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Cybergogy-Assisted E-Module to Boost Middle Schoolers' Digital Literacy in the Mixture Separation Topic

Novitasari Ramadhani[1]*, Hasan Subekti[2]
Universitas Negeri Surabaya, Indonesia
***Email Correspondence:** novitasariramadhani.21026@mhs.unesa.ac.id

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Abstract

This study aims to describe the effect of a cybergogy-based approach supported by an e-module in fostering students' digital literacy on the topic of mixture separation. Motivated by the demands of Industry 4.0/Society 5.0 and low literacy outcomes (e.g., PISA 2022) as well as preliminary findings at SMP Negeri 1 Bagor—where only 50% of students surpassed the Minimum Mastery Criterion (KKM) of 70 in science—the research employed a pre-experimental one-shot case study design with 32 Grade VIII-D students. Digital-literacy performance was measured through a verified posttest and analyzed descriptively and inferentially. Shapiro–Wilk testing indicated non-normality, so a Wilcoxon test was conducted against the KKM benchmark. The mean posttest score was 82.28 (min 75.00; max 91.66), with average achievement across components of 79% (high category); hypertext navigation was the strongest component (94%, very high), while content evaluation was the weakest (64%, high). The Wilcoxon test yielded Asymp. Sig (2-tailed) < 0.001, indicating a significant improvement relative to the benchmark. These findings suggest that the cybergogy-assisted e-module is effective for cultivating students' digital literacy in mixture separation, with device-access constraints noted as a practical limitation for future implementations.

Keywords *cybergogy, e-module, digital literacy, mixture separation.*

INTRODUCTION

The rapid diffusion of digital technologies associated with the Fourth Industrial Revolution—together with the human-centered aspirations of Society 5.0—has reshaped expectations for schooling. Classrooms are increasingly connected, learning resources are digitized, and participation in knowledge building is expected to transcend the constraints of space and time. Within this landscape, cybergogy offers a purposeful framework for orchestrating cognitive, social, and emotional engagement through information and communication technologies, enabling learning that is not limited by traditional classroom boundaries.

At the same time, digital literacy has become a foundational competence for students. Beyond operational fluency, it entails strategic searching, purposeful hypertext navigation, critical evaluation of sources, and the integration of knowledge for problem solving and communication. These competencies condition students' ability to benefit from digital environments and to participate in a labor market that increasingly rewards information-handling expertise. National indicators underscore this urgency. Indonesia's performance in the 2022 Programme for International Student Assessment (PISA) shows persistent challenges in literacy: the country ranked 69th of 81 participating systems, and the reading score declined relative to 2018.

Such signals suggest that schools must not only expand access to devices and connectivity but also cultivate the dispositions and skills necessary to navigate and make sense of information-rich settings.

Local classroom realities echo these national concerns. Preliminary interviews at SMP Negeri 1 Bagor revealed a steep performance gap on the mixture separation topic: during the 2024/2025 school year only 50% of students reached the Minimum Mastery Criterion (KKM) of 70 in science.

Teachers also reported that instruction remained largely conventional and print-centric, relying on articles, textbooks, and modules issued by the local subject teachers' association. While useful, such media are difficult to update, cannot present dynamic processes, and tend to encourage linear reading rather than exploratory learning—limitations that dampen opportunities to practice digital literacy in authentic ways.

E-modules present a promising response to these constraints. Conceptually, an e-module is an electronically packaged set of learning materials that can bundle concept explanations, worked examples, embedded multimedia, curated links to articles and videos, and formative checks such as online quizzes and short reflections.

When thoughtfully designed, these features scaffold the core components of digital literacy: targeted searching (through linked resources and guided prompts), purposeful navigation (via hyperlinked sections and multimedia), critical evaluation (through source-comparison tasks and credibility checklists), and knowledge organization (via summaries, glossaries, and concept maps embedded in the module). In principle, therefore, e-modules are well-suited to help students learn science content while simultaneously cultivating the literacies required to learn with and from digital texts.

However, instructional media alone are insufficient without an overarching pedagogical design that fosters participation and reflection. Cybergogy provides this alignment: it positions the e-module not as a stand-alone digital textbook but as a catalyst for inquiry cycles, collaborative discussion, and feedback within and beyond the classroom.

In a cybergogical sequence, students might preview ideas asynchronously using the e-module; explore curated links, data sets, or short simulations during class; and then synthesize insights through peer dialogue and reflective prompts. The teacher's role shifts toward curating trustworthy resources, facilitating sense-making, and orchestrating social interaction around evidence and claims—activities that are central to digital literacy and to scientific reasoning alike.

Despite the intuitive appeal of pairing cybergogy with e-modules, applied studies at the lower-secondary level in Indonesia that focus specifically on the mixture separation topic and explicitly measure digital literacy outcomes remain limited. Much of the extant literature is product-oriented—demonstrating that an e-module functions properly or is well-received—rather than implementation-oriented—examining how a digital resource is enacted within a pedagogical framework to yield specific competencies. Narrowing this gap matters for two reasons. First, mixture separation is conceptually rich and experimentally accessible at the junior-high level, providing a natural context for students to practice locating, evaluating, and organizing information about procedures, apparatus, and real-world

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applications. Second, the skills rehearsed in this topic (e.g., comparing sources, interpreting diagrams, planning steps) are transferable to other areas of science and to cross-curricular tasks in which students must make judgments about information quality.

The present study responds to this need by implementing cybergogy assisted by an e-module in a Grade VIII science class at SMP Negeri 1 Bagor. The school context is typical of many Indonesian junior high schools: device access and ICT facilities are uneven, instruction has relied on conventional methods, and digital teaching materials have not been systematically adopted.

The intervention is anchored both in the observed performance deficit on mixture separation and in the local benchmark of mastery (KKM 70), ensuring that results are interpretable relative to a standard already familiar to teachers and students.

Methodologically, the study adopts a pre-experimental one-shot case study design and involves 32 students from class VIII-D at SMP Negeri 1 Bagor.

This choice is appropriate for a first implementation in a specific setting where immediate goals are to establish feasibility, document outcome patterns, and generate effect evidence against a meaningful benchmark. Operationally, the cybergogy-assisted e-module sequence was delivered across two meetings, after which students completed a validated posttest of digital literacy aligned with components such as searching, hypertext navigation, content evaluation, and knowledge organization.

While the design does not include a comparison group, it enables an initial test of whether post-intervention performance exceeds the KKM—a criterion-referenced question of high practical value to the school.

Two implementation considerations are salient. First, access constraints can dilute the effects of any technology-enhanced approach. Observations identified limited ICT facilities and uneven device ownership—issues that require mitigation strategies such as providing loaner devices, structuring pair work, and simplifying access to online materials through QR codes or short links.

Second, the success of a cybergogy-assisted sequence depends on teachers' readiness to curate digital resources and facilitate online interaction. Because the school had not previously used e-modules systematically in science, professional conversations focused on aligning e-module activities with lesson goals, pacing inquiry tasks, and integrating brief formative checks to support students who were less familiar with digital navigation.

Against this background, the study advances three aims. First, it articulates a pragmatic implementation model that aligns specific e-module features with cybergogy's engagement principles—cognitive challenge (e.g., problem-based prompts and checkpoints), social interaction (e.g., peer review of source credibility), and emotional support (e.g., formative feedback and reflective journaling). Second, it operationalizes digital literacy as a set of assessable components pertinent to science learning and examines students' performance after the intervention. Third, it evaluates whether observed outcomes exceed the KKM benchmark, thus providing actionable evidence to teachers and school leaders about the effectiveness of the approach in their context.

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This contribution is both local and general. Locally, it offers a feasible pathway for a school that has not previously implemented e-modules in science to foster digital literacy through a structured, technology-supported sequence.

More generally, it illustrates how cybergogy can transform an e-module from a static repository of content into a participatory environment that nurtures the habits of mind required for literate participation in digital spaces. By making the alignment between pedagogy and medium explicit, the study adds to a growing conversation about how schools can meet the twin demands of content mastery and digital competence under realistic resource conditions.

In summary, Indonesian schools face simultaneous pressures to expand digital access, improve literacy outcomes, and make learning more engaging and resilient to disruption. Cybergogy, when paired with well-designed e-modules, offers a route to integrate these imperatives: it leverages ICT to structure participation and reflection, while digital materials provide flexible, interactive pathways through content. Situated in the mixture separation topic at SMP Negeri 1 Bagor, this study investigates whether such a pairing can measurably strengthen students' digital literacy relative to the KKM benchmark and, in doing so, provides grounded insights to inform future iterations and broader implementation.

METHOD

This study uses a quasi-quantitative approach with a *pre-experimental design* experiment design in the form of *a one-shot case study design*. to find out the response of students after treatment (Diraya et al., 2021). This research is determined based on the purpose of the research, which is to describe the impact of the implementation of *cybergogy* assisted by e-modules to train students digital literacy.

Table 1. Research Design *One-shot case study design*

Treatment	*Posttest*
X	O

Source: Sugiyono (2017)

Information:
X = Learning with the implementation of *cybergogy* assisted by e-modules
O = Posttest score

The e-module that has been developed is piloted on 32 students in grades VIII-D SMP Negeri 1 Bagor for the 2024/2025 school year with *a cluster random sampling* technique. According to Lestari, et al. (2017) stated that *cluster random sampling* is a regional sampling technique that aims to determine a sample if the object or subject or data source being studied is very broad (Handayani & Muhammadi, 2023). The test method was carried out on the 32 students, before and after the implementation *of cybergogy* assisted by e-modules. This research was conducted at SMP Negeri 1 Bagor which is located in Banarankulon Village, Bagor District, Nganjuk Regency. This study uses validated digital literacy *ability posttest* questions and teaching tools in the form of teaching modules and e-modules that have been validated. Data on the results of students working on digital literacy *posttest* questions was

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collected through answer sheets after being treated for two meetings in October 2024. Students are given clear questions and instructions on how to answer the *digital literacy* skills posttest questions.

The data analysis technique used in this study is a quantitative descriptive technique. The value of students digital literacy skills is summed up in each aspect, including aspects *of searching, hypertext,* content evaluation and knowledge preparation. Then the average value is sought. The average score of *the posttest* and the reference score or KKM will be compared. Analyze the results of students mastery of concepts by looking at the results of *the posttest*. The results of *the posttest* score are calculated using the following formula (Pratiwi & Indana, 2022):

$$Knowledge\ score = \frac{Total\ scores\ obtained}{Maximum\ score}\ x\ 100$$

Students are declared complete if they get a *posttest score* with a score of ≥ 70 which is the KKM score for science subjects at SMP Negeri 1 Bagor. The indicator is declared complete by the researcher if the average assessment is ≥ 70%. The guidelines for the value of the digital literacy category, adapted by (Ayun, 2021) in Arikunto (2013) are as follows.

Table 2. Guidelines for Digital Literacy Value Categories

Score (x)	Category
x ≥ 80	Very High
60 < x ≤ 80	High
40 < x ≤ 60	Medium
20 < x ≤ 40	Low
X ≤ 20	Very Low

The results of achieving digital literacy skills will be analyzed using a data normality test using the *Kolmogorov-Smirnov* and *Shapiro-Wilk* formulas, hypothesis tests using *the one sample t test* formula. The normality test and hypothesis test were processed using *the SPSS version 25.0 for windows* program. If the data is abnormal, then it can be tested with *a wilcoxon* test.

RESULTS AND DISCUSSION

The achievement of digital literacy in each aspect was obtained from *the posttest*. The achievement of digital literacy in each aspect can be seen in Figure 1 below.

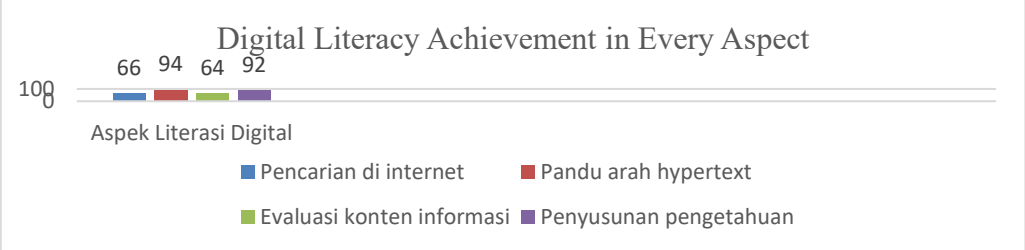

Figure 1. Achievement of Digital Literacy in Each Aspect
Source: Primary Data

Based on Figure 1, it can be seen that the achievement of digital literacy in each aspect of the *posttest* results in different percentages. The average percentage of the overall achievement of each aspect of digital literacy in the *posttest* was obtained at 79% which was categorized as high. The achievement of the lowest aspect in the *posttest*, namely the evaluation of information content with 64% which is categorized as high, while the achievement of the highest aspect lies in the *hypertext direction guide* aspect with a percentage of 94% which is categorized as very high.

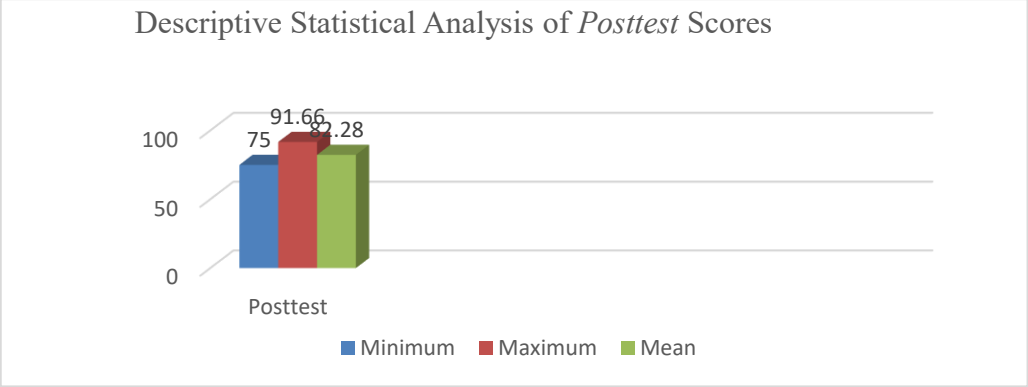

Figure 2. Diagram of descriptive statistical analysis of *posttest scores*
Source: Primary Data

Based on the results of the descriptive analysis that has been described in Figure 2, it shows that the average posttest score is 82.28 with a minimum score of 75.00 and a maximum score of 91.66. These values cannot be used as a conclusion to see significant differences, so it requires statistical inferential testing, namely hypothesis testing, namely using *a one-sample t-test*.

Before conducting a hypothesis test, the data that has been obtained needs to be carried out a prerequisite test for data analysis, namely the normality test. A normality test is used that aims to see the normality or abnormality of the data. Based on a small sample size or no more than 100 samples, the researcher used the *Shapiro-Wilk normality test* with a significant level α = 0.05. If the significance is above 0.05, it means that there is no significant difference between the data tested and the standard normal data or the normally distributed data in another sense, that is, the data tested for normality is no different from the standard normal. The following are the results of the calculations obtained.

Table 3. Normality test

Data Type	*Shapiro-Wilk*			Information
	Statistic	df	*Sig.*	
Posttest	0.413	32	0.000	Abnormal

Based on Table 3, the results of the data normality test obtained in the *posttest* data are not normally distributed with a value of sig. < 0.05, which is 0.000. So, it can be concluded that the data is not normally distributed. If the results of the data distribution obtained are abnormal, then the data cannot be parametrically tested with the *one sample t-*

SINOMICS JOURNAL
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test but tested through non-parametric statistical tests, namely the *Wilcoxon Sign Rank Test* (Mardiah et al., 2024; Navila & Toharto, 2023).

Decision making in hypothesis testing can be known by looking at a comparison of values from probability *Asymp. Sig (2-tailed)* at the level of significance $\alpha = 0.05$. The data acquisition is shown in the following table.

Table 4. *Wilcoxon* Test *Rank*

		N	Mean Rank	Sum of Rank
Digital Literacy *Posttest* Results – Reference Score/KKM	Negative Ranks	0^a	.00	.00
	Positive Ranks	32^b	16.50	528.00
	Ties	0^c		
	Total	32		

a. Digital Literacy *Posttest* Results < Reference Score/KKM
b. Digital Literacy *Posttest* Results > Reference Score/KKM
c. Digital Literacy *Posttest* Results = Reference Score/KKM

Based on Table 4 of the results of the *Wilcoxon* Test *Rank,* it was found that the negative difference obtained from digital literacy skills between the reference score of 70 and the *posttest*, which was 0 on the N value, the average rating, and the total ranking. This states that between the reference score and the results of the digital literacy *posttest,* there is no decrease in the results of students digital literacy skills after learning with the implementation of *cybergogy* assisted by e-modules. Meanwhile, the positive difference obtained, namely students digital literacy skills, increased by 32 students overall in the *posttest* from the reference score. The average rating listed is 16.50 and the number of ratings is 528.00. There was no similarity between the results of students digital literacy skills in the reference score and the digital literacy *posttest* score. Therefore, it can be concluded that there are 32 students who experienced an increase in digital literacy skills from the reference score with the *posttest* score after the implementation of *cybergogy* assisted by e-modules.

Table 5. *Test Statistics*[a]

Test Statistics[a]

	Digital Literacy *Posttest* Results – Reference Score/KKM
Z	-5.210^b
Asymp. Sig. (2-tailed)	.000

a. *Wilcoxon* Signed Ranks Test
b. Based on negative ranks

Based on **Table 5** of the *Wilcoxon* test statistics, *the Asymp* value was obtained. *The Sig (2-tailed)* in the *Wilcoxon* test result is 0.000 which is less than the significance value $\alpha = 0.05$ (0.000 < 0.05) which results in H_o being rejected and H_1 being accepted. This

indicates that there is a significant average difference between the reference score and the results of the students digital literacy *posttest* in the implementation of *cybergogy* assisted by e-modules.

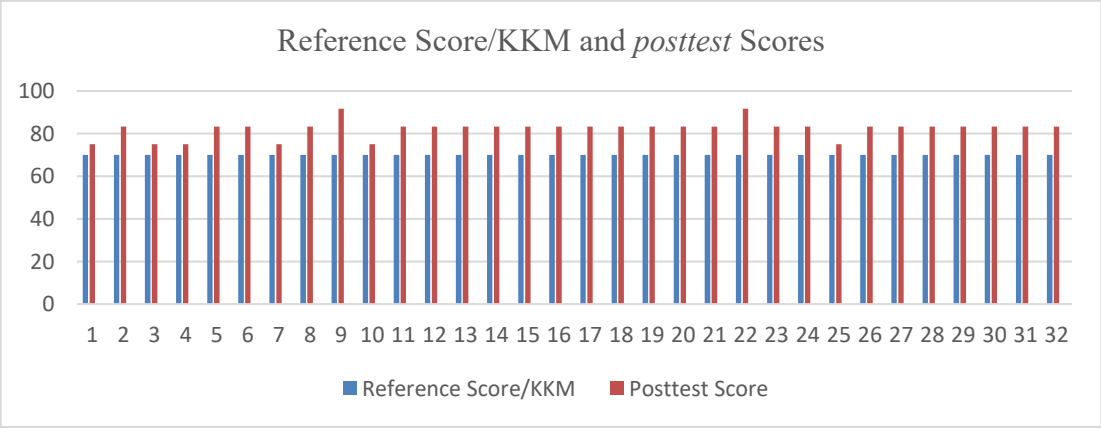

Figure 3. Diagram of reference value/KKM and *posttest* score
Source: Primary Data

Based on **Figure 3** of the diagram of the reference score/KKM and *posttest* scores, it can be reviewed that all students get a significant influence. The *posttest* score obtained by students is higher than the reference score/KKM which shows that the application of learning with the implementation of *cybergogy* assisted by e-modules is able to have an influence on students digital literacy skills.

Interpretation of Key Findings

Based on the hypothesis test with the *Wilcoxon* test, it is stated that the value of Asymp. *Sig (2-tailed)* in the *Wilcoxon* test result is 0.000 which is less than the significance value $\alpha = 0.05$ (0,000 < 0,05) which results in H_o rejected and H_1 accepted. This indicates that there is a significant average difference between the reference score and the results of the students digital literacy *posttest* in the implementation of *cybergogy* assisted by e-modules. This is in line with research (Mardiah et al., 2024) which shows that the use of e-modules in learning with a significance value of 0.000 < 0.05 on the *Wilcoxon* test improves student learning outcomes and is effectively used in learning. In addition, other research from (Budihardjo & Prapanca, 2023; Rofi'i et al., 2022; Rohmayanti & Hidayah, 2023) also produced a value *PvalueasympSig (2-tailed)* as 0,000 < 0,05. Therefore, the use of e-modules in *cybergogy* learning can affect the extent of students digital literacy skills towards lessons.

Comparison with Previous Studies

The use of e-modules in learning with the implementation of *cybergogy* has been proven to have an influence on students digital literacy skills. According to (Astuti et al., 2024; Lestari et al., 2024; Maulidiyah et al., 2024; Muhsam et al., 2024) the application of e-modules can train digital literacy skills. Referring to the significant average difference between the reference score and *the posttest* score in the implementation of e-module-assisted *cybergogy*, there is an influence on the implementation of e-module-assisted

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cybergogy in class VIII-D at SMP Negeri 1 Bagor. This is in line with other research conducted by (Khoirunisa, 2023), explaining that the use of e-modules can channel messages learning well, as evidenced by the average *posttest* score of the experimental class is better than that of the control class. Several other studies (Alyspa et al., 2022; Rahman et al., 2023; Siswanto et al., 2022) stated that students must master digital literacy skills considering that all areas of life have used various technological products.

Limitations and Cautions

Based on the results of observations in the field, it is stated that there are several obstacles in the field. According to (Muktamar et al., 2023), researchers must make decisions in dealing with them. The problem in this study is that a student does not carrying a mobile phone. The solution, namely before learning begins, the researcher has provided a *handphone* If there are students who do not carrying a mobile phone. Another obstacle is that some students have difficulty accessing the link to the *posttest* questions. The solution is that the researcher directs his students to use *Google Lens* or a scanner to copy the link. *Google Lens* is used to scan and copy links (Ruhaliah et al., 2022). Therefore, researchers can solve problems by providing solutions and as a form of reference for further research.

Recommendations for Future Research

Future research focuses on overcoming limitations by providing backup devices in the form of mobile phones before learning begins to ensure all students have equal access to technology. In addition, to face difficulties in accessing the links in the questions, you can use *Google Lens* technology or a similar scanner. Researchers take these steps to improve the success of research in facing obstacles in the field and make an important contribution to future research.

CONCLUSION

This study aims to describe the influence of the implementation of e-module-assisted *cybergogy* to train students digital literacy. The findings showed that the *results of the students* posttest were in the form of an average score of 82.28, a minimum score of 75.00, and a maximum score of 91.66 with a level of complete achievement. Test Statistics *Wilcoxon* test, obtained a score *Asymp. Sig* (*2-tailed*) is 0,000 < 0.05, Highlighting that digital literacy is currently a skill in using digital media is very important to master. In particular, *cybergogy* implemented with the help of e-modules can contribute to improvement and innovation using digital media in learning. In addition, certain limitations must be considered, such as a student who does not carry a mobile phone. Future research should focus on identifying future directions or opportunities to build on studies that have the potential to improve understanding of this research.

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