Analysis of Student Concepts Understanding in Solving Scientific Literacy on the Topic of Momentum and Impulse

W A Al Faizah1*, Suparmi2, N S Aminah1

1Physics Education of Post Graduate Program Sebelas Maret University
2Physics Department of Post Graduate Program Sebelas Maret University

*wilujengafahalfaizah@student.uns.ac.id

Abstract. This study aims to analyze students' concepts understanding in solving scientific literacy on the topic of momentum and impulses. The subjects in this study were 124 students from 4 senior high schools in Sragen. The instrument used in this study was 10 questions in the form of an essay test. The results of the analysis show that 70 (56.45%) of students have conceptual understanding in solving scientific literacy competencies as interpreting scientific data on the subtopic of conservation of momentum and collisions, 30 (24.19%) of students have conceptual understanding in solving scientific literacy competencies as scientific design on the subtopic of impulses, and 24 (19.35%) of students have a conceptual understanding in solving scientific literacy competencies as explaining scientific phenomena on the subtopic of momentum. This shows that some students still do not have a conceptual understanding in solving scientific literacy problems on the topic of momentum and impulses.

1. Introduction

Physics is a part of science which is born and developed through steps of observation, problem formulation, hypothesis formulation, hypothesis testing through experimentation, drawing conclusions, and the discovery of theories and concepts [1]. The nature of physics is science that studies symptoms through a series of processes known as scientific processes. It was built on a scientific basis and the results were realized as scientific products composed of the three most important components in the form of universally applicable concepts, principles, and theories. Physics is a discipline that studies natural phenomena and explains how these symptoms occur [2].

The purpose of physics learning is essential to deliver students' understanding of concepts and their relationships to be able to solve related problems in daily life [3]. Students are said to understand if they can construct the meaning of learning messages, both in the form of writing, oral, and graphic, conveyed through learning, books and computer screens [4].

Most students have difficulty applying for their role in the learning process due to the low mastery of the physics concepts they have. Lack of students' ability to understand the concepts they possess causes low learning outcomes. The low student learning outcomes greatly affect the conceptual understanding of students' scientific literacy. So it is necessary to analyze students' conceptual understanding to measure students' scientific literacy in order to know the level of understanding of the concept of physics material in learning.

Current scientific literacy has become a widespread concern for scientists, lecturers, and public policyholders [5], because it is necessary for modern society to deal with various problems of science and technology [6], as well as supporting development sustainable [7]. Science literacy according to the
National Science Education Standards is knowledge and understanding of scientific concepts and processes needed for personal decision making, participation in civil cultural affairs, and productive economics[8].

PISA (Program for International Student Assessment) measures student scientific literacy in several countries every three years. The 2012 PISA scientific literacy measurement results published by the OECD (Organization for Cooperation and Development) show that the level of Indonesian students' scientific literacy is still low. Indonesia ranks 64th out of 65 OECD member countries with an average score of 382, this result is far from the average score obtained by other countries that can achieve a mean score of 501 and experienced a decline in rank from 2009 with the same number of participants [9]. Based on the Program for International Student Assessment (PISA) study the average score obtained in 2015 was 403, ranking 63rd out of 71 countries. This result is far from the mean score obtained by other countries that can achieve a mean score of 493[10].

The aspect of PISA assessment defines scientific literacy as individuals who have competencies, namely (1) explaining scientific phenomena, (2) evaluating and scientific design, (3) interpreting data and evidence (PISA, 2015). In the PISA framework states that students' knowledge must be consistent with the world of students (context) which includes personal, social and global life that includes five fields of application (health, natural resources, environment, limits of science and technology) [11].

Initial knowledge possessed by students influences in constructing new physics knowledge. Students enter the classroom with various conceptions formed from their life experiences. Student conception that is not in accordance with the views of the scientific community is called misconception. The misconception often occurs in Physics subjects, the field of mechanics is at the top of the fields of physics that experience misconceptions [12]. The material of momentum, impulse, and collision is one of the material contained in the field of mechanics, so that the concept of students regarding material momentum and impulses is still many who experience errors in understanding the concept.

Previous research has discussed much the difficulties students have in applying concepts to material momentum and implies on daily problems [13]. Students are weak in linking physical equations with their application to everyday facts, for example, students misinterpret momentum and kinetic energy of colliding objects because they have not linked the momentum and impulse theorem and energy business theorems in collision demonstrations [14]. The difficulty of students in understanding the concepts in the material of momentum and impulses, among others, is in linking the relationship between the concept of momentum and impulses in problem-solving [15], understanding momentum as a vector quantity in relation to conservation of momentum [13]. Students find it difficult to interpret concepts of momentum and energy qualitatively which are applied to everyday physical problems [16]. Students 'difficulties in understanding the concept of physics illustrate that students' conceptual understanding of material momentum and impulses in the category is still low.

Previous research mostly only discusses students' difficulties in applying the material concept of momentum and impulse, has not been able to measure understanding related material of momentum and impulses in measuring scientific literacy. From the various opinions that have been expressed, it shows that the understanding of the material concept of students' momentum and impulse is still a lot wrong in understanding the concept so that scientific literacy abilities have not been able to be measured. Scientific literacy skills can be interpreted as a person's ability to distinguish scientific facts from various information, recognize and analyze using scientific investigation methods and the ability to organize, analyze, interpret quantitative data and scientific information [17]. So it is necessary to have a study to analyze students' conceptual understanding of material momentum and impulses to measure scientific literacy. The existence of this research is expected to be students not only correct in understanding the material concepts of momentum and impulses but also can see the students' scientific literacy abilities to what extent apply scientific literacy in everyday life.

Based on the description, the researchers conducted this research focused on analyzing the concept of momentum and impulse to measure the scientific literacy of high school students of XI MIA class in Sragen Regency. The results of this study can be used as further research to improve understanding of the concepts of momentum and impulse in measuring students' scientific literacy.

2. Research Method
This research is a descriptive study that aims to analyze the understanding of the concept of impulse momentum to measure students' scientific literacy. The research subjects were class XI students in the 2017/2018 school year. There are 124 students consisting of public and private schools in Sragen Regency. The sample selection uses a random sampling technique. Data collection tools for this study use essay and interview tests for data on student conceptions in science. The data consists of student test results that are used to analyze the achievement of each literacy indicator. Indicators of scientific literacy include explaining scientific phenomena, evaluating and scientific design, and interpreting scientific data and evidence [11].

The essay test model in the evaluation of learning is an important instrument to determine the level of development of students in mastering the material. Essay tests have the advantage of measuring cognitive aspects, developing language skills, practicing regular thinking or reasoning and developing problem-solving skills [18]. The provision of essay questions should be more intensity than objective questions because it can be used to monitor students' cognitive abilities and be used if the group that will be tested is small, and the test will not be used repeatedly [19].

3. Results and Discussion
In this study, students answer sheets of problems based on scientific literacy indicators are analyzed. Analysis of scientific literacy abilities is important for students because it relates to how students understand the environment and other problems faced by society in the digital era by relying on the development of science and technology. The importance of scientific literacy is to deal with everyday life in society, participate in various science-complex issues, part of cultural heritage and greatly influence our view of the world and human places in it and the need for literacy labor in a scientific manner [20]. The indicators of scientific literacy consist of: (1) explaining scientific phenomena, (2) evaluating and scientific design, (3) interpreting scientific data and evidence. Each indicator of student scientific literacy is represented by the student conceptual understanding of momentum and impulses which is provided in the form of student answer sheets. The division of subtopic and scientific literacy competencies on each question can be seen in Table 1.

| No | Sub Topic                          | Scientific Literacy                  | Number of question |
|----|------------------------------------|--------------------------------------|--------------------|
| 1  | Momentum                           | explaining scientific phenomena      | 2, 3               |
| 2  | Conservation of momentum and collisions | interpreting scientific data and evidence | 1, 4, 9, 10 |
| 3  | Impulses                           | evaluating and scientific design     | 5, 6, 7, 8         |

In table 1 it can be seen that the scientific literacy-based question instrument used in this study consisted of 2 scientific literacy questions on the competence to explain scientific phenomena in the sub-topic momentum, 4 questions about scientific literacy on the competence of interpreting scientific data and evidence on the sub-topic of the law of conservation of momentum and collisions, and 4 questions about scientific literacy on evaluation competencies and scientific design. The problem on the subtopic of law conservation of momentum and impulses more than the problem of subtopics of momentum. This is because the question of the law of conservation of momentum and impulses often causes students do not understand the concept. This is supported by Maya and Suliyanah that the lowest percentage of concept understanding lies in the concept of energy conservation and momentum in collision events [21]. The results of students' conceptual understanding in each scientific literacy competency can be seen in Figure 1.
In Figure 1 it can be seen that 80.65% of students still have difficulty understanding the concept of momentum in explaining scientific phenomena literacy competencies. This shows that some students still have difficulties in explaining scientific phenomena related to momentum events that exist in everyday life. One of the factors that cause students' misunderstanding in explaining scientific phenomena in everyday life is that students assume that scientific phenomena have nothing to do with physics because physics is identical to various formulas and experiments are only carried out by the laboratory. Besides that students are also unable to see the phenomenon around their environment because they are less sensitive to the surrounding environment and even more sensitive to cyberspace. This is supported by Rustandi that in this modern era where technology is advancing, many children prefer to play digital games rather than trying to understand or study the causes of scientific phenomena that commonly occur in everyday life [22]. Examples of answers to students who understand the concept and do not understand the concept in completing explaining scientific phenomena scientific literacy competencies can be seen in table 2.

Table 2 Students understanding the concept of answer and students do not understand the concept of the answer to solving explaining scientific phenomena

| Students understanding concept answer | Students do not understand concept answer |
|--------------------------------------|------------------------------------------|
| Kendaraan yang memiliki momentum lebih besar adalah sepeda motor. Jika ditambah dengan sepeda motor bergerak lebih cepat sebesar 4 kali dari kecepatan truk dan juga memiliki percepatan. Jika ditambah dengan massa, maka sepeda motor memiliki massa lebih kecil dari pada truk. Semakin kecil massa maka kecepatan yang dimiliki akan semakin besar dan momentumnya juga semakin besar. | Sepeda motor, karena sepeda motor memiliki kecepatan 4x lebih besar dari truk dan kecepatan sepeda motor dipacu cepat lalu mereka kecepatan truk terlepas |

In table 2 it can be seen that students who do not understand the concept state that vehicles that have greater momentum are motorcycles that are 4 times larger than trucks and the speed of motorcycles is accelerated while the speed of trucks remains. From the students' answers indicate that momentum is only influenced by the speed and rate of the vehicle, students are unable to explain the magnitude of the object mass can also affect the momentum of an object. While students who understand the concept state that vehicles that have greater momentum are motorcycles because motorcycles move faster by 4
times the speed of trucks and also have acceleration. When viewed from the masses, motorcycles and
trucks have different masses, compared to the mass of motorcycles smaller than the mass of trucks. The
smaller the mass of an object (motorcycle) the greater the speed it has and the greater the momentum.
So on the contrary, if the mass of a large object (truck) then the speed that is owned will be smaller and
the momentum gets smaller.

In Figure 1 it can also be seen that 75.81% of students still have difficulty understanding the concept
of impulse in scientific design literacy competencies. This shows that some students still have difficulty
in carrying out scientific design in the form of providing solutions to scientific literacy problems. One
factor that causes students to experience difficulties in using science to solve various problems that occur
in everyday life is the lack of understanding of students. This is due to the good understanding of science
can be used to solve various problems that occur in everyday life [23]. Examples of answers to students
who understand the concept and do not understand the concept in completing scientific design literacy
competencies can be seen in table 3.

Table 3 Students understanding concept answer and students do not understand concept answer in
solving scientific design

| Students understanding concept answer | Students do not understand concept answer |
|---------------------------------------|------------------------------------------|
| Pilihan yang terbaik dilakukan Andi adalah membalikkan sepedanya ke dalam tumpukan jerami karena tumpukan jerami wampu mengubah momentum sepeda Andi dalam waktu yang lebih lama jika dibandingkan dengan dinding beton sehingga mengurangi gaya rata-rata. Namun perubahan momentum sama antara tumpukan jerami dan dinding beton. | 6. Loncok Andi yang baik dalam mengungkapkan masalah rem blongnya yaitu lebih baik membalikkan styrinya ke jerami daripada ke tendok karena jerami akan menghematkan lariya tanpa membahayakan luka dan tumpukan jerami lebih membutuhkan tendok. |

In table 3, it can be seen that students who do not understand the concept stated that Andi’s step was
good in overcoming his brake’s problem, namely slamming the steering wheel into the straw rather than
the wall because the straw would stop the speed without making it hurt and the haystack was more
helpful than the wall. From the students’ answers, it indicates that the understanding of physics concepts
about momentum and impulses is still not able to explain scientifically about the concept of momentum
change. Whereas students who have an understanding of the concept that the best choice Andi must do
is slam his bicycle into a haystack because the haystack can change Andi’s bike momentum in a long
time compared to the concrete wall thus reducing the average style. But keep in mind that the change in
momentum is the same, between stacks of hay and concrete walls.

Figure 1 also shows that 43.55% of students still have difficulty understanding the legal concepts of
conservation of momentum and collisions in the interpretation of scientific data competencies. This
shows that some students still have difficulty in interpreting the data. One factor that causes students’
misunderstanding in interpreting data is the teaching material used only using verbal representations.
This is due to the available teaching material is only in the form of textbooks that contain material by
being presented in the form of verbal representations in the form of theories and mathematical formulas
that are difficult to understand [24]. Whereas good teaching materials must be arranged in a variety of
ways with a lot of representation [25-26]. Examples of answers to students who understand the concept
and do not understand the concept in completing interpreting science literacy competencies can be seen
in table 4.
Table 4 Students understanding concept answer and students do not understand concept answer in solving explaining interpreting data

| Students understanding concept answer | Students do not understand concept answer |
|---------------------------------------|------------------------------------------|
| [Image of a table showing data]       | [Image of a table showing data]          |

In table 4 it can be seen that students who do not understand the concept show that students miscalculate the value of the angle direction and the magnitude of the combined speed of the two cars after the collision, assuming that the vehicles experience incomplete collision impacts (both stick together after collision), so students are said to understand the interpretation of data and evidence scientifically. Whereas students who have an understanding of the concept are able to calculate the value of the angular direction and the combined speed of the two cars after the collision, assuming that the vehicles experience imperfect collisions (both sticking together after collision), so students are said to understand data interpretation and evidence scientifically.

4. Conclusion
Based on the results and discussion it can be concluded that students still do not have a conceptual understanding in solving scientific literacy problems on the topic of momentum and impulses. It can be shown that 70 (56.45%) of students have conceptual understanding in solving scientific literacy competencies as interpreting scientific data on the subtopic of conservation of momentum and collisions, 30 (24.19%) of students have conceptual understanding in solving scientific literacy competencies as scientific design on the subtopic of impulses, and 24 (19.35%) of students have a conceptual understanding in solving scientific literacy competencies as explaining scientific phenomena on the subtopic of momentum.

References
[1] Trianto 2011 Model Pembelajaran Terpadu (Jakarta)
[2] Bektiarso 2000 J. Saintifikasi, 11 1–15
[3] A. Yuwarti, Pasaribu, M & Hatibie 2013 J. Pendidik. Fis. Tadulako 3 12–15
[4] S. Rofiah 2015 Jurnal Ilmiah Pendidikan Fisika Al-Biruni. 4 2 165–177
[5] Impey 2013 Departement of Astronomy: University of Arizona
[6] P. Turiman, J. Ömar, A. M. Daud & K. Osman 2012 Procedia-Social and Behavioral Sciences 59 110–116
[7] Udompong, L, Traiwicitkhun, D & Wongwanich 2018 Procedia-Social and Behavioral Sciences 116, 1581-158
[8] R. To 2011 Washington: National Academy Press 15–17
[9] F. Look 2014 Washington: U.S Department of Education
[10] F. Look 2017 Washington: U.S Department of Education
[11] OECD PISA 2015 Draft science framework (Paris, OECD) 1–54
[12] P. Suparmo 2013 PISA 2015 DRAFT SCIENCE FRAMEWORK (Jakarta: Grasindo)
[13] H. G. Close & P. R. L. Heron 2011 American Journal of Physics 1068
[14] P. Mihas 2018 *American Journal of Physics*
[15] T. G. K. Bryce & K. Macmillan 2009 *Journal of Research in Science Teaching*, 46 7 739–761
[16] C. Singh, D. Rosengrant, C. Singh & D. Rosengrant, *American Journal of Physics* 60 7 3
[17] C. Gormally, P. Brickman, and M. Lutz 2012 *CBE-Life Science Education*. 11 364–377
[18] N. Sudjana 2005 (Bandung: Remaja Rosdakarya)
[19] S. Arikunto 2002 (Jakarta: PT Rineka Cipta)
[20] E. K & M. F. Henriksen 2000 *Public Underst. Sci.* 9 3–14
[21] Diah Maya Anggraeni, Suliyah 2017 *Jurnal Inovasi Pendidikan Fisika (JIPF)* 6 3 271–274
[22] I. Rustandi 2008 (Bandung: Universitas Komputer Indonesia)
[23] P. N. Salamah & A. Rusilowati 2017 *Unnes Physics Education Journal* 6 3
[24] I. Dan, M. Dengan & P. Saintifik *Jurnal Pembelajaran Fisik*, 1 27–38
[25] Payudi Abdurrahman, Apriliyawati 2008 *Payudi 2008 Proceeding 2nd Int. Semin. Sci.* 3 1 373–377
[26] Abdurrahman 2017 *Tadrix: Jurnal Keguruan Dan Ilmu Tarbiyah*, 2 1 1–9