Development of Acid Base E-Module Based on Guided Discovery Learning to Improve Digital Literacy Skills of Senior High School Phase F Students

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Abstract: This study aims to analyze the validity, practicality, and effectiveness of the acid-base e-module based on guided discovery learning on students' digital literacy skills. The development model used is the Plomp development model. The developed e- module was validated by three lecturers and two chemistry teachers. The module's practicality test was carried out by three chemistry teachers and 33 high school students. The module's effectiveness test was carried out using the pre-experimental method with a non-equivalent control group design. The validity test is explained using Aiken's V formula. The overall validity test results were obtained of 0.91 with a valid category. The results of the e-module practicality test carried out by teachers and students were 89.4 and 87.09% with a very practical category. The average N-Gain value in the experimental class was 0.75, which is in the high category. Based on the results of data analysis, it can be concluded that the acid-base e-module, based on guided discovery learning that was developed, is valid, practical, and effective in improving the digital literacy skills of Phase F (Grade XI) high school students.

Keywords: Acid base; Digital literacy skills; E-module; Guided discovery learning

Introduction

21st century learning requires students to have 4C skills, namely critical thinking, creativity, communication, and collaboration (Saavedra & Opfer, 2012; Daryanto & Karim, 2017). 4C skills aim to form an independent generation by improving critical thinking skills and being able to solve problems (Kemendikbud, 2017). However, students still have difficulty applying critical thinking skills, especially in understanding chemistry. As a science subject that contains abstract and complex concepts, chemistry is often a problem for students, this is evident because some students still use memorization methods in understanding chemistry learning (Herron, 1977; MacGuire & Johnstone, 1987). One of the materials that is classified as difficult because it requires understanding and memorization is acids and bases.

Acid-base material is one of the fundamental topics in chemistry learning that requires not only memorization skills, but also deep conceptual understanding, because it is the foundation for mastering advanced materials such as salt hydrolysis, buffer solutions, and product solubility (Ksp) (Amalia & Susilaningsih, 2014). To build a comprehensive understanding, the concept of acid-base is not sufficiently taught abstractly, but must be linked to real contexts through collaborative learning and problem solving based on authentic situations in the student's environment (Alabi, 2016). However, based on the results of observations in three schools, namely SMA N 12 Padang, SMA Pertiwi 1 Padang, and SMA Pembangunan Laboratorium UNP, it shows that the majority of students as much as 76.3% still have difficulty in understanding the concept of acid- base. This is reinforced by the results of interviews with chemistry teachers at these schools which revealed that

only a small number of students were able to achieve the Learning Objective Achievement Criteria (KKTP) which indicates the need for a more contextual, interactive learning approach that supports the development of high-level thinking skills.

The results of interviews with chemistry teachers in several schools showed that the learning process is still dominated by a teacher-centered learning approach, where the lecture method is the main choice because it is considered easy to apply, practical, and efficient in terms of time. However, this approach has a fundamental weakness, namely the limited opportunities for students to actively explore concepts, ask questions, or construct their knowledge independently. As a result, students' critical thinking skills and conceptual understanding levels tend to be low, especially when dealing with abstract and complex materials such as acids and bases (Hafifah & Hardeli, 2022; Hardeli et al., 2023). To answer this challenge, one solution that can be applied is the use of the Guided Discovery Learning learning model.

The Guided Discovery Learning learning model is designed to encourage students to think critically, creatively, and develop high-level thinking skills. In this model, students play an active role in finding concepts through exploration, observation, and discussion, with teacher guidance so that the learning process remains focused (Daryanto, 2013; Yerimadesi et al., 2017). This model is also effective in improving conceptual understanding, especially in abstract chemistry material, because students experience the process of forming concepts meaningfully (Asrizal et al., 2017; Wulandari et al., 2018; Ibad et al., 2019; Lestari, 2019; Ardilah, 2020; Fatmawati & Safitri, 2020; Nugraha & Octavianah, 2020; Debby et al., 2023).

In accordance with the demands of the 21st century or 4C education curriculum, learning must be based on the development of science and technology. The integration of technology and information in the learning process also plays an important role in developing students' thinking skills (Darimi, 2017). 21st century learning integrates literacy skills into mastery of technology (Sari & Asmendri, 2020). There are six basic literacies, namely reading and writing, science, numeracy, digital, financial, and cultural and citizenship literacy. Digital literacy is one of the skills that students must have in preparing themselves to face the industrial revolution 4.0. There are also digital learning media that support this, namely e-modules. E-modules that combine text, images, animations, videos, and interactive simulations allow students to learn independently and according to their learning style. In addition to being a learning resource, e-modules also train digital literacy, namely the ability to understand and use information from various digital sources well

(Gilster, 1997; Suarsana, 2013; Widiana et al., 2021; Thahir et al., 2022; Hussain & Phulpoto, 2024).

Based on the description above, an electronic teaching material in the form of an e-module is needed to improve the 21st century skills or 4C of students in line with the demands of the independent curriculum. So the researcher is interested in conducting a study entitled "Development of an e-module based on guided discovery learning on acid-base material to improve digital literacy skills of high school phase F students". It is hoped that the development of teaching materials in the form of an e-module based on guided discovery learning on acid-base material can increase students' learning motivation and can be a solution to problems that occur in students, especially learning difficulties.

Method

This study was designed using the type of educational design research (EDR). Educational design research (EDR) is a type of research that uses qualitative methods by developing and producing a new product or improving an existing product (Reeves, 2005). The development model used in this study is the Plomp development model proposed by Tjeerd Plomp. The Plomp model consists of 3 stages, namely the first stage, preliminary research, namely the activity of analyzing needs, concept analysis, student analysis, curriculum analysis, literature review, and development of a conceptual framework. The second stage, development or prototyping phase, namely the design/design stage of products such as learning media on basic smoke material, using formative evaluation. The third stage, assessment (assessment phase), namely the semi-summative evaluation stage to conclude whether the product can be used in practice in the field and whether the prototype produced is in accordance with what has been determined (Plomp & Nieveen, 2007).

E-module development based on guided discovery learning as a teaching material on acid-base material was conducted at FMIPA UNP and SMA Pertiwi 1 Padang in the 2024/2025 academic year. The subjects of this study were chemistry lecturers at FMIPA UNP, chemistry teachers, and phase F students at SMA N 12 Padang, SMA Pertiwi 1 Padang, and SMA Pembangunan Laboratorium UNP. The data instruments used in this study were teacher interview sheets, student questionnaire sheets, self-evaluation questionnaire sheets, individual evaluation interview sheets, validity test questionnaire sheets, practicality test questionnaire sheets, and evaluation questions for effectiveness tests. The validity analysis technique uses Aiken's V scale. The formula for calculating the validity coefficient is as follows:

$$S = r - l_0 \qquad (1)$$

Information:

r = number given by the validator

l_0 = low validity assessment number (e.g., 1)

c = highest validity assessment number (e.g., 5)

n = number of validators (Aiken, 1985)

The practicality analysis technique uses a descriptive statistical formula, namely, as follows (Arikunto, 2012):

$$NP = \frac{R}{SM} \times 100\% \qquad (2)$$

Information:

NP = Percentage value sought or expected

R　= Raw score obtained by students

SM = Ideal maximum score (Purwanto, 2010)

The effectiveness analysis technique is measured using the N-gain formula (Sugiyono, 2013):

$$N_{-gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Ideal score} - \text{Pretest score}} \qquad (3)$$

Results and Discusion

The Prototyping Stage

This stage discusses the creation of prototypes. Four prototypes were created and revised using Tessmer's Formative Evaluation stage before being used in learning. This is explained as follows:

Prototype I

In the prototype stage I, the e-module design was carried out based on guided discovery learning on acid-base material. The e-module was compiled based on the results of CP and element identification, as well as the decomposition of ATP and TP. The following is a description and specification of the resulting product.
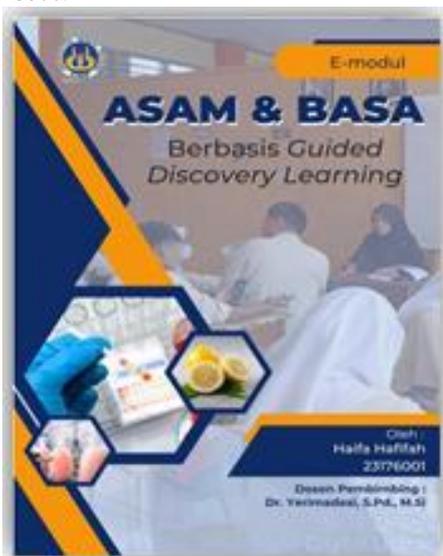
E-Module Cover

Figure 1. Cover of acid base e-module

The cover section contains the title, the author's name, the supervisor's name, supporting images, and target users. The e-module cover design can be seen in Figure 1.

Instructions for Using E-Module

The e-module usage instructions section contains instructions for using the e-module with guided discovery learning syntax for teachers and students.

Competencies to Be Achieved

The competencies to be achieved contain learning outcomes, learning objectives, and learning objective flow in acid-base material (Aulia et al., 2023; Afif & Siregar, 2024).

Supporting Information

Supporting information contains an overview and scope of the material to be studied.

Student Worksheet

The student worksheet for acid-base material is arranged based on the steps of the guided discovery learning model. Learning in this module consists of five stages, as follows Permatasari & Yerimadesi (2020):

Motivation and Problem Presentation

At this stage, students read the discourse, observe the images and videos that have been presented in the e-module containing contextual problems related to acid-base material. The design of this stage can be seen in Figure 2.

Figure 2. Stage motivation and presentation problem

At this stage, students are directed to observe information from digital sources such as text, tables, images, and videos. This trains students to access and understand digital content, as well as develop critical thinking skills in identifying problems or important information.

Data Collection

At this stage, students collect information to prove the truth of the hypothesis, either through discussion, reading literature, or observing to obtain facts related to the problems that have been presented. At this stage, students are asked to collect data from examples, objects, and other sources. They learn to search, select, and evaluate digital information from various platforms responsibly and according to learning needs.

Data Processing

At this stage, students process data that functions to form concepts and generalizations for students. The design of the data processing stage can be seen in Figure 3.
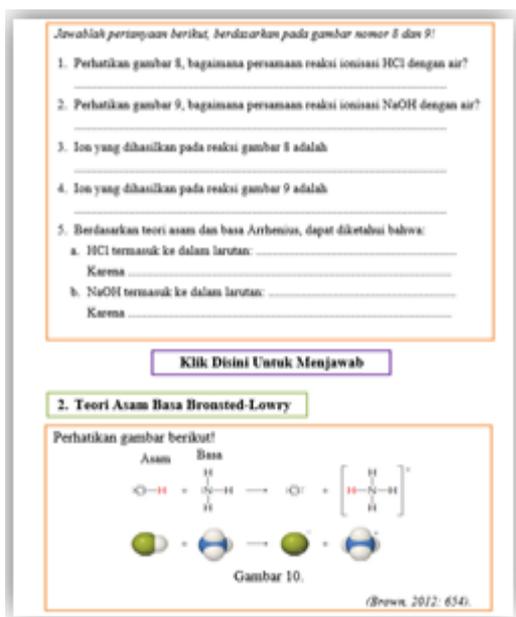

Figure 3. Stage data processing

At this stage, students are guided to process the information that has been collected. Here, they use digital skills to analyze and organize information into new, meaningful knowledge.

Verification

At this stage, students verify the truth of the hypothesis by comparing the results of the processed data analysis with the findings of other groups, source books, or related articles. At this stage, students re-evaluate the digital information that has been obtained to prove the truth of the hypothesis. This process trains

them to criticize and verify digital information, as well as to make data-based reasoning.

Closing

At this stage, students draw conclusions from what has been learned based on the learning objectives that have been set. The design of the closing stage can be seen in Figure 4.
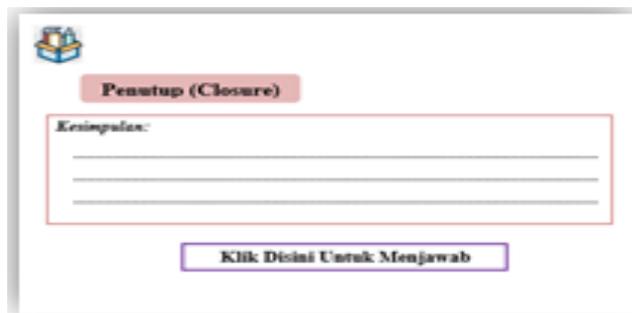

Figure 4. Stage closing

At this stage, students conclude learning based on the data that has been obtained. This involves the ability to communicate the results of digital information processing clearly and logically, both verbally and in writing.

Evaluation Sheet

The evaluation sheet in this e-module aims to measure the mastery of student competencies after participating in acid-base learning. The design of the evaluation sheet in the e-module can be seen in Figure 5.

Figure 5. Evaluation sheet

Prototype II

At this stage, a formative evaluation is carried out in the form of self-evaluation of the components that must be in the e-module. This stage is an assessment stage carried out by researchers using the checklist method.

Prototype III

At this stage, expert reviews and one-to-one evaluations are carried out to obtain the level of validity of the e-module being developed.

Expert Assessment (Expert Review)

At this stage, the e-module produced is validated by 5 validators. The validators in this validity test consist of 3 chemistry lecturers and 2 chemistry teachers. The validity test conducted consists of content validity, construct validity, language validity, and graphic validity. The results of processing all e-module validity assessment data can be seen in Table 1.

Table 1. V values of validation in general overall

Rated aspect	V	Category
Content Components	0.91	Valid
Construction Components	0.91	Valid
Language Components	0.91	Valid
Graphics Components	0.91	Valid
Average	0.87	Valid

The next stage after the e-module is validated by the validator, a revision is carried out, which aims to improve the acid-base e-module section that was developed according to the suggestions given by the validator.

Prototype IV

At this stage, a practical test was conducted on 15 students (small group evaluation). The students selected represented students with high, medium, and low abilities. The results of the practicality test of the acid-base e-module can be seen in Table 2.

Table 2. Analysis results practicality (small group)

Rated aspect	P (%)	Category
Ease of Use	93.3	Very Practical
Learning time efficiency	96	Very Practical
Benefit	92.7	Very Practical
Average Practicality	94	Very Practical

Based on Table 2 above, it can be seen that the average practicality value is 94%, with a very practical category. The e-module based on guided discovery learning on acid-base material is concluded to be practical in terms of ease of use, time efficiency, and benefits.

Assessment Stage

This stage is a field test of the acid-base e-module based on guided discovery learning, the practicality of which is assessed by teachers and students, and then an effectiveness test is carried out. The following is a description of the assessment stage. In this study, the practicality test of teacher responses was carried out by 2 chemistry teachers of SMA Pertiwi 1 Padang, while the practicality test of large groups of student responses was carried out on 33 students of class XI.F.6 SMA Pertiwi 1 Padang. The results of the analysis of practicality data

tested at the field test stage can be seen in Tables 3 and 4.

Based on Tables 3 and 4 above, it can be seen that the average value of the practicality of teacher and student responses is 89.4 and 87.09% the category. The acid-base e-module based on guided discovery learning is concluded to be practical in terms of ease of use, efficiency of learning time, and benefits.

Table 3. Practical data analysis results teacher response

Rated aspect	Practicality (%)	Practicality Category
Ease of Use	95	Very Practical
Learning Time Efficiency	80	Very Practical
Benefit	93.3	Very Practical
Average	89.4	Very Practical

Table 4. Practical data analysis results students response

Rated aspect	Practicality (%)	Practicality Category
Ease of Use	87.88	Very Practical
Learning Time Efficiency	85.45	Very Practical
Benefit	87.94	Very Practical
Average	87.09	Very Practical

The effectiveness of the developed e-module is seen by comparing the digital literacy skills of students in the experimental class with the control class. The experimental class learned using an undeveloped e-module, and the control class did not using the developed e-module. Before learning began, a pretest was conducted to determine the initial abilities of students. The average pretest score for the experimental class was 15, and the control class was 17.37. After the posttest, there was an increase in the average posttest score for the experimental class by 79.18 and the control class by 67.77. To be able to see the increase in students' digital literacy, an N-Gain test was conducted. The results obtained were that the N-Gain values in the experimental class and control class were 0.75 and 0.61. This is also in line with the results of the analysis of students' digital literacy skills which can be seen in Tables 5.

Table 5. Analysis Results of Students' Digital Literacy Abilities

Rated aspect	Digital literacy skills (%)	Category
Technical Ease of Use of Technology	90.7	Very good
Ability to Search and Process Digital Information	86.9	Very good
Digital Communication skills	89	Very good
Digital Ethics and Responsibility	86.1	Very good
Digital Creativity	90.3	Very good
Average	88.6	Very good

Based on Table 5 above, it can be seen that the average value of digital literacy skills is 88.6%, with a very good category. E-modules based on guided discovery learning on acid-base material are concluded to be able to improve students' digital literacy in the aspects of digital literacy, ease of technical use, ability to search for and process digital information, digital communication skills, digital ethics and responsibility, and digital creativity.

The GDL learning model is a learning model that facilitates students in improving critical thinking skills and gaining experience in finding concepts from a problem through finding information with a series of scientific activities (Novrika, 2016; Maya et al., 2018; Yerimadesi et al., 2018; Pramunando & Yerimadesi, 2019). In the first syntax of the GDL model, namely motivation and presentation of problems are presented in discourse and videos according to learning objectives. The second syntax is that students collaborate to collect information in their groups to find solutions. The third syntax is that students conduct individual/group investigations through a series of activities to work on questions. In the fourth syntax, verification, namely, students present the results of their work in the form of reports, videos, or other forms that are presented in class. The last stage is closing, students find solutions and draw conclusions based on the learning objectives.

Conclusion

Acid-base e-module based on guided discovery learning produced through research and development using the Plomp development model to improve digital literacy skills of phase F students, which are categorized as valid and practical. The acid-base e-module, based on guided discovery learning that was developed has proven to be effective in improving digital literacy skills of phase F high school students.

Conflicts of Interest
The authors declare no conflict of interest.

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