Using Android-Based E-Module to Improve Students' Digital Literacy on Chemical Bonding

https://doi.org/10.3991/ijim.v16i22.34151

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Abstract—Digital literacy is critical in the current era of digitalization. Therefore, students are required to be digitally literate. This study aims to improve students' digital literacy using an android-based e-module in chemical bonding. This study used a quasi-experimental method with a pre-experimental design that included a pretest and posttest for one group. For this study, 70 pre-service teachers (10 males and 60 females) from the Department of Chemistry Education at a private university in Indonesia were recruited. The Digital Literacy Questionnaire (DLQ) was used to measure students' digital literacy. To analyze the data, we used paired *t-tests* and *N*-gain. The results indicated a significant increase in digital literacy scores before and after treatment. Thus, it can be concluded that using an android-based e-module significantly enhances students' digital literacy on chemical bonds. Due to its effectiveness, we recommend teachers use this e-module to elevate students' academic performance, in general, in chemistry.

Keywords—mobile learning, e-module, digital literacy, chemical bonding

1 Introduction

Digital literacy is the ability to find and share information using digital tools. High-level critical thinking skills including probing, inquiring, problem-solving, and deciding are required for digital literacy [1]. Being digitally literate does not imply that you can use technology at a high level. Consequently, the ability to summarize, synthesize, produce, and display knowledge and accurately access information stored in virtual environments is expected of digitally literate individuals. Digitally literate individuals gain skills such as using the information they receive, transferring it, and

critically assessing their knowledge [2]. Individuals who possess these abilities gain an advantage over others over time. For example, when we look at job advertisements in various sectors, we often see expressions such as mastered office programs, analytical thinking, and so on, which indicate digital literacy.

In this case, one of the must-have aspects today is digital literacy. Digital literacy has a fundamentally important role in improving technology. It is essential in today's world to be able to use digital gadgets like computers and cell phones [3]. This context cannot overstate the importance of digital literacy and capability. Digital literacy can be defined as individuals' knowledge, attitudes, and skills to use digital tools appropriately and facilities that assist in locating, accessing, managing, integrating, evaluating, analyzing, and synthesizing digital resources for constructive social action [4]. In terms of teaching and learning, digital media has a particular benefit over other teaching and learning methods [5]. Several worldwide experts, such as America, Europe, Australia, Asia, and Africa, and various figures conducted the digital literacy survey, including David Bawden, Gloria E. Jacobs, Sonia Livingstone, Guy Merchant, to EszterHargittai. This suggests that the field of digital literacy is quite interesting in encouraging experts to work together to develop digital literacy studies [6]. The Indonesian Internet Service Association (IISA) indicated that internet developments in Indonesia now have a favorable effect. The poll showed that Internet use in Indonesia increased to 143. 26 million out of 262 million people in Indonesia from 132. 7 million in 2018. From 2019 to 2020, IISA will develop in Indonesia to provide 10-20 Mbps Internet access for metropolitan communities [7]. The high number of internet users in Indonesia is not necessarily in line with the quality of digital literacy of its people. According to the Economist Intelligence Unit [8], Indonesia ranks 61st out of 100 countries below Singapore and Malaysia which rank 22nd and 33rd for internet readiness and education level.

Based on the results of research conducted by [9][10][11][31] shows that most students have low digital literacy in both media literacy, information literacy, and ICT literacy. The reason is that in the field of media literacy, it was revealed that teachers rarely use Information and Technology-based learning media, such as android-based e-modules [58][66][75][89][90]; this happens due to the lack of facilities and infrastructure available in learning media, and the lack of understanding and skills of teachers in designing android-based e-learning learning media. In the field of information literacy, the ability of teachers and school and campus library staff is currently inadequate [21][85]. In addition, the lack of quality teacher-student interaction in the learning process [12]. Students cheat on exams, play games, access malicious websites, and communicate online while in class if education is conducted online [13]. The low digital literacy in the education sector in Indonesia is currently driving several government initiatives, such as the National Literacy Movement and the reintroduction of ICT into school curricula. However, it has not been implemented effectively, focusing on improving students' digital literacy. The Universitas Pendidikan Mandalika has not attempted to map digital literacy competencies at the educator and student levels [51]. In other words, the Universitas Pendidikan Mandalika relies on ICT competencies obtained by students in high school. Digital literacy is a prerequi-

site for students to fully participate in various systems that regulate personal and collective life, especially in the learning process in the 21st century.

Thus, students need to acquire digital literacy skills or the ability to use digital technology [14]. With strong digital literacy, students can better protect themselves from the negative consequences of online learning [15]. [14] A strong understanding of how to use technology for information gathering, organization, coordination, and estimation is essential for students in today's culture. [16] In today's world, students must be able to use technology effectively for data collection, organizing, coordination, and estimation. It is based on the fact that digital literacy can affect students' educational outcomes and academic performance [17][18]. Azzahra and Amanta [8] state that digital literacy requires critical thinking to assess the material contained in digital media. Information and communication technology development due to media convergence is still developing in terms of digital literacy competence, which helps handle information in various digital sources [9]. Students need to be equipped with digital literacy because the tendency to operate technological problems in online-based chemistry learning can prevent students from negative influences when doing online activities. In this case, teachers must be able to apply various online learning strategies or media to reduce the harmful risks of online learning [19][20]. The study [51] shows that students are less interested in learning chemistry because they find it difficult to understand chemistry concepts and materials. Chemistry learning will be more exciting and easy to understand if there are teaching innovations using digital technology in its implementation [85].

One of the online learning media that is effectively applied to improve students' digital literacy is an android-based e-module. Android-based e-modules are learning media that can provide opportunities for students to enhance their digital literacy, which is becoming increasingly important [86]. Teaching media in the form of android-based e-modules can save students time accessing learning materials, provide solutions for students to use information and communication technology wisely, and offer space for students to learn independently, find the latest news and obtain helpful information to encourage different perspectives [87]. Android-based e-modules are considered very convenient to use in learning chemical bonding. This is because the concepts in learning chemical bonds that are abstract make it easier for students to learn it, especially the process of forming chemical bonds that cannot be seen with the naked eye but can be illustrated through android media in the form of an android-based e-module [21] [22]. Moreover, the android-based e-module is easily accessible [23] [24]. Mobile-assisted Android-based e-modules can contribute to self-taught support and train critical thinking concepts [25][26][27]. The presence of android-based e-modules can be an effective and fun alternative learning resource [28]. To make it easier for students to absorb the material presented, lecturers need to prepare teaching materials that are by the progress of the industrial revolution 4.0 era, namely: learning that can be delivered through the concept of e-learning in the form of digital electronics in the form of android-based e-modules [29][30]. Android-based e-modules facilitate students in education and can be used for self-study, which is practiced anytime and anywhere [31][32][33].

Therefore, it's appropriate that Digital Literacy in higher educational institutions can become agents of change by implementing learning designs in digital form media to present engaging, contextual, and interactive materials, both audio and visual [34][35]. Using digital media in learning will lead to self-directed learning (SDL) for students to learn to solve problems and evaluate their thinking and performance to a given set of tasks. Many other scholars' digital literacy research examines the influence of student learning outcomes on digital literacy. Student motivation and cognitive development are discussed in this study, which focuses on digital literacy-based education and its effect on student motivation and cognitive outcomes [36][37]. Other research examines digital literacy and independent education in thesis students, where digital literacy significantly influences independent learning [38][39]. Therefore, the novelty of this study is to investigate the effect of using an android-based e-module to improve students' digital literacy on chemical bonding.

This study aims to improve students' digital literacy through a chemistry e-module. The main research question posed in this study is as follows: *Was there a significant increase in digital literacy after the intervention using Android-based e-modules?*

2 Literature review

2.1 The importance of digital literacy for students

Digital literacy is one of the markers to measure students' ability to gain knowledge from the internet and computer resources [40]. One of the characteristics of digital literacy possessed by students is mastery of digital technology devices [51]. Digital literacy becomes better if it can be developed in real-life situations, especially in solving problems, including student assignments [85]. Digital literacy competence is essential because: a) emphasis on raising awareness of thinking in critically evaluating information; b) emphasis on improving the ability to create digital information; c) emphasis the mastery of other skills in the form of computers, the internet, text, media, visual, audio, or the web presented through digital technology devices [41][42]. Some of the results of the research show that e-learning, Google Classroom, social media, and mobile learning can help people learn how to use technology better [43][44][45][46][47].

2.2 E-modules for Android as a learning tool for chemical bond

These days, most modules are completed by printed means [48]. This format of the module is typically boring and unappealing to students [49]. One of the modules that students can be interested in is a module in an electronic format that can be used as an interactive media because it can be inserted by other media such as images, animation, audio, and video [88]. E-modules are online learning resources with materials, methods, limits, and ways to test that are set up in a systematic and interesting way to help students get the skills they need for the curriculum [89]. E-modules become more attractive by equipping the use of android [86]. Android is a software stack

system that is connected and distributed open source (open), consisting of an operating system, middleware, and basic applications (critical applications) for smartphones and tablets [87]. To make up for textbooks' flaws, the android-based e-module incorporates multimedia (audio-visual integration in the form of video), is highly interactive, and uses multi-source learning (internet network connection) [89]. Several studies show that e-modules built for the Android platform boost students' motivation, understanding, and creativity in the classroom [88][89][90]. Learning chemistry bonds includes concepts of an abstract nature [50]. Most students have difficulty understanding and studying chemical bonding material because of its submicroscopic characteristics [51]. As a result, e-modules built for the Android platform can aid students' ability to conceptualize chemistry's abstract principles.

3 Method

3.1 Research design

The research is currently being conducted in March-May 2022 in the 2021/2022 school year. We used a quasi-experimental design in this study to investigate the influence of the use of Android-based e-modules to improve digital literacy on the topic of chemical bonding. Quasi-experimental is a research method that, in its implementation, does not use random assignments but uses existing groups [91]. The quasi-experimental is based on considerations so that in the performance of this research, learning takes place naturally, and students do not feel experimented so within such a situation; it is expected to contribute to the level of validity of the research.

3.2 Participants

The sampling technique is convenience sampling, where samples are taken based on the availability of elements and the ease of getting them at the right place and time. In our selection, we recruited 70 students (10 male and 60 female) from the Department of Chemistry Education at a private university in Indonesia. The age range of the respondents is 17-19 years. They have enrolled in General Chemistry I, a compulsory course in the first year. All respondents are taught by a male lecturer with more than ten years of teaching experience. He earned his M.Ed in Chemistry Education from a local university.

3.3 Data collection instrument

In this study, we developed the Digital Literacy Questionnaire (DLQ). This instrument was adapted from [52], which consists of three subscales; technical skills, critical understanding, and communicative abilities (see Table 1). The indicators described from the subscale are constructed according to the operational definition and characteristics of the respondents, who are students. Based on the indicators that have

been constructed, several sub-indicators are obtained so that the appropriate statement items can be written. Therefore, the points of statement on this instrument also pay attention to the use of technology in the learning process carried out by students. The DLQ instruments that have been developed include 20 items on a Likert scale of 4, ranging from "4" always to "1" never. All items were positive. Examples of items in DLQ instruments are as follows: "*I use educational games and digital books as learning media*", "*I use textbooks during learning*", and "*I use android-based e-module during learning*". It took 40 minutes to complete this instrument.

Table 1. Subscales of digital literacy

Subscales	Indicators of Digital Literacy	Aspects Observed
Technical Skills	• Limited • Fluent • Active	• Using only textbooks in learning activities • Utilizing digital media such as educational games and digital books as learning media • Can use several types of digital media
Critical Understanding	• Understand • Analyze • Evaluate	• Digital media can help me understand the subject matter chemistry bonding. • Students prefer to use printed books instead of using digital media • Using digital media can increase my interest in learning
Communicative Abilities	• Cooperation • Caution • Active participation	• Through digital media, students can exchange ideas with friends about the chemistry bonding • Digital media makes it difficult for students to complete assignments • Students use digital media to discuss

Through SPSS 20, this research validated the instrument used to assess students' digital literacy. The results show that the 20 items are within the valid criteria, as shown in Table 2.

Table 2. The instrument validity from digital literacy

Items	Pearson Correlation	Sig. (2-tailed)	Category
1	.655	.001	Valid
2	.865	.001	Valid
3	.483	.002	Valid
4	.565	.000	Valid
5	.551	.002	Valid
6	.566	.001	Valid
7	.566	.003	Valid
8	.555	.004	Valid
9	.541	.002	Valid
10	.554	.001	Valid
11	.583	.000	Valid
12	.627	.001	Valid

13	.682	.001	Valid
14	.746	.001	Valid
15	.552	.003	Valid
16	.876	.001	Valid
17	.516	.002	Valid
18	.656	.001	Valid
19	.544	.002	Valid
20	.521	.002	Valid

The reliability coefficient of Cronbach's alpha was found to be 0.80 with very high criteria, as shown in Table 3.

Table 3. The instrument reliability from digital literacy

Cronbach's Alpha	***N* of Items**
.80	20

3.4 Procedure

The treatment was carried out for eight meetings (8 x 50 mins = 400 mins), including two meetings for the pretest and posttest and six meetings to study ionic bonds for three meetings and covalent bonds for three sessions. Beginning of the intervention, the lecturer made an apperception by asking: "*Do you know what the nature of a compound is based on the bond?*". Then the lecturer presented an illustration as a case in the provided e-module. The lecturer asked students to discuss the issue that had been given and solve the problem in small groups. The lecturer encouraged students to present the results of their group discussions. Then, the lecturer reinforced the results of the debate. Students were also asked to watch a video about the process of forming ionic bonds presented in the e-module (see Figure 1). The lecturer then asked the students to discuss developing experimental plans related to ionic bonds in collaboration with their peers. The lecturer evaluated a project that the students had made. At the last meeting, students conducted experiments, and the lecturer guided students in conducting investigations on the identification of ionic compounds. The lecturer also directed students to reflect on the investigation processes that students have carried out.

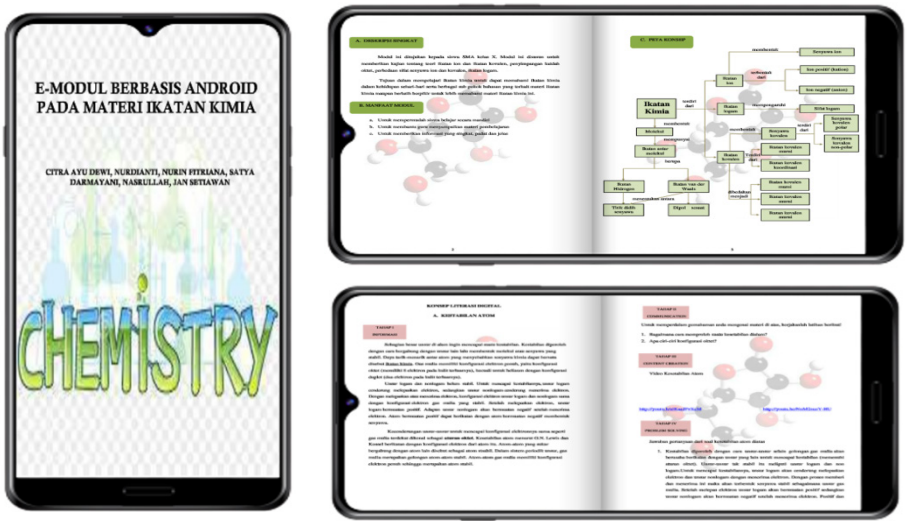

Fig. 1. Screenshot of the e-module on chemical bonds

3.5 Data analysis

The data were analyzed using prerequisite tests, namely the normality test to determine whether the distribution of the data to be analyzed was normally distributed and the homogeneity test to test the similarity of population variants that were normally distributed. Based on the results of the analysis using the Kolmogorov-Smirnov Test, a significant value (p = 0.099) > 0.05, which means that the data is normally distributed, while the homogeneity test using Levene's testwith a significant value (p = 0.328) > 0.05 which means homogeneous data. There is a difference in the average score from the pretest to the posttest using paired t-tests, while the *N-gain test* measures how much the digital literacy improvement score is between before and after the intervention. The calculation results obtained by the value are <g> then interpreted into three categories, namely<g>:

Table 4. Gain value classification[92]

Average Gain	Criteria
0.00 <g ≤ 0.30	Low
0.30 <g ≤ 0.70	Medium
0.70 <g ≤ 1.00	High

4 Result and discussions

In this session, we present the results of the t-test analysis. There is a significant difference between pretest and posttest scores in favor of posttest scores (t = -106.702; p = 0.033). The results can be seen in Table 5.

Table 5. The results of the paired *t*-test for digital literacy

Scale		Mean	SD	*t*	*P*
Technical Skills	Pretest	42.3	6.43	-320.388	0.014
	Posttest	73.0	7.00		
Critical Understanding	Pretest	56.3	7.77	-144.414	0.041
	Posttest	75.3	5.51		
Communicative Abilities	Pretest	61.0	9.29	-613.111	0.032
	Posttest	81.0	4.00		
All subscales	Pretest	53,2	3.32	-106.702	0.033
	Posttest	76.4	4.12		

This indicates that the use of an android-based e-module significantly increases students' digital literacy on the topic of chemical bonding. Students can better grasp concepts related to chemical bonding through the use of Android-based E-modules. Students' self-study motivation directly increases because they already have provisions with the material discussed. Android-based e-modules are a type of digital media that may be used in the classroom since they have both easy-to-read text and illustrative graphics to help students grasp complex concepts [59]. E-module-based android isone type of learning tool that lecturers can use [60]. The android-based e-module is a tool that has teaching materials that were made in a systematic and interesting way to help students get the skills they need [61]. The android-based e-module teaches students how to effectively leverage digital and paper resources to further their education [62][63][64]. Android-based e-module can be defined as the presentation of student learning materials that can be understood independently and arranged systematically to achieve learning objectives [65][66][67].

4.1 Improving digital literacy in the technical skills

To see the improvement in students' digital literacy in each subscale, we employed paired *t*-tests and *N*-gain scores. Specifically, the results of the analysis are presented in Tables 6-8.

Table 6. Student digital literacy of technical skills

Technical Skills	Paired differences		*T*	*df*	*p*	*G*
	Mean	*SD*				
Limited	50	15.053	-455.961	70	0.038	0.46
Fluent	61	15.583	-186.466	70	0.039	0.56
Active	63	15.555	-471.159	70	0.019	0.58
All subscales	58	15.397	-371.195	70	0.020	0.53

Table 6 shows that the technical skills aspect of the little indicator is at an *N*-gain score of 0.46, the fluent indicator is at an *N*-gain score of 0.56, and the activity indicator is at an *N*-gain score of 0.58 with a medium category. They indicated that technical skills in students' digital literacy have improved after being taught using an android-based e-module. Technical skills are part of personal competencies' ability to use media [54]. Technical skills are a person's ability to operate and use a specific press effectively. The ability to access digital media for a person depends on the type of digital media, the needs, and the particular functions of digital media [55].

4.2 Improving digital literacy in the critical understanding

Table 7 shows that the critical understanding aspect of the understand indicator is at an *N*-gain score of 0.38, and the analyze indicator is at an *N*-gain score of 0.40. The evaluate indicator is at an *N*-gain score of 0.50 with a medium category. This study's results show that students' critical understanding can improve through the use of an android-based e-module. Students with critical understanding abilities can reach the level of understanding, analyzing, and evaluating well.

Table 7. Student digital literacy of critical understanding

Critical Understanding	Paired Differences		*T*	*df*	*p*	*G*
	Mean	*SD*				
Understand	60	9.859	-107.710	70	0.027	0.38
Analyze	72	7.206	-50.683	70	0.014	0.40
Evaluate	66	12.080	-147.632	70	0.022	0.50
All subscales	66	9.715	-102.008	70	0.023	0.43

The critical understanding level in digital literacy is defined as the level of understanding possessed by students at the level of assessing the accuracy and correctness of the information. The critical understanding level is already included in the ability to think at a high level. Students are asked to evaluate information that is appropriate and incompatible with understanding the readings that have been read. From this, the student repeatedly thinks about the conformity of the news with his understanding. In addition, the critical understanding level is also related to the student's ability to indicate errors in language elements (words, phrases, clauses, sentences) and spelling

used in reading. If it is associated with Bloom's taxonomic formulation, the critical understanding level is included in the evaluation ability.

In the learning process, the android-based e-module is used as a primary information provider because it presents various subject matter. In addition, the android-based e-module is also used as instruction material for students who review teaching materials in full with interesting images [68][69][70]. Another use of an android-based e-module is to train students to assess their abilities through tests that have been presented on mobile [71][72]. This makes an android-based e-module exciting and very much needed in learning. In addition, the use of an android-based e-module also causes the role of lecturers to be less dominant in learning activities. Another advantage of an android-based e-module is that they accommodate various student learning speeds [65][73][74]. Students with a high learning speed will complete the module faster or understand the content more easily. On the other hand, slow students can have the learning material repeated as often as they want to understand it better. This is what helps students understand what they are learning.

4.3 The Improving digital literacy in the communicative abilities

Table 8 shows that the communicative abilities aspect of the cooperation indicator is at an *N*-gain score of 0.54, the caution indicator is at an *N*-gain score of 0.46, and the active participation on indicator is at an *N*-gain score of 0.55 with the medium category. This means that students' communicative abilities can be improved by using an android-based e-module.

Table 8. Student Digital Literacy of Communicative Abilities

Communicative Abilities	Paired differences		*T*	*df*	*p*	*G*
	Mean	*SD*				
Cooperation	64	13.559	-285.376	70	0.009	0.54
Caution	73	8.032	-387.484	70	0.005	0.46
Active participation	76	7.029	-339.049	70	0.015	0.55
All subscales	71	9.540	-337.303	70	0.009	0.52

Communicative abilities are the ability to understand ideas and chemical symbols and convey the results to others [56]. Communicative abilities can be used as a communication tool to communicate chemical ideas in writing [57][58]. Based on the research results by [58][75], an android-based e-module can increase student learning motivation. E-module can improve students' understanding of concepts and chemistry literacy [76][77]. E-module can improve students' critical and creative thinking skills [78][50][79]. E-module can improve students' visual-spatial intelligence, communication, and higher-order thinking skills [80][81][51][82]. The use of e-module is easy to understand than reading books, exciting and not dull, and the language delivery is more transparent [83]. The use of e-module is easy to use because it is user-friendly with the support of e-module content integrated with web-based learning internet links [84].

5 Conclusion

Based on the results of the study, it can be concluded that there is a significant increase in students' digital literacy through the use of android-based e-modules on aspects of technical skills, critical understanding, and communicative ability in the medium category. The impact of using android-based e-modules in the learning process is that as a multi-source, learning is more flexible because it can be carried out anywhere and anytime, not only limited to the classroom, providing opportunities for teachers to develop digital-based learning techniques. The limitation of this study is that the Android-based e-module is a reasonably new medium for students, so many are not used to using it during the learning process. Practitioners should prepare for engaging learning scenarios by using Android-based e-modules to maximize the learning process more enjoyable. Suggestions for subsequent researchers to conduct similar research from other areas of learning.

6 Acknowledgment

We would like to thank the Universitas Pendidikan Mandalika for guiding and supporting this study.

7 References

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Article submitted 2022-07-22. Resubmitted 2022-10-07. Final acceptance 2022-10-15. Final version published as submitted by the authors.