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Development of Acid-Base E-Modules Based on Guided Discovery Learning Using React Native to Improve Problem Solving Skills of Phase F High School Students

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Abstract: The study aims to develop an acid-base e-module based on guided discovery learning using React Native to improve the problem-solving skills of senior high school students. The research method is Educational Design Research (EDR) using the Plomp model. The e-module using React Native is presented in the form of a mobile application that can be accessed on smartphones. The presentation of acid-base material in the e-module is adapted to the syntax of Guided Discovery Learning. The e-module was validated by 5 validators, including 3 subject matter experts and 2 media experts, using a questionnaire analysed with Aiken's V. Practicality was assessed by 9 students representing low, medium, and high ability categories using a questionnaire in the small group stage, analysed using achievement percentages. Effectiveness was determined by comparing pre-test and post-test scores of students using the N-gain formula. The validation results of the acid-base e-module using React Native were 0.90, categorized as valid, and the practicality of the e-module was 92%, categorized as highly practical. Effectiveness was obtained from N-gain data of 0.71, categorised as high (sufficiently effective). Hypothesis testing was conducted using the Wilcoxon test because the data was not normally distributed, with a sign of < 0.001, indicating that the acid-base e-module based on guided discovery learning using React Native can improve the problem-solving skills of senior high school students in phase F.

Keywords: Acid base; E-modules; Guided discovery learning; React native

Introduction

In the increasingly advanced digital era, education is undergoing a significant transformation with the integration of information technology in the learning process. The development of information and communication technology has impacted the education world, especially in the learning process (Effendi & Wahidy, 2019). Students are more inclined to stare at devices rather than to study, even if it's just reading books or printed teaching materials provided. The development of technology use, such as smartphones, tablets, and Personal Digital Assistants (PDAs), has particularly increased among students because this technology offers attractive services and applications (Fatma & Partana, 2019). The influence of technology, especially the use of smartphones among students, can be seen in its impact on their environment and daily life. This affects both input and output in education, especially the achievements and learning outcomes of students (Apriansyah & Tureni, 2019; Kurniawati, 2020; Mista, 2023).

Chemistry learning in high school often faces challenges in conveying abstract concepts that are difficult for students to understand. Students often struggle to comprehend concepts in chemistry learning,

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one of which is the material on acids and bases. This is due to the complexity of the material being studied. Most students find it difficult to understand several concepts of acids and bases such as acid-base theory according to experts, acidity level (pH), and degree of ionization (Gazali & Yusmaita, 2018).

Students need more interactive and engaging learning media. The use of technology in education can help teachers deliver abstract materials to students, such as the use of PHET, Macromedia Flash, and so on (Aripin et al., 2023; Meiliawati & Sugiarto, 2024; Pratiwi et al., 2023; Rohimat, 2022; Rosmita & Revita, 2024).

In addition to developing technology-based learning media, educators can also create more attractive and interactive teaching materials to enhance students' motivation in learning. One form of innovative teaching materials that can be used in learning is by developing application-based e-modules that can be accessed through mobile devices. These e-modules not only serve as additional learning resources but also as tools that can increase interaction and engagement of students in the learning process. E-modules are one of the teaching materials that can help students learn chemistry material (Khaira & Yerimadesi, 2020).

Based on the results of interviews with educators and questionnaires from students, it was found that the e-module has not been used in teaching in several schools, especially at SMAN 2 Lubuk Basung, and students feel more interested when using technology in learning. With the presence of this e-module, it is hoped that it can make a real contribution to supporting the development of skills relevant to the educational needs of the 21st century, improve the quality of chemistry learning in high schools, and assist students in mastering chemical concepts better. In addition, the development of this e-module is also expected to serve as a model for the development of other technology-based teaching materials in various chemistry subjects and other subjects.

The essential 21st-century skills that students must possess to face academic challenges and daily life are critical thinking and problem-solving skills. Chemistry learning also requires problem-solving abilities from students, particularly in addressing given chemistry problems. Problem-solving skills are crucial abilities that students must have to tackle challenges in both academic and everyday life. According to Ertmer et al. (2012), technology integration enables student-centered learning, allowing students to learn to solve problems according to their skill levels (Fatma & Partana, 2019; Kusuma et al., 2022; Manurung & Zubir, 2023). However, the learning conducted has not yet fully developed these skills effectively.

One of the main objectives of developing this e-module is to enhance the problem-solving skills of high school phase F students. Through the use of this e-module, it is hoped that students can be more active in exploring chemistry concepts, finding solutions to various problems, and developing their critical thinking skills. Several studies have shown that the use of technology-based e-modules can improve problem-solving abilities, motivation, and learning outcomes for students. The use of technology-based e-modules can enhance problem-solving abilities, motivation, and learning outcomes for students (Jupinta & Yerimadesi, 2024; Yuni et al., 2022; Febrianti et al., 2023).

Acid-base materials, as one of the important topics in chemistry, require problem-solving skills and effective learning models to help students better understand these concepts. Guided Discovery Learning (GDL) is one of the effective models for improving students' problem-solving abilities (Sulistyowati et al., 2012). The GDL model actively involves students in the learning process, encouraging them to discover concepts and solve problems through structured guidance and support. The GDL model can enhance student activity in learning both in the classroom and in the laboratory, indicating that the GDL model aligns with the characteristics of high school students (Yerimadesi, 2018; Zulkifli & Sutrio, 2020; Yerimadesi et al., 2022).

Several studies report that the use of guided discovery-based modules in chemistry learning can enhance student learning outcomes and critical thinking skills, including modules on chemical elements, acid-base modules, and redox and electrochemistry modules (Luthfiani & Yerimadesi, 2022).

E-modules can be developed using mobile application technology that can be accessed on smartphones by educators and learners using React Native. React Native is a JavaScript framework used to create mobile applications for Android and iOS. It is based on the JavaScript React library from Facebook to build user interfaces but cannot be accessed through a browser, instead, it can be accessed through mobile platforms. In other words, programmers now have the ability to create engaging mobile applications using the convenience of the JavaScript library (Eisenman, 2015).

React Native not only provides efficiency in development, but also allows developers to create a consistent and engaging user experience across various devices. The simplicity of using JavaScript in mobile app development makes React Native an attractive option for developers looking to speed up the development process and enhance their productivity (Yuni, 2024).

The development of a Guided Discovery Learning-based e-module using React Native allows learners to access learning materials anytime and anywhere, with an interactive and user-friendly interface. The development of technology-based e-modules can enhance interaction and engagement among learners in the learning process (Syahputri et al., 2023).

However, there is still little research focusing on the development of an e-module based on Guided Discovery Learning integrated with React Native technology in the form of an application. This facilitates participants in accessing the e-module anytime on their smartphones, which can be accessed both online and offline, and is more interactive. Therefore, this study aims to develop a guided discovery learning-based acid-base e-module using the React Native mobile application and to measure its effectiveness in improving students' problem-solving abilities.

Method

This study uses a type Educational Design Research (EDR) with the model used being the Plomp model. The Plomp model divides the development stage into three phases: preliminary research, development or prototyping phase, and assessment phase (Plomp & Nieveen, 2013).

The Preliminary Research

The preliminary research stage aims to obtain an overview of the characteristics of the products to be developed and can be used in the learning process by identifying the problems or obstacles occurring in schools, establishing and defining the needs in chemistry education. The activities conducted at this stage include needs analysis, context analysis, analysis of student characteristics, and literature study.

Needs Analysis

This needs analysis is conducted to gather information regarding the problems present in the learning process and related to the needs of teaching materials used in chemistry education, particularly on acid-base material. Thus, it obtains the characteristics of e-modules preferred by the students targeted for the development of the e-module, and determines the e-modules required by teachers as aids in the learning process. The activities carried out at this stage involve collecting and analyzing information by conducting interviews with chemistry educators and providing an open questionnaire filled out by educators and students in Phase F of the high school chemistry class. The results of this needs analysis are then used as considerations in the design and development of the e-module.

Context Analysis

This context analysis is conducted to determine the sequence and scope of material needed according to the existing learning outcomes (LO) and to formulate the learning objectives (LO) of the material. This activity aims to identify the concepts being taught, systematically arrange the main points of acid-base material, and relate one concept to another relevant concept and the skills that students must acquire. This analysis aims to ensure that the resulting e-module meets the competency demands that students must achieve, the process of developing or detailing learning outcomes into learning objectives for competency achievement, and refers to the indicators of problem-solving abilities, so that learning becomes focused and the goals to be achieved are clear.

Analysis of Student Characteristics

This stage aims to analyze or study the characteristics of students to understand their general abilities, learning methods, problem-solving approaches, language, color, and the use of letters in the learning tools with e-modules that are easy for students to understand so that the developed learning tools with e-modules are suitable for the students. This analysis is conducted by providing questionnaires to the students.

Literacy Study

At this stage, the collection of sources or references related to the activities being carried out is conducted. The references that can be used include books, journals, and online articles.

Prototype Development Phase

Based on the results of the analysis in the preliminary research phase, a design for the development of a GDL-based e-module is created to enhance the problem-solving abilities of students in the F phase of high school Chemistry. When designing the product, three product characteristics must be considered: content/material feasibility, graphics, and language. In this prototyping development phase, a series of prototypes are developed. The prototypes are evaluated based on the formative evaluation proposed by Tessmer (1993). Formative evaluation is viewed as a process of collecting data about a product during the development phase, aimed at improving the product prior to producing the final product.

Prototype I

Prototype I is designed in the form of GDL-based e-modules to improve students' problem-solving abilities based on learning objectives (TP) that align with learning outcomes (CP). After the design phase is completed, it is followed by the implementation phase to produce Prototype I. The resulting prototype is evaluated through Self Evaluation.Self Evaluation is the process of evaluating the designed prototype with the assistance of peers or the design team (Tessmer, 1993). This involves self-revising any errors that may still be present in the development of the GDL-based e-module. The aspects assessed at this stage include content, typographical errors, consistency in punctuation use, layout/graphics.

Prototype II

After prototype I is deemed satisfactory, the next stage is expert review and one to one evaluation.

Expert Review

The expert review is a process where one or several experts examine a product that is still in the design phase to determine its strengths and weaknesses (Tessmer, 1993). The review process is carried out to assess the validity of prototype I. The validation of the GDL-based e-module development is consulted and discussed with chemistry lecturers and high school chemistry teachers. Discussions and consultations continue until the experts declare the developed GDL-based e-module valid. Validation is carried out by filling out a validity instrument in the form of a questionnaire and also providing critiques and suggestions for the refinement of the developed prototype. After being validated and revised, the GDL-based e-module that has been revised is named prototype II. This discussion and consultation activity is conducted until a valid and feasible development of the chemistry e-module on acid-base material based on GDL is achieved to improve problem-solving skills.

Individual Evaluation (One to One Evaluation)

After the product has been validated by experts, it results in prototype II, and then a trial is conducted to evaluate the e-module through individual evaluation (one to one evaluation). According to Dick & Carey, individual evaluation is conducted on 1-3 subjects (Setyosari, 2015). The purpose of the one to one evaluation is to identify the clarity of the product, clarity of direction, completeness, level of difficulty, errors, and grammar (Tessmer, 1993).

This evaluation was conducted by asking three students from SMAN 2 Lubuk Basung, class XI Chemistry, with different abilities (high, medium, and low) to provide their responses or comments on the GDL-based e-module designed to enhance problem-solving skills that had been developed. The one-to-one evaluation process was carried out by observing students' activities during e-module learning and conducting interviews aimed at obtaining assessments or feedback from students and educators as individual users of the e-module.

The instruments used in the individual evaluation consist of interview guidelines and field notes during the observation. Based on the results of one-to-one evaluation, improvements to the e-module were made to obtain an even better e-module. The revised GDL-based e-module aimed at enhancing problem-solving skills is called prototype III.

Prototype III

After the development of the GDL-based e-module was revised based on the results of the one-to-one evaluation, a small group evaluation was then conducted. This GDL-based e-module was tested in a small group evaluation consisting of six students from the eleventh grade Chemistry class. The six students can represent all levels of student abilities (low, medium, high). The objective is to assess the practicality and effectiveness of using the learning device with the developed e-module. The instruments used are practicality questionnaires and problem-solving ability tests. The instruments were first validated by several experts.

Based on the evaluation results from the small group evaluation, the practicality of the developed e-module is assessed. The e-module provided in the small group evaluation has met the requirements for practicality and effectiveness, but there are still issues that need to be addressed. The improvements to the GDL-based e-module after the small group activity are called prototype IV, which cannot yet be used as a reference. Therefore, according to the Plomp development model used, prototype IV needs to be tested again in the field test stage.

Prototype IV

After revisions based on the results of the small group evaluation, a formative test was conducted by performing a field test of the GDL-based e-module development to enhance problem-solving skills in a large group. The purpose of this testing is to strengthen the validity, practicality, and effectiveness of the GDL-based e-module for improving students' problem-solving abilities.

Assessment Phase

This phase is carried out during the field test conducted in a class or large group. The revisions obtained from the small group test are followed by a field trial in one class. At this stage, activities are focused on evaluating the quality of the product produced in the previous stage. Assessment is conducted to determine whether the product has met expectations, and is practical and effective in enhancing students' problem-solving abilities. After the trial, educators and students will be given a questionnaire. The purpose is to understand the responses of educators and students regarding the development of the GDL-based e-module used during the learning process. This field test is conducted to see the level of practicality of a designed product.

Practicality Test

The practicality test is conducted to assess the level of practicality of the teaching device with the e-module when used in the learning process. This activity is carried out to find out the extent of the benefits, ease of use, and efficiency of time in using the teaching device with the e-module by educators and learners. The practicality test is conducted by giving a questionnaire to educators and learners regarding their responses to the developed product.

The Effectiveness Test

The effectiveness test aims to determine the effectiveness of the developed GDL-based e-module on the problem-solving ability of students that has been designed. The observed aspects of effectiveness are problem-solving ability and student involvement obtained from test administration. The instrument used is an essay-type test that aligns with the indicators of problem-solving ability and learning objectives.

Before conducting the test, the researcher first prepares test items to measure problem-solving abilities, creates an answer key, develops a scoring rubric, and validates the test items. After the test items are validated, the effectiveness test of the GDL-based e-module will be carried out with the following steps: Conducting the test; Scoring the students' answer sheets based on the prepared scoring rubric; Analyzing the test results to determine the effectiveness of the GDL-based e-module on students' problem-solving abilities.

Product Trial

The product trial in the form of a GDL-based e-module to enhance students' problem-solving abilities was conducted at SMAN 2 Lubuk Basung. The data obtained from the trial will be used as a basis for revising the e-module, ensuring that the resulting GDL-based e-module is truly suitable for use in learning. Data was collected through observation sheets on the implementation of the GDL-based e-module to improve problem-solving abilities and questionnaires. The field test was conducted by chemistry educators at the school to assess the practicality and effectiveness of the developed product on students' problem-solving skills.

The subjects of the research trial are students in phase F of the Chemistry class at SMAN 2 Lubuk Basung for the 2024/2025 academic year. In determining the subjects for each stage of the research, it refers to the development procedures, so they are established according to the needs of each research stage.

In this study, non-test data collection instruments are used in the form of teacher interview sheets, validation sheets for e-module development, questionnaires on the use of e-modules for students and teachers, as well as test data collection instruments in the form of problem-solving ability tests for students after the learning process. These instruments consist of instruments used in the preliminary research stage, validity instruments, practicality instruments, and effectiveness instruments.

The data collection techniques used in this research are: A questionnaire for the validation of data collection instruments obtained through validation by expert lecturers; A questionnaire for the validation of GDL-based e-modules validated by expert lecturers and chemistry educators, as well as the practicality of the e-modules based on data from educators and students' responses to the e-modules; Tests conducted before and after learning to assess problem-solving abilities before and after using the GDL-based e-modules; Photo documentation of students' activities during the learning process.

The type of data collected in this study is data from research instruments, namely data from validation by validators, practicality, and effectiveness of the GDL-based acid-base e-module. The data collected from the limited trial implementation on the trial subjects includes observational results during the learning process, questionnaires of teacher responses and student responses, as well as problem-solving ability tests. The data obtained through data collection instruments are then analyzed using descriptive statistical analysis for quantitative data and qualitative (non-statistical) analysis for qualitative data.

Researchers used Aiken's formula for the validity analysis of the developed e-module. The data obtained from the validators were inputted into the formula to obtain the validity results of the e-module that has been developed (Azwar, 2016). The formula used is:

$$V = \frac{\sum s}{[n\,(c-1)]} \tag{1}$$

Description:
s = r – lo
lo= the lowest validation score
c = the highest validation assessment score
r = the number given by an assessor
n = the amount of data or the number of validators

The coefficients of Aiken’s V range from 0 to 1. According to Aiken (1985), if the results of the validation data processing approach 1, the validity score is higher. Conversely, if the results obtained approach 0, then the validity is lower (Putri, 2024). The level of validity is determined based on the Aiken's table according to Table 1.

Table 1. Categories of e-module validation levels

Achievement Level	Category
≥ 0.760–1.00	Valid
< 0.760	Invalid

Source: modified from Riduwan (2012)

The practicality of the e-module is analyzed from the data obtained from the practicality test questionnaire of teachers and students. According to Sudijono (2016), the data obtained is analyzed using the formula:

$$\text{Practical Value} = \frac{\sum \text{Score obtained}}{\sum \text{Maximum score}} \times 100\% \quad (2)$$

Table 2. E-module practicality categories

Achievement Level (%)	Category
81–100	very practical
61–80	Practical
41–60	Quite Practical
21–40	Less Practical
0–20	Not practical

According to Arikunto (2009), the students' answers were analyzed based on the following formula.

$$\text{Student Values} = \frac{\sum \text{Score obtained}}{\sum \text{Maximum score}} \times 100\% \quad (3)$$

Table 3. Criteria for the ability level of students

Achievement Level (%)	Category
81–100	Very good
61–80	Good
41–60	Enough
21–40	Less
0–20	Very poor

The improvement in students' problem-solving abilities before and after using the e-module can be seen from the scores obtained, which are analyzed using the gain standard. The improvement results from the pre-test and post-test scores, expressed as gain scores. Gain scores are calculated to obtain the relationship between the pre-test and post-test scores achieved by the students. According to Hake (1999), the n-Gain scores of each student can be calculated using the formula.

$$N_{-\text{Gain}} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}} \quad (4)$$

The N-Gain results obtained can be categorized based on Table 4.

Table 4. N-Gain classification

Value <g>	Classification
<g> ≥ 0.7	Height
0.7 <g> ≥ 0.3	Moderately
0.3 > <g>	Low

The Prerequisite tests are used to ensure that the formulas used do not deviate from applicable regulations. Since the data in this study is dependent, the prerequisite test performed is a normality test. If the data is normally distributed, parametric statistics are used for data analysis, and if the data is not normally distributed, Wilcoxon non-parametric statistics are used. Hypothesis testing in this study will use SPSS software.

Hypothesis testing is conducted to see the effect of using e-modules on students' problem-solving abilities by analyzing the problem-solving skills data of students in classes that have been given treatment. This study uses statistical data in the form of dependent samples where all classes are given the same treatment, namely using e-modules in classroom learning. The hypotheses for the t-test of problem-solving are:

Ho: There is no significant difference in the improvement of students' problem-solving abilities before and after using the e-module.

Ha: There is a significant difference in the improvement of students' problem-solving abilities before and after using the e-module.

In this study, a t-test is used if the data is normally distributed, namely the dependent/paired sample t-test or dependent t-test. A dependent/paired sample is part of parametric statistical analysis used to test whether there is a difference in the average scores of two paired data groups. The type of data used in the t-test is generally interval or ratio scale data. Basis for decision making:

1) If significance < 0.05, Ho is rejected indicating that there is a difference between before and after.
2) If significance > 0.05, Ho is accepted indicating that there is no difference between before and after.

Results and Discusion

Results of the Preliminary Research Phase

Needs Analysis

Based on interviews with two chemistry educators at SMA Negeri 2 Lubuk Basung and several educators from various schools, the following information was obtained: The problem-solving abilities of students are not yet optimal and there is a lack of focus among students during the learning process; The limited learning resources used, making chemistry learning not yet optimal; There is a need for innovative teaching materials that can support students' problem-solving, but these are not available in the school; The teaching materials used are still limited to textbooks, student worksheets, and occasionally using sources from the internet; There are no electronic teaching materials that can be accessed with smartphones; The usual learning models employed are discovery learning, discussion, and lectures, but the Guided Discovery Learning (GDL) model, which could optimize students' understanding of the subject matter, has never been used; There is no availability of GDL-based e-modules, particularly on acid-base material in schools, which could be a potential solution to improve the quality of chemistry education. Based on this analysis, teaching materials in the form of GDL-based e-modules are then developed using React Native to enhance students' problem-solving skills in accordance with the Merdeka curriculum for the chemistry topic of acid-base.

Context Analysis

Context analysis is conducted so that students can more easily understand the material to be learned. The purpose of context analysis is to identify the main concepts being taught, detail them, and organize them systematically to achieve the learning objectives. This context analysis also aims to determine the content and subject matter needed for the development of acid-base e-modules based on guided discovery learning using React Native.

Based on the analysis of the General Learning Outcomes (CPU) of the chemistry phase F, it is derived into Specific Learning Outcomes (CPK) for the acid-base material, which is that students are able to understand the concept of acids and bases in daily life. The CPK is then analyzed to be derived into Learning Objectives (TP) and the Path of Learning Objectives (ATP). The learning objectives for the acid-base material are that students have the ability to analyze the properties of solutions based on the concepts of acids and bases and calculate the pH of solutions. These learning objectives include: Distinguishing the concepts of acids and bases from the three experts: Lewis, Bronsted Lowry, and Arrhenius through chemical reactions and their examples; Detecting the properties of acidic and basic solutions; Calculating the pH of a solution based on the strength of acidity. The path of learning objectives is derived by arranging the learning objectives in a systematic order. The path of learning objectives expects that students are able to: Explaining the concept of acids and bases according to experts in one's own words; Comparing the concepts of acids and bases according to experts and summarizing them; Analyzing the color changes that occur in acid and base solutions accurately when tested with indicators; Being able to use experimental data that has been conducted to predict the acidic or basic properties of a solution; Being able to analyze the relationship between Ka and Kb with the pH of a solution; Being able to accurately conclude the differences between strong acids and weak acids as well as strong bases and weak bases; Being able to calculate the pH of acid and base solutions accurately.

Analysis of Student Characteristics

The analysis of students is conducted to understand their characteristics. Identifying the behaviors and characteristics of students is essential to determine the quality of individuals that can serve as a guideline in lesson planning (Uno, 2007). Therefore, the design of the e-module to be developed can be effectively used in the chemistry learning process. The analysis of students is carried out by administering a characteristics questionnaire to the students. The characteristics analyzed include academic ability, group work skills, background experience, preferences for colors and images, as well as students' attitudes.

Based on the questionnaire given to the students, several pieces of information about the students were obtained. According to the answers from the students, it is known that the majority of the students consider chemistry to be a subject that is quite difficult to understand. This is because the students feel that there is a lack of good teaching materials, that the formulas used are too many and hard to understand, and that the material is too abundant and complex. During class activities, the students' participation is classified as quite active. The students are aware of the usefulness of chemistry in everyday life.

Based on the questionnaire provided, during the learning process, educators tend to use textbooks, and according to the students, the learning resources commonly used are quite interesting for them. When asked if they wanted more interesting learning resources, 99.3% of the students stated that they wanted more engaging learning resources at school. In terms of utilizing technology in the learning process, generally, students have used technology such as smartphones in their learning and stated that they have never learned with e-modules. The conclusion of this analysis indicates that students have become accustomed to using smartphones as a learning resource in the educational process. However, students have not yet utilized learning resources like e-modules to study chemistry.

Based on the analysis of the characteristics of the students, it is also known what colors the students prefer. The selection of these colors consists of colors for the cover and content of the chemistry e-module. The analysis results show that the most preferred color among the students is blue. Based on the students' experiences in chemistry learning related to everyday life issues, students stated that they have learned chemistry related to everyday life. When given chemistry problems tied to everyday situations, 60% of the students indicated that they sometimes can solve those chemistry problems. During the chemistry learning process, if the students do not understand the material explained by the educator, they tend to ask their friends, and only a few students are willing to ask the educator during the learning process. In terms of learning methods, students prefer to learn in groups and independently. It can be concluded that students are already accustomed to learning in groups and independently to complete specific tasks assigned by the educator. However, having too many group members can reduce the effectiveness of the chemistry learning process.

Results of the Development Phase (Development or Prototyping Phase)

The results of the preliminary research serve as a guideline for researchers to carry out the planning stage of the developed product, namely an acid-base e-module based on guided discovery learning using React Native to enhance the problem-solving skills of students in the 11th grade of high school. The development process will be detailed in the following discussion.

Prototype I

Prototype I is a prototype designed as part of the preliminary research stage. The design of the e-module begins by creating a storyboard for the e-module, followed by designing the systematic presentation of the material and the learning objectives to be achieved, and dividing it into several learning activities. Then, the developed e-module is created online using the React Native framework. However, before the e-module is designed in React Native, the module is first designed in Microsoft Word combined with the Canva application (Ceria et al., 2022), which is then converted into a PDF. To change its format into an APK, development is done using the React Native framework. React Native is a JavaScript framework used to create attractive mobile applications for Android and iOS using the ease of JavaScript libraries (Eisenman, 2015). The simplicity of using JavaScript in mobile application development makes React Native an attractive choice for developers who want to speed up the development process and increase productivity (Yuni, 2024).

The prototype I produced is in the form of an e-module consisting of several parts, namely, a cover, a login page, a main menu containing a preface, learning outcomes, usage instructions, materials divided into four sections, evaluation, a glossary, a bibliography, a concept map, and a developer profile. In each material section, there are learning materials, exercises complete with answer keys, and a reflection sheet. For evaluation, students can view the answer key or discussion after they have completed their answers in the evaluation section. Below is the display of the e-module.

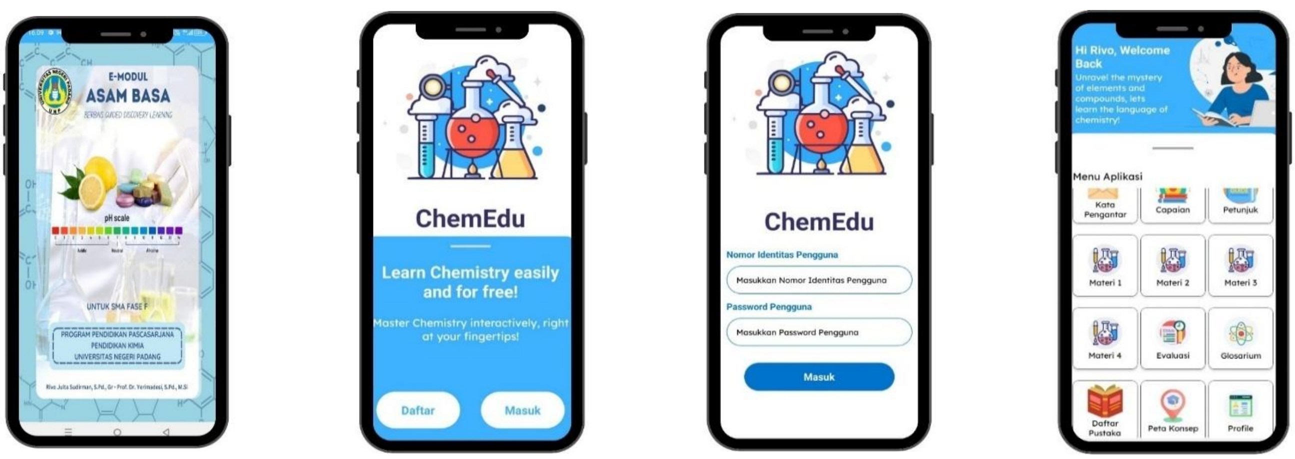

Figure 1. Display of the e-modules

In the main menu, there are navigation buttons for material 1, material 2, material 3, and material 4. This material is divided into 4 sections, each of which represents 1 meeting and corresponds to its own learning objectives. Each section of the material in this e-module contains navigation buttons that direct users to the acid-base lesson materials that will be discussed in the module, exercises, and reflection sheets.

Exercises in the e-module are accompanied by answer keys that learners can view after they answer each question. However, learners cannot change their submitted answers because these answers are directly saved in the database that can be accessed by the educator's account. Uploaded answers can be corrected or re-answered if the educator has deleted the previous answers.

The lesson material in the e-module is presented using the syntax of guided discovery learning. Here is the section of the e-module regarding the syntax of GDL related to research.

Motivation and Problem Presentation

In this stage, discourse, images, and videos related to the material being studied are presented. The discourse, images, and videos serve as the initial stage in the learning process, where educators provide stimuli or initial prompts and outline the problems to be explored and solved by the learners. This stage functions to build motivation and present problems contextually so that learners are encouraged to seek solutions and actively solve problems through guided discovery. At this stage, learners also formulate hypotheses as temporary answers to the given problems.

Data Collection

At this stage, learners are given the opportunity to collect data related to problem identification from the information provided in the e-module, whether through reading literature, observing objects, or conducting experiments in groups. At this stage, learners seek information to answer questions or to prove whether the hypotheses they have made are correct.

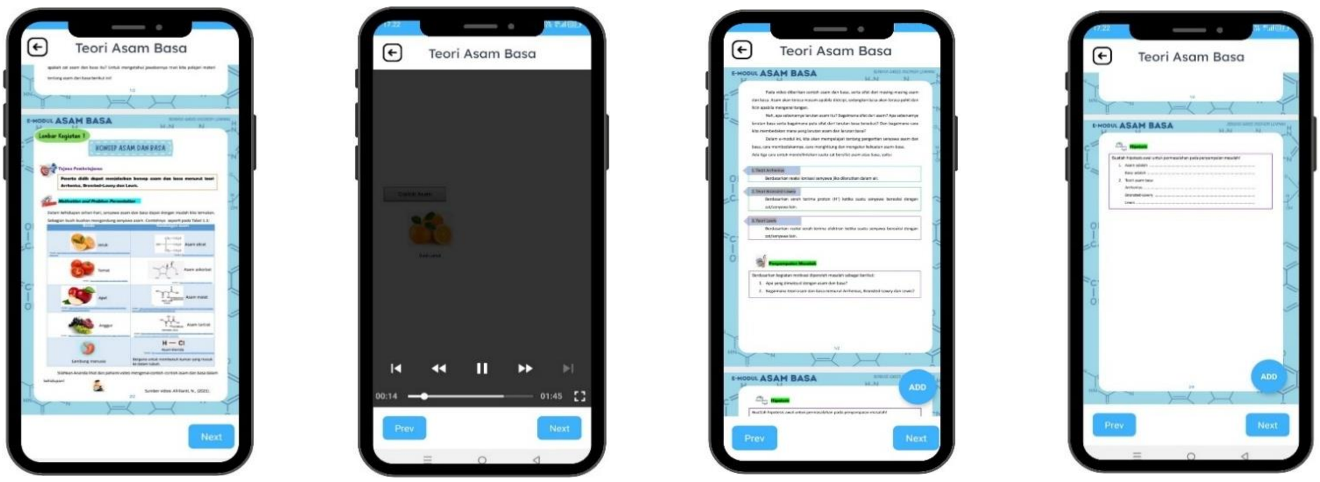

Figure 2. Presentation of information display using GDL syntax in the e-module

Prototype I included a self-evaluation which showed that e-module already contained the components and characteristics of the e-module mentioned by Kemendikbud (2017).

Prototype II

Table 5. Validity test results of e-module produced prototype II

Aspect	V	Category
Content Suitability	0.90	Valid
Presentation Feasibility (Construction)	0.90	Valid
Language Suitability	1	Valid
Contextual Feasibility	0.90	Valid
Display	0.91	Valid
Programming	0.86	Valid
Utilization	0.85	Valid
Average	0.90	Valid

At this stage, the e-module has been verified by 5 experts, consisting of 3 content experts and 2 media experts. The results of the validation can be seen in the Table 5.

Prototype III

A one-to-one evaluation was conducted by distributing a questionnaire to 3 students with different abilities, each representing high, medium, and low ability groups. From the analysis of the questionnaire, it was found that the appearance of the e-module was very attractive, easy to use, and the instructions were easy to understand. In addition, the images, videos, and colors in the e-module made students interested in learning. The presentation of the material in the e-module was very clear and easy to understand, using very simple language.

Furthermore, the steps of guided discovery learning included in the e-module were easy to understand and helped the students comprehend the subject matter of acids and bases.

Prototype IV

Prototype IV was produced by evaluating Prototype III through conducting small group tests. This trial was conducted on 9 students, each representing groups with high, medium, and low capabilities. The instrument used was a practicality questionnaire. The results of the practicality are as shown in Table 6.

Table 6. Practicality of small group test results

Aspect	P (%)	Category
Ease of Use	91	Very Practical
Appeal	93	Very Practical
Efficiency	92	Very Practical
Benefits	91	Very Practical
Average	92	Very Practical

Results of the Assessment Phase

Prototype IV that is practical are then tested in the field by teachers and students to determine the level of practicality of the developed e-module. The practicality results for students and teachers can be seen in the following Table 7.

Table 7. Practical field test results of teachers

Aspect	P (%)	Category
Usable	84	Very Practical
Easy to Use	85	Very Practical
Appealing	90	Very Practical
Clear	97	Very Practical
Efficiency	92	Very Practical
Average	90	Very Practical

In addition to examining the practicality of the developed e-modules, this study also aims to assess the effectiveness of the e-modules. The effectiveness of the e-modules is evaluated based on the problem-solving abilities of the students and the impact on their problem-solving skills before and after using the guided discovery learning-based e-modules developed using React Native. The effectiveness test was conducted in two classes that received the same treatment, namely using the e-modules in acid-base learning. The improvement in problem-solving skills is evaluated by administering a test created according to problem-solving indicators. Before the learning, students were given a pre-test and after the learning, they were given a post-test. To assess effectiveness, an analysis was conducted using the N-Gain formula, which produced N-Gain values as shown in the Table 8.

Table 8. Results of e-module effectiveness test

Pre-test score	Post-test scores	N-Gain	Category	Representative
37	81	0.71	Height	Quite Effective

The use of e-modules to observe the improvement of students' problem-solving skills was tested using a hypothesis test or t-test. The requirements for the t-test are that the values must be normally distributed. The results of normality testing and the t-test were conducted using SPSS Version 31. The normality test using Kolmogorov-Smirnov resulted in significance values of 0.200 for the pretest and 0.003 for the posttest. Since the significance < 0.05, it can be said that the data is not normally distributed. Next, hypothesis testing was performed using a non-parametric test, namely the Wilcoxon test. The results of the Wilcoxon test showed a significance value of < 0.001. Since the sign < α, Ho is rejected and Ha is accepted.

Thus, it can be concluded that there is an effect of using guided discovery learning-based acid-base e-modules using React Native on improving the problem-solving skills of Phase F high school students.

Conclusion

Based on the results of the research that has been conducted, the following conclusions were obtained: The acid-base e-module based on guided discovery learning using react native to improve problem-solving abilities of high school phase F students can be developed using the Plomp development model; The acid-base e-module based on guided discovery learning using react native that has been developed is valid and practical; The acid-base e-module based on guided discovery learning using react native that has been developed is quite effective in improving the problem-solving abilities of students. Based on the research that has been conducted, the author suggests several things as follows: For educators, it is hoped that they can use the guided discovery learning-based acid-base e-module using React Native as one of the teaching materials used in learning at school; For students, it is hoped that they can take advantage of the guided discovery learning-based acid-base e-module using React Native to make it easier to understand the concepts in acid-base material, as well as to practice problem-solving skills. The acid-base e-module based on guided discovery learning using React Native has been developed using the Plomp development model and produces a valid, practical, and effective e-module in enhancing students' problem-solving skills. Therefore, this e-module can be utilized as teaching material that can be used in chemistry learning, especially on acid-base material. This e-module is structured based on the syntax of the guided discovery learning model; thus it is capable of training students' problem-solving abilities. In addition, this e-module is also developed using the JavaScript framework React Native, which is made in the form of a mobile application, allowing access on smartphones by educators and students anytime and anywhere.

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