

# Analysis of Dynamic Fluid Problem-Solving Ability in Prospective Physics Teacher

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**Abstract:** This research is focused on analyzing the problem-solving ability of Malang State University students who have taken the basic Fundamental of Physics I course, especially fluid dynamics. The research method used is mix methods model explanatory sequential the method and design used mixed qualitative methods to support quantitative data. Identification uses an instrument in the form of 7-item questions with rubrics or stages of Doctor-Heller problem-solving. The results showed the Usefull Description was 76.10%, Physics Approach was 52%, Specific Application of Physics was 49.09%, Mathematical Procedure was 40.00%, and Logical Progression was 24.94%. In the grouping of problem-solving abilities, 9.09% or one student is in the expert problem-solving ability category, 18.18% or two students are in the proficient category, 27.27% or three others are competent, and 18.18% or two students are in the Advance beginner. Some students are still classified as a novice by 27.27% of the remaining respondents. The student's ability to work on sub-topic items showed that the percentage on the principle of continuity of the relationship between flow velocity and cross-sectional area was 61.81%, the application of the principle of continuity was 58.18%, Bernoulli's equation on the relationship between flow velocity and fluid pressure was 39, 64%, the relationship of flow velocity, cross-sectional area, and height of 45.82%, application of Bernoulli's principle to leaky tanks or Toricelli's theorem of 56.73%, application of Bernoulli's principle to venturi meter tubes of 38.91% and application of Bernoulli's principle to pitot tubes by 37.82%. Although this study only focuses on case studies of students' ability to solve problems according to the Doctor-Heller indicator with interviewees who have difficulty solving problems with novice abilities, suggestions for future research researchers can interview all subjects related to obstacles that occur when doing or conducting research classroom actions.

**Keywords:** Doctor-Heller Problem Solving Ability, Students.

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## Introduction

Physics is one of the branches of science that ideally can provide experience to students in studying and solving various problems (Serevina 2018). Its characteristics containing many mathematical representations make physics quite abstract, so it requires strict problem-solving skills (Pal and Rinki 2022). The importance of problem-solving in the physics learning process makes a significant contribution, especially when individuals carry out further studies, including playing a role in developing students' creative thinking and consolidating theoretical knowledge (Olimbojevich 2022). Problem-solving skills are

not only important for physicists but also have a role for prospective physics teachers because they enable them to recognize, understand and combine various concepts to have intelligence in solving physics problems (Good et al. 2018). Moreover, the demands of the 21st century make problem-solving skills one of the indispensable skills, although so far this ability has not shown a significant increase when implemented with a learning model (Agustoni, Suratno, and Suparti, 2021).

Problem solving skills are defined as the ability to solve problems using effective methods without any obstacles (Kiong 2022). These problem-solving skills can be used to analyze the causes of a problem which are then used to develop solutions

that can be implemented, even though these abilities are considered separate skills and must be complemented by various other skills, such as conceptual understanding, critical thinking, and higher-order thinking. (Choudhar 2022). Situations and real life associated with 21st century work require graduates with problem-solving competencies in an unfamiliar and challenging environment, so that students have the demands of skills with various kinds of problems (Iwuanyanwu 2022).

Although problem solving skills are important to be mastered by students, the results of research conducted by a number of students in Indonesia, show that students' initial problem solving abilities on dynamic fluid topics are very low (Handayani and Simamora 2019; Makrufi, Hidayat, and Muhardjito 2018; Rahmatsyah 2020). The fluid topic is a subject that is closely related to everyday life. A number of students also showed that their problem-solving abilities were less than optimal with the results of research that found students working on a problem according to the example and not continuing when experiencing difficulties (Aji, Hudha, and A Rismawati 2017). Some of the causes of the low problem-solving ability of students, among others, 1) Knowledge that has not been well conceptualized, or the knowledge still depends on the context, 2) The lack of a portion of problem-solving exercises and tends to memorize mathematical equations ; 3) Mathematical ability low; 4) Learning resources have not been integrated with technology, thus making learning less in line with the times; 5) There are difficulties in understanding problems and planning solutions that will be used in problem solving (Bao and Koenig 2019; Rahmatullah and Tamami 2022; Ratnaningdyah 2017; Reddy 2017; Sartika and Humairah 2018).

The solution to overcome the lack of problem-solving abilities that have been carried out by previous researchers is the use of *causalitic learning-models* and PjBL. *Causalitic learning-model* is a sequence of learning activities that are oriented to guide students in developing analytical skills

through the causes and effects of a phenomenon and followed by the preparation of arguments in explaining the causes of phenomena to produce each determined effect (Rokhmat et al. 2020). While PjBL is a project-oriented learning model that is proven to improve problem solving abilities (Makrufi et al. 2018). Both solutions contain problem-solving indicators, such as problem description, selection of physics concepts, linking several physics concepts, mathematical procedures, and solutions to logical problems.

From the results of several literature studies and previous research, it was found that problem-solving skills were not maximal and still low, especially in dynamic fluid materials (Aji et al. 2017; Handayani and Simamora 2019; Makrufi et al. 2018; Rahmatsyah 2020)]. The learning that has been done is considered to lack emphasis on concepts, practice problem solving, practice low memorization and mathematical skills, and the absence of adequate learning resources for problem solving abilities, making it difficult for students to understand problems and find appropriate solutions (Bao and Koenig 2019; Rahmatullah and Tamami 2022; Reddy 2017; Sartika and Humairah 2018). Therefore, it is important to recognize problem-solving abilities in the learning process in lectures to design effective learning.

## Materials and Methods

### Study area

This research is focused on analyzing students' difficulties in solving a problem related to dynamic fluid material. This study uses 7 descriptive questions that are used to reveal students' difficulties using the Doctor-Heller indicator. Indicators of problem solving ability include *Useful Description, Physics approach, Specific application of physics, Mathematical procedure, and Logical progression* (Dockett and Heller 2009). These questions are a description of the 7 subtopics presented in the table 1.

**Table 1.** Problem Solving Subtopic Distribution

Subtopic	Item
Principle of Continuity (relationship between flow velocity and cross-sectional area)	1
principle continuity (application of the principle of continuity)	2
Bernoulli's equation (relationship between flow velocity and fluid pressure)	3
Bernoulli's equation (relationship of flow velocity, cross-sectional area and height)	4
Bernoulli's equation (application of Bernoulli's principle in leaky tanks or torricelli's theorem)	5
Bernoulli's equation (applying Bernoulli's principle to a venturimeter tube)	6
equation (application of Bernoulli's principle to a pitot tube)	7

### Procedures

This research is a descriptive research type. This research method uses mixed methods with an *explanatory sequential* in which this research combines two qualitative and quantitative studies systematically. The mixed methods design of this research combines quantitative and qualitative research methods in a coherent manner. The first stage uses quantitative methods in the form of data and numerical results, then in the second stage uses qualitative methods in the form of data and text results. This research design has a character where quantitative data and results are more important than qualitative data and results. Therefore, the qualitative method becomes a support in explaining the complete quantitative data obtained (Agus Kurniawan 2021; Rokhmat et al. 2020)

### Data analysis

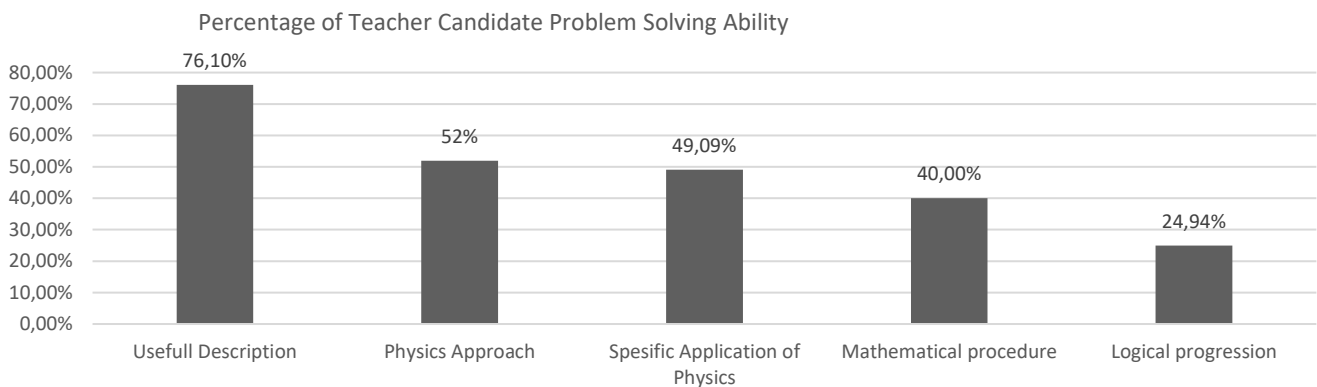
The questions used are problems with complex problem-ability answers rubrics adapted to the Doctor-Heller indicator. The test questions are structured in such a way as to identify the process problem solving abilities experienced by students when studying dynamic fluids. This makes the difficulties experienced by students during tests both at the problem-solving ability stage and the

proposed sub-topic. In addition, there are interviews conducted to consider the difficulties experienced by students.

### Results and Discussion

This study uses a quantitative description using mixed methods. The purpose of this study was to find out the difficulties of students in solving problems on dynamic fluid materials according to the one developed by Doctor-Heller. The research subjects in collecting data were students of the Department of Physics, State University of Malang who had followed the Basic Physics 1 course. Data collection was carried out in the 2022 lecture mass distributed using the google form link

This study focuses on analyzing student difficulties in solving problems on dynamic fluid problems. Students' problem solving difficulties are obtained through the questions given. This study uses 7 descriptive questions that are used to reveal the difficulty of problem solving abilities in dynamic fluid materials. The sub-topics used are as shown in Table 1. Data analysis used quantitative descriptive. The extent to which students understand the problem and find a solution will be reviewed in detail for each item.



**Figure 1.** Percentage of Problem-solving Stages.

**Table 2.** Percentage Distribution Classification of Problem-Solving Ability Physics Department Students.

Classification	Presentase
Expert	9,09%
Proficient	18,18%
Competent	27,27%
Advanced Beginner	18,18%
Novice	27,27%
Naive	0%

**Table 3.** Percentage Distribution of Problem Solving Ability for each Subtopic.

Subtopic	Percentage
Principle of Continuity (relationship between flow velocity and cross-sectional area)	61,81%
principle continuity (application of the principle of continuity)	58,18%
Bernoulli's equation (relationship between flow velocity and fluid pressure)	39,64%
Bernoulli's equation (relationship of flow velocity, cross-sectional area and height)	45,82%
Bernoulli's equation (application of Bernoulli's principle in leaky tanks or torricelli's theorem)	56,73%
Bernoulli's equation (applying Bernoulli's principle to a venturimeter tube)	38,91%
equation (application of Bernoulli's principle to a pitot tube)	37,82%

### The results of students' problem-solving abilities are seen from the Doctor-Heller stages

At the *useful description* percentage is 76.10%, overall students can be said to be good at organizing problems symbolically and visually with various representations of the problems that have been given. The problem-solving ability of students at the *physics approach* obtained a test percentage of 52%, this indicates that the student's ability at the *physics approach* is quite good. Some students are quite capable in determining the physics concepts that will be used in solving problems, although some are wrong or only use one concept which should require collaboration of

two or three concepts and some are unable to determine which concept will be used in solving the problem. Students' problem-solving abilities at the *specific application of physics* obtained a percentage of 49.09%, the ability of students majoring in physics can be classified as quite good. At the *specific application of physics*, some students are able to apply and connect existing physics concepts or principles as well as the *Physics Approach*, the rest there are those who stop in the middle of the road or are unable to work. The next ability *Mathematical procedure* obtained a percentage of 40.00% which is the ability of *Mathematical procedure* can be said to be less good.

Some students are able to execute and choose procedures or follow mathematical rules in solving problems of some of the items given, but more are wrong or even unable to work at the problem-solving stage. Finally *logical progression* was obtained by a percentage of 24.94% which showed that the student's ability at that stage was still not good. In the process of delivering results and evaluating student solutions, it is low because most students stop at the ability stage before *logical progression*, such as in the *specific application of physics* and *mathematical procedure* stages.

The biggest problem solving ability is at the *Useful Description*, followed by *specific application of physics*, *Physics Approach*, *Mathematical procedure skills* and the lowest is *logical progression*. In contrast to research (Misbah, M., Hafizah, E. and An'nur 2017) where *Mathematical procedure* is the stage with the highest percentage of 76.11% followed by *specific application of physics* (69.17%), *Physics Approach* (61.25%), *logical progression* (49.3%) and lowest *Useful Description* (40,14). The three stages are classified as good and the other two are sufficient with the suggestion that the learning process must be problem-based to deal with this problem.

The data in Table 2 shows that abilities are naive. However, as many as 18.18% of research subjects or 2 students of physics education at the State University of Malang have proficient problem-solving abilities. 27.27% of the total research subjects or 3 students classified as *competent* and 18.18% or 2 other students in the *Advanced beginner*. There are still students who are classified as *novice* by 27.27% or 3 of the remaining respondents.

From interviews conducted to several research subjects, students who were classified as *novices* experienced difficulties starting from the *specific application of physics*, *Physics Approach* to the *Mathematical process* so that they did not find the final result which did not reach the *logical progression*. Students who are novices are also not sure of the answer. Some students admitted that they did not memorize basic formulas such as continuity equations and Bernoulli's law so they could not formulate the application of dynamic fluids, especially the sub-topic concepts of

Torricelli's theorem, venturimeter, and pitot tube. Another factor besides not understanding the concept of dynamic fluid and memorizing the continuity equation and Bernoulli is also the difficulty of students analyzing the meaning of the problem so that they do not know the direction of solving the problem. Students also claim to be able to work by matching known formulas to existing quantities later, checking again the calculations without paying attention to the correctness of the concepts that have been chosen in solving the given problem. Therefore, dynamic fluid learning needs to apply learning that implements problem solving so that students are able to solve existing problems.

#### **The results of the percentage of achievement of each indicator of the achievement of the sub-concept of dynamic fluid material**

As in Table 3, the data analysis is obtained as follows. In the sub-topic of the principle of continuity (the relationship between flow velocity and cross-sectional area) contained in problem 1 with a percentage of 61.82% which is the biggest achievement of students. Of the 11 respondents, 7 students worked until the end and only 4 students answered the questions correctly according to the stages of solving the Doctor-Heller problem. At the *Useful Description*, students are able to state the existing quantities and unit conversions, but many are constrained in the *specific application of physics*, *Physics Approach* and *Mathematical process* so that most of them do not complete or get wrong answers at the *logical progression*.

In the sub-topic of the principle of continuity (application of the principle of continuity) contained in question number 2 with a percentage of 58.18%. There were 9 out of a total of 11 students who were able to do it until the end and 2 students did it correctly according to the Doctor-Heller problem solving. There are still 3 students who have not been able to work until the end. The average student is only able to answer correctly until the *Physics Approach* then declines at the stage of *specific application of physics* so, experiencing difficulties at the stage of *Mathematical process* and *logical progression*.

The next sub-topic related to the Bernoulli equation (relationship between flow velocity and fluid pressure) obtained a percentage of 39.64%. This subtopic is in question number 3 with 5 students who managed to work until the final stage even though there was no correct answer. On average, students are only able to do 3 stages of the Doctor-Heller problem-solving stage in the form of *Useful Description*, *Physics Approach* and *specific application of physics*. This subtopic in number 3 is one of the sub-topics that need to be emphasized again to students.

Next, in the sub-topic of the Bernoulli equation (relations of flow velocity, cross-sectional area and height) contained in number 4, the percentage is 45.82%. There are 5 students out of 11 who are able to work until the end of the *logical progression stage*. On average, students are able to work up to the stage and *specific application of physics* and start making mistakes in the *Mathematical process*.

The next sub-topic, Bernoulli's equation (application of Bernoulli's principle in leaking tanks or Torricelli's theorem) contained in question number 5 obtained a percentage of 56.73%. There are 7 students who can work until the end with 3 of them able to answer correctly according to the Doctor-Heller stage. However, there are still 4 students who did not reach the final stage (*logical progression*) and stopped at the previous stage.

Next, related to the sub-topic, the Bernoulli equation (application of Bernoulli's principle on the venturimeter tube) contained in question number 6 obtained a percentage of 38.91%. There are 3 students who are able to work to the end but only 1 is almost right according to the Doctor-Heller stage. On average, students are only able to do the *Useful Description*. Most students are confused about what principle or equation to use, so many do not answer or stop in the middle of the road.

Finally, related to the sub-topic of Bernoulli's equation (application of Bernoulli's principle on Pitot tubes) which is found in question number 7. In this sub-topic, the percentage is 37.82%. This subtopic is the one with the lowest score compared to the others. There were 4 students who did it until the end with 2 of them answered correctly according to the Doctor-Heller stage. Therefore, the understanding of the application material of

dynamic fluids such as pitot tubes and so on needs to be improved.

### Discussion

The suggestions from previous research can be by 1) giving sufficient assignments on each topic and recruiting educators with good quality, 2) In classroom learning, lecturers can give mock tests before the final exam, prepare and run a detailed Blueprint on physics. 3) Prepare a resume related to the main topic along with solving physics problems. 4) It is necessary to emphasize explanations on basic equations that can be used in solving physics problems. 5) The need to provide a good textbook with an emphasis on problem solving. 6) Provide tutorials in an organized manner about solving problems easily when there are problems. 7) Revise key topics and fundamentals in math and physics skills. In addition, it can use learning that can improve problem solving such as *causalitic learning-model* and PjBL (Makrufi et al. 2018; Rokhmat et al. 2020) In preparing learning instruments that focus on practicing problem solving skills, it is necessary to consider the existing suggestions so that learning can maximize all student problem solving abilities. Existing learning must certainly provide the experience of academic knowledge and gradual procedural skills as well as the stages of Doctor-Heller problem solving. Thus, students are able to maximize all their problem-solving abilities and can meet the demands of the times.

This research is only to find out how far the problem solving ability of students of the Department of Physics, State University of Malang from each stage has been formulated by Doctor-Heller. Furthermore, this research also finds out the grouping of student indicators in solving dynamic fluid problems along with sub-topics that are easy for students to work on and difficult to solve. In interviews that have been carried out only asking students with novice abilities regarding what obstacles they face when working on the items that have been given. Further research is expected to find out each student's problem from all indicator groups as well as the need for classroom action research by providing actions as suggested, such as using learning models,

improving the quality of existing teachers, and providing various tasks that implement problem solving abilities.

### Conclusions

From the analysis of the power obtained, it can be concluded that the dynamic fluid problem solving ability of students measured from the Doctor-Heller stage is still relatively weak. Most students have the highest score in the Useful description stage and decline in the next stage. Students are able to write down what is asked and are known both symbolically and visually by converting the required units, but at the specific application of physics stage, some students in answering certain items are confused about the concepts and principles of physics used. Then, in the Physics Approach stage, many Mathematical procedures find it difficult to apply or connect the concepts and principles used, and make mistakes or stop in the middle of the calculation. This makes students unable to reach the stage of Logical Progression. Only a few can solve the problem to the end of the various items that have been given.

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