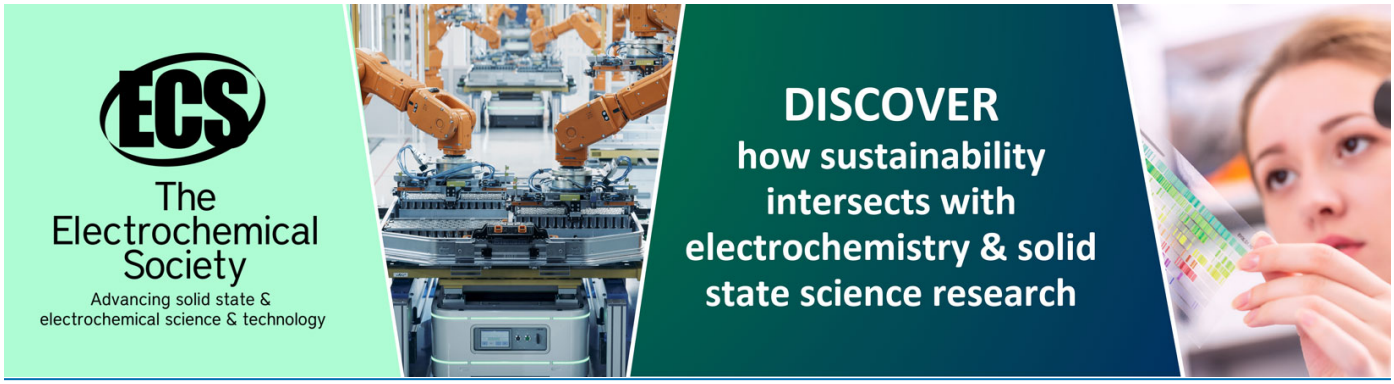
The scientific argumentation profile of physics teacher candidate in Surabaya



The scientific argumentation profile of physics teacher candidate in Surabaya

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Abstract. The ability of scientific argumentation is an essential factor that must be mastered by physics teacher candidate as a requirement in explaining good and accurate scientific concepts. In the process of arguing, students develop explanations or persuade colleagues to support their hypotheses, express doubts, ask questions, relate alternative answers, and confirm what is unknown to develop the ability to provide rational and scientific explanations. The design of this research is descriptive qualitative with the subject of research is 20 undergraduate students of Physics Education Department in Surabaya. The research instrument consists of four casuistic questions related to the concept of kinematics. The argumentation pattern of physics teacher candidate is coded using Toulmin's argumentation pattern. The results show that the student's ability in providing scientific argument is at the level of providing claims with the support of a weak warrant. The students are not able to provide excellent rebuttals. In each case given, the student can give a good claim statement in answering the questions. However, the concept used to support the claim is not correct. This case causes the warrant used to support the claim is weak. Students also do not analyse other facts that affect the system. Students have not reached a higher level because the understanding of physics is not deep enough.

1. Introduction

As a branch of the natural sciences, physics has an important role in explaining natural behavior and predict the possibility of changes in the universe. Therefore, the study of physics cannot be solved only through a set of mathematical formulas, but also rather requires a scientific explanation. This explanation includes supporting the empirical facts, analyzing the fact, and verifying the truth [1]. To explain a natural phenomenon with an accurate and reliable scientific explanation, the physics teacher must have good scientific argumentation ability. The ability of the argument must be based on scientific thought and must be supported by empirical evidence.

The ability of physics teachers to explain the concept of physics is needed because many students are still having difficulty in learning physics. From previous research, the greatest difficulty of students in learning physics is understanding the physical concept of the topic[2]. Mentioned in other research [3], one of the problems in learning physics is the students just memorise the formula without deep understanding concepts. Also in the same paper mentioned that most of the students feel challenged to learn more about physics. That, because they know concepts of physics are easy to find in daily life.

Educating a good teacher who has an excellent scientific competence requires good critical and reflective thinking skills. One way to accelerate this ability is by equipping the power of good scientific argumentation. As a prospective teacher, physics education program students also should be

able to explain the physics topics to learners. The ability to provide rational and scientific explanation can be developed through the habituation of arguing [4]. While the scientific argumentation ability can be improved in various ways. The physics teachers candidate who is weak in scientific argumentation ability must learn more and deeply to improve their ability[5].

One of material physics that requires good scientific argumentation from the students is kinematics concept. The subject of kinematics is quite easy to apply because its physical phenomena are often encountered in everyday life. The mastery of a kinematics concept that can be reflected in the physical implementation is needed to be owned by physics teacher candidate students so that their knowledge is not limited to using the formula to solve mathematical problems only [6]. The ability to solve kinematics problems correctly is not enough for physics teacher candidates [7]. It needs precision analysis through scientific argumentation in explaining the concept. Therefore, research on the ability of physics teacher candidates in scientific argument needs to be done, especially on kinematics material.

2. Related Studies

2.1. Scientific Argumentation of Physics Teacher Candidate

Arguments are a strategy for explaining the concept. Argumentation comes from rational thinking and critical thinking. The argumentation process enables the student to process the explanation to support their opinion, to invite or persuade colleagues to support their opinion, to express doubts, to ask questions, to relate alternative answers, and to analyses the interrelationships between concepts that affect a particular physical system [8]. Also, through the process of argumentation, there is a social interaction between the personal and the social dimensions that can ultimately lead to a wider and deeper development of knowledge [9].

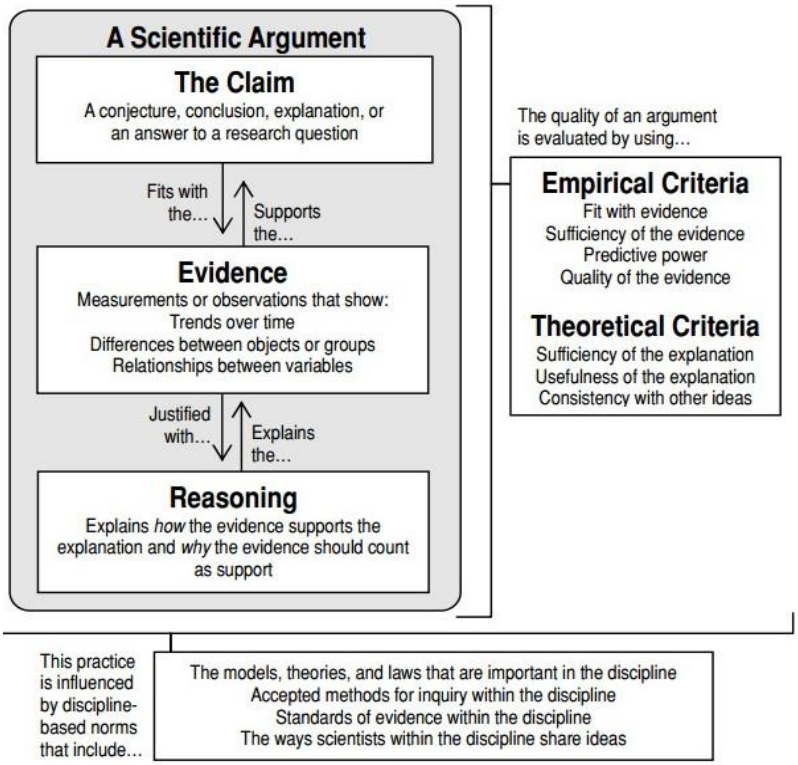

Figure 1. Illustration of the components that build scientific argumentation [11].

In the era of technology and ASEAN Economic Community challenges, physics-minded students must take on the role of being actively involved in the latest issues related to science. One of the skills

a physics teacher should have is to argue scientifically "well" and appropriately using evidence in explaining and testing their opinion [10]. The scientific argument requires the analysis of critical thinking based on logical evidence and reason to substantiate a claim. The illustration of the components that explain a scientific argument well processed is presented in Figure 1.

2.2. Toulmin Argumentation Pattern (TAP)

There are researches on the argument in the learning process have been done. One of the studies was Toulmin's (1958) research on Okumus [1] which produced the following model of argumentation capability.

Table 1. Toulmin Argumentation Pattern [1].

Term	Description
Data	Facts, based on reality, used to prove claims.
Claim	The statement used to answer a problem (hypothesis).
Warrants	Describing the relationship between data and claim. Warrants explain how data support claims.
Qualifiers	The expression of the degree of certainty and uncertainty of an argument, such as the use of the word "possibility", "dependent", and "certain".
Rebuttals	Counter-arguments or statements used when a claim is not accepted.
Backing	Assumptions that support the acceptance of warrants. The backing is needed if the warrant is not acceptable.

Osborne [12] mention that the claim given by the student is the most important factor in argument construction. This is because the claim is the first foundation given by students in building great argumentation. The simplest argument is an argument that consists of data and claims only, whereas complex arguments are arguments that contain rebuttals. Arguments that have rebuttals are the best arguments. Students have to use complex analytical skills which are relating concepts that influence the claims given to form rebuttals. This causes the use of arguments consisting of data, claims, warrants, backing, and rebuttals have a positive impact on learning [1]. The division of argument levels based on Erduran, Simon, and Osborne [1] is presented in the Table 2.

Table 2. The TAP Argument Level was developed by Erduran, Simon and Osborne [1].

Level	Characteristic of the Argument
Level 5	Extensive arguments with more than one rebuttal
Level 4	Arguments with a claim with a clearly identifiable rebuttal. This argument may also have multiple claim and counter-claims.
Level 3	Arguments in the series of claims or counter-claims with data, warrant, or backing are sometimes accompanied by weak rebuttal
Level 2	Arguments consist of data, claims, warrant, or backing, but without rebuttal Osborne advocated further distinction at this level: Level 2B - arguments consist of claims supported by more than one data, warrant, or backing, but without rebuttals Level 2A - arguments consist of claims supported by data, warrant, or backing, but without rebuttals
Level 1	Simple arguments in the form of claim and counterclaim or claim versus claim

3. Method

This research used survey research method. Surveys are research methods to check and to measure the empirical symptoms that take place at the location of study. The survey method was conducted on the sample units faced as respondents and not the entire target population.

3.1. Subject of the Research

The subject of this research is 20 students of the Physics education program in Surabaya. The first-year students are chosen because in the first semester they have studied kinematics material. They are students who are prepared to be prospective teachers with adequate pedagogy and scientific skills.

3.2. Research Design

The implementation of this research is done gradually by the research flow in Figure 2.

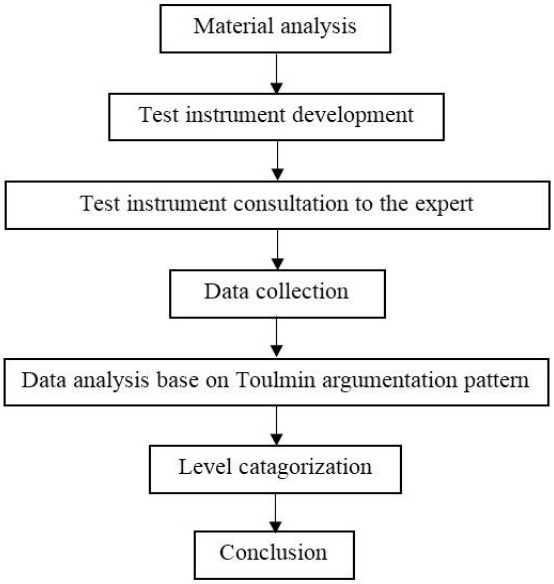

Figure 2. The scheme of research implementation.

The first step that researchers do is analyse the concept of kinematics material that became a topic in this study. Furthermore, researchers made a test instrument adapted from physics book [13]. The test instrument is then consulted to the expert who explores the field of assessment. Collecting data in this research is by test instrument and interview. The results of the data then analysed and categorised based on Toulmin's argumentation pattern.

3.3. Data Collection Technique

Data collection technique in this study used the test instrument in the form of four description questions adapted from [9]. The four questions of the description contain matters of kinematics concepts related to the free fall motion chapter, upward vertical motion, and parabolic motion which requires good argument in solving them. Besides that, the researcher also conducts direct questioning to the students to ensuring the answers and conceptual knowledge of students.

3.4. Data Analyze Technique

Data analysis technique used in this research is quantitative descriptive analysis technique. Data related to the students' scientific argument are analyzed by using an observer rubric adapted of Toulmin. The data that had been analyzed categorized into the level of argumentation developed by Erduran, Simon, and Osborne.

4. Results and Discussion

Student's scientific argument profile is analysed based on the answers given by 20 physics education program students in the Surabaya area on four questions about casuistic essay related to kinematics material. The pattern of argumentation is analysed by Toulmin's argumentation pattern which is then categorized into levels as shown in Table 2. Toulmin's argumentation pattern consists of Claim (C), Data (D), Warrants (W), Qualifiers (Q), Rebuttals (Q) and Backing (B). Student argumentation patterns consisting of Data (D) and Claim (C) are marked C-D, whereas if student argumentation pattern is Data (D), Claim (C), Warrants (W), and Rebuttals (R) then marked D-C-W-R.

The following is a description of the mapping of ability profile of physics teacher candidate in giving scientific argumentation. The first question discusses the concept of instantaneous velocity and average velocity on three kinds of motion. The first question used in this study is:

Question 1

Based on the following phenomenon, give your argument and analysis. Is there an object that has an instantaneous velocity equal to the average velocity at a particular point as long as the object moves?

A. A ball is thrown vertically upward until it reaches its highest point then falls back into the hands of the thrower.

B. A racing car moves from the rest to achieve a speed of 100 m / s.

C. Spacecraft in space that travels at constant speed.

Student responses to the above questions are very diverse. Most students provide clear claims that three phenomena have the same average speed as the instantaneous speed at a certain point along the moving object. However, the claim is not supported by the correct data, so the warrants become weak. The majority of students are only able to reach a level 2B; the argument consists of claims, data and a simple warrant (C-D-W). Others are only able to provide arguments at level 1 that contains claims and data (C-D). The simple argument at level one presents data with a claim without a clear relationship to support the data already mentioned in the claim given.

The weak argumentation given by the students for the above case is due to the concept of instantaneous velocity, and average speed are often given separately. Students are accustomed to being given a matter of instantaneous velocity or on average speed only. So when the students are given a phenomenon in which both concepts involve, students are confused to identify data that support the given opinion. Through simple interviews of some students who became subjects in this study, the authors can provide conclusions that students are accustomed to the problem related to the average speed and instantaneous speed in the form of mathematical calculations without adequate physical explanation.

The second question is related to the concept of free falling motion of two skydivers as follows:

Question 2

In the case of a skydiver who flies from the plane, the first skydiver jumps from the plane. Later, the second skydiver jumps so that both of them move freely in the vertical direction. Give the argument and analysis whether:

A. During free-fall motion, their speed at all times is the same.

B. During free-fall motion, their speed is different at any time.

C. During free-fall motion, both skydivers always have the same distance until landing on the ground.

The argumentation pattern given by the student for this case is better than the argument given in the first case. In this phenomenon, the student has been able to explain the concept that although the motion experienced by skydivers are uniformly accelerated motion, the acceleration owned by each skydiver are equal that is the earth gravitational acceleration. So, the skydiver who jumped first always has greater speed. This is then increasing separation between the two skydivers. Students have also been able to provide rebuttals in the form of factors that may affect the system such as a negligible air friction force, the mass of objects is assumed to be the same and skydivers jumping are assumed to have no significant effect.

The argumentation ability given by the students, in this case, has reached level 3 with the C-D-D-W-R argumentation pattern. The others are still at level 2B with the C-W and C-D-W argumentation patterns. Students who give level 1 of argumentation pattern in the form of claim only (C) is the student who is analysing this problem using the unsuitable concepts of air pressure, the uniform linear motion concept, and gravity. This proves that the students' concept of understanding is the basic requirement for giving argumentation.

The third question discusses the concept of parabolic motion as follows:

Question 3

A stone is thrown at a certain speed, so it moves with a parabolic path. According to your understanding, is there a point along the path taken by the rock where speed and acceleration that:

A. Parallel or in line each other.

B. Perpendicular each other.

In this case, the students are divided into two categories namely level 1 and level 2B category. There is only one student who gives the argumentation pattern at level 3. This problem is because the students can not describe velocity vector and acceleration vector on parabolic motion correctly and precisely. The student has not understood that in parabolic motion there is a uniform linear motion in the x-axis and non-uniform linear motion in the y-axis. Through an interview to the students who can not describe the parabolic motion with vector analysis, the student argued that the concept of parabolic motion they received so far did not explain vector analysis and concept of parabolic motion correctly. The material they receive is mostly about the formula of the maximum distance, the maximum height, and the travel time of the object in parabolic motion. One student who gives the argumentation pattern at level 3 mentions rebuttal that is the conditions affected the system, for example, the angle which affects the parabolic motion.

The last question is:

Question 4

Three balls are on the roof of the house with the same height. The first ball (A) is thrown vertically upward with initial speed (x m/s), the second ball (B) is thrown horizontally at speed (x m/s), the third ball (C) is released vertically down.

A. Will all balls reach the ground at the same time? If it is not, mention the order of the balls reached on the ground. Give your analysis of your answer.

B. Do all balls have the same speed when touching the ground? If not, specify the order of the speed with the relevant analysis.

The fourth question is about the velocity of the objects which is thrown vertically upwards, and horizontally to form parabolic motion, and also the velocity of the objects which being free thrown to form free fall motion. In this case, there are three different levels of argumentation given by the students: level 1, level 2B, and level 2A. The student can state that form the three of the motions, the

vertical upward motion takes the longest time for the object to touch the ground compared to the others. However, students have not been able to analyse the parabolic motion with a free fall motion will give the same time for the ball for moving to the ground. This has an implication when the student answers the point B about the speed of three objects. Students' weakness in giving the argument, in this case, is because students are not used the critical thinking to analyse the physical phenomena. When interviewing a student who writes the C-D-W-C-W pattern (level 2), the researchers gradually and deeply guide the analysis that students write until the student finds that the time and velocity of B and C are equal. The majority of students argue that the fastest ball reaches the ground is ball C because it is affected by the acceleration of gravity and the shortest distance assumption without scientific proof of accurate data.

Based on the whole analysis of the argumentation pattern that the students are given, it can be seen that the argumentation has an important role in building students' concept of understanding. As a prospective teacher, students of physics education should have a good understanding of concepts and scientific argumentation to explain the physical phenomenon to their students later. This research is the first step for further research for improving students ability in the pedagogical and conceptual knowledge.

5. Conclusion

Based on the results and discussion, the students' scientific argument ability is at the level of providing claims with weak warrant. It can be concluded that most students are unable to provide appropriate rebuttals. Students need to deepen the physical concept, not only paying attention to the mathematical aspects but also other possibilities that have been described separately including enriching the field's direct observation of the phenomenon that has been studied. As a Physics teacher candidate, it is bad if the understanding of problems is limited to the mathematical solution that has often been obtained.

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