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Uncovering The Profile Of The Influence Of Problem-Solving Skill Dimensions On Concept Understanding Through Inquiry Learning Strategies

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ABSTRACT
Inquiry learning strategies are recognized as having the capability in improving concept understanding. However, information on the contribution of each problem-solving skill dimension to concept understanding has never been revealed. This study uncovers the contribution of each problem-solving skill dimension to concept understanding. The study uses a quasi-experimental design of 2x2 factorial with a pretest/posttest non-equivalent control group. Each problem-solving skill dimension is assessed from each inquiry stage. Concept understanding is evaluated from essay test questions. Data of each problem-solving skill dimension and concept understanding are analyzed with multiple regression. The study finds that in the free inquiry, the brainstorming dimension has a significant contribution to the improvement of concept understanding, whereas in the guided inquiry, carrying out the plan dimension has the highest contribution.

INTRODUCTION

Education is a learning process that demands learnear to actively involved instead of merely listening to the teachers; therefore, teachers must put some effort for learners to be actively involved in learning using learning strategies. The occurrence of global movement calls for new learning strategies. Degeng (1998) states that perspectives on study and learning have started to change from behavioristic to constructivist perspectives. The behavioristic perspective states that study is the acquisition of knowledge, whereas constructivist perspective states that study is the construction of knowledge and concrete experiences, collaborative and reflective activities, and interpretation. The behavioristic defines teaching as transferring knowledge to people who learn, whilst constructivist defines it as arranging the environment so the learners could be motivated to explore meaning and respect uncertainties.

The change in the perspective about study and learning affects the changes in learning approaches. Currently, a shift occurs from a teacher-centered learning approach to a student-centered learning approach. Each individual should be involved in meaningful inquiry-based learning, have truth values and relevances to developing the high-order thinking skills needed (Darling-Hammond et al., 2008).

Carlgreen (2013) opines that communication, critical thinking, and problem-solving skills are crucial to develop as 21st-century citizens. These skills are required to give a contribution as a member of society once they graduated from school and to be competitive in the global market. Three factors contribute to the lack of communication, critical thinking, and problem-solving skills among senior high school (SMA) students, namely education systems, skill complexity, and teacher competencies in teaching the skills.

Based on the aforementioned, problem-solving skills are much needed in developing students' skills. Problem-solving skill is a process of synthesizing various concepts, rules, or formulas to solve problems (Kirkley, 2003). According to Greenstein (2012), steps in solving problems include formulating problems, brainstorming, arranging plans, carrying out the plans, and evaluating results.

Each college student learns in different ways; thus, lecturers are challenged to find a method to assist the students effectively. Consequently, lecturer functions change to a motivator, facilitator, and mediator in learning from previously as a source of main information and to explain concepts. The new functions required the lecturer to be more creative, innovative, and professional.

Several studies indicate that there are pedagogical forms that are consistently succeeded in helping students to gain a deeper comprehension of 21st-century skills compared to other forms. Kubicek (2005) states that inquiry learning strategies could help in improving student understanding by actively involving them in a learning activity process; hence, achieving better concepts. Similar to Kubicek's study, Bilgin (2009) suggests that a student group that employs a guided-inquiry learning strategy has a better understanding of concept mastery. The guided-inquiry learning strategy allows the students to be actively involved using physical processes in finding for themselves several concepts and principles learned with the guidance of lecturers. With the learning strategy, students could find a concept through direct creativity; therefore, active communication occurs between lecturers and students. An inquiry learning strategy can develop the following skills, asking questions, assuming hypotheses, designing an inquiry, performing an experiment, processing data, evaluating results, and communicating the finding results.

Based on the above description, the research aims to find out the influence of the inquiry learning strategies on problem-solving skills and to what extent the contribution of the problem-solving skill aspects to the problem-solving skills.

METHOD

Research Design

The research is quasi-experimental research of 2x2 with a pretest-posttest non-equivalent control group design. The design is presented in Table 1. Steps in learning employed a guided-inquiry learning strategy.

Phases	Lecturer Activities	Student Activities
Phase 1: Present the problems	Describe problems to be solved by students	Solve problems provided by the lecturer
Phase 2: Collect data	Assist students in defining and organizing assignments related to the problems	Define and organize assignments related to the problems
Phase 3: Guide an inquiry	Motivate students to search for suitable information to perform an experiment in solving the problems	Search for suitable information to carry out an experiment in solving the problems

Phases	Lecturer Activities	Student Activities
Phase 4: Organize data and formulate explanations	Ask students to organize and formulate explanations to solve the problems	Organize and formulate explanations to solve the problems
Phase 5: Analyze and evaluate the problem-solving process	Guide students to analyze and give them an opportunity to ask more effective and productive questions	Analyze the finding results and ask more effective and productive questions

Steps in learning using a free-inquiry learning strategy

Phase	Lecturer Activities	Student Activities
Phase 1: Present the problems	Convey the learning objectives, motivate students by informing the context of the problem situations	Identify problems independently
Phase 2: Collect data	As a source, facilitate students by providing them with information sources	Find ways to solve problems by themselves
Phase 3: Conduct an experiment	Supervise the implementation of the self-designed experiments, provide tools and materials for the experiments	Collect information through the experiment activities and record them
Phase 4: Organize data and formulate explanations	As a source, ask students to discuss the experiment results in class and communicate the results to each other groups	Formulate the explanation to organize data and formulate explanations of problems, discuss the experiment results with other groups.
Phase 5: Analyze and evaluate the problem-solving process	Pay attention to students in the analysis and allow them to ask more effective and productive questions	Analyze the finding results and ask more effective and productive questions

Research Sample

The research sampling was carried out in two stages. The first stage was class selection using purposive sampling. Two homogenous classes were selected from the three classes (n = 105 students). Students in the classes had the equivalent academic ability. The stage was conducted by giving an essay test. The essay test results were analyzed using an ANAVA test. The two classes with the same test average were chosen as the research classes. The determination of experimental and control classes employed random sampling. A guided-inquiry learning strategy was applied to the first class (control class), whereas the second class (experimental class) used a free-inquiry learning strategy.

Profile of students who become the research sample

Gender	Class	
	Control	Experiment
Male	10	3
Female	24	33
Total	34	36

Research Instruments and Procedure

Instruments used in the research consisted of the syllabus, lesson plans, student worksheets, a rubric to measure problem-solving aspects, and a concept understanding rubric. The preparation of the syllabus, lesson plans, and student worksheets referred to the higher education curriculum guidance. The compiled documents were validated by two experts (Biology learning) with an average score of 89.90 (feasible and without revision). The results of the instrument validation are presented in the following table.

Validator	Score (60/32)		Criteria
	Teaching device (60)	Question (32)	
Validator 1	56	30	Very Feasible
Validator 2	52	28	Very Feasible
Average	54	31	Very Feasible

Data Analysis

Data of scores of the problem-solving skill aspects both in the control class and experimental class were tested for their normality (Kolmogorov-Smirnov) and homogeneity (Levene). If the normality and homogeneity tests were satisfied, multiple regression analysis was conducted using the SPSS for Windows 2010. Data of each score of the problem-solving aspects in the control class were compared to those of the experimental class.

RESULTS

GUIDED INQUIRY

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	X5, X2, X3, X4, X1[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Y

Model Summary

Model	R	R Square	Adjusted R	Std. Error of the

			Square	Estimate
1	.582[a]	.338	.220	9.6625 4

a. Predictors: (Constant), X5, X2, X3, X4, X1

ANOVA[b]

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1337.400	5	267.480	2.865	.033[a]
	Residual	2614.209	28	93.365		
	Total	3951.609	33			

a. Predictors: (Constant), X5, X2, X3, X4, X1

b. Dependent Variable: Y

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	27.534	13.441		2.048	.050
	X1	-.529	1.693	-.095	-.313	.757
	X2	-.171	1.491	-.028	-.114	.910
	X3	.664	1.074	.138	.618	.541
	X4	2.329	1.360	.421	1.713	.098
	X5	.882	1.138	.192	.775	.445

a. Dependent Variable: Y

Correlations

		X1	X2	X3	X4	X5	Y
X1	Pearson Correlation	1	.749**	.679**	.647**	.727**	.389*
	Sig. (2-tailed)		.000	.000	.000	.000	.023
	N	34	34	34	34	34	34
X2	Pearson Correlation	.749**	1	.533**	.642**	.544**	.348*
	Sig. (2-tailed)	.000		.001	.000	.001	.044
	N	34	34	34	34	34	34
X3	Pearson Correlation	.679**	.533**	1	.629**	.570**	.432*
	Sig. (2-tailed)	.000	.001		.000	.000	.011
	N	34	34	34	34	34	34
X4	Pearson Correlation	.647**	.642**	.629**	1	.680**	.559**

	Sig. (2-tailed)	.000	.000	.000		.000	.001
	N	34	34	34	34	34	34
X5	Pearson Correlation	.727**	.544**	.570**	.680**	1	.472**
	Sig. (2-tailed)	.000	.001	.000	.000		.005
	N	34	34	34	34	34	34
Y	Pearson Correlation	.389*	.348*	.432*	.559**	.472**	1
	Sig. (2-tailed)	.023	.044	.011	.001	.005	
	N	34	34	34	34	34	34

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Variable	Standardized Coefficients	Correlation Coefficients	EC (%)	RC (%)
X1	-0.095	0.389	-3.70%	-10.90%
X2	-.028	0.348	-0.97%	-2.88%
X3	.138	0.432	5.96%	17.59%
X4	.421	0.559	23.53%	69.44%
X5	.192	0.472	9.06%	26.74%
	Total		33.89%	100.00%

FREE INQUIRY

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	X5, X2, X3, X4, X1[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Y

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.793[a]	.628	.564	4.8902

a. Predictors: (Constant), X5, X2, X3, X4, X1

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1172.618	5	234.524	9.807	.000

					a
Residual	693.508	29	23.91 4		
Tota l	1866.126	34			

a. Predictors: (Constant), X5, X2, X3, X4, X1

b. Dependent Variable: Y

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	22.302	9.436		2.36 4	.025
	X1	1.112	1.012	.263	1.09 9	.281
	X2	1.647	.776	.378	2.12 2	.043
	X3	1.411	.666	.324	2.12 0	.043
	X4	.213	1.073	.038	.198	.844
	X5	-.628	.988	-.116	-.635	.530

a. Dependent Variable: Y

Correlations

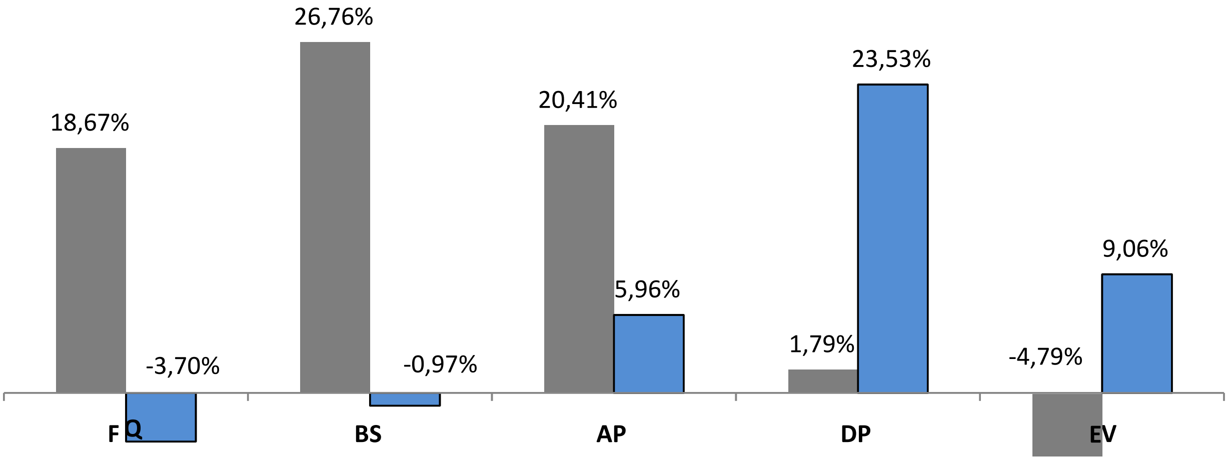
		X1	X2	X3	X4	X5	Y
X1	Pearson Correlation	1	.763**	.635**	.711**	.638**	.710**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	35	35	35	35	35	35
X2	Pearson Correlation	.763**	1	.490**	.475**	.405*	.708**
	Sig. (2-tailed)	.000		.003	.004	.016	.000
	N	35	35	35	35	35	35
X3	Pearson Correlation	.635**	.490**	1	.474**	.556**	.630**
	Sig. (2-tailed)	.000	.003		.004	.001	.000
	N	35	35	35	35	35	35
X4	Pearson Correlation	.711**	.475**	.474**	1	.748**	.471**
	Sig. (2-tailed)	.000	.004	.004		.000	.004
	N	35	35	35	35	35	35
X5	Pearson Correlation	.638**	.405*	.556**	.748**	1	.413*
	Sig. (2-tailed)	.000	.016	.001	.000		.014
	N	35	35	35	35	35	35
Y	Pearson Correlation	.710**	.708**	.630**	.471**	.413*	1
	Sig. (2-tailed)	.000	.000	.000	.004	.014	
	N	35	35	35	35	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Variable	Standardized Coefficients	Correlation Coefficients	EC (%)	RC (%)
X1	0.263	0.710	18.67%	29.71%
X2	0.378	0.708	26.76%	42.58%
X3	0.324	0.630	20.41%	32.48%
X4	0.038	0.471	1.79%	2.85%
X5	-0.116	0.413	-4.79%	-7.62%
	Total		62.85%	100.00%

COMPARISON CHART OF INQUIRY SKILL CONTRBUTION TO CONCEPT UNDERSTANDING



free inquiry ■ **guided inquiry** ■

Where: FQ = formulating question, BS = brain stroming, AP = arranging plan, DP = carrying out the plan, and EV = evaluation

DISCUSSION

The data analysis results indicate that there was an influence of problem-solving skill dimensions on concept understanding through inquiry learning strategies. In learning using the guided-inquiry learning strategy, the contribution of the problem-solving skill dimensions to the conceptual understanding was -3.7% for understanding the problem dimension, -0,97% for brainstorming, 5.96% for arranging a plan, 23.53% for carrying out the plan, 9.06% for result evaluation. In learning using the free-inquiry strategy, the contribution of the problem-solving skill dimensions to the conceptual understanding was 18.67 for understanding the problem, 26.76% for brainstorming, 20.41% for arranging a plan, 1.79% for carrying out the plan, and -4.79% for result evaluation. There was a difference in the contribution of the problem-solving skill dimensions in learning using a guided-inquiry strategy and a free-inquiry strategy. In the learning using the guided-inquiry learning strategy, the highest percentage was in carrying out the plan dimension, whereas in the free-inquiry learning strategy, the highest percentage was in the brainstorming dimension. The difference was because in the guided-inquiry learning strategy students were guided by the lecturer from the problem presentation phase up to the evaluation. The initial step in the guided-inquiry learning strategy is students are provided with a problem related to the content to be studied. The next process is students are guided from conducting an experiment until analyzing and evaluating the problem solving. Guided-inquiry learning presents problems, questions, and contents that are set by the educator so that students are motivated to conduct an inquiry to find solutions to the problem (Putra, 2016); hence students are less capable of expressing ideas in searching for solutions to problems given by the lecturer. Students are guided systematically to solve the problems and they cannot develop scientific thinking (Zion & Mendelovici, 2012). Consequently, the problem-solving and brainstorming dimensions are low. On the contrary, the arranging a plan dimension was high since students are guided in performing an inquiry that maximizes their inquiry activity. Sartono, et al., (2017) states that students' analysis thinking skills will be increasingly sharpened in the application stage. This is consistent with rikko, et al., (2018) suggesting that the application of a guided inquiry strategy increases concept implementation.

In learning with the free-inquiry strategy, students have the freedom to search for their own problem solving; hence, the brainstorming dimension is higher than those in the guided inquiry learning strategy. The first step of learning using the free-inquiry strategy is motivating students and conveying the contexts of the problem situations. Using various learning sources, students look for their ideas to solve problems. Students are required to think actively in preparing questions to be asked in formulating problems to gain data and information that will direct them to the next learning steps (Suryani & Sudargo, 2015; Ramayanti & Lismaya, 2019). This will lead to high problem-solving and brainstorming dimensions. Putri, dkk (2015) state that student independence was higher with the application of a free-inquiry learning strategy than with a guided-inquiry application. However, the dimensions of planning and carrying out research were low due to each research group having different ideas to find solutions to the problems (Erikko, et al., 2018). Sweca (2012) asserts that learning using a free-inquiry strategy drives students to be able to identify problems and design an inquiry. Students are encouraged to look for ideas and test the ideas independently. Therefore, the contribution of problem-solving skill dimensions to the conceptual understanding of each inquiry learning strategy is different.

CONCLUSION

Brainstorming in the free-inquiry stages had the largest contribution to the improvement of conceptual understanding, whereas in the guided inquiry the largest contribution was in the activity of carrying out the plan. In the free inquiry, each dimension tended to experience a decline. These findings contradict the score of the guided-inquiry dimensions that tended to increase.

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