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# The Effect of Using Guided Discovery Learning-based Acid-Base E-Modules on Students' Reading Literacy and Numeracy Skills

# Pengaruh Penggunaan E-Modul Asam Basa berbasis *Guided Discovery Learning* terhadap Kemampuan Literasi Membaca dan Numerasi Peserta Didik

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***Abstract***

*The Acid Base E-Module based on Guided Discovery Learning (GDL) has been validated and tested for practicality, but its effectiveness and impact on students' reading and numeracy literacy have not yet been tested. The purpose of this study is to analyze the effect of using e-modules on improving reading and numeracy literacy among Phase F students at SMAN 3 Bukittinggi. This research is a quasi-experimental study using a non-equivalent control group design. The research population included Phase F students at SMAN 3 Bukittinggi, with samples from classes XI F 3 and XI F 4 selected using purposive sampling. This study uses test instruments to evaluate students' reading literacy and numeracy skills. Data analysis employs N-gain tests, normality tests, homogeneity tests, and hypothesis tests. The study results show that the average N-gain for reading literacy in the experimental class (0.52) is higher than that of the control class (0.5). The normality and homogeneity tests showed a normal and homogeneous distribution in reading literacy. The hypothesis test using the t-test produced a* $t_{count}$ *value (2.0032) that was greater than the* $t_{table}$ *value (1.9955). The average N-gain in the experimental class for numeracy literacy (0.36) was also higher than that of the control class (0.26). Normality and homogeneity tests produced a normal and non-homogeneous distribution in numeracy literacy, and the t' test produced a* $t'_{count}$ *value (3.5492) greater than the* $t_{table}$ *value (2.0058). These findings indicate that the application of the acid-base e-module with the GDL approach has a significant impact on reading and numeracy literacy.*

***Keywords:*** *Acids and bases, e-module, guided discovery learning, numeracy literacy, reading literacy.*

**Abstrak**

E-Modul Asam Basa berbasis *Guided Discovery Learning* (GDL) telah divalidasi dan diuji kepraktisannya, namun efektivitas dan pengaruh terhadap literasi membaca dan numerasi peserta didik belum diuji. Tujuan studi ini untuk menganalisis pengaruh pemanfaatan e-modul tersebut dalam peningkatan literasi membaca dan numerasi pada peserta didik Fase F di SMAN 3 Bukittinggi. Jenis riset ini ialah *Quasi Experiment Research* memakai desain *non-equivalent control group design*. Populasi riset mencakup peserta didik Fase F di SMAN 3 Bukittinggi dengan sampel kelas XI F 3 dan XI F 4 yang dipilih secara *purposive sampling*. Riset ini menggunakan instrumen soal tes untuk mengevaluasi kemampuan literasi membaca dan numerasi peserta didik. Analisis data menggunakan uji N-gain, uji normalitas, uji homogenitas, dan uji hipotesis. Hasil riset didapatkan rata-rata N-gain pada kelas eksperimen untuk literasi membaca (0.52) lebih tinggi daripada kelas kontrol (0.5). Uji normalitas dan homogenitas menunjukkan distribusi normal dan homogen pada literasi membaca. Uji hipotesis menggunakan uji t menghasilkan $t_{hitung}$ (2.0032) yang lebih besar daripada $t_{tabel}$ (1.9955). Rata-rata N-gain pada kelas eksperimen untuk literasi numerasi (0.36) juga lebih tinggi daripada kelas kontrol (0.26). Uji normalitas dan homogenitas menghasilkan distribusi normal dan tidak homogen pada literasi numerasi, dan uji t' menghasilkan $t_{hitung}$ (3.5492) lebih besar dibandingkan $t_{tabel}$ (2.0058). Temuan ini mengindikasikan bahwa penerapan e-modul asam basa dengan pendekatan GDL berdampak signifikan terhadap literasi membaca dan numerasi.

**Kata Kunci:** Asam basa, e-modul, *guided discovery learning*, literasi membaca, literasi numerasi.

## 1. Introduction

Modern 21st-century education integrates character development, literacy, practical skills, technology utilization, and knowledge (Maulidia et al., 2023). This concept is in line with the characteristics of 21st-century skills published by the 21st-century Skills Partnership. The document emphasizes that every 21st-century learner needs to hone skills that meet the demands of the times. The importance of these skills becomes apparent in 21st-century learning, which is not limited to traditional literacy such as reading and memorization, but also includes problem-solving abilities. In this case, learners are also expected to master the 4C skills, namely Critical Thinking, Communication, Collaboration, Creativity (Griffin & Care, 2015).

Learners facing the challenges of life in the 21st-century also need to hone and strengthen their character and literacy skills to adapt and live life in the era of globalization. According to PIAAC (Programme for the International Assessment of Adult Competencies), literacy is the ability to understand, assess, utilize, and interact through written text to play a role in society, achieve goals, and develop individual insight and potential (OECD, 2012). This literacy includes reading and numeracy literacy. These two literacies are fundamental skills that are an important part of the Merdeka Curriculum. Based on Permendikbudristek RI No. 17 of 2021 related to National Assessment, this evaluation is designed to measure cognitive learning outcomes. According to Article 2 letter a, reading and numeracy literacy are assessed through a minimum competency assessment (Permendikbudristek, 2021).

Reading literacy is students' skill in finding information, understanding, evaluating, and reflecting on texts needed in social life. Numeracy literacy is knowing, applying, and integrating mathematical concepts in everyday life (Pusmenjar, 2020). In this context, reading literacy enables learners to understand and analyze text effectively, while numeracy literacy helps them apply mathematical concepts appropriately to solving chemical problems theoretically and practically. These two skills are important indicators in assessing learners' competencies. In addition, according to the PISA assessment, the selection of reading and numeracy literacy competencies is based on the low literacy skills of students in Indonesia. The results of the PISA assessment for Indonesia from 2000 to 2022 are shown in Figure 1.

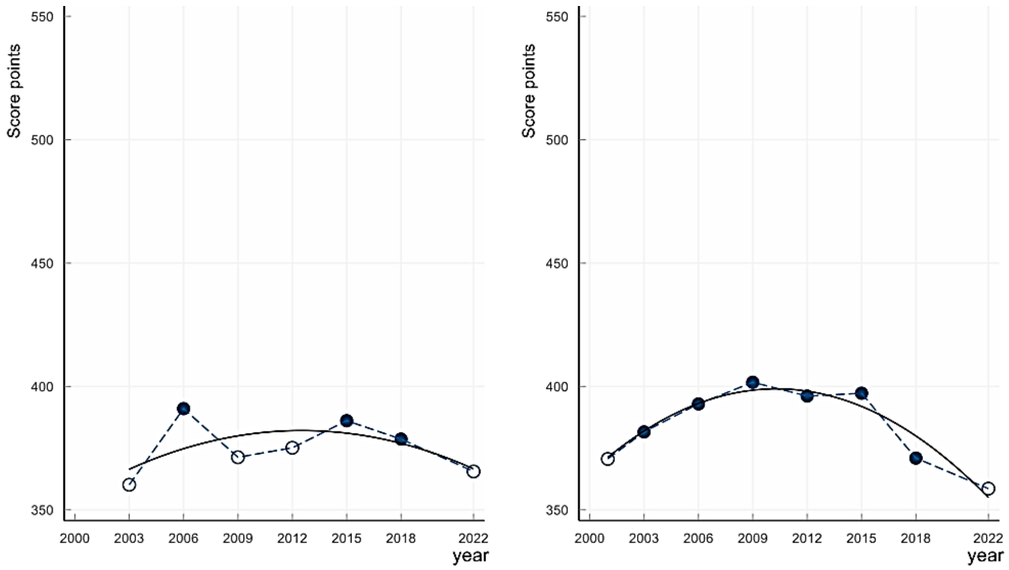


**Figure.1**. PISA Research Results for Indonesia, 2000-2022


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Based on the results of the 2022 PISA conducted by the OECD, Indonesia's ranking is still low in reading and numeracy skills. The PISA results indicate that Indonesia ranks 65th out of 81 countries in reading literacy and 66th in the numeracy category (OECD, 2023). Therefore, effort to improve students' reading literacy and numeracy skills require appropriate learning. One of them is the Guided Discovery Learning (GDL) model.

GDL is a learning model that prioritizes the involvement of learners during the learning process or student-centered learning (Afrianti, 2022). This approach allows learners to express themselves and get their material concepts, while the teacher becomes a facilitator who guides them in understanding specific concepts (Ramadhaniyati et al., 2023). This approach is worth considering by teachers because it has a high level of validity and practicality in learning chemistry (Yerimadesi, Kiram, et al., 2019) and effectively improves chemical problem-solving skills (Sulistyowati et al., 2012). In addition, the syntax in GDL can also be scientifically linked to reading literacy and numeracy. Each stage in the GDL syntax systematically demands the active involvement of learners in determining information, understanding, evaluating, and reflecting on texts and discourse. In addition, syntax in GDL, such as data processing and verification, is very relevant in honing numeracy skills because it involves counting skills, analyzing numbers, and making conclusions based on quantitative evidence.

On the other hand, this learning model can also develop various abilities and skills of students, especially at the high school level. This approach has proven effective in improving science process skills (Destrini et al., 2018), critical thinking skills (Bayharti et al., 2019; Nursidah et al., 2019; Yerimadesi, Bayharti, et al., 2019), higher order thinking skills (Yerimadesi et al., 2023), and learning outcomes (Fitriani & Yerimadesi, 2022; Lase & Andromeda, 2023; Marewa, 2021).

In its implementation, this learning model requires teaching tools that support students in forming concept understanding independently. One of the teaching tools utilized is the module. Research results prove the effectiveness of this module in improving learning outcomes in various chemical materials such as electrolyte and non-electrolyte solutions (Lusi et al., 2018), chemical equilibrium (Said & Yerimadesi, 2021), buffer solution (Agustina et al., 2019), thermochemistry (Gunawan & Yerimadesi, 2022), and training critical thinking skills related to redox and electrochemical cells (Bayharti et al., 2019) and acid-base (Yerimadesi, Bayharti, et al., 2019).

The rapid development of the digital world requires students to master media and technology in learning activities. To answer this challenge, modules are developed electronically, known as e-modules. In the context of chemistry, e-modules have been proven to be able to encourage increased learning outcomes on various topics, such as electrolyte and non-electrolyte solutions (Kristalia & Yerimadesi, 2021; Sakinah & Yerimadesi, 2022), elemental chemistry (Putri & Yerimadesi, 2022), hydrocarbons (Fitriyanti & Yerimadesi, 2023), acid-base (Alvi & Yerimadesi, 2022), acid-base titration (Dewita & Andromeda, 2023). In addition, E-modules have also proven effective in developing students' problem-solving skills (Zhafirah et al., 2021) and higher-order thinking skills (Subarkah et al., 2020).

Acid-base is an important part of chemistry that needs to be mastered by phase F students according to the independent curriculum (Kemendikbudristek, 2024). Students often consider Acid-base material in chemistry difficult, especially in understanding concepts, linking relationships between concepts, and applying formulas to solve acid-base-related problems (Farizal et al., 2024). Understanding acid-base materials requires mastery of prerequisite materials, including chemical reactions, chemical equilibrium, stoichiometry, the nature of matter, and solutions. This topic is an important foundation in understanding acid-base material (Amry et al., 2017). Acid-base is a learning material that can integrate reading and numeracy literacy because it has strong conceptual and quantitative characteristics and is relevant in everyday life. Understanding acid-base concepts such as Arrhenius, Bronsted-Lowry, and Lewis theories requires students to read, interpret, and understand scientific texts critically, while calculating pH and ionizing equilibrium in solutions can train numeracy literacy skills.

In research, Warlinda & Yerimadesi (2020) showed that implementing literacy strategies supported by the GDL model significantly influences student learning outcomes. In addition, Warlinda et al. (2022) revealed that applying GDL with SETS (Science, Environment, Technology, Society) approach supported by chemistry e-modules influences students' science literacy. As for acid-base, there is already a GDL-based e-module that has been verified valid, practical by Afrilianti & Yerimadesi (2021), effective by Alvi & Yerimadesi (2022), and affects learning outcomes by Defri & Yerimadesi (2023). However, research on the influence of e-modules on reading literacy and numeracy skills has not yet thoroughly explored the positive impact of literacy integrated with the Guided Discovery Learning (GDL) model and science literacy. Therefore, the researcher is interested in investigating students' levels of reading and numeracy literacy. Although numerous previous studies have developed e-modules for chemistry instruction, most have primarily focused on enhancing cognitive learning outcomes and conceptual understanding alone. Moreover, the application of the GDL model has typically been studied in relation to the improvement of critical thinking or problem-solving skills, without directly linking it to students' literacy achievement.

In fact, within the framework of the Merdeka Curriculum, reading and numeracy literacy are essential competencies that must be fostered across all subjects, including chemistry. To date, there remains a gap in knowledge regarding how the use of chemistry e-modules, particularly those dealing with acid-base concepts that involve both theoretical and numerical understanding, can effectively enhance students' reading literacy (such as the ability to comprehend scientific texts and experimental procedures) and numeracy literacy (such as the ability to interpret data, graphs, and perform scientific calculations). Therefore, this study aims to address this need by developing and implementing GDL-based e-modules that serve not only as interactive learning media but also as tools to comprehensively develop students' literacy skills. This research is expected to fill an existing research gap, offer innovative alternatives for chemistry learning, and respond to the growing demand for strengthened literacy in $21^{st}$-century education.

Based on this rationale, the researcher conducted a study entitled "The Effect of Using Guided Discovery Learning-Based Acid-Base E-Modules on Students' Reading and Numeracy Literacy Skills".

## 2. Literature Review

### 2.1. Guided Discovery Learning (GDL) Model

The Guided Discovery Learning model is a variation of the discovery learning model with differences in guidance. It prioritizes students' ability to understand concepts and find mathematical solutions (Utami, 2020). Using GDL, students can express themselves and understand the material by finding a concept that the teacher guides through examples related to specific material (Smita, 2012). In the guided discovery learning model, teachers also design statements or questions that can guide students to achieve learning objectives (Yerimadesi et al., 2017).


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According to Smita (2012), the guided discovery learning model has several concepts including: (1) Creating an atmosphere in the classroom that gives students the freedom to make discoveries through experiments (2) Learners are invited to analyze and share experiences (3) Guiding students in data analysis and concept discovery (4) The results of learning activities are interpreted by analyzing experiences (5) Teachers direct learning by creating an intellectual atmosphere. Furthermore, the advantages of this learning model include: (1) increasing the intellectual abilities of students, (2) encouraging increased intrinsic motivation of students, (3) improving heuristic and metacognition skills, and (4) guiding students in obtaining information (Carin, 1993). The disadvantages of this model are as follows: (1) for certain materials, learning with the guided discovery learning model takes longer, (2) the effectiveness of this model in learning has not been felt equally by all students, (3) the lecture method is still the most straightforward approach for some students to understand because they are used to using it, (4) not all learning materials are suitable for delivery using the GDL model (Utami, 2020).

The syntax of the GDL model was developed by Carin (1993), Smitha (2012) and Permendikbud No. 59 of 2014 (2021), modified by Yerimadesi, et al. (2017) so that a new syntax is obtained, namely: (1) motivation and problem presentation (2) data collection (3) data processing (4) verification (5) closing.

### 2.2. Reading Literacy

Reading literacy is a fundamental skill that allows learners to understand, utilize, assess, and reflect on various types of written texts needed in social life. Readers can develop their knowledge and potential through written texts and contribute to social life (Pusmenjar, 2020). According to OECD (2019), reading literacy is the ability to understand, utilize, assess, reflect on, and interact with texts to develop knowledge and potential, achieve goals, and contribute to society. The reading process is closely related to critical thinking skills because this activity can stimulate the brain, familiarize us with thinking, and foster creativity through the many ideas and knowledge gained. In addition, every reading also enriches our vocabulary. Doing regularly will allow the brain to work more optimally and produce critical thinking (Rahma et al., 2024). The reading literacy indicators can be found in Table 1.

**Table.1.** Indikator Literasi Membaca

| No | Reading Literacy Ability Indicator |
|---|---|
| 1. | Determining information (access and retrieval) |
| 2. | Understand (interpret and integrate) |
| 3. | Evaluate and reflect |

(Pusmenjar, 2020).

### 2.3. Numeracy Literacy

Numeracy literacy is the ability of learners to think by applying mathematical procedures, facts, tools, and concepts to solve everyday problems in relevant contexts, both as individuals and groups. Numeracy is defined as an individual's ability to apply mathematical concepts to understand events, solve problems, or make decisions in everyday life (Pusmenjar, 2020). This ability effectively supports learners in overcoming their fear of mathematics and improving problem-solving skills.

Reading and numeracy literacy skills are fundamental to developing higher-order cognitive skills, such as analytic reasoning, and are essential for gaining access to understanding specific knowledge domains. In addition, these skills are relevant in various aspects of life, covering education, work, and social and public interactions, and are considered part of social activities in various contexts (Windisch, 2015). Literacy mastery is needed as the main capital to face various changes, especially in the world of education in the 21st-century. The numeracy literacy indicators are listed in Table 2.

**Table.2**. Indicators of Numeracy Literacy Skills

| No | Numeracy Literacy Indicator |
|---|---|
| 1. | Apply various numbers and basic math symbols to solve problems in various contexts of daily life. |
| 2. | Analyze data presented in various forms, including diagrams, graphs, tables, charts, etc. |
| 3 | Interpret the results of analysis to make predictions and make decisions. |

(Pusmenjar, 2020).

### 2.4. Relevant Research

Research conducted by Warlinda & Yerimadesi (2020) resulted in integrating literacy strategies based on the GDL model, which significantly impacts the learning outcomes of 9th-grade students of SMPN 4 Sungai Penuh. As for some other research regarding reading literacy and numeracy, this has been done before. Research by Antika et al. (2024) states that chemical equilibrium e-modules that combine PBL and TPACK approaches effectively improve students' numeracy literacy at SMAN 1 Luhak Nan Duo. Furthermore, research by Fauziah et al. (2024) also stated that the reaction rate module based on PBL integrated with TPACK effectively improved the numeracy literacy of phase F students at SMAN 2 Payakumbuh. Furthermore, research by Susanti & Yerimadesi (2025) shows that applying discovery learning-based thermochemical modules positively affects students' reading and numeracy literacy. Finally, research by Hirawan & Yerimadesi (2025) indicates that using GDL-based chemical equilibrium e-modules effectively improves students' numeracy and reading literacy skills at SMAN 12 Padang. In research conducted by Alvi & Yerimadesi (2022), e-modules with a GDL approach were produced that effectively improve learning outcomes. However, it has not been empirically tested for reading literacy and numeracy skills.

Based on previous studies, research on reading literacy and numeracy in chemistry learning has indeed been carried out. However, it is still limited to various learning approaches and material topics, such as PBL and TPACK on chemical equilibrium and reaction rate materials, and discovery learning on thermochemical materials. Until now, no research has examined the effect of using Guided Discovery Learning-based e-modules on acid-base on improving reading and numeracy literacy skills simultaneously. Therefore, this study has novelty in integrating the GDL approach with interactive e-modules and focuses on reading literacy and numeracy in acid-base learning.

## 3. Research Methods

This research uses a quantitative method through a quasi-experiment approach and a non-equivalent control group design. The sample is selected through purposive sampling, where there are experimental and control classes. The experimental class will use GDL-based e-modules as teaching materials, while the control class will use teaching materials from schools using the


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same approach model. The same pretest and posttest instruments were used to measure the effect of these two lessons.

This study involved Phase F students at SMAN 3 Bukittinggi during the 2024/2025 academic year. The instrument used in the research was a written test, adopted from the book "Collection of AKM Chemistry Model Questions on Reading Literacy and Acid-Base Numeracy Literacy," published by UNNES PRESS. The test consisted of 11 reading literacy questions, including single and complex multiple-choice questions, true-false, reasoned true-false, and open-ended items. For numeracy literacy, there were 13 questions of similar types. All questions had been previously tested and revised to ensure validity, reliability, strong discriminatory power, and appropriate levels of difficulty.

The independent variable in this study was the use of e-modules based on the Guided Discovery Learning (GDL) model, while the dependent variables were students' reading and numeracy literacy skills. The study was conducted over a four-week period during the even semester, from May to June 2025. The research began with administering pretests and posttests to both the experimental and control groups at each meeting. The experimental group received instruction using GDL-based e-modules, while the control group used conventional learning modules available at school.

To minimize the influence of external variables, both groups were taught by the same teacher, with identical time allocations and duration. The teaching tools and lesson plans were also standardized across groups. Moreover, classroom conditions and learning environments were carefully controlled to avoid treatment bias. The same test instruments were administered simultaneously to both groups to ensure fairness.

Data analysis involved the calculation of normalized gain (n-gain), along with tests for normality, homogeneity, and hypothesis testing. The Lilliefors test was used to determine whether the data were normally distributed. Homogeneity of variances was assessed using the F-test. If the data were found to be both normal and homogeneous, the t-test was applied. However, if the data were normal but not homogeneous, the alternative t' (t-prime) test was used.

## 4. Result and Discussion

### 4.1. Research Result

#### 4.1.1 Result of Reading Literacy and Numeracy Skills

Reading literacy skills are obtained from the n-gain value, which is obtained according to the pretest and posttest results. The experimental class's n-gain is higher than that of the control class. The n-gain data are shown in Table 3.

**Table.3**. N-Gain Test Results of Reading Literacy and Numeracy Literacy

| Literacy Type | Class | N | Pretest | Posttest | N-Gain | Category |
|---|---|---|---|---|---|---|
| Reading | Control | 35 | 23 | 67 | 0.50 | Medium |
| | Experiment | 35 | 28 | 76 | 0.52 | Medium |
| Numeracy | Control | 35 | 12 | 35 | 0.26 | Low |
| | Experiment | 35 | 20 | 47 | 0.36 | Medium |

4.1.2 Hypothesis Test

The differences between the two sample classes were analyzed using statistical tests, including normality, homogeneity, and hypothesis tests. Table 4 shows the results of the normality test using the Lilliefors test.

**Table.4**. Normality Test Results of Reading Literacy and Numeracy Literacy

| **Literacy Type** | **Normality Test** | | | | **Decision** |
|---|---|---|---|---|---|
| | Experiment | | Control | | |
| | $L_o$ | $L_{table}$ | $L_o$ | $L_{table}$ | |
| Reading | 0.1308 | 0.1477 | 0.1404 | 0.1477 | Normal |
| Numeracy | 0.1415 | | 0.1379 | | Normal |

Next, the homogeneity test was carried out for both sample classes, which are shown in Table 5.

**Table.5**. Numerasi Homogeneity Test Results of Reading Literacy and Numeracy Literacy

| **Literacy Type** | **Homogeneity Test** | | **Decision** |
|---|---|---|---|
| | $F_{count}$ | $F_{table}$ | |
| Reading | 1.2607 | 1.7721 | Homogeneous Data |
| Numeracy | 2.2507 | | Non Homogeneous Data |

Hypothesis testing was then carried out for both sample classes, as shown in Table 6 and Table 7.

**Table.6**. Hypothesis Test Results of Reading Literacy Skills

| **Literacy Type** | **Hypothesis Test** | | **Decision** |
|---|---|---|---|
| | $t_{count}$ | $t_{table}$ | |
| Reading | 2.0032 | 1.9955 | $H_o$ rejected $H_1$ accepted |

**Table.7**. Numeracy Literacy Hypothesis Test Results

| **Literacy Type** | **Hypothesis Test** | | **Decision** |
|---|---|---|---|
| | $t'_{count}$ | $t'_{table}$ | |
| Numeracy | 3.5492 | 2.0058 | $H_o$ rejected $H_1$ accepted |

### 4.2. Discussion

The findings from the n-gain analysis (Table 3) indicate significant differences in the reading literacy and numeracy skills between the experimental and control classes. Based on the generated n-gain data, the experimental class experienced a greater improvement compared to the control class. The n-gain score for reading literacy in the experimental class was 0.52, while in the control class, it was only 0.50. Although both fall into the "medium" category, the results from the experimental class demonstrate that the e-module used was more effective in enhancing reading literacy skills. For numeracy literacy, the experimental class achieved an n-gain of 0.36, whereas the control class only reached 0.26. The control group's score falls into the “low” category, while the experimental group is in the “medium” category. These findings indicate that


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using an acid- base e-module based on the GDL approach is appropriate to support learning and effectively improve reading and numeracy literacy skills.

The normality test results in Table 4 show an $L_{table}$ value of 0.1477 for both reading literacy and numeracy. For reading literacy, the $L_o$ values in the experimental and control classes were 0.1308 and 0.1404, respectively, at a 95% confidence level. For numeracy literacy, the $L_o$ values were 0.1415 and 0.1379, also at the same significance level. Since all $L_o$ values in both groups for both skills are lower than the $L_{table}$ value ($L_o < L_{table}$), it can be concluded that the data from both classes are normally distributed.

The homogeneity of variance test in Table 5 shows an $F_{table}$ value of 1.7721 for both reading literacy and numeracy. The $F_{count}$ values were 1.2607 for reading literacy and 2.2507 for numeracy literacy. For reading literacy, $F_{count} < F_{table}$ indicates that the variances between the two groups are homogeneous. However, for numeracy literacy, $F_{count} > F_{table}$, indicating that the variances between the two groups are not homogeneous. This suggests that, although the data are normally distributed in both groups, the variance across classes is not consistent. This inhomogeneity should be taken into account during further analysis, particularly in hypothesis testing, as unequal variances can affect the validity of statistical results.

Subsequently, hypothesis testing was conducted to determine the significance of the differences between the experimental and control groups. For reading literacy, since the data were normally distributed and variances were homogeneous, a t-test was used. As shown in Table 6, the $t_{count}$ value was 2.0032, while the $t_{table}$ value at a 95% confidence level was 1.9955. Since $t_{count} > t_{table}$, the null hypothesis ($H_o$) is rejected and the alternative hypothesis ($H_1$) is accepted. This means there is a significant difference in reading literacy skills, with students using the GDL-based acid- base e-module outperforming those who did not.

In terms of numeracy literacy, although the data were normally distributed, the variance was not homogeneous. Therefore, hypothesis testing was conducted using a modified t-test (Welch's t- test). According to Table 7, the $t'_{count}$ value was 3.5492, and the $t'_{table}$ value at the 95% confidence level was 2.0058. Since $t'_{count} > t'_{table}$, the null hypothesis ($H_0$) is rejected, and the alternative hypothesis ($H_1$) is accepted. This indicates a significant difference in numeracy literacy skills, where students using the GDL-based acid-base e-module achieved better results than those who did not.

These findings are consistent with the study by Hirawan & Yerimadesi (2025), which states that the implementation of the GDL model can enhance students' reading and numeracy literacy skills. This is also in line with the design of e-modules that are tailored to literacy indicators. For instance, the syntax structure used in the e-module supports the development of reading literacy skills, as illustrated in Figure 2.

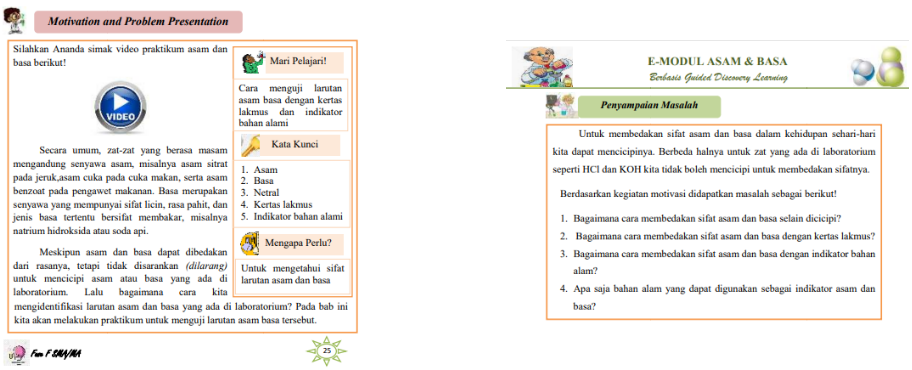


**Figure.2.** Example of Syntax in Reading Literacy E-Modules

Figure 2 shows the syntax of activity sheet 2 contained in the GDL-based acid-base e-module. In the syntax of motivation and problem formulation, events in life are presented. Learners at this stage are asked to distinguish the properties and indicators of acid-base by paying attention to the existing video and then formulating a hypothesis. This is related to the indicators of reading literacy skills in indicators 1 to 3, which can be seen in Table 1.

Then, an example of syntax in the e-module related to numeracy literacy indicators is shown in Figure 3.

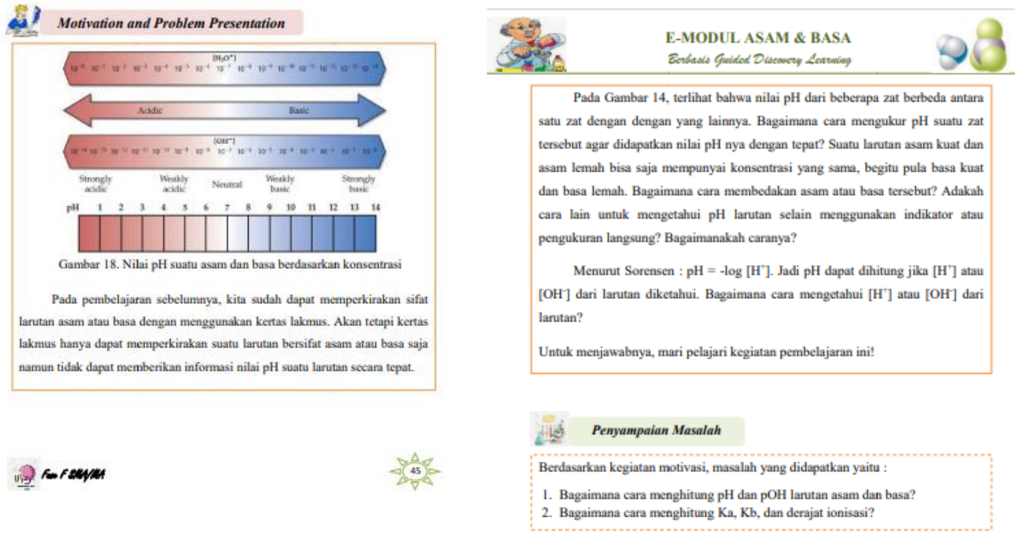


**Figure.3**. Example of Syntax in the Numeracy Literacy E-Module

Furthermore, Figure 3 shows the syntax on sheet 4 contained in the GDL-based acid-base e-module. In the syntax of motivation and problem formulation, data is presented in the form of the pH value of an acid and base based on concentration. In the picture, students can find out the information presented, and students are also asked to formulate problems and hypotheses to calculate the pH accurately. This relates to numeracy literacy indicators 1 to 3, as seen in Table 2. The characteristics of learning with the GDL model are a learning approach that leads students to find a concept themselves with the help of a teacher, making it easier to understand the material, remember, and solve existing problems (Ramananda et al., 2024). This approach requires students to make hypotheses more directed in finding concepts and solving problems (Yerimadesi et al., 2017). Learners have interest and curiosity and are challenged to solve problems, especially with teacher direction and guidance in finding concepts or answers to prove the hypotheses that have been made (Hariyanti & Lestari, 2023). In addition, this learning model is designed to guide students gradually to build understanding of concepts independently (Dwilestari & Fitriani, 2017).

This strategy can also support students in deepening their mastery of concepts and memories of learning (Natalisca et al., 2024). Figure 4 shows the examples of questions displayed in the e-module that match the two indicators of literacy skills.


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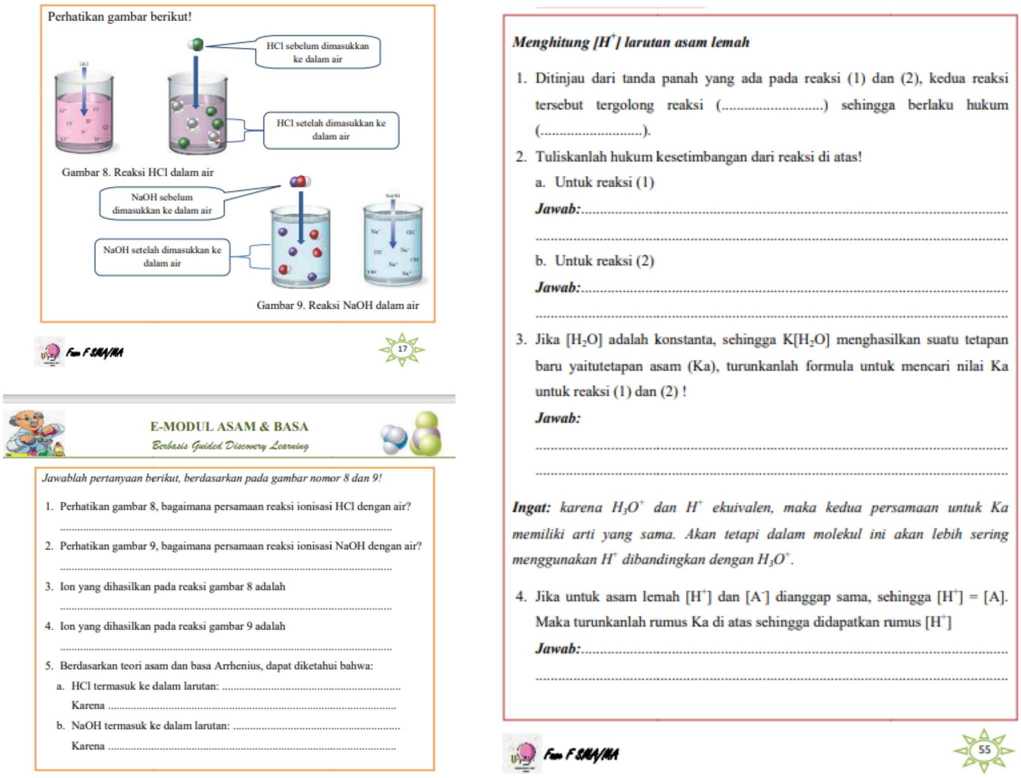


Perhatikan gambar berikut!



*Jawablah pertanyaan berikut, berdasarkan pada gambar nomor 8 dan 9!*

1. Perhatikan gambar 8, bagaimana persamaan reaksi ionisasi HCl dengan air?
...........................................................
2. Perhatikan gambar 9, bagaimana persamaan reaksi ionisasi NaOH dengan air?
...........................................................
3. Ion yang dihasilkan pada reaksi gambar 8 adalah
...........................................................
4. Ion yang dihasilkan pada reaksi gambar 9 adalah
...........................................................
5. Berdasarkan teori asam dan basa Arrhenius, dapat diketahui bahwa:
   a. HCl termasuk ke dalam larutan: ...........................
   Karena ...........................................
   b. NaOH termasuk ke dalam larutan: ...........................
   Karena ...........................................

***Menghitung [H⁺] larutan asam lemah***

1. Ditinjau dari tanda panah yang ada pada reaksi (1) dan (2), kedua reaksi tersebut tergolong reaksi (...........................) sehingga berlaku hukum (...........................).
2. Tuliskanlah hukum kesetimbangan dari reaksi di atas!
   a. Untuk reaksi (1)
   ***Jawab:***...........................................
   b. Untuk reaksi (2)
   ***Jawab:***...........................................
3. Jika $[H_2O]$ adalah konstanta, sehingga $K[H_2O]$ menghasilkan suatu tetapan baru yaitutetapan asam (Ka), turunkanlah formula untuk mencari nilai Ka untuk reaksi (1) dan (2) !
   ***Jawab:***
   ...........................................

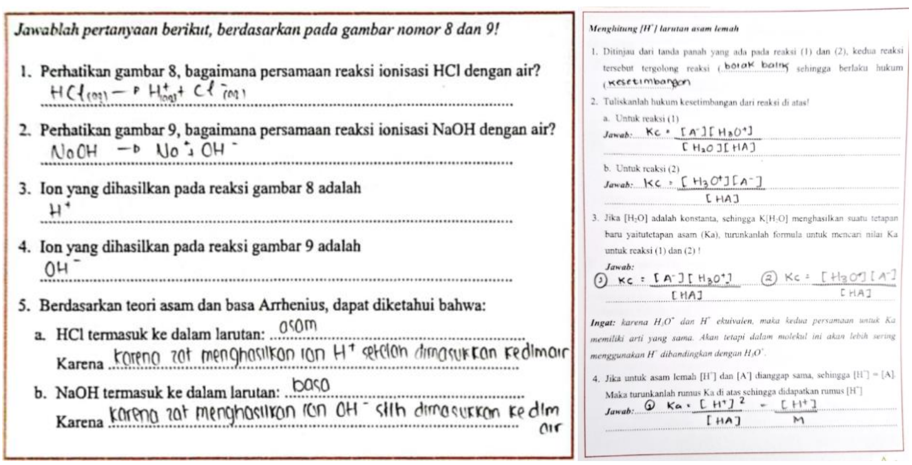
***Ingat:*** *karena $H_3O^+$ dan $H^+$ ekuivalen, maka kedua persamaan untuk Ka memiliki arti yang sama. Akan tetapi dalam molekul ini akan lebih sering menggunakan $H^+$ dibandingkan dengan $H_3O^+$.*

4. Jika untuk asam lemah $[H^+]$ dan $[A^-]$ dianggap sama, sehingga $[H^+] = [A]$. Maka turunkanlah rumus Ka di atas sehingga didapatkan rumus $[H^+]$
   ***Jawab:***...........................................



**Figure.4**. Examples of Reading Literacy (Left) and Numeracy Literacy (Right) Questions

In the two images above, students are asked to answer questions based on the image and data processing syntax in the e-module. In the series of questions, learners are guided to be able to answer questions related to acid-base. The reading literacy questions are presented in the form of images related to the concept of acids and bases based on the Arrhenius theory. In questions 1 and 2, students are asked to write the chemical equations and identify the ions produced in the reactions. This indicates that students are guided to answer questions concerning the concept of acids and bases according to Arrhenius. Meanwhile, the numeracy literacy questions present a chemical equation along with a sequence of guiding questions that help students determine the appropriate formula to calculate the concentration of $H^+$ ions in a weak acid solution. One example of a learner's answer is shown in Figure 5.



*Jawablah pertanyaan berikut, berdasarkan pada gambar nomor 8 dan 9!*

1. Perhatikan gambar 8, bagaimana persamaan reaksi ionisasi HCl dengan air?
   $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
2. Perhatikan gambar 9, bagaimana persamaan reaksi ionisasi NaOH dengan air?
   $NaOH \rightarrow Na^+ + OH^-$
3. Ion yang dihasilkan pada reaksi gambar 8 adalah
   $H^+$
4. Ion yang dihasilkan pada reaksi gambar 9 adalah
   $OH^-$
5. Berdasarkan teori asam dan basa Arrhenius, dapat diketahui bahwa:
   a. HCl termasuk ke dalam larutan: asam
   Karena karena zat menghasilkan ion $H^+$ setelah dimasukkan ke dalam air
   b. NaOH termasuk ke dalam larutan: basa
   Karena karena zat menghasilkan ion $OH^-$ stlh dimasukkan ke dlm air

*Menghitung [H⁺] larutan asam lemah*

1. Ditinjau dari tanda panah yang ada pada reaksi (1) dan (2), kedua reaksi tersebut tergolong reaksi (bolak balik) sehingga berlaku hukum (kesetimbangan
2. Tuliskanlah hukum kesetimbangan dari reaksi di atas!
   a. Untuk reaksi (1)
   *Jawab:* $Kc = \frac{[A^-][H_3O^+]}{[H_2O][HA]}$
   b. Untuk reaksi (2)
   *Jawab:* $Kc = \frac{[H_3O^+][A^-]}{[HA]}$
3. Jika $[H_2O]$ adalah konstanta, sehingga $K[H_2O]$ menghasilkan suatu tetapan baru yaitutetapan asam (Ka), turunkanlah formula untuk mencari nilai Ka untuk reaksi (1) dan (2) !
   *Jawab:*
   ① $Kc = \frac{[A^-][H_3O^+]}{[HA]}$ ② $Kc = \frac{[H_3O^+][A^-]}{[HA]}$

*Ingat: karena $H_3O^+$ dan $H^+$ ekuivalen, maka kedua persamaan untuk Ka memiliki arti yang sama. Akan tetapi dalam molekul ini akan lebih sering menggunakan $H^+$ dibandingkan dengan $H_3O^+$.*

4. Jika untuk asam lemah $[H^+]$ dan $[A^-]$ dianggap sama, sehingga $[H^+] = [A]$. Maka turunkanlah rumus Ka di atas sehingga didapatkan rumus $[H^+]$
   *Jawab:* ① $Ka = \frac{[H^+]^2}{[HA]} = \frac{[H^+]}{M}$

**Figure.5**. Example of Learner Answers on the E-Module

Figure 5 (left) presents a student's answer sheet, illustrating that the reading literacy questions are specifically designed to integrate visual interpretation skills with an understanding of the Arrhenius acid-base theory. Analysis of the student responses indicates an adequate level of conceptual comprehension regarding acids and bases. In questions 1 and 2, the student successfully wrote the correct ionization equations for HCl and NaOH. These responses demonstrate the student's understanding of strong electrolyte dissociation in water and the ability to translate visual representations into appropriate chemical notation. The construction of these questions systematically reflects the implementation of the three main indicators of reading literacy competence.

The first indikator, access and retrieve information is evident in questions 1 to 4, where students are required to identify and extract specific details from the ionization reactions. Students are expected to recognize the components of the reactions based on visual representations and determine the types of ions produced in each ionization process. This reflects foundational skills in information retrieval. The second indikator, interpret and integrate information is reflected in the students' ability to connect visual content with theoretical concepts. Here, students must combine their understanding of the Arrhenius theory with the information presented in the diagrams, linking molecular illustrations with chemical formula writing to provide accurate responses. The third indikator, evaluate and reflect is addressed in question 5, where students are prompted to define Arrhenius acids and bases based on their conceptual understanding. The responses indicate that students can reflect on their knowledge and independently evaluate scientific concepts. For example, students were able to explain that an Arrhenius acid is a substance that produces $H^+$ ions in water, whereas an Arrhenius base yields $OH^-$ ions.

Figure 5 (right) illustrates how the assessment measures students' numeracy literacy skills within the context of chemistry learning, specifically in calculating the acid dissociation constant (Ka) of weak acids. The analysis of student answers shows that they are capable of applying mathematical concepts to solve complex chemical problems. In the first item, the student correctly identified the equilibrium reactions and formulated the expressions for $Ka_1$ and $Ka_2$ as $Ka_1 = [A^-][H_3O^+]/[H_2O][HA]$ and $Ka_2 = [A^-][H_3O^+]/[HA]$, respectively. Since $H_3O^+$ and $H^+$ are equivalent, both expressions carry the same meaning. In subsequent questions, students were guided through the derivation of the simplified formula, $Ka = [H^+]^2/[HA]$. These responses reflect an understanding of how the Ka formula can vary under different conditions and an ability to apply equilibrium concepts accurately.

The design of these numeracy questions reflects a comprehensive application of the three primary indicators of numeracy literacy. The first indikator, the ability to apply various numbers and basic mathematical symbols to solve problems in real-life contexts is demonstrated through the use of the formula $Ka = [H^+]^2/[HA]$. Students must understand the significance of each symbol, including bracket notation to denote concentration and the use of exponents. This shows students' ability to translate chemical concepts into a mathematical framework. The second indikator, the ability to analyze data presented in different formats such as diagrams, graphs, tables, or charts is evident in students' processing of numerical information. Even though the data are not given in graphical form, students must organize values such as initial concentration, degree of ionization, and equilibrium constants to perform accurate calculations. This requires a systematic and logical approach to quantitative data analysis. The third indikator, the ability to interpret the results of analysis for prediction and decision-making is observed in students' answers to questions 3 and 4. After calculating the Ka values, students must interpret these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results to understand the relative acidity of different substances. The Ka values are then used to predict the degree of acid ionization in solution and to compare acid strength across compounds. This interpretive ability shows that students are not only capable of performing calculations but also of extracting meaningful chemical insights from their results.

In this case, students can answer and solve existing problems to draw conclusions and successfully meet the achievement indicators in reading literacy and numeracy. Thus, using GDL- based acid-base e-modules can encourage improving students' reading literacy and numeracy skills. The learning that uses GDL can increase learning outcomes by Hastuti (2018), student learning activities, and motivation (Sapitri et al., 2023). This fact is also supported by using e- modules that are systematically organized in electronic format and equipped with interactive media and links that provide attractive and engaging content for students (Nurhidayati, 2024). E- modules provide flexibility in the learning process, allow learners to access materials independently and repeatedly, and encourage active engagement through structured exercises and feedback.

This study also showed increased reading and numeracy literacy skills after applying e-modules, although the increase in the numeracy literacy aspect tended to be lower. This is possible because numeracy literacy demands more complex skills, such as understanding data, symbols, graphs, and applying mathematical logic in the context of science. In contrast, reading literacy is more related to understanding text structure, identifying key information, and the ability to reflect meaning contextually, which is generally easier to hone through directed reading activities in e- modules. This imbalance of improvement suggests that while e-modules can support the strengthening of both types of literacy, additional, more specific strategies are needed to optimize numeracy literacy. For example, by increasing contextual data-based exercises, graded numerical problems, and guidance in interpreting mathematical visuals such as graphs and tables. This finding emphasizes the importance of e-module design, which is adaptive to different literacy characteristics, so learners' abilities can develop evenly and thoroughly.

## 5. Conclusion

The study results indicate that students who were taught using GDL-based acid-base e-modules showed significantly higher reading and numeracy literacy skills than those who did not use the e-modules. Thus, the application of e-modules positively improves reading literacy and numeracy of phase F students at SMAN 3 Bukittinggi. The increase was proven quantitatively through the N-gain test and hypothesis testing, with higher achievement in the experimental class than the control class. Reading literacy improved in the aspects of finding information, understanding text, and reflecting on the content of reading, while numeracy literacy developed in data processing skills and making number-based decisions. Although both literacies improved, numeracy literacy achievement was relatively lower. This study has limitations in the scope of the material and the short treatment time. Further research is recommended to expand the topic and treatment duration and integrate a broader literacy context to improve learning effectiveness.

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