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Profile of Student Problem Solving Skills Using Discovery Learning Model with Cognitive Conflict Approach

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Abstract: Instruction that focuses on remembering and understanding domains become one of the factors causing students' low ability on problem-solving skill (PSS) in physics. Discovery learning with a cognitive conflict approach becomes one of the solutions to solve this problem. This research aims at finding students' problem-solving skill improvement through discovery learning using the cognitive conflict approach. This research is a Research and Development. The lesson plan that has been developed was widely tried out in the two classes. Data collection of such improvement used to pretest and posttest result on problem-solving skill. The problem-solving indicators applied in this research refer to Docktor & Heller's indicator (2009), such as problems identification, physics description, and specific application of physics, mathematical procedure, and logical conclusion. Based on the N-gain analysis result, it was found that discovery learning using the cognitive conflict approach can improve students' problem skills. Moreover, the N-gain test result on every sub-material work, energy, work and energy conversion, and conservation of energy laws were included in the moderate and high improvement category. Likewise, every problem-solving skill indicator was included in moderate and high improvement categories.

Keywords: Discovery learning model; Cognitive conflict approach; Problem-solving skill

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Introduction

Physics is one subject that learns about the abstract concept of natural phenomena in our surrounding area (Anggara & Rifai, 2019; Gunawan et al., 2021). Physics learning demands educators to show the real natural phenomenon through observation or direct experiment so that students understand the whole concept comprehensively (Astra et al., 2015). It is expected that students show the attitude of achieving the physics learning objective. One of the indicators of learning objective achievements in physics is the ability to sort out problems or problem-solving skills (Huang & Asghar, 2016).

Problem-solving skills (PSS) are one of the high-level thinking skills one must possess (Funke & Greiff, 2017; E. Purwaningsih et al., 2020; Zhong and Xu, 2019). Problem-solving skill (PSS) is one of the competencies owned by students from an early age (Wahyu Widada et al., 2019; Akben, 2019). One of the 21st-century skills covers innovation and learning ability. Such innovative skills and learning emphasize the importance of sorting the problem or problem-solving skills (Juana Wu et al., 2019). Problem-solving skill (PSS) is crucial in one's daily life (Hasibua, et. al., 2019; Siswanto et al., 2018; Pandiangan, et. al., 2017). In physics subject, problem-solving skill (PSS) is a student's ability to solve problems using a physics concept (Putranta et al., 2021) with problems category presented to allow the student to analyze, synthesize, and evaluate (Ultay, 2017). Problem-solving skill (PSS) requires high-level skills (Selcuk et al., 2007) and the problems provided. In

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solving the problem, students must have knowledge and strategies to find the solution to such problems (Ince, 2018; Burkhard Priemer et al., 2019). Problem-solving skill (PSS) is highly needed by the student (Ibrahim, et al., 2017). Next, Yu et al., (2015) state that two types of knowledge required in problem-solving skills (PSS) are procedural and conceptual knowledge.

The importance of improving students' problem-solving skills (PSS) through the discovery learning model using the cognitive conflict approach motivated several reasons: students only focus on simple questions that do not require further analysis. Subsequently, students only make figure representation if they feel they have to solve the problems. This issue was also observed in research conducted by Ningsih, (2017) and Riyadi et al., (2021) 43.62% of university students have low problem-solving skills (PSS). The same research also carried out by Gunawan et al., (2020) resulted by 35.20%; Peranginangin et al., (2019) resulted by 50.70%; Jua et al., (2018) resulted by 42.10%; Yulindar et al., (2018) resulted by 40.65%. Furthermore, Akben, (2019) found low problem-solving skills (PSS) of students, where students already had decent skills in formulating problems (formulating) but were still lacking in interpreting, evaluating & applying.

Several aspects indicated student's low of such problem-solving skills (PSS), e.g. (1) only a few students who are willing to participate in conveying their opinion; (2) only a few students who participate in asking the question to the lecturer during the lecture; (3) if any student was asking a question, the question only on the level of knowledge and understanding and almost no student can asking questions on analysis and synthesis levels; (4) only a few students are willing to answer when the lecture ask a question; (5) even if a student is presenting material, only a few students respond and ask the question (Suhadianto, 2021).

The low problem-solving skill (PSS) of students is due to the learning tool application has not yet been optimized. In some schools, the learning tools have not involved students' active role and accommodates to improve problem-solving skills (PSS). In making the lesson plan, teachers do not fully understand the curriculum and have not designed the lesson conforming to the curriculum (Sukaesih et al., 2019). The other learning tools, such as student worksheets, have not accommodated students to master the lesson material and high-level thinking (Dewi et al., 2019). Additionally, the activities at school only focus on the domain of memorizing methods without further analysis of such problems. This problem aligns with Nisrina et al., (2017) research stating that in the school, physics lessons still focus on remembering and comprehension without requiring the student to explore further. Students lack articulating the strategy they used to solve the problems (Naylor & Keogh, 2013).

Based on the problems above, students' ability to solve problems needs to be improved. The proper lesson to accommodate the skill is by applying the discovery learning model. The discovery learning model is an instructional model designed to assist students in seeking and finding knowledge through involvement in learning (Pursitasari et al., 2019). This discovery learning model regards students as the active agent in the knowledge acquisition process (Bravo et al., 2002). Parallel with Balim's (2009) argument and the discovery learning model is the learning process that occurs when the learning material is not presented in its final form; instead, it expects the student to self-organize. This discovery learning model demands students' active role and involves students to discover a structured, analytical, reasonable, and critical concept so that they can formulate their discovery individually (Prilliza et al., 2020; Swaak et al., 2004). In a discovery learning model, students have the main task of gathering information; besides, they can also organize their learning (Festiyed et al., 2019; Nusantari et al., 2021). The Discovery learning model is a series of learning activities emphasizing students' ability to prove their hypothesis actively and independently through experimentation and observation (Hajian, S., 2021; Andayani S, 2020).

The Discovery learning model implies that students must be ready for their minds to study. Less intelligent students will encounter difficulties thinking or conveying the correlation between the knowledge they have so that eventually, it creates frustration (Fitri & Marlina, 2015). Hence, to achieve a student's problem-solving skill (PSS), the knowledge within the student self must be met with new information (confirm). According to Makhrus et al., (2014), when the knowledge within students conflicts with new information, the information is corrected with evidence in the learning process. Cognitive conflict is something that shows a discrepancy that occurs in a person's cognitive structure with his environment (information from outside) or between different components from one's cognitive structure (Zulkarnain, 2017; Hajian et al., 2021). Cognitive conflict is an essential factor required in the learning process, particularly during concept learning (Kang et al., 2004 & Jun-Young & Lederman, 2018). The cognitive concept is usually triggered by the discrepancy between students' initial concept with the new concept they learned. According to Bahtiar et al, (2016), the initial concept brought by the student is some scientific conceptions and misconceptions. Students were expected to confront their concept through the cognitive conflict approach and then replace this misconception with the correct scientific concept (Akmam et al., 2018).

The novelty of this research is that the discovery learning model using the cognitive conflict approach constitutes a discovery learning model by involving contradicting in the learning. The use of the discovery learning model combined with the cognitive conflict approach means that the stages of the discovery learning model are elaborated with the stages of learning the cognitive conflict approach. The advantages of the discovery model with a cognitive approach are: (1) students are able to solve problems well in the learning process, as well as in everyday life. Problem-solving is a student's first step in developing ideas in building new knowledge and developing science process skills; (2) students are directed to rediscover the concepts they have and facilitate students to conduct experiments to prove whether the concepts they previously had or were not true. In this process, students will be encouraged to think deeply and criticize their previous understanding of physical concepts. So that with the implementation of these activities, students will find and prove for themselves whether the concepts they create are in accordance with the concepts adopted by the researchers or not, of course, this is based on students' critical thinking skills.

Thus, the writers want to conduct research using the discovery learning model with the cognitive conflict approach. This research aims to determine students' problem-solving skill (PPS) improvement through discovery learning using the cognitive conflict approach. Therefore, the formulation of problems are as follows: Can a discovery learning model with a cognitive conflict approach improve students' problem-solving skills (PSS)?, Is there any significant difference between students' problem-solving skills (PSS) pre-and post-test using the discovery learning model with the cognitive conflict approach?, Is there any result difference in the N-gain score between sub-material work and energy?, and Is there any result difference in N-gain score among students' indicators problem-solving skills (IPSS)?

Method

Research Design

This research is a series of Research and Development. This research design uses One Group Pretest-Postest. This design was used to determine students' problem-solving skill (PSS) improvement after the learning. The learning implements physics learning tools of discovery model with cognitive conflict approach.

Sample / Participants / Group

The population applied in this research are students of grade X at Senior High School or similar throughout Mataram city. In this research, the sample was selected using the purposive sampling technique. This research samples were 75 students in grade X in two Senior High schools in Mataram city.

Instrument and Procedures

The discovery model-based physics learning tools with a cognitive conflict approach used in this study were the worksheets, syllabus, handouts, evaluation instruments, and lesson plans. In this research, data collection implements an instrument test of problem-solving skills (PSS). The instrument test applied consisted of eight essay questions. The data were collected from the student's problem-solving skill (PSS) initial and final tests (Rokhmat & Putrie, 2019). The problem-solving skill (PSS) indicators used in this research refer to Docktor & Heller's (2009): problems identification, physics description, physics specific application, mathematics procedure, and logical conclusion.

Analyzing of Data

The initial and final test results were analyzed using the N-gain score to determine students' problem-solving skill (PSS) improvement. The formula for N-gain is as equation (1).

$$N-gain = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} x100\% \quad (1)$$

After it was carried out the data analysis, it was continued with categorizing the N-gain result. The N-gain result categorization is presented in the following table. After it was carried out the data analysis, it was continued with categorizing the N-gain result. The N-gain result categorization is presented in the following table.

Table 1. Criteria of N-Gain Result

Interval	Criteria
g > 70	High
30 ≤ g ≤ 70	Medium
g < 30	Low

(Cheng et al., 2004)

Result and Discussion

N-Gain Test Results for Students' Problem-Solving Skill (PSS) in General

The data of the student's initial skill applied in this research was derived from the student's initial test result before conducting the treatment. Meanwhile, the data of final skill was obtained from the student's final test result. The data of students' initial test, final test, and problem-solving skill (PSS) N-Gain is presented in Figure 1.

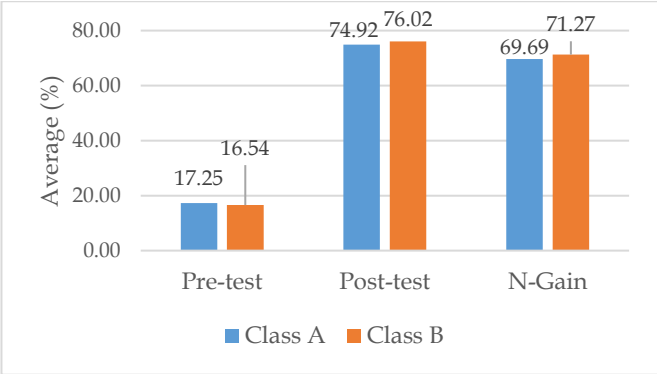

Figure 1. Comparison of Student's Initial Test, Final Test, problem-solving skill (PSS) N-Gain Average Score

Figure 1 shows that the average students' problem-solving skill (PSS) before conducting the treatment is 16.54 and 17.25. The average of students' problem-solving skill (PSS) after treatment improves to 74.92 and 76.02. This improvement is also observed in N-Gain average score, e.g., 69.69% and 71.27%. In these two experiment classes, the average students' problem-solving skill (PSS) improvement was included in the high category (70.48%).

N-Gain Test Results for Students' Problem-Solving Skill (PSS) in Every Sub Material

The problem-solving skill (PSS) data was also analyzed per sub-material to determine its improvement. The result is presented in the following Table of N-gain data of every sub-material.

Table 2. N-Gain Test Result for Student's Problem-Solving Skill (PSS) in Every Sub-Material

	Work	Energy	Work & Conversion of Energy	The laws of Mechanical Energy Conversion
Class A	76.79	58.18	71.22	72.66
Class B	68.01	70	69.67	82.07
Average	72.40	64.09	70.45	77.37
Criteria	High	Medium	High	High

Based on Table 2, it is observed that there are differences in N-Gain average score in each sub-material. The most considerable improvement is on work sub-material by 72.40%; meanwhile, energy sub-material occupies the lowest improvement by 64.09%. The average improvement of students' problem-solving skill (PSS) in every sub-materials is included in the medium and high categories.

N-Gain Test Results for Students' Problem-Solving Skill (PSS) in Every indicator

Indicators of problem-solving skills (IPSS) that are applied are problem identification (IPSS-1), problem description (IPSS-2), application of physics concepts (IPSS-3), mathematical procedures (IPSS-4), and drawing conclusions (IPSS-5). The results of the data analysis of students' problem-solving skills (PSS) on each indicator are presented in Figure 2 as follows.

Figure 2. Comparison of Problem-Solving Skill (PSS) Improvement in Every Indicator

Based on Figure 2, students' problem-solving skills in every indicator are different. The most considerable improvement is on the mathematic procedure indicator (IPSS-3), and the lowest improvement is the indicator of problems description (IPSS-2). Nonetheless, in each category, the improvement of students' problem-solving skills (PSS) is included to medium and high.

This research aims to determine students' problem-solving skills (PSS) using the cognitive conflict approach through the discovery learning model. The learning was carried out in three meetings in two experiment classes. The measured skill was the ability to solve problems consisting of five indicators. Before it was used, the expert validated the problem-solving skills (PSS) instrument and tested its empirical validity. The data on students' skill test results before and after treatment were obtained through the initial and final tests.

Based on Figure 1, it was observed that the average of students' problem-solving skills (PSS) before the treatment was categorized into a low level. This result is because the student has not learned the material of work and energy extensively, students' have not been accustomed to answering problem-solving skills (PSS) questions, and the students did not answer most of the questions provided. The final skill of the student after the treatment has a high average score. Based on the initial and final test data, it is observed that students' problem-solving skills (PSS) scores in both classes were improving on average. Students' problem-solving skills (PSS) score improvement is also observed from the N-Gain score, in which the value for both classes was included in the high category.

N-Gain score result on high category was caused by the implementation of discovery learning model using cognitive conflict approach in the learning. Through

discovery learning combined with contradicting problem presentation, students can find the right concept used to sort out the problems. This outcome is also strengthened by Simanjuntak et al., (2018) research, in which they concluded that students' problem-solving skill (PSS) N-Gain is higher when they are taught using a guided discovery learning model. The research conducted by Lubis et al., (2019) also states that the guided discovery learning model influences students' problem-solving skills (PSS) in mathematical problems.

Gusnidar et al., (2018) research conclude that implementing a cognitive conflict learning approach assisted Wingeom software can improve students' mathematical problem-solving skills (PSS). In addition, through the discovery learning model, students have more intense opportunities to solve the problems (Nurcahyo & Djono, 2018). It is found out that the discovery learning model can train students' specific skills both from content and ability aspects (Abrahamson & Kapur, 2018; Chase & Abrahamson, 2018). The discovery learning model is able to develop students' new ideas, such as developing thinking skills (Jatmiko et al., 2016; Siswanto et al., 2018; Chusni et al., 2021). Some other research investigates that the discovery learning model can improve students' problem-solving skills (PSS) (Wartono et al., 2017; Wartono et al., 2018, Yuliati & Munfaridah, 2018). This improvement can occur if the teacher's guidance follows the discovery process.

Students' problem-solving skill (PSS) is also analyzed based on work and energy sub-material. The problem-solving skill (PSS) improvement in every sub-material analyzed using the N-Gain percentage average was shown by Table 2 in the medium and high category. This improvement outcome is parallel with the study by Gunawan et al., (2020), revealing that students' problem-solving skills (PSS) in every sub-material of work and energy ranks medium and high category. Nisyah et al.'s (2020) research also show that each work and energy sub-material encountered a significant increase. The application of the discovery learning model with the cognitive conflict approach is very suitable. Students are directed to excavate their misconception again and accommodate students to experiment to prove whether their concept absorbed is correct or not (Lestari et al., 2019). Parwati et al, (2019) add that the cognitive conflict approach can make students feel satisfied with their learning.

The analysis was also carried out on problem-solving skills (PSS) improvement based on the indicators of problem-solving skills (IPSS). Figure 2 shows that the problem-solving skills (PSS) improvement category indicator which gets a high score is IPSS-1 and IPSS-3. These indicators are problem identification and specific application of physics concepts. The researchers define problem identification as students' ability to make a list of quantities they know, and quantities asked in the questions. Meanwhile, the specific application of the physics concept is the student's ability to determine the correct equation to solve the problems. In the learning process, students were accustomed to working on student worksheets in the group this worksheet, students were commanded to understand, state the known and asked in the question, and conduct experimentation as one of the forms of physics concept application. This indication is strengthened by Lin & Singh, (2013) mentioning that one of the crucial components in physics problem-solving skills (PSS) is the identification of relevant physics principles contained in the problems or questions. Additionally, the research conducted by Yazid and Suprapto, (2018) shows that IPSS-1, problem identification, is included in the high category.

Figure 2 reveals three indicators of problem-solving skills (IPSS) with medium category, i.e., IPSS-2, IPSS-4, and IPSS-5. This outcome is because the student did not involve the influential component toward each IPSS component. In addition, students have difficulty making good representations in graphic shapes, diagram shapes, or verbal during learning or during problem-solving in the test. This research outcome is also strengthened by Gunawan et al., (2020), conveying that the indicator of problem-solving skills (PSS) is improving, but the slightest improvement is IPSS-2. Problem-solving skill and producing something new is complex activity closely related to each other (Zunanda & Sinulingga, 2015). In understanding the problem, students are expected to identify the known and asked elements and the adequacy of the necessary elements (Riyadi et al., 2021). After passing several problem-solving activities, students become more aware of the ongoing thinking process and the requirement to solve the problems (Osman, 2010).

Problem-solving skill (PSS) improvement in every indicator was because the learning is student-centered, and they are instructed to find the answers to such problems or questions so that students explore deeply to solve the problems at hand. In discovery-based learning, students are required to do various activities such as gathering information, comparing, analyzing, and concluding information they got (Irmita & Atun, 2018). Moreover, at the beginning of learning, students in both classes were given a stimulus in the form of contradictory problems, followed by activities in student worksheets and handouts. This treatment intended for students to understand the concept to make students' understanding more comprehensive and eventually improve students' problem-solving skills (PSS) toward every indicator.

Conclusion

Implementing discovery model-based physics learning tools using a cognitive conflict approach can improve students' problem-solving skills (PSS). This outcome was reflected from the N-Gain score result of students' problem-solving skills (PSS), which ranks in the high category. The average students' problem-solving skills (PSS) scores before the treatment were 16.54 and 17.25. Meanwhile, the N-Gain test result on every sub-material of work, energy, work & energy conversion, and conservation of energy laws was included in medium and high improvement categories. Likewise, every indicator of problem-solving skill (IPSS) was included in medium and high improvement categories.

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