison, assimilation and reorganization of new knowledge with existing knowledge and transferring it to solve new problems (Saricayir, Ay, Comek, Cansiz, & Uce, 2016). So it can be understood that the ability to understand concepts is closely related to the ability of students in problem-solving. There are five kinds of knowledge required for successful problem solving: understanding the facts, concepts, procedures, strategies, and beliefs (Fauziyah, Lant, Budayasa, & Juniati, 2019). As (Rodzalan & Saat, 2015) states that student involvement in the learning process can be through memorization, understanding and reflection. All of those processes require them to think to achieve effective learning outcomes and improve problem-solving ability.

Based on the explanation above, there needs to be an improvement in aspects of learning strategies, especially student-centered learning strategies in building and gaining knowledge. As (Dumford, Cogswell, & Miller, 2016) states that learning strategies are specific patterns or combinations of various academic activities that students use to gain knowledge and have become an essential component in the success of learning.

In the case learning strategies, there are various studies explaining the learning strategies features that fit the students' characteristics, such as (Kresma, 2014) that found problem-based learning factors to train student sensitivity, student creativity (Geller et al., 2017), student independence (Barak & Williams, 2007) and Problem-Solving (Yusof, Hassan, Jamaludin, & Harun, 2012). This learning strategy is often referred to as Problem Based Learning (PBL), which is an effective learning strategy (Yusof et al., 2012) and can be utilized to obtain the skills needed in social studies classes (Zeliha, 2017).

Problem-based learning in educational practice remains hugely impactful on all levels of education (Erdogan, 2015) because integrating knowledge across disciplines makes students proactive in expanding their knowledge base and using various sources of information from textbooks and informal discussions with peers (Kadir, Abdullah,

Anthony, Salleh, & Kamarulzaman, 2016). PBL involves students' knowledge and skills identifications to apply those skills in new situations or achieve definite goals (Sangestani & Khatiban, 2013).

PBL has been widely implemented in learning, and it had a positive effect (Sugiharto, Corebima, Susilo, & Ibrohim, 2019). PBL is an appropriate strategy to promote critical thinking skills and Problem-Solving abilities because students are actively involved in handling significant problems (Yew & Goh, 2016). PBL uses a constructivist approach, where students try to solve problems in everyday life in a collaborative environment (Mustofa, R.F & Hidayah, 2020). In PBL, students are confronted with real-life problems that occur in the community, so students engage in innovative and creative learning processes in their problem-solving approaches. This is in line with what was conveyed by (Alrahlah, 2016) that the principal goal of the PBL approach is to show students the relevance of subject matter by delivering appropriate, realistic and practical context. In addition, PBL was built to promote various required learning outcomes and targets, including: (1) help students build a broad and flexible knowledge base, (2) help students to be effective collaborators, (3) enhance effective problem-solving ability, (4) motivate students to learn intrinsically, and (5) develop independent learning skills.

Problem scenarios used in PBL, called complex problems (that is, problems that can be solved in multiple ways) require several features that can encourage a high level of cognitive involvement (Loyens et al., 2015). Problems are presented in an unstructured and unresolved way so students will produce not only some thoughts about the cause of the problem, but various thoughts about how to overcome them (Strobel & van Barneveld, 2009). Students in small groups usually work based on problems that are formulated to obtain information and choose the right self skills in investigating problems and offering the best solutions (Palupi, Subiyantoro, Rukayah, & Triyanto, 2020)

Multiple types of research proved that PBL is successful and effective in improving students' understanding of concepts and problem-solving abilities. An empirical study recently added further evidence of the PBL effectiveness indicated by PBL groups which have a higher likelihood of conceptual change, outperforming independent-based, or lecture-based learning groups. This advantage occurs in two post-tests, namely after learning and one week later (Yew & Goh, 2016). The (Loyens et al., 2015) finding shows the effect of PBL on conceptual change, showed that the PBL group outperformed both the lecture and the independent learning group at the posttest directly after learning. These results support the hypothesis that PBL can increase the likelihood of conceptual change. Besides, the research finding on the effect of PBL on students' achievement and problem-solving ability shows that students who learn through PBL are better at problem-solving ability compared to students who do not learn through PBL. This finding reinforces that the use of PBL is effective in improving students' problem-solving abilities (Kadir et al., 2016).

Apart from the learning strategy factors, the learning condition is critical to consider. As (Reigeluth, C.M., & Cheliman, 2009) suggested that in organizing learning content, it is necessary to pay attention to variables of learning condition, one of which is the

characteristics of students. Student characteristic is one of the conditions learning variables that are defined as aspects or qualities of individual students (Degeng, 2013). One of these characteristics is every student's uniqueness in obtaining and constructing knowledge that is called cognitive style. Cognitive style is the way individuals think, feel, and remember information (Sellah, Jacinta, & Helen, 2017).

The cognitive style reflects individual characteristics in learning. Cognitive style is crucial because it determines the mechanism of individual processing information when solving problems, making decisions, or when interpreting stimuli and responses (Al-Salameh, 2011). Cognitive style is a way that individuals use to process, store and use information to respond to tasks or situations in their environment (Margunayasa, Dantes, Marhaeni, & Suastra, 2019). Cognitive style has the effect of a positive relationship on problem solving abilities as research findings (Jena, 2014) state that there is a significant influence and positive relationship between cognitive style and problem solving abilities. This is reinforced by the findings (Sudarman, Setyosari, Kuswandi, & Dwiyoogo, 2016) which states that there are differences in problem solving abilities in students with different cognitive styles. Cognitive styles can be distinguished by categorizing them in several ways, one of which is conducted by (Witkin, 1977), which identifies and groups a person based on the characteristics of the global-analytic continuum. Referring to (Witkin, 1977) grouping method, cognitive styles are divided into two groups, namely field-independent and field-dependent cognitive styles. An individual with a field-dependent cognitive style is someone who thinks globally, accepts existing structures or information, possesses a social orientation, prefers a profession requiring social skills, tends to follow existing goals and information, and tends to prioritize external motivation. Whereas an individual who possesses field-independent cognitive style is characterized with the ability to analyze objects separated from their environment, able to organize objects, possesses an impersonal orientation, prefers professions that do not require socialization and prioritize internal motivation.

The purposes of this study include: (1) to examine differences in Problem-Solving abilities between students who learn using the Problem Based Learning (PBL) strategy with those who do not, (2) to examine differences in Problem-Solving abilities between students who have field-independent cognitive style with students who have a field-dependent cognitive style, and (3) to study the interaction between the PBL and Direct Instruction strategy by considering different cognitive styles on students' Problem-Solving abilities.

METHOD

Research Design

This type of research is a quasi-experiment. Researchers cannot randomly choose subjects nor can modify the existing design. The researchers instead are forced to accept classes or groups of subjects that have been determined by the school (Setyosari, 2013). The factorial experimental design used was a 2x2 nonequivalent control group design. In this design, research subjects were not randomly chosen to be involved in the experimental and control groups (Setyosari, 2013). In this design, there are two groups

which were selected purposively and were then given a pretest to find out the initial state of the tested groups. The experimental group applied the treatment of Problem Based Learning learning strategies while the control group applied the Direct Instruction learning strategies as the treatment.

The strategy used as the comparison in this study is the Direct Instruction strategy (direct learning). In general use, the term direct instruction refers to (1) instructional approach that is structured, ordered, and led by the teacher, and/or (2) presentation of academic content to students by the teacher, as in lectures or demonstrations. In other words, the teacher "directs" the instructional process or the teaching is "directed" at students. The direct instruction strategy creates a more organized learning atmosphere. The direct teaching model involves five stages or phases, namely: orientation phase, presentation/demonstration phase, structured training, guided training, and independent training.

Research Subject

The subjects of this study were 120 students consisting of 60 students in the experimental class (2 classes) with the treatment of the Problem Based Learning strategy and 60 students in the control class (2 classes) with the Direct Instruction strategy treatment. Researchers did not randomly select groups of research subjects, because they were organized from schools for administrative reasons, so researchers use intact groups.

Data Collection Technique

Cognitive style test

Cognitive style tests use a standardized measuring instrument called the Group Embedded Figures Test (GEFT) which is used to obtain psychometric data developed by (Witkin, H., Moor, C. A., Goodenough, D., & Cox, 1977). The data consists of characteristics differences among individuals which reflects intellectual development that is divided into field-independent and field-dependent. GEFT tests the ability to find simple picture patterns hidden inside complicated picture patterns. The cognitive style identification of the subjects in this study was conducted by referring to the results of GEFT cognitive style test consisting of 25 items divided into 3 parts, where 7 items in part I are exercises while 18 items in parts II and III are the core of GEFT. Each subject is required to thicken the exact form of a simple picture hidden in a complex picture, then students are given a score of 1 if they answer it correctly. In this study, students who score > 9 are classified as Field-independent (FI) and subjects who score ≤ 9 are classified as Field-dependent (FD).

Problem-solving test

Problem-solving tests consist of test items in a descriptive form conducted before and after the treatment to measure students' Problem-Solving abilities. This test consists of 10 items referring to the content standards in the 2013 School curriculum of Indonesia for seventh-grade students in social science classes. Problem-solving ability tests are prepared by the researcher, under the direction and intensive guidance by the supervisor.

The steps in preparing the test begin with determining the competency standard, determining the indicators, compiling the questions grid, compiling the questions, compiling the answer keys and scoring rules. Then the test is validated using a validation sheet with a Likert scale by experts who are appointed following the supervisor's recommendations.

To obtain data in accordance with the actual subject conditions, researchers need to ensure that the data collection instruments used are valid and reliable. The test instrument used to measure students' problem-solving abilities has been tested for validity through Product Moment Pearson Correlation and reliability testing with Alpha Cronbach Correlation. The validity test results show the Pearson Correlation value for all items exceeds 0.349 with a significance of less than 0.05 so that all instrument items are declared valid. While the reliability test results showed the Alpha Cronbach Correlation value of 0.786 with a significance of 0.00 (<0.05) so that the instrument was declared reliable. With the fulfilment of valid and reliable criteria, the test instruments in this research can be used to measure students' problem-solving abilities.

Data Analysis Technique

The data analysis technique used in this research is the Multivariate Analysis of Variance (MANOVA). MANOVA is used because the number of dependent variables is more than one. Thus, the assumption underlying multivariate data analysis is that the dependent variable must be normally distributed and the data groups possess homogeneity.

FINDINGS

The data of this study was obtained through experimental learning activities as well as providing pretest and posttest to the research subjects to measure the level of students' Problem-Solving abilities. Before being tested using MANOVA, the research data must first meet the requirements for normality and homogeneity. The normality test used in this study is the *Kolmogorov-Smirnov test* with the significance of *Lilliefors*, while the homogeneity test is performed with *Levene's Statistics*. The results of the normality test are presented in Table 1 below.

Table 1
Normality Test Results of Research Data

Variable	Significance for Kolmogorov-Smirnov test				Description
	Experimental		Control		
	<i>Pretest</i>	<i>Posttest</i>	<i>Pretest</i>	<i>Posttest</i>	
Problem-Solving Abilities	0.186	0.099	0.069	0.092	Normal

Based on table 1 above, the normality test results of research data through the Kolmogorov-Smirnov test shows the lowest significance value of 0.069 and the highest significance value of 0.186. Given that all data tested have a significance value greater than 0.05, so the problem-solving ability data in the experimental and control classes are stated to be normally distributed and feasible to be carried out by the MANOVA test.

The homogeneity test results using *Levene's Statistics* are shown in table 2 below.

Table 2
Homogeneity Test Results of Research Data

Variable	Significance for Levene's Homogeneity Test		Description
	Pretest	Posttest	
Problem-Solving Abilities	0,783	0,707	Homogeneous

The test results in table 2 above show that the homogeneity test results of research data using the Levene's Statistics test obtained pretest significance value of 0.783 and posttest significance value of 0.707. Given that all data have a significance value greater than 0.05, the Problem-Solving ability data is claimed to be homogeneous and is feasible to be carried out by the MANOVA test.

Table 3
Normality Test Results of Cognitive Style

Variable	Significance for Kolmogorov-Smirnov test		Description
	Experiment	Control	
Cognitive Style	0,174	0,139	Normal

The test results in table 3 above show that the normality test results of research data using the Kolmogorov-Smirnov test obtained experimental significance value of 0.174 and control significance value of 0.139. Given that all data have a significance value greater than 0.05, the cognitive style data in the experimental and control classes are stated to be normally distributed and feasible to be carried out by the MANOVA test.

Table 4
Homogeneity Test Results of Cognitive Style

Variable	Significance for Levene's Homogeneity Test		Description
	Experiment	Control	
Problem-Solving Abilities	0,081	0,223	Homogeneous

The test results in table 4 above show that the homogeneity test results of research data using the Kolmogorov-Smirnov test obtained experimental significance value of 0.081 and control significance value of 0.223. Given that all data have a significance value greater than 0.05, the cognitive style data in the experimental and control classes are claimed to be homogeneous and is feasible to be carried out by the MANOVA test.

The Effect of Learning Strategies on Students' Problem Solving Ability

Table 3
Multivariate Test Results

Effect	Value	F	Hypothesis df	Error df	Sig.	
Model	Pillai's Trace	.100	3.127 ^b	4.000	113.000	.018
	Wilks' Lambda	.900	3.127 ^b	4.000	113.000	.018
	Hotelling's Trace	.111	3.127 ^b	4.000	113.000	.018
	Roy's Largest Root	.111	3.127 ^b	4.000	113.000	.018

The multivariate test results in Table 3 show that the F class prices for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root have a significance value of 0.018 < 0.05. This shows that the F price for Pillai's Trace, Wilks' Lambda, Hotelling's

Trace, and Roy's Largest Root are all significant. So it can be concluded that there is a significant influence between the variables of learning strategies on students' problem-solving abilities.

Furthermore, to determine difference in the students' problem-solving ability in the experimental class with the PBL strategy and the control class with the direct instruction strategy can be seen in the following table.

Table 4
Descriptive Statistics

	Model	Cognitive Style	Mean	Std. Deviation
Problem-Solving Abilities	Problem Based Learning (Eksperiment Class)	Field Independent	7.14	2.065
		Field Dependent	5.84	1.881
		Total	6.47	2.062
	Direct Instruction (Control Class)	Field Independent	6.19	1.786
		Field Dependent	4.46	2.219
		Total	5.38	2.164
Total		Field Independent	6.64	1.967
		Field Dependent	5.19	2.145
		Total	5.93	2.174

Descriptively it can be seen in Table 4 that, students who learn with PBL strategies have an average value of 6.47 and students with Direct Instruction strategies have an average value of 5.38. Thus we can conclude that students who learn with PBL strategies have more excellent problem-solving abilities than students who learn with Direct Instruction strategies.

Table 5
Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	Problem-Solving Pretest	27.661	1	27.661	6.959	.009
	Problem-Solving Posttest	40.424	1	40.424	10.250	.002

The results of the F pretest on Problem-Solving ability obtained F_{value} of 6.959 and significance of 0.009, while the value of $F_{\text{statistic}}$ for df 1: 1 and df 2: 118 at 95% significance level was 3.920. Considering the value of $F_{\text{count}} > F_{\text{table}}$ ($6.959 > 3.920$) with the significance level of $0.009 < 0.05$, thus H_1 is accepted and H_0 is rejected, or it can be concluded that there is a significant difference in the results of the Problem-Solving pretest between students learning through PBL strategy and strategy Direct Instruction.

The results of the F posttest on Problem-Solving ability obtained F_{value} of 10.250 and significance of 0.002, while the value of $F_{\text{statistic}}$ for df 1: 1 and df 2: 118 at 95%

significance level was 3.920. Considering the value of $F_{count} > F_{table}$ ($10.250 > 3.920$) with the significance level of $0.002 < 0.05$, thus H_1 is accepted and H_0 is rejected, or it can be concluded that there is a significant difference in the results of the Problem-Solving pretest between students learning through PBL strategy and strategy Direct Instruction.

The Effect of Cognitive Style on Students' Problem Solving Abilities

Table 6
Multivariate Test Results

Effect		Value	F	Hypothesis df	Error df	Sig.
Cognitive Style	Pillai's Trace	.344	14.792b	4.000	113.000	.000
	Wilks' Lambda	.656	14.792b	4.000	113.000	.000
	Hotelling's Trace	.524	14.792b	4.000	113.000	.000
	Roy's Largest Root	.524	14.792b	4.000	113.000	.000

The multivariate test results in table 6 show that the F class prices for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root have a significance value of $0.000 < 0.05$. This shows that the F price for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root are all significant. So it can be concluded that there is a significant influence between the variables of cognitive style on students' problem-solving abilities.

Furthermore, to determine the differences in students' problem-solving abilities who have field-independent cognitive styles and dependent cognitive styles can be seen in the following table.

Table 7
Descriptive Statistics

	Model	Cognitive Style	Mean	Std. Deviation
Problem-Solving Abilities	Problem Based Learning (Eksperiment Class)	Field Independent	7.14	2.065
		Field Dependent	5.84	1.881
		Total	6.47	2.062
	Direct Instruction (Control Class)	Field Independent	6.19	1.786
		Field Dependent	4.46	2.219
		Total	5.38	2.164
Total		Field Independent	6.64	1.967
		Field Dependent	5.19	2.145
		Total	5.93	2.174

Descriptively it can be seen in Table 7 that, students who have field-independent cognitive styles have an average value of 6.64 and students who have field-dependent cognitive styles have an average value of 5.19. Thus we can conclude that students with field-independent cognitive styles have more excellent problem-solving abilities than students with field-dependent cognitive styles.

Tabel 8

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Cognitive	Problem-Solving Pretest	21.241	1	21.241	5.344	.023
Style	Problem-Solving Posttest	68.323	1	68.323	17.324	.000

The results of the F pretest on Problem-Solving ability obtained F_{value} of 5.344 and significance of 0.023, while the value of $F_{\text{statistic}}$ for df 1: 1 and df 2: 118 at 95% significance level was 3.920. Considering the value of $F_{\text{count}} > F_{\text{table}}$ ($5.344 > 3.920$) with the significance level of $0.023 < 0.05$, thus H_1 is accepted and H_0 is rejected, or it can be concluded that there is a significant difference in the results of the pretest of students' problem-solving skills in social studies subjects between those who have field-independent and field-dependent cognitive styles.

The results of the F posttest on Problem-Solving ability obtained F_{value} of 17.324 and significance of 0.000, while the value of $F_{\text{statistic}}$ for df 1: 1 and df 2: 118 at 95% significance level was 3.920. Considering the value of $F_{\text{count}} > F_{\text{table}}$ ($17.324 > 3.920$) with the significance level of $0.000 < 0.05$, thus H_1 is accepted and H_0 is rejected, or it can be concluded that there is a significant difference in the results of the pretest of students' problem-solving skills in social studies subjects between those who have field-independent and field-dependent cognitive styles.

Interaction between Learning Strategies, Cognitive Styles and Problem Solving Abilities

Table 9
Multivariate Test Results

Effect		Value	F	Hypothesis df	Error df	Sig.
Model *	Pillai's Trace	.010	.290b	4.000	113.000	.884
Cognitive Style	Wilks' Lambda	.990	.290b	4.000	113.000	.884
	Hotelling's Trace	.010	.290b	4.000	113.000	.884
	Roy's Largest Root	.010	.290b	4.000	113.000	.884

The multivariate test results in table 9 show that the F class prices for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root have a significance value of $0.884 > 0.05$. This shows that the F price for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root are all insignificant. So it can be concluded that there is no interaction between learning strategies, cognitive styles and problem solving abilities.

DISCUSSION

In general, the results of the study indicate that the PBL strategy has a significant influence on students' problem-solving abilities. Students who learn with PBL strategies have the broadest opportunity to construct and use knowledge to find solutions in a collaborative environment (Mustofa, R.F & Hidayah, 2020). (Arends, 2008) states that the essence of PBL presents a variety of problematic situations that are authentic and meaningful to students, which can serve as a stepping stone for investigation and inquiry. PBL is designed to help students develop thinking skills and problem-solving

ability. The findings of this study support the hypothesis that PBL can increase the likelihood of conceptual change (Loyens et al., 2015). In addition, in research on the effect of PBL on students' problem-solving ability, the results showed that students in the experimental group were better at problem-solving ability compared to those not learning through PBL strategies. This finding reinforces the use of PBL as an effective strategy to improve students' problem-solving abilities (Kadir et al., 2016).

The cognitive style reflects individual images in learning. Cognitive style is a pattern of ongoing behaviour that determines how a person obtains and processes information (Sellah et al., 2017). Cognitive style is very important because it determines how to process information when solving problems or make decisions when interpreting stimuli and responses (Al-Salameh, 2011). In this study, it was found that students with a field-independent cognitive style have better problem-solving abilities compared to students who have a field-dependent cognitive style. This finding is in line with the results of research conducted by (Karaçam, Sedat; Digilli Baran, 2015) that there are significant differences in students' problem-solving abilities between those who have the Field Independent and Field Dependent cognitive styles.

The absence of interaction between the PBL learning strategy and the Direct Instruction strategy and the cognitive style of students' problem-solving abilities in social studies subjects indicates that in order to achieve maximum student problem-solving abilities, teachers only need to emphasize the learning process on one of the two variables studied, namely the application of student learning strategies or cognitive styles. Thus, it can be a choice for teachers to implement learning strategies or simply by paying attention to the cognitive styles that each student has.

CONCLUSIONS

The results of this study prove that (1) there is a significant difference in the Problem-Solving ability between students who learn using the Problem Based Learning and the Direct Instruction strategy, (2) there is a significant difference in the Problem-Solving abilities of students who possess field independent and field-dependent cognitive styles, and (3) there is no interaction between the learning strategies concerned (i.e PBL and Direct Instruction) and the cognitive style on students' Problem-Solving ability.

For further research, researchers should be able to choose different moderator variables, because from the research findings it is known that learning models and cognitive styles have a partially significant effect on students' problem solving abilities and there are no interactional relationships between variables.

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