Concept acquisition and scientific literacy of physics within inquiry-based learning for STEM Education

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Abstract. This research to describe the acquisition of concepts and scientific literacy of students, especially in physics material, namely Newton's Law, in inquiry-based learning for STEM education. This research is non-experimental research with descriptive and correlational approaches. The concept acquisition of students is explored based on Bloom's Taxonomy indicators and scientific literacy is explored based on 3 dimensions, namely the dimensions of content, context, and competence. The research sample was 34 high school grade X students in East Java Indonesia who were determined by purposive sampling technique. Data obtained from opened ended and observation questions. Data were analyzed with descriptive statistics and product-moment correlation \( r = 0.88 \). The results showed that the acquisition of Physics concepts in C3 level students (medium category) 14.70%; C4 level (high category) 47.06%; and the C5- C6 level (very high category) 38.23%. Whereas students' scientific literacy in the context category was 34%, content 52%, and competence 14%. Students who have good concept acquisition, they have good scientific literacy tendencies.

Keyword: concept acquisition, scientific literacy, physics, inquiry-based learning for STEM Education

1. Introduction

Newton's Law is the law of science put forward by Sir Issac Newton regarding the law of motion [1]. The material of Newton's Law equation, especially the sub material about motion is difficult. Difficulties experienced by students in learning Newton’s Law include students having difficulty understanding concepts and understanding questions [2], student difficulties are also due to a large number of formulas that must be memorized and understood, so students often experience concept errors [3; 4; 5; 6; 7] Physic misconceptions on Newton's Law material about the motion experienced by students are caused by students lacking the acquisition of concepts [8].

The acquisition of physical concepts is one's ability to understand scientific processes and process information scientifically and meaningfully. The acquisition of concepts also reflects broad and functional acquisitions of science [9; 10] The aspect of concept acquisition intended in this research corresponds to the level of remembering, understanding, applying, analyzing, evaluating, and creating [11]. The acquisition of this concept can illustrate a person's ability to think in formulating strategies.

Strategy development can describe students' scientific literacy. Students who have high concept acquisition can solve problems, both physically and mathematically, and students who have low concept acquisition will have difficulty in solving problems [12]. Scientific literacy can identify
the ability of students to use scientific knowledge, identify problems, draw conclusions and changes that occur in nature [13]. Scientific literacy can be measured through four aspects, namely: science content, science processes, science competencies, and science context [14]. The content aspect of scientific literacy refers to the key concepts needed to understand phenomena [15]. The science process is used to answer a question in solving problems [16], [24]. The context of science directs students to recognize situations in life that involve science and technology. In the aspect of scientific competence, students can identify scientific issues, explain scientific phenomena, and use scientific evidence [14]. Evaluation of scientific literacy gives attention to the cognitive and affective aspects of students [17].

The purpose of this research is to explore the acquisition of concepts and scientific literacy in Newton's Law material. Scientific literacy assessment is obtained after conducting an assessment stage of concept acquisition [12; 18]. The acquisition of student concepts can be grown through inquiry-based learning for STEM education. Scientific literacy of students can be known after the exploration of the acquisition of concepts owned by students. The presence of problems in schools and the potential for solutions to inquiry-based learning in STEM education makes research necessary to explore the acquisition of student concepts so that scientific literacy is known in Newton's Law material.

2. Method
This research is non-experimental research with a descriptive and correlational approach. This type of research is used to explore the acquisition of concepts and scientific literacy to 34 students in East Java, Indonesia. The aspects measured in concept acquisition and scientific literacy are presented in Table 1 and 2.

Table 1. Aspects of Concept Acquisition

| Indicator | Descriptor |
|-----------|------------|
| **Remember** | a. Mentioning the application of Newton's Law in daily life  
| | b. Explaining Newton's Law based on phenomena in daily life |
| **Understand** | a. Comparing the concept of acceleration based on Newton's Second Law  
| | b. Classifying the events in daily life based on the force a given |
| **Applying** | a. Calculating the amount of force that occurs on an object  
| | b. Calculating the weight of objects in daily life |
| **Analyzing** | a. Analyzing the direction of the resultant force versus the force applied  
| | b. Analyzing the weight of objects and the forces on moving objects |
| **Evaluate** | a. Considering the direction and resultant forces  
| | b. Testing science with experiments |
| **Create** | a. Composing hypotheses on Newton's Law material  
| | b. Creating a product application of Newton's Law |
Table 2. Newton's Law Scientific Literacy Based on Inquiry-Based Learning for STEM Education

| Syntax                          | Scientific Literacy |
|--------------------------------|---------------------|
| Presentation of the problem     | 1) Context          |
|                                | 2) Competence       |
| Data collection and verification| 1) Competence       |
| Experiment and collect data     | 1) Competence       |
|                                | 2) Content          |
|                                | 3) Competence       |
| Experiment and collect data     | 1) Competence       |
| Formulation of Explanation      | 1) Context          |
|                                | 2) Content          |
| Analysis of the inquiry process | 1) Competence       |

Data collection is done by tests and observations. Data acquisition concepts and scientific literacy scores were analyzed using quantitative descriptive analysis. This analysis is presented in the form of average, standard deviation (SD), maximum score, minimum score, lowest score, and highest score. The relationship between the two was analyzed using Pearson product-moment analysis.

RESULT

a. Exploration of Concept Acquisitions

Based on the data, the results of the descriptive analysis of students' concept acquisition are presented in Table 3.

| Statistics                      | Statistics Value |
|---------------------------------|------------------|
| Number of Students              | 34               |
| An average score                | 7,56             |
| Maximum score                   | 90               |
| Minimum score                   | 70               |
| Standard deviation              | 1,19             |

Table 4. Frequency Distribution and Cumulative Percentage of Student Concept Acquisition Test

| No. | Score  | Frequency | Relative Frequency (%) | Category | Achievement of Bloom's Cognitive |
|-----|--------|-----------|------------------------|----------|----------------------------------|
| 1.  | 0-20   | 0         | 0,00                   | Very low | C1                               |
| 2.  | 21-40  | 0         | 0,00                   | Low      | C2                               |
| 3.  | 41-60  | 15        | 14,70                  | Is       | C3-C4                            |
| 4.  | 61-80  | 16        | 47,06                  | High     | C5                               |
| 5.  | 81-100 | 13        | 38,23                  | Very high| C6                               |

b. Exploration of Scientific Literacy

Scientific literacy of students is presented in Table 5
### Table 5. Analysis Results of Scientific Literacy

| Statistics            | Value     |
|-----------------------|-----------|
| Number of Students    | 34        |
| An average score      | 64.53     |
| Maximum score         | 41        |
| Minimum score         | 80        |
| Standard deviation    | 11.18     |

Scientific literacy data were analyzed based on context, content, and competency dimensions, which are presented in Figure 1.

**Figure 1. Dimension Description of Scientific Literacy**

*Figure 1.* Dimension Description of Scientific Literacy

**c. Relationship of Concept Acquisition-Scientific Literacy**

Correlation analysis of the relationship between concept acquisition and scientific literacy was measured using the formula $r_{xy}$. This aims to prove that there is a significant relationship between concept acquisition and scientific literacy of Grade X students of Natural Sciences. Explanation of correlation analysis using the $r_{xy}$ correlation formula is presented in Table 6.

### Table 6. Correlation Analysis of Concepts Acquisition and Scientific Literacy

| Variable | $r_{-count}$ | $r_{-table}$ | Sig. |
|----------|--------------|--------------|------|
| PK $\rightarrow$ SL | 0.881        | 0.436        | 0.000 |

Correlation test results between the acquisition of concepts with scientific literacy obtained $r_{-count} = 0.881$ and $r_{-table} = 0.436$ with a significance level of 0.000, because $r_{-count} > r_{-table}$ (0.881 > 0.436). This means that the hypothesis stating the relationship between concept acquisition and scientific literacy is accepted.

**DISCUSSION**

The results showed that the acquisition of students' physics concepts in inquiry-based learning for STEM education became better. The acquisition of student physics concepts is important and must be had by students when solving problems [19]. The acquisition of concepts is defined as the ability of a person to express a particular object again. Concept acquisition can make students define concepts...
and know their critical attributes [20]. The acquisition of low physics concepts has become a major problem in learning [21]. Existing knowledge does not just happen, students get relevant knowledge through some combination of formal and informal activities. The formulation of these strategies can describe students' scientific literacy [18].

Based on the results of data analysis, scientific literacy uses the dimensions of content, students have the largest percentage, which is 52%. This indicates that students have been able to analyze the relationship between the problems they have known with the knowledge received [17]. Students are generally able to recognize concepts, principles correctly, but their understanding is very limited to the aspect of definition so that students have difficulty in solving problems. This is obtained from the test results that students only know certain concepts or laws, but cannot explain in detail about the reasons, relationships, and applications in daily life.

Students who understand the natural phenomena around by using their knowledge show that these students can apply their knowledge [22], [24]. Scientific literacy is part of the competencies achieved in inquiry-based learning for STEM education. Inquiry-based learning for STEM education is a breakthrough in learning that can improve students' scientific literacy [23], [25]. Through scientific literacy, students are expected to become individuals who are broad-minded by considering aspects of context, content, competencies, and attitudes in decision making, so students can solve problems and solve them in real life.

Scientific literacy exploration of students can be done by instructing students to make an understanding of the concept, apply, analyze, synthesize, and conclude it according to the data obtained. Besides, inquiry-based learning support in scientific literacy mapping teaches students to understand and evaluate concepts that are provided independently and are discussed in groups. Students conduct investigations in daily life and convey the results in the form of projects.

This shows that the advantages of inquiry-based learning in STEM education can develop students' scientific literacy and think in decision making. The results of this research indicate that inquiry-based learning in STEM education can help students understand each dimension in scientific literacy. Students can recognize life situations that involve science and technology, understand the natural surroundings with knowledge, identify scientific issues, explain phenomena and draw conclusions based on evidence [17].

CONCLUSIONS
This research concludes that students' scientific literacy is in the dimension of content, where students, in general, can recognize concepts, principles, theories or scientific law correctly but their understanding is on average up to the C3 - C4 level. Exploration of concept acquisition is needed to improve students' scientific literacy. This research can be further developed because this research only explores the acquisition of students' scientific literacy concepts and their relationship to inquiry-based learning for STEM education so that further research is needed that can measure other aspects of learning assessment based on different variables.

References
[1] Serway R A and Jewwet J W 2014 Fisika untuk Sains dan Teknik Edisi Keenam. (Jakarta: Salemba Teknika)
[2] Ogilvie C A 2009 Changes in students’ problem-solving strategies in a course that includes context-rich, multifaceted problems Physical Review Special Topics–Physics Education Research 5 (2)
[3] Yuliati L, Parno, Hapsari F, Nurhidayah, and Halim L 2018 Building Scientific Literacy and Physics Problem Solving Skills through Inquiry-Based Learning for STEM Education. J. Phys. Conf. Series 1108 012026
[4] Han L S & Won P J. 2013. Deductive reasoning to teach newton’s law of motion. International Journal of Science and Mathematics Education 11 p1391–1414
[5] Obaidat I and Malkawi E 2009 The graphs of physics concepts of motion: Identifying particular patterns in students’ thinking. *International Journal of the Scholarship of Teaching and Learning* 3 (1) p 19

[6] Saglan A A and Devecioglu Y 2010 Student teachers’ levels of understanding and model of understanding Newton’s laws of motion *Asia-Pacific on Science Learning & Teaching* 11 p 1

[7] Handhika J, Cari C, Soeparmi A, and Sunarno W 2016 Student conception and perception of Newton’s law *AIP Conference Proceedings* 1708 070005

[8] Campanario J M 2006 Using textbook errors to teach physics: examples of specific activities. *European Journal of Physics* 27 (4) [https://doi.org/10.1088/1.4941178](https://doi.org/10.1088/1.4941178)

[9] Hurd P D 1998 Scientific literacy: New minds for a changing world. *Science Education* 82 (3) p 407–416

[10] DeBoer G E. 2000 Scientific Literacy; Another Look at Its Historical and Contemporary Meanings and its Relationship to Science Education Reform *Journal of Research in Science Teaching* 37 582-601

[11] Anderson I W & Krathwohl D R 2001 *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of education objectives: Complete edition.* (Newyork: Longman)

[12] Delhita A and Sunaryono 2012 *Penguasaan Think-Aloud Protocols untuk mengatasi Miskonsepsi Siswa pada Materi pokok Stokiometri di SMA Khadijah Surabaya.* Prosiding Seminar Nasional Kimia, Universitas Negeri Surabaya

[13] Fang Z and Wei Y 2010 Improving Middle School Students’ Science Literacy Trough Reading Infusion *The Journal of Educational Research* 103 p 262-273

[14] OECD 2007 *PISA 2006 Science Competencies for Tomorrow’s World Vol.1.* (Paris: OECD)

[15] Ekohariadi 2009 Faktor-faktor yang Mempengaruhi Literasi Sains Siwa Indonesia Berusia 15 tahun. *Jurnal Pendidikan Dasar* 10 (1)

[16] Sani 2015 *Pembelajaran Sainstifik untuk Implementasi Kurikulum 2013* (Jakarta: PT Bumi Aksara)

[17] OECD 2013 *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science Problem Solving and Financial Literacy* (OECD Publishing)

[18] Holbrook J & Rannike M 2007 The Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education* 29 (11) 1347-1362

[19] Brickman P, Gormally C, Armstrong N, and Hallar B 2009 Effect of Inquiry-Based Learning On Students’ Scientific Literacy Skill And Confidence *International Journal Scholarship of Teaching and Learning* 3 (2)

[20] Arends R J 2012 *Learning to teach 6th Edition* (New York: Me-Graw-Hill)

[21] Lottery M J 2005 Students Understanding of The Primitive Spring Concept: Effect of Prior Classroom Instruction and Gender. *Electronik Journal of Science Education* 9 (3) p 1-23.

[22] Wenning C J 2010 Levels of inquiry: Hierarchies of Pedagogical Practices and Inquiry Processes *Journal of Physics Teacher Education Online* 5 (4) p 11-20

[23] Guzzetti B J & Bang E 2010 The Influence of Literacy-Based Science Instruction on Adolescents’ Interest, Participant, and Achievement *Science. Literacy Research and Instruction* 50 p 50-55

[24] Yuenyong, C. and Narjaikaew, P. 2009. Scientific Literacy and Thailand Science Education. *International Journal of Environmental and Science Education*, 4 (3): 335 – 349

[25] H Suwono, R Fachrunnisa, C Yuenyong, L Hapsari 2019. Indonesian Students’ Attitude and Interest in STEM: An Outlook on The Gender Stereotypes in The STEM Field. *Journal of Physics: Conference Series*, 1340 (1), 012079