Exploring the Relationship Between Students’ Digital Literacy and Analytical Skills in Chemistry Education

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ABSTRACT

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| **Background:** Digital literacy is a key competency in 21st-century learning, particularly in higher education. This capability encompasses students' skills in accessing, evaluating, and using digital information critically and ethically. Furthermore, learning chemistry demands higher-order thinking skills, including analytical skills, to understand abstract concepts and solve problems. **Aims:** This study aims to determine the relationship between students' digital literacy skills and their analytical skills in chemistry learning. **Methodology:** The study used a quantitative correlational approach involving 31 chemistry education students from a private university in Indonesia. The research instruments consisted of a validated digital literacy questionnaire and a descriptive-based chemical analysis ability test.**Results:** The results of data analysis using the Pearson correlation test showed a significant positive relationship between digital literacy and students' chemical analytical skills (r = 0.624, p < 0.01). This finding indicates that students with high digital literacy tend to have better analytical skills in chemistry learning. Digital literacy facilitates scientific information searches, data processing, and understanding of chemical concept visualizations through digital media. Therefore, strengthening digital literacy needs to be an integral part of the chemistry education curriculum to encourage students' critical thinking and analytical skills. **Conclusion:** The implications of this research encourage lecturers and institutions to design adaptive and contextual technology-based learning to improve students' skills in integrating digital information into the learning process. Further research is recommended to explore the role of digital literacy mediation in improving chemistry learning outcomes longitudinally. |

*Keywords: literacy, digital literacy, chemical analysis skills, Thinking skills*

1. INTRODUCTION

The digital revolution has brought about a major transformation in the world of education, including in the way students access, process, and communicate information. In today's digital era, digital literacy skills are a necessity, no longer an option. Digital literacy encompasses not only technical skills in using technological devices, but also includes critical thinking skills in evaluating digital information, ethical skills in cyberspace, and the ability to communicate effectively through digital media [1]. UNESCO states that digital literacy is an important part of information and media literacy in the context of 21st-century learning [2]. In the context of chemistry education in higher education, students are confronted with various abstract and complex concepts. Understanding these concepts cannot be achieved simply through memorization, but requires higher-order thinking skills, including analytical skills. Analytical skills enable students to solve problems, compare data, draw conclusions, and evaluate arguments based on available data and information [3]. Therefore, good digital literacy skills are believed to support students' analytical skills in chemistry learning.

Digital literacy is an individual's ability to use information and communication technology to find, evaluate, create, and communicate information with appropriate cognitive and technical skills [8]. According to Gilster, digital literacy is the ability to understand and use information in various formats from digital sources [9]. Components of digital literacy include: technical skills, evaluative skills, digital ethics, and problem-solving [10]. In learning, digital literacy helps students access scientific journals, utilize chemistry software (such as ChemDraw, Avogadro, or virtual laboratory simulations), and compile digital scientific reports [11]. Several studies have shown that students with high digital literacy are better able to access credible learning resources, utilize interactive chemistry simulations, and process and present experimental data digitally [4,5]. The integration of digital literacy into the chemistry learning process enables students to become not only consumers of information, but also critical and reflective producers of scientific information.

However, in practice, many students still have limitations in digital literacy, both technically and critically. This problem can impact students' poor analytical skills in understanding and applying chemical concepts [6]. This aligns with PISA findings, which show that the digital literacy skills of students in Indonesia are still relatively low compared to other countries [7].

As digital technology advances in education, it is important to examine how digital literacy contributes to improving students' higher-order thinking skills, particularly analytical skills. Previous studies have shown that digital literacy correlates with improved critical and analytical thinking skills [15]. Students with high digital literacy tend to be more critical in selecting information and more reflective in formulating answers to scientific problems [16]. In the context of chemistry learning, these skills are essential for understanding abstract and complex concepts [17]. Therefore, this study aims to examine the relationship between digital literacy and students' analytical skills in chemistry learning at the higher education level.

2. material and methods

This research is a descriptive quantitative research with primary data collection using test and non-test instruments. The research instruments used were pre-post tests and a Likert scale. The pre- and post-tests were questions about the periodic table of elements, while the Likert scale instrument used ordinal data. Data collection was conducted both online and offline, with a schedule tailored to the participants' readiness. Students first completed a digital literacy questionnaire, then completed a chemical analysis skills test within a specified time limit.

The collected data was analyzed using the latest version of SPSS statistical software. The analysis stages included:

1. Normality Test: Using Shapiro-Wilk to examine data distribution.
2. Pearson Correlation Test: To determine the relationship between digital literacy and chemical analysis skills. The correlation was considered significant if the p-value was <0.05.
3. Interpretation of the Correlation Coefficient (r):
* 0.00–0.199 = very weak
* 0.20–0.399 = weak
* 0.40–0.599 = moderate
* 0.60–0.799 = strong
* 0.80–1.000 = very strong.

This research has received permission from the faculty and study program. All respondents were given an explanation of the purpose, benefits, and guaranteed confidentiality of their data. Participation was voluntary, and participant identities were encrypted to maintain anonymity.

3. results and discussion

The research approach is a quasi-experimental study with a descriptive quantitative research type with a one-sample post-test only model. In this study, the form of intervention is that students are taught by implementing digital literacy based on gamification assisted by clasdojo. Then, at the end of the learning process, the students complete five open-ended questions related to the subject matter "hydrocarbon compounds" which is a test instrument (validated by an expert validator) given by the researcher. To identify the ability of chemical analysis based on gamification assisted by ClassDojo, the researcher asked students to express their opinions why they chose the answer options. Data related to the students' answers were then given an assessment or score by the researcher according to the predetermined answer standards.

**Table 1. Data Description**

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| --- |
| **Description of Statistical Data** |
| **Post test results for the experimental class** |
| **N**MeanMedianVariance**Minimum**Maximum | **Valid****Missing** | 31034.6540.00569.770170 |

Based on the data above, it was found that the average post-test score of 31 experimental class students was 34.65 with the highest (maximum) score of 70 and the lowest (minimum) score of 1. Continued by analyzing the data per post-test question item. Before analyzing the questions, first identify the students' answers per question and then add them up per question item to find the total score of each student. Analytical abilities can be categorized based on the assessment score according to Watson Glaser Critical Thinking Appraisal as in table 2 below:

**Table 2. Interpretation of Analytical Ability Values based on Watson Glaser Critical Thinking Appraisal**

|  |  |
| --- | --- |
| **Interval** | **Category** |
| 𝟖𝟏, 𝟐𝟓 < 𝒙 = 𝟏𝟎𝟎𝟕𝟏, 𝟓 < 𝒙 = 𝟖𝟏, 𝟐𝟓𝟔𝟐, 𝟓 < 𝒙 = 𝟕𝟏, 𝟓𝟒𝟑, 𝟕𝟓 < 𝒙 = 𝟕𝟏, 𝟓𝟎 < 𝒙 = 𝟒𝟑, 𝟕𝟓 | Very highHigh ModerateLow Very Low |

Based on the tabulated assessment score data, the total score for 31 students was 1074, with a maximum score of 3100 for each of the five test items. The total score for 31 students was 34.6%. This represents a very low analytical ability score, which is categorized as 34.6%. Next, data analysis was conducted per analytical ability indicator, each represented by five test instruments. The indicator classification and test instrument numbers are shown in Table 3 below:

**Table 3. Classification of Questions Based on Analytical Ability Indicators**

|  |  |  |
| --- | --- | --- |
|  |  | Question Number |
|  | 1 | 2 | 3 | 4 | 5 |
| Analytical Capability Indicator | Element analysis |  | ★ |  | ★ |  |
| Relationship analysis | ★ |  |  |  |  |
| Organizational analysis |  |  | ★ |  | ★ |

From Table 3 above, it can be seen that:

* 1. Question item number one is an interpretation of the Analytical Ability indicator - Relationship Analysis.
	2. Question items number two and four are interpretations of the Analytical Ability indicator - Element Analysis.
	3. Question items three and five are interpretations of the Analytical Ability indicator - Organizational Analysis.
	4. The scores obtained per question number on the test instrument, as shown in Table 1, can be rewritten as in Table 4 below.

**Table 4. Percentage per Post Test Item**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Questionare Number** | **1** | **2** | **3** | **4** | **5** |
| Score Total  | 58 | 189.9 | 280.2  | 168  | 381.1 |
| Percentage | 9.35% | 30.63% | 45.19% | 27.10% | 61.47%  |

Based on Table 4, it can be concluded that the highest percentage was achieved in questions number three and five, which interpret organizational analysis skills, followed by the second highest percentage, namely for relationship analysis skills. For a clearer explanation of each indicator of analytical skills, see the following discussion**.**

Element Analysis Indicators The element analysis indicator is defined as the focus on problem solving and the perspective procedures in analyzing each element/element must also be continuous and related to real life. In question number two, the percentage obtained was 30.63% while in question number four, the percentage obtained was 27.10%. Both percentages are in the range of 0 <x ≤43.75 (interpreted as the post-test value of analytical ability). Thus, the interpretation of the post-test value is categorized as very low, which means that the analysis ability indicator - element analysis is very low. Or in other words, the focus on problem solving and the perspective procedures in analyzing each element in questions number two and four is considered very low. The learning indicators for both questions are hydrocarbon structures with atomic characteristics. In question number two, two elements of student analysis were found. First, the elements/elements analyzed are limited to hydrocarbon structures. One of them is the statement "because pentane contains 5 carbons." The element analysis consisted of 11 students. Second, the elements analyzed have linked hydrocarbon structure to atomic characteristics. One such statement is "This statement is false because there are three skeletal isomers of pentane: pentane, 2-methylbutane, and 2,2-dimethylpropane. It is true because pentane contains five carbon atoms." The elemental analysis consisted of 10 students. Furthermore, in question number four, two elements of student analysis were found. First, the elements/elements analyzed were also limited to recognizing the number of carbon atoms. One of them was "because butane and octane have different numbers of atoms." Consisting of two students who met this criterion. Second, the elements/elements analyzed had connected the number of carbon or hydrogen atoms with the boiling point due to van der Waals forces. Consisting of 11 students who met this criterion. Thus, it can be concluded that the indicator of student elemental analysis ability in questions number two and four was 22 out of 31 students who achieved the elemental analysis indicator.

**Relationship Analysis Indicators**

The relationship analysis indicator is defined as the focus on the relationship between problem elements and their relationship with background knowledge. In question number one, the percentage obtained was 9.35%. This value is in the range of 0 <x ≤ 43.75, so the interpretation obtained is in the very low category. It was re-examined based on the learning indicator, namely the relationship between hydrocarbon structure and the uniqueness of carbon atoms. Hydrocarbon isomerism is known from the characteristics of hydrocarbons. The average opinion expressed was that ethane and ethene are isomers of each other. Consisting of seven student answers with these criteria. It can be concluded that there is a lack of understanding of hydrocarbon characteristics (elemental analysis is lacking).

**Organizational Analysis Indicator**

Organizational analysis is defined as the grouping of elements into a new concept. For questions three and five, the percentage scores were 45.19% and 61.47%, respectively. For question three, the score was interpreted as being in the range 0 < x ≤ 43.75, which is categorized as very low, while for question five, the score was interpreted as being in the range 43.75 < x ≤ 71.5, which is categorized as low. Returning to question three, the learning indicator focuses on the relationship between hydrocarbon structure and the characteristics of carbon atoms. Essentially, student answers pointed to the relationship between the number of carbon atoms and boiling point, but they could not yet relate the number of carbon atoms to van der Waals forces. This means a more in-depth analysis of the relationship, which was then grouped. Continuing to question five, the learning indicator focuses on analyzing reaction results. Essentially, student answers were able to connect the chemical reactions of hydrocarbon compounds. There were 15 student answers that met this criterion. From the explanation above, it can be concluded that the implementation of digital literacy based on gamification assisted by ClassDojo cannot be used to improve analytical skills. This is in line with research conducted by Noviyanti, which showed that the use of ClassDojo gamification did not have a positive impact on student motivation and learning outcomes. It is known that ClassDojo is a structural gamification, gamification that encourages students to discuss.

4. Conclusion

Based on the research results, it can be concluded that there is a significant positive relationship between digital literacy and students' analytical skills in chemistry learning. This indicates that the higher the students' digital literacy, the better their ability to analyze chemical concepts and problems. Digital literacy not only helps students access and evaluate scientific information but also contributes to data processing and understanding of chemical concepts through visualization and digital media. Therefore, digital literacy is an important competency that needs to be systematically integrated into the chemistry education curriculum to encourage the development of critical and analytical thinking skills. This study recommends that lecturers and higher education institutions design digital technology-based learning strategies in an adaptive and contextual manner. Furthermore, further research is recommended to further examine the role of digital literacy as a mediator in improving chemistry learning outcomes sustainably and longitudinally.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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