Data Literacy of Prospective Physics Teacher Students in STEM Learning

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Keywords: Data Literacy, Prospective Physics Teacher, STEM Learning.

Abstract: The solution to a problem, among others, requires identifying and collecting, processing, and interpreting data. This process involves data literacy skills. Data literacy is one of the hidden variables in the physics learning process, and only a few are analysed. This study aimed to assess the data literacy possessed by prospective physics teacher students. The research uses a case study research design. The scope of the research is on prospective physics teacher students taking Electromagnetic courses at the Physics Education Department, Siliwangi University, in the 2022/2023 academic year. Data analysis used descriptive statistical analysis. Data Literacy in this research consists of data introduction, data collection and recording, data analysis and interpretation, data communication, and data use. The context of this data literacy study is the search for a solution to the problem of contamination of combustion smoke in the chimney by applying the concept of physics. The findings are that students' data literacy is still at the primary and intermediate data literacy level. The remarkable thing that needs attention is data literacy in the aspects of data recognition, data interpretation, data collection, and data use. These results mean that students still need to be more to identify data according to the problem, categorize data according to its use to solve problems, make connections between the results of data analysis, and use data to provide arguments. The findings of this study can be the basis for developing a learning program that involves data literacy training.

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1 INTRODUCTION

Data literacy is a hidden variable/hidden curriculum in physics learning. Science process skills may have become a general topic/study in Physics learning. Data literacy also intersects with Science Process Skills, especially regarding data collection, analysis, visualization, and interpretation. Data literacy requires meaning and the impact of using data on people's lives, both from natural and social knowledge. It is the meaning and use of data that differentiate Data Literacy and Science Process Skills. Data literacy must be identified as a hidden variable/hidden curriculum at the university student level.

Identification of data literacy at the university student level needs to be done because students are expected to be able to solve problems, think critically, and make decisions based on valid and reliable data. These abilities need to be possessed in an interdisciplinary context and able to be applied in the context of social life. This data literacy is helpful as a basis for building a data-based society. Recognizing misinformation and disinformation becomes more complicated if the data literacy level of students is unknown, especially during a post-pandemic situation(Schreiter et al., 2022). In addition, data literacy can also be the basis for other literacy, i.e., scientific literacy. Students with data literacy skills will have more potential to understand data patterns presented in scientific studies and be able to predict and utilize scientific knowledge. Thus, it is necessary to do research related to student data literacy.

Data literacy research is more commonly carried out in studies of Computer Science and Informatics, Mass Media, Environmental Science, and Library Metadata(Wolff, Gooch, Montaner, Rashid, & Kortuem, 2016, Wolff, Wermelinger, & Petre, 2019, Pangrazio & Sefton-green, 2020, Deahl, 2014). Wolff researched data literacy to uncover learning principles that train data literacy. Wolff uses the context of the position of solar panels in each house

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Sujarwanto, E.
Data Literacy of Prospective Physics Teacher Students in STEM Learning.
DOI: 10.5220/0012199800003738
Paper published under CC license (CC BY-NC-ND 4.0)
In *Proceedings of the 4th International Conference on Innovation in Education (ICoIE 4 2022) - Digital Era Education After the Pandemic*, pages 287-291
ISBN: 978-989-758-669-9; ISSN: 2975-9676
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in a residential area on energy consumption. The actual results from Wolff are the principles of data literacy learning, including learning that needs to involve complex data, interesting teaching materials, and STEM learning situations. Research by Mandinach & Gummer (2013) and Schildkamp, Lai, & Earl (2013) states that good data literacy helps educators plan and implement learning. Gasevic, Dawson, & Siemens (2015) added that if used effectively and ethically, data is an essential part of education, for example, in giving feedback. Pangrazio & Sefton-green (2020) and Bhargava et al. (2015) also emphasized that data literacy will impact technological innovation and positive societal changes.

Research on data literacy in physics is still less significant than in metadata and informatics. In addition to these gaps, data literacy in the context of STEM education, especially at the university student level, has yet to be explored too much. This research will enrich data literacy research in education, especially physics education in the STEM context. The STEM context in this study was that students were asked to provide alternative solutions with physics concepts for air pollution from combustion chimneys. Students are asked to provide a solution so that the solid particles in the smoke are not released freely with the smoke gas phase. After getting a potential solution, students are asked to expand the effect of using data on society.

This study aims to reveal the data literacy of prospective physics teacher students. This research will see to what extent physics education students utilize the concepts and laws of physics to solve problems in the context of air pollution from chimneys. Knowing the position of university students' data literacy can help design learning programs, media, teaching materials, or learning models that support data literacy.

2 METHOD

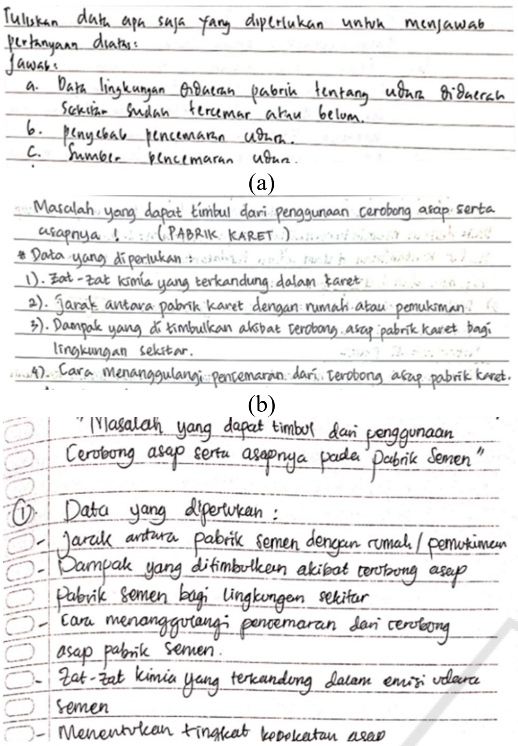
These case studies reveal the data literacy of physics teacher candidates at the Department of Physics Education, Siliwangi University, who are taking the Electromagnetics course for the 2022/2023 academic year. The case study method was chosen because it wanted in-depth data about data literacy for a certain period. This research can be called a one-shot case study because the timeframe is only two weeks and only one problem context. Case studies are also helpful when the group being studied has a different context from others' research. The context of this research is the problem of air pollution originating from chimneys. Students are asked to provide a solution so that the solid particles in the smoke do not spread freely along with the smoke gas phase. The collection uses task assignments related to the problems given earlier. In addition, questions and answers were conducted regarding the problem-solving process. Data analysis used descriptive qualitative, which was carried out on the problem-solving process by students.

3 RESULT AND DISCUSSION

This case study has studied the data literacy of prospective physics teacher students at Siliwangi University. The prospective physics teacher students in this case study emphasized that the physics concepts learned can and must be used to solve problems. From the problems given to students, they initially worked in groups to brainstorm about separating the solid and gas phases in the smoke coming out of the chimney. Then the students do independent work to solve problems through task assignments.

Student data literacy is seen in Data Recognition, Data Collection and Recording, Data Analysis and Interpretation, Data Communication, and Data Use(Sujarwanto, Madlazim, & Ibrahim, 2022). The remarkable thing that needs attention in this case study is data literacy in the aspects of data recognition, data interpretation, and data use. Data literacy owned by students has varying levels for each component.

Data recognition is crucial before going further in problem-solving. Data recognition is also a starting point for data literacy. The introduction phase is essential in problem-solving(Sujarwanto, Hidayat, & Wartono, 2014; Fakcharoenphol, Morphew, & Mestre, 2015; Good, Marshman, Yerushalmi, & Singh, 2018; Good, Marshman, Yerushalmi, & Singh, 2020) and in data literacy (Wolff et al., 2019; Gibson & Mourad, 2018). Students, in this case, study have a Data Introduction level at the Intermediate level. It is characterized by being able to predict the variation of available data, being able to identify appropriate data for solving problems, but not being specific about the type of data, for example, related to specific pollutant sources of Ozone, SO_2, or CO. Data introduction by students is shown in Figure 1.



Tuliskan data apa saja yang diperlukan untuk menjawab pertanyaan diatas:
Jawab:
a. Data lingkungan didaerah pabrik tentang udara didaerah sekitar sudah tercemar atau belum.
b. penyebab pencemaran udara.
c. sumber pencemaran udara.

(a)

Masalah yang dapat timbul dari penggunaan cerobong asap serta asapnya ! (PABRIK KARET)
* Data yang diperlukan :
1). Zat-zat kimia yang terkandung dalam karet
2). Jarak antara pabrik karet dengan rumah atau pemukiman
3). Dampak yang di timbulkan akibat cerobong asap pabrik karet bagi lingkungan sekitar.
4). Cara menanggulangi pencemaran dari cerobong asap pabrik karet.

(b)

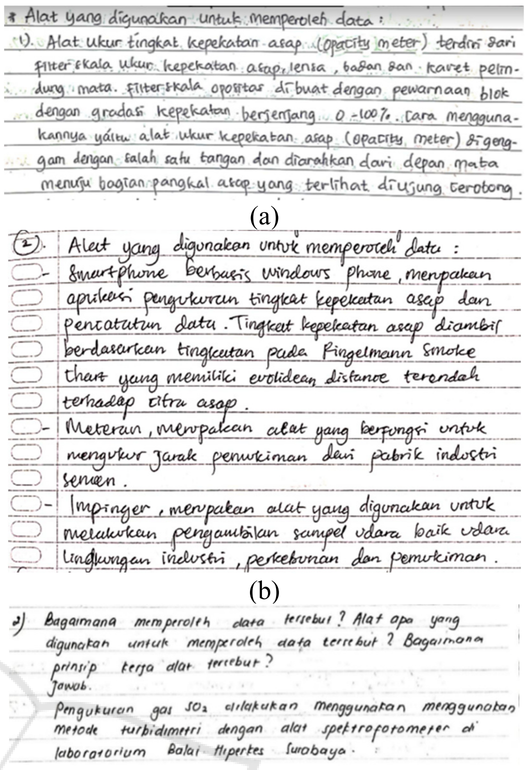
"Masalah yang dapat timbul dari penggunaan Cerobong asap serta asapnya pada Pabrik Semen"
① Data yang diperlukan :
- Jarak antara pabrik semen dengan rumah / pemukiman
- Dampak yang ditimbulkan akibat cerobong asap pabrik semen bagi lingkungan sekitar
- Cara menanggulangi pencemaran dari cerobong asap pabrik semen.
- Zat-zat kimia yang terkandung dalam emisi udara semen
- Menentukan tingkat kepekatan asap

(c)

Figure 1: Data Recognition by Students.

Figure 1 shows students can predict and identify the data needed to solve problems. Students propose the data about environmental air quality data around settlements, sources of air pollution (Figure 1a), chemicals in smoke, and the distance of pollution sources from settlements (Figure 1b and Figure 1c).

Data collection is characterized by knowing how to use tools and technology to collect, store, integrate, manage, and check the correctness of data. From a series of these characteristics, aspects of data collection owned by students are at the primary level. It was indicated by mentioning the tools and their functions used to obtain data sources but did not specifically mention the working principles of the tools. Figure 2 shows the data collection aspect of the task assignment. Students have been able to name tools that support data collection to solve chimney air pollution problems, for example, opacity meters to measure smoke density (Figure 2a), utilizing sensors on smartphones and impingers (Figure 2b), and a spectrophotometer (Figure 2c).



* Alat yang digunakan untuk memperoleh data :
1). Alat ukur tingkat kepekatan asap (opacity meter) terdiri dari filter skala ukur kepekatan asap, lensa, badan dan karet pelindung mata. Filter skala opasitas dibuat dengan pewarnaan blok dengan gradasi kepekatan berjenjang 0-100%. Cara menggunakannya yaitu alat ukur kepekatan asap (opacity meter) digenggam dengan salah satu tangan dan diarahkan dari depan mata menuju bagian pangkal asap yang terlihat di ujung cerobong.

(a)

② Alat yang digunakan untuk memperoleh data :
- Smartphone berbasis windows phone, merupakan aplikasi pengukuran tingkat kepekatan asap dan pencatatan data. Tingkat kepekatan asap diambil berdasarkan tingkatan pada Ringelmann Smoke Chart yang memiliki euclidean distance terendah terhadap citra asap.
- Meteran, merupakan alat yang berfungsi untuk mengukur jarak pemukiman dari pabrik industri semen.
- Impinger, merupakan alat yang digunakan untuk melakukan pengambilan sampel udara baik udara lingkungan industri, perkebunan dan pemukiman.

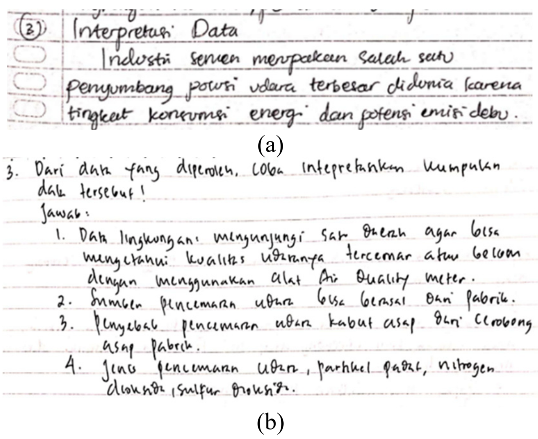
(b)

2) Bagaimana memperoleh data tersebut? Alat apa yang digunakan untuk memperoleh data tersebut? Bagaimana prinsip kerja alat tersebut?
Jawab.
Pengukuran gas SO_2 dilakukan menggunakan menggunakan metode turbidimetri dengan alat spektrofotometer di laboratorium Balai Hipertes Surabaya.

(c)

Figure 2: Description of Data Collection by Students.

Data interpretation is a challenging aspect of data literacy(Glazer, 2011;Edwards et al., 2017). Incorrect interpretation of data can lead to errors in decision-making. Interpretation of data owned by students is still at the primary level. The characteristics shown at the basic level of interpretation are that the majority have not been able to interpret in-depth but only explain/re-describe the data obtained and cannot provide models or compare analysis results. The results of data interpretation are shown in Figure 3.



③ Interpretasi Data
Industri semen merupakan salah satu penyumbang polusi udara terbesar di dunia karena tingkat konsumsi energi dan potensi emisi debu.

(a)

3. Dari data yang diperoleh, coba interpretasikan kumpulan data tersebut!
Jawab:
1. Data lingkungan: mengunjungi satu daerah agar bisa mengetahui kualitas udaranya tercemar atau belum dengan menggunakan alat Air Quality meter.
2. Sumber pencemaran udara bisa berasal dari pabrik.
3. Penyebab pencemaran udara kabut asap dari cerobong asap pabrik.
4. Jenis pencemaran udara, partikel padat, nitrogen dioksida, sulfur dioksida.

(b)

Figure 3: Data Interpretation by Students.

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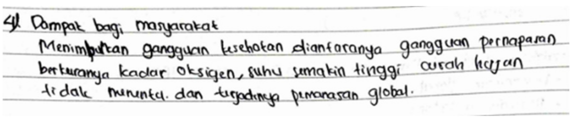
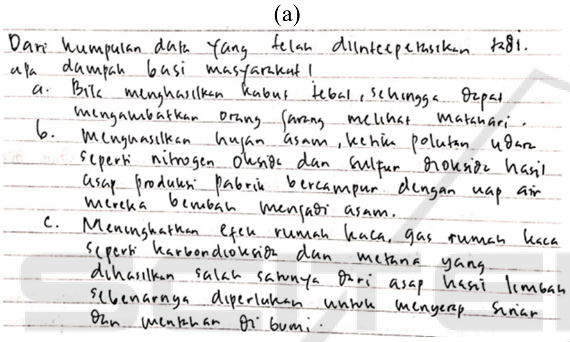
The use of data is not only limited to scientific inquiry and giving arguments but also connecting data with scientific or social issues and knowing the impact of using data on society(Gibson & Mourad, 2018; Sujarwanto et al., 2022). In the aspect of data usage, students are at the intermediate level. It was marked by being able to describe data presentations (tables and graphs), providing/suggesting problem-solving using physics concepts, relating to science but not yet to social utilities, and the solutions put forward by the majority of students using a centrifugal and electrostatic deposition. The results of using data from students are shown in Figure 4.


4) Dampak bagi masyarakat
Menimbulkan gangguan kesehatan diantaranya gangguan pernapasan berkurangnya kadar oksigen, suhu semakin tinggi curah hujan tidak menentu. dan terjadinya pemanasan global.

(a)


Dari kumpulan data yang telah diinterpretasikan tadi. apa dampak bagi masyarakat!
a. Bila menghasilkan kabut tebal, sehingga dapat mengakibatkan orang jarang melihat matahari.
b. Menghasilkan hujan asam, ketika polutan udara seperti nitrogen oksida dan sulfur dioksida hasil asap produksi pabrik bercampur dengan uap air mereka berubah menjadi asam.
c. Meningkatkan efek rumah kaca, gas rumah kaca seperti karbondioksida dan metana yang dihasilkan salah satunya dari asap hasil limbah sebenarnya diperlukan untuk menyerap sinar dan menahan di bumi.

(b)

Figure 4: Description of Data Usage by Students.

Recognizing data and its sources is an essential aspect of data literacy. Students are still at the primary and intermediate levels when data literacy is associated with the chimney problem project because the problem is less contextual. This results because students' prior knowledge needs to be improved to carry out the process. Thus, if a learning process aims to increase data literacy, the data context must be close to students. It follows the suggestion by Wolff et al. (2019) and Sujarwanto et al. (2022). In sustainable development, data literacy results in pollution through chimneys are supported by the research of Ridwan, Kaniawati, Suhandi, Samsudin, & Rizal (2020). The research stated that students are aware of sustainable development but are less effective in practical skills related to sustainable development.

Interest affects the components of data usage. Because the student's background is physics and science, students associate the use of data and problem solutions with the science field, namely environmental pollution, the greenhouse effect, and health problems. Nothing has yet been linked to economic and policy aspects. It is supported by cognitive theory for situational interest type motivation Moreno (2010) and the research results by Wolff et al. (2019).

4 CONCLUSIONS

The results and discussion show that students still need to be improved in identifying data according to the problem, categorizing data according to its use to solve problems, making connections between the results of data analysis, and using data to provide arguments. The findings of this research can be the basis for developing learning programs that involve data literacy training.

ACKNOWLEDGEMENTS

This research is supported and funded by LPPM-PMP Siliwangi University.

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