



## **The effect of digital literacy on student learning outcomes in chemistry learning**

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**Abstract:** The study aims to measure the effect of digital literacy levels on learning outcomes of eleven-grade students in chemistry learning with a distance learning system during the COVID-19 pandemic. This study used a quantitative inferential method with 74 students as a sample who took chemistry learning. The digital literacy level of students was determined through digital literacy instruments. Meanwhile, students' chemistry learning outcomes consisted of the results of daily tests on buffer solution and solubility product chapter. Based on the results, the digital literacy level of students consisted of 57% in the high category, 43% in the medium category, and no students in the low category. The results of the Mann-Whitney test between groups of students with high and medium categories prove a significant difference in learning outcomes in the buffer solution chapter between students with high and medium digital literacy levels ( $p= 0.003$ ). In addition, there is a significant difference in learning outcomes in the solubility product chapter between students with high and medium digital literacy levels ( $p= 0.001$ ). These results indicate that the student's digital literacy level has a significant effect on students' learning outcomes in chemistry distance learning.

**Keywords:** chemistry, digital literacy, distance learning, learning outcome.

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### **INTRODUCTION**

Digital literacy is necessary for a digitalization-oriented era, including in the learning process (Yazon et al., 2019; Johnston, 2020). In the context of distance learning (DL) during the Covid-19 pandemic, digital literacy is important in determining the continuity of the teacher-student interaction process. During the pandemic, teachers and students can only be connected to learning by utilizing digital technology through devices such as computers, laptops, and gadgets to access the learning platform. Furthermore, Reichert et al. (2020) state that interaction and communication through digital technology can change the way students learn and think.

In distance learning that utilizes technology, digital literacy consists of the skills of teachers and students in managing devices, platforms, and pieces of information. Besides, teachers and students also need to use video conferencing platforms for synchronous. In practice, digital literacy is diverse between one student and another. The diversity of digital literacy of these students is influenced by several factors, including the availability of technological equipment, the frequency of student interactions with technology (Meyers et al., 2013; Mabayoje et al., 2016; Pratolo & Solikhati, 2020), academic and digital experience (Helsper & Smahel, 2019; Hamutoglu et al., 2019; Bulger et al., 2014), family background and school performance (Hatlevik et al., 2015).

The diversity of digital literacy in students is a challenge in utilizing digital-based learning facilities (Dashtestani & Hojatpanah, 2020). In addition, the diversity of students' digital literacy is also a challenge for teachers in presenting subject matter during DL. Teachers must be able to manage and adjust teaching materials, media, and learning strategies during DL to accommodate students with various levels of digital literacy. In addition, teachers must also hone and improve students' digital literacy, directly and indirectly, by inserting it into the learning process. The reason is that teacher



support can positively influence the development of students' digital literacy (Santos et al., 2019). Sharpening digital literacy is crucial for students because it is a prerequisite to effective learning in an online environment (Tang & Chaw, 2016).

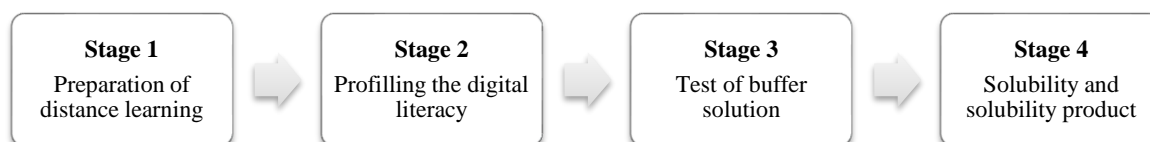
In online learning, digital literacy influences various aspects of learning, such as the ease of students in using e-learning (Feriady et al., 2020), improving students' communication skills (Abbas et al., 2019), and is positively correlated with motivation desire to learn (He & Wray, 2017; Techataweewan & Prasertsin, 2017; He et al., 2020). Other studies have also shown that digital literacy influences academic achievement and student learning outcomes (Shopova, 2014; Pagani, 2016; Santos et al., 2019; Johnston, 2020).

Regarding the influence of digital literacy on student learning outcomes, Maphosa & Bhebe (2019) stated that digital literacy can lead students to build their understanding of the concepts being studied through the ability to access, find, analyze and combine the information they obtain. In addition, digital literacy skills will have an impact on students' desire to access various information through digital media, and it will have an impact on increasing their academic achievement (He et al., 2020). Therefore, one that will determine student learning outcomes in distance learning with an online system during the Covid-19 pandemic is the level of student digital literacy. In distance learning, students will be exposed to various media and technology-based facilities, so accessing, managing, and using them requires special abilities. If students cannot access, manage, and use these various learning facilities and media, students will experience obstacles during the ongoing learning process.

This study measured and analyzed the effect of students' digital literacy levels on learning outcomes on the concept of buffer solution and solubility products obtained in distance learning for chemistry subjects. The measured digital literacy relates to the activities carried out by students during distance learning which refers to predetermined indicators. Meanwhile, learning outcomes consist of students' daily test scores in 2 chapters studied during distance learning, namely the buffer solution and the solubility product chapter (Ksp). The analysis results will answer the following research questions: 1) how is the profile of digital literacy in 11<sup>th</sup> grade high school students?; 2) is there a significant difference in buffer solution learning outcomes between students with different levels of digital literacy?; and 3) is there a significant difference in solubility multiplication learning outcomes between students with different levels of digital literacy?

## METHOD

The research method used in this study is the inferential method. The inferential method in this study analyzes the relationship between digital literacy levels and student learning outcomes in chemistry subjects through statistical testing. In addition, the inferential method in this study tries to make research conclusions based on smaller sample data so that conclusions are more general for a population. This study involved 74 high school students in class 11<sup>th</sup> grade who took chemistry lessons with a distance learning system. This inferential method is used to measure and determine the relationship between digital literacy level variables and student learning outcomes in chemistry subjects. This research was conducted for approximately 3 months, with the research flow consisting of three main activities, as seen in Figure 1.



**Figure 1.** Research Procedure

In this study, an analysis was conducted to determine the relationship between the level of digital literacy and student learning outcomes. Students' digital literacy level is measured through an instrument, a digital literacy questionnaire, adapted from Ozdamar-Keskin et al. (2015). The questionnaire consists of 25 statements about digital literacy with 5 alternative answers, namely very capable (5), capable (4), neutral (3), less able (2), and very poor (1). Then, the results were categorized into 3 categories: students with high, medium, and low levels of digital literacy. The 3 criteria for categorization are shown in Table 1.

**Table 1.** The Level of Digital Literacy Criteria

Level	Score
High	93-125
Moderate	59-92
Low	25-58

Meanwhile, student learning outcomes in this study were obtained from daily test data conducted by the teacher at the end of the buffer solution and solubility product chapter. An average difference test was carried out to determine the effect of digital literacy levels. This average difference test was conducted to determine the significance level of differences in learning outcomes between students with various categories of digital literacy levels.

## RESULTS AND DISCUSSION

This section describes the research findings, which consist of two main parts: the findings and discussion of the digital literacy level of students participating in distance learning during the Covid-19 pandemic and the findings and discussion of the average difference test results—student learning on the topic of buffer solution and the topic of solubility product (Ksp). The average difference test was carried out on two groups of digital literacy levels, namely groups with high and medium digital literacy levels obtained from the research findings.

### Student Digital Literacy Level

In this study, digital literacy was measured based on 4 aspects of digital literacy, namely 1) aspects of the ability to use digital media, 2) aspects of managing digital learning platforms, 3) aspects of using advanced digital media, and 4) aspects of ethics and security in the use of media. digital (Ozdamar-Keskin et al, 2015). Each aspect of digital literacy consists of several activities that show indicators of that aspect. Based on the digital literacy questionnaire, the data obtained are in Table 2.

**Table 2.** Student Digital Literacy

Level	N	Σ	%
High	42		57%
Moderate	32	74	43%
Low	0		0%

Table 2 shows the categorization of students based on digital literacy levels, which are 57% of students with high digital literacy levels and 43% with moderate digital literacy levels. In addition, there are no students with low digital literacy categories. These findings indicate that students who take distance learning during the pandemic for chemistry subjects already have relatively good digital literacy. In general, students have good skills in using digital media, can manage digital learning platforms, use advanced digital media, and understand ethics and security in using digital media. Table 3 is an example of a recap of students' average DL scores regarding the ability to use digital media.

**Table 3.** Examples of Digital Literacy Aspects measured in Students

Activity	Mean	Category
Using DL support applications, such as Google Documents, Google Forms, and Google Classroom.	87.03	High
Join various Vicon online learning platforms, such as Zoom, Webex, Google Meet	88.11	High
Actively participate such as commenting, asking questions, giving suggestions, and answering questions during learning using online learning platforms	69.73	Moderate

Digital literacy has various definitions from the point of view of various skills that are indicators of digital literacy. Kaeophanuek et al. (2019) stated that digital literacy is related to understanding and applying various sources and re-presenting that information. Meanwhile, Shovopa (2014) mentions that digital literacy is related to using technology as a basic skill that will make it easier to access, obtain, analyze, and integrate new knowledge and skills. Prayaga et al. (2017) emphasize DL as the ability to understand and create knowledge using technological devices or other platforms. These various

definitions have relevance to the activities and abilities that students carry out during the implementation of DL during the Covid-19 pandemic.

The findings in this study indicate that the digital literacy of students who took DL for the 4 aspects measured obtained categorization consisting of 57% of students in the high category, 43% of students in the medium category, and no students in the low category. These results indicate that students already have good skills in using digital media in distance learning, such as learning management systems (LMS) and video conferencing. In each learning process, students use LMS in the form of Google Classroom as a medium of interaction between teachers and other students. In Google Classroom, students download materials, upload assignments given by the teacher, and discuss the topics presented in the study of buffer solutions and solubility products.

Meanwhile, another platform that cannot be separated from DL activities is the video conferencing platform. Students and teachers can connect synchronously through zoom meetings or google meet to carry out the learning process and discuss the buffer solution material and solubility product. These activities take place continuously so that student interaction with digital media and learning platforms continues to increase during distance learning. The frequency of students' interaction with digital media continuously during distance learning makes students trained in using digital media to support learning. This statement is in line with some opinions that the frequency of student interaction with technology affects students' digital literacy (Pratolo et al., 2019; Olumuyiwa & Segun, 2013).

The results also show that most students already have good skills in managing digital learning platforms and using advanced digital media outside of learning. In distance learning, students and teachers must produce learning processes and assessments that adapt to conditions. One of the advanced skills in digital media management that develops during distance learning is the ability of students to make videos and design posters. Students are assigned to make experimental videos of buffer and solubility solutions carried out independently. These assignments can train students for advanced digital literacy not directly related to the learning process, such as the ability to design and edit videos as needed. This finding is in line with Churchill's (2020), which states that digital literacy related to advanced abilities will develop if teachers facilitate learning by involving various platforms and digital media. This advanced digital literacy is related to the ability to create messages using written language, graphic design, images, and audio management. The examples of videos made by students that have been made during the online learning process are provided in Figure 2.

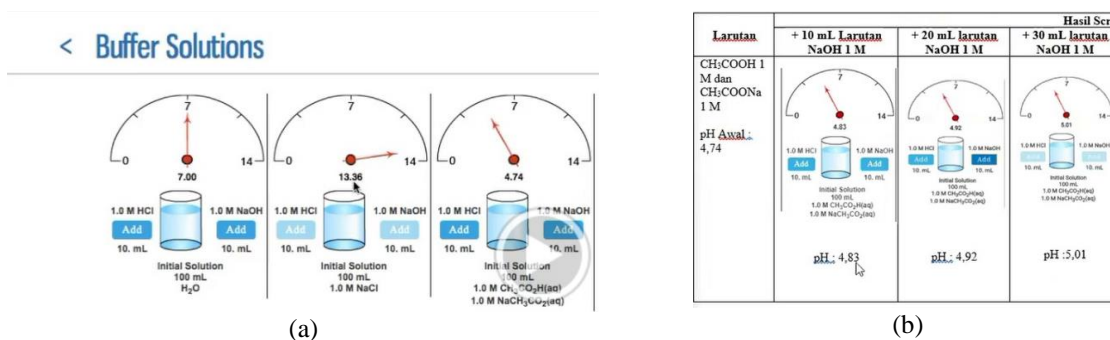


Figure 2. Self-Exploration Assignment (a) Experimental Video, (b) Experimental Result Report/Record

In addition to using and managing digital media on learning platforms, students' digital literacy also shows good results in the ethical and security aspects of using digital media. An understanding of ethics and safety in the use of digital media will develop if students are guided and directed regularly by the teacher. In addition, introducing high-frequency digital media can make students better understand how to use and manage these digital media well. This shows that digital literacy in the learning process is not just the ability to use software and digital media but is also related to ethics in using digital media (Techataweewan & Prasertsin, 2017). Abbas et al. (2019) stated that students with high digital literacy could take advantage of opportunities in the learning process and avoid things that are not useful from the information accessed. Thus, students with high levels of digital literacy can minimize the negative impact of using digital media during the distance learning process.

Based on this explanation, it can be concluded that distance learning during the Covid-19 pandemic that utilizes and involves technology will impact the development of students' digital literacy

skills. Digital literacy development includes using and managing technology in learning, such as LMS, video conferencing, and other learning platforms. Another digital literacy developed in distance learning is managing information relevant to learning, starting from finding, obtaining, and managing information for learning needs. Finally, the digital literacy developed is also in the form of awareness about ethics and safety in using digital media so that students are responsible for using various digital media. This digital literacy will be a provision for students in the learning process and can be applied and used in everyday life. The categorization of digital literacy levels is then analyzed concerning student learning outcomes during the chemistry learning process, which is carried out using a DL system.

### The Effect of Digital Literacy Level on Student Learning Outcomes

The effect of digital literacy level on student learning outcomes was analyzed using the average difference test on both high and medium digital literacy groups' learning outcomes. The average difference test on learning outcomes of buffer solutions aims to determine the effect of digital literacy levels on student learning outcomes in the buffer solution chapter. The average difference test of student learning outcomes was carried out in groups of students with high and medium categories. This test is carried out through the normality and average difference tests. The results of the normality test can be seen in Table 4.

**Table 4.** Normality Test Results of Buffer Solution Learning Based on Digital Literacy Level

Level of Digital Literacy	N	Kolmogrov-Smirnov Test ( <i>p</i> )
High	42	0.044
Moderate	32	0.001

The normality test results show that the resulting significance value (*p*) is less than 0.05, so it can be concluded that the data are not normally distributed. Therefore, the average difference test uses the Mann-Whitney test. The results of the Mann-Whitney test on student learning outcomes for the buffer solution chapter based on digital literacy levels are shown in Table 5.

**Table 5.** Mann-Whitney Test Results Learning Outcomes of Buffer Solutions Based on Digital Literacy Level

Level of Digital Literacy	N	Mean	SD	Asymp. Sig. (2-tailed)
High	42	86.92	12.25	0.003
Moderate	32	78.68	19.98	

Table 4 shows the results of the average difference test with the Mann-Whitney test obtained a significance value of 0.003 ( $p < 0.05$ ), these results indicate that there is a significant difference in buffer solution learning outcomes between groups of students with high literacy levels and groups of students with high literacy levels. Moderate literacy.

Meanwhile, the same analysis was carried out on the learning outcomes of the solubility product by conducting an average difference test. The difference test of the average learning outcomes of solubility product (*K<sub>sp</sub>*) aims to determine the effect of students' digital literacy level on learning outcomes in the solubility product chapter. The normality test on the results of the study of the solubility product chapter obtained the Table 6.

**Table 6.** Normality Test Results of Learning Outcomes Solubility Products based on Digital Literacy Level

Level of Digital Literacy	N	Kolmogrov-Smirnov Test ( <i>p</i> )
High	42	0.000
Moderate	32	0.001

The normality test results show that the resulting significance value (*p*) is less than 0.05, so it can be concluded that the data are not normally distributed. Therefore, the average difference test uses the Mann-Whitney test. The results of the Mann-Whitney test of student learning outcomes in the buffer solution chapter based on digital literacy levels are as in Table 7.

**Table 7.** Mann-Whitney Test Results Ksp Learning Outcomes Based on Digital Literacy Level

<b>Level of Digital Literacy</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Asymp. Sig. (2-tailed)</b>
High	42	95.48	7.71	0.001
Moderate	32	85.31	15.02	

Table 7 shows that the significance value of 0.001 ( $p < 0.05$ ) indicates significant differences in learning outcomes for the Ksp chapter between groups of students with high and moderate literacy levels. The Mann-Whitney test of chemistry learning outcomes in the buffer solution chapter and solubility product shows a significant difference between the group of students with high digital literacy levels and with moderate digital literacy levels. Students with high levels of digital literacy have greater learning outcomes than students with moderate levels of digital literacy. The statistical test results indicate that the level of digital literacy in students influences student learning outcomes in the buffer solution chapter and solubility product. This study's results align with several studies showing that digital literacy influences student learning outcomes and academic achievement (Alavi et al., 2016; Pagani et al., 2016; Johnston, 2020).

Differences in chemistry learning outcomes during distance learning between students with high and moderate levels of digital literacy are influenced by several aspects of digital literacy that are honed and guided during the distance learning process. These aspects include the ability to find and manage information, the desire to learn using digital media, and creation of a collaborative online learning environment during the learning process. Students with a high level of digital literacy will be able to manage online learning facilities and materials well. In addition, students with a high level of digital literacy will also be able to manage information well so that the information obtained follows learning needs. This is in line with several findings in other studies, which state that students with higher levels of digital literacy will be able to build an understanding of the concepts being studied by searching and managing information effectively and efficiently according to learning needs (Ozdamar-Keskin et al., 2015; Maphosa & Bhebe, 2019).

Furthermore, Shopova (2014) states that students' ability to find, understand, evaluate, and use information effectively and efficiently is a basic need that is very important to support the success of the learning process. Managing information during distance learning is one aspect that causes students with high levels of digital literacy to have better learning outcomes than students with moderate levels of digital literacy. Students with high digital literacy can manage information effectively and efficiently when implementing distance learning by using various features on the LMS, video conferencing, and other learning platforms that support the learning process carried out by teachers and students.

In addition, students with higher levels of digital literacy will also have more ability to take advantage of every opportunity during the learning process (Abbas et al., 2019). These opportunities are related to the ease of accessing information in various features of the learning platform to benefit understanding concepts. Students with high digital literacy will take advantage of learning opportunities that can be carried out anytime and anywhere. Students who can utilize and manage digital media well will take advantage of every opportunity to learn by accessing the information on LMS, websites, and other sources outside of learning hours. On the other hand, students with low digital literacy will experience problems in the learning process (Dashtestani & Hojatpanah, 2020). This is related to the lack of student's ability to process information, which will hinder understanding of the concepts being studied. In addition, students with low digital literacy levels will tend not to learn outside class hours due to limitations in using digital media and other learning platforms.

Another aspect that causes differences in learning outcomes between students in the high digital literacy group and those with moderate digital literacy is the desire to learn in students. Students with higher digital literacy have high motivation to learn various concepts through digital media and available learning platforms. The availability of digital media and learning platforms makes information more accessible and easier, making students highly motivated and curious to continue learning every piece of information they access. This is in line with research findings which state that students with good digital literacy will also have a high desire to learn digital content during the learning process in online classes and outside online classes (He et al., 2020). Furthermore, the study results show that using learning platforms such as Edmodo can increase student learning independence so that students can study material independently whenever and wherever (Aulia et al., 2019). In addition, students with high



digital literacy also want to continue learning following technological developments (Techataweewan & Prasertsin, 2017). This shows that students with high digital literacy will also have a high desire to learn content on an ongoing basis in accordance with technological developments to improve their learning outcomes.

In the next aspect, differences in student learning outcomes in chemistry subjects between high digital literacy and moderate digital literacy are being influenced by the effectiveness of the online learning environment, such as the ease of using learning applications/platforms, the availability of a stable internet network, and the availability of tools/gadgets. Digital literacy is a prerequisite for creating an effective learning environment in online learning (Tang & Chaw, 2016). An effective learning environment will affect students' processes and learning outcomes. He & Wray (2017) stated that digital literacy could create a collaborative online learning environment and is more effective in learning various content through digital platforms. This collaborative online learning environment can be created by utilizing several collaborative features, such as features on Google, namely Google Docs, Google Slides, and Google Drive. These features will be put to good use if students can manage them to create an effective and collaborative online learning environment. Thus, students with high digital literacy can create a more effective learning environment during distance learning so that understanding of concepts and learning outcomes is better than students with lower digital literacy.

Exposure to aspects that support students with high levels of digital literacy will have good learning outcomes, illustrating that digital literacy is very important in the learning process, especially learning that is carried out online by utilizing various digital learning features and platforms. These findings and results align with research findings that state that students' digital literacy positively affects learning outcomes in science subjects (Akhyar et al., 2021). Furthermore, this digital literacy needs to be developed in students early to be a provision both in the learning process and to face the challenges of the times. In this day and age, technology and digitalization are used as important elements in all forms of processes and activities of daily life.

## CONCLUSION

The use of technology to support distance learning during the COVID-19 pandemic needs to be balanced with digital literacy skills for students and teachers. Students' digital literacy level is influenced by various factors, namely educational background, family, availability, frequency of interaction with technology, and experience using and managing technology. The diversity of digital literacy levels in students affects the process and learning outcomes with distance learning systems. The results showed significant differences in chemistry learning outcomes between students with high digital literacy and students with moderate digital literacy. The learning outcomes of students with high levels of digital literacy are better than students with moderate levels of digital literacy. Therefore, the use of technology in distance learning during the COVID-19 pandemic needs to pay attention to the level and diversity of students' digital literacy so that online learning can facilitate all students with diverse levels of digital literacy.

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