Development of E- Modules To Improve Students' Problem Solving Abilities on Ethnoscience Integrated Colloidal Material with the Problem Based Learning Model

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Abstract. Research has been carried out on the development of e-modules to improve student problem solving on ethnoscience integrated colloidal material using the problem based learning model. This study aims to determine the validity, practicality, and effectiveness of the e-modules developed. This research is a research & development research with the ADDIE model (analysis, design, development, implementation, and evaluation). The subjects of this study were 5 validators and 33 students of grade XI MIPA 5 SMA Negeri 2 Banjarmasin. Data collection using test and non-test instruments (questionnaires and observation sheets). Data analysis using descriptive techniques. The results of this study show that this e-module is very valid, very practical, and effective. The N-Gain value is 0.89 in high category, which is that this colloidal e-module is able to improve problem solving capabilities.

Keywords: E-module, problem solving ability, colloid, ethnoscience, problem based learning

Introduction

The education system encourages teachers' efforts to create superior and competitive graduates. It takes several competencies of students that must be possessed and mastered as a provision for career success in future life, specifically, developing critical thinking, creativity, problem-solving, teamwork, and communication skills; life and career skills; and social responsibility, tolerance, and productive, flexible, as well as media, information, and technology usage abilities (Aufa, et al., 2021). Of the many skills that must be mastered, one of them is the ability to solve problems.

Problem solving is a process that consists of a series of cognitive processes involving behaviors, actions, or activities that guide individuals to think about finding solutions (Alsarayreh, 2023; Arifin, 2020; & Fitriani, et al., 2020). Problem solving means that the process involves a task whose solving method is not yet known in advance (Ripai & Sutarna, 2019). This is in line with Rahman (2019), problem solving is defined as a cognitive process that focuses on achieving goals that learners do not know the solution to. There hasn’t been much prior study on high school students' problem solving abilities, particularly in chemistry. According to Zhafirah, et al. (2021), students' problem solving skills, which stand at 39.92%, fall into the low group. This is due to the fact that
Instructional materials are only adhered to printed chemistry books that do not allow for the development of problem-solving abilities. However, it is uncommon to use the problem-based learning model in the classroom, which makes it less effective in enhancing students' problem-solving skills. Salfa et al. (2021)'s research shows that it is still rarely applied the problem-based learning model by teachers to chemistry learning.

Facts in the school show that chemistry is still considered difficult according to almost all learners. As a result, student learning outcomes and problem-solving abilities are low. Most only understand the concept or theory, but still have difficulty in connecting it into everyday life. Results of initial needs analysis conducted on class students XI MIPA 5 SMAN 2 Banjarmasin, They are more interested in learning if they use smartphones that can be accessed flexibly and learning becomes more varied or interesting. The learning media used is also common, only sourced from books which of course are not enough to develop these problem-solving skills. Of course, this must be the focus of attention for a teacher to prepare students to have problem-solving skills needed in the world of work (Fitriani et al., 2020). Chemistry is a material that is abstract and not easily understood by most students (Manurung, 2021; Zhafirah et al., 2021; & Rahmila et al., 2022), for example, colloidal topic. Colloidal topic encompasses both microscopic and abstract ideas. Since the material is meant to be memorized, students will not be as engaged in learning it (Rahmila et al., 2022).

To ensure that learning objectives are reached, a professional teacher must not only be an expert in the subject matter but also be able to create strategies, approaches, methods, models, and learning media (Pontoh et al., 2021). For the example of learning models that can help students in learning chemistry, especially colloidal material, is the problem-based learning model. Problem-based learning model is a learner-centered learning model. Students are given space to build their own knowledge starting from understanding the problem to finding a solution (Duda et al., 2019). Students are designed to build their knowledge from surrounding problems so that they are accustomed to solving problems and strategizing according to their learning style, as well as practicing cooperation with groups (Dibyantini & Sulastri, 2022 & Syahmani et al., 2021). In addition, with problem-based learning model, the material is easy to understand because they are the ones who discover the concept independently in pure life (Zhafirah et al., 2021).

One of a learning approach that is directly integrated into real life is ethnoscience integrated learning. Ethnoscience is an approach with culture or local wisdom being the object of science learning (Ardianti et al., 2019; Ardianti & Raida, 2022; Dewi et al., 2019; Sholahuddin et al., 2021 & Zidny & Elks, 2022). By studying science from the perspective of culture and local knowledge from people connected to certain natural phenomena, it will be easy to understand (Dewi et al., 2021). That’s way, learning becomes more effective because students become helped in learning and improve cognitive outcomes (Hastuti et al., 2020). Chemicals that are suitable integrated ethnoscience are colloidal materials. This is because colloidal material can be found and is closely related to everyday life so it is suitable if applied to ethnoscience, which connects science with local wisdom (Rahmila et al., 2022).

The development of increasingly advanced technology has led to innovations, including e-modules that can be accessed through electronic devices (Syahmani et al., 2022). Students can enhance their problem-solving skills by using technology, such as electronic modules (e-modules) which is more practicality and effective (Safitry & Iskandar, 2023). E-modules are instructional resources that facilitate idea development and can be used in a student-centered learning environment (also known as a student center) (Aufa et al., 2021). E-modules can draw students to education and provide teachers with answers to the problems posed by information and technology advancements in the classroom (Rismayanti et al., 2022).
The development of e-modules on ethnoscience integrated colloidal material with the problem based learning model is one of the innovative discoveries for teachers to be used as a learning medium in the classroom to improve problem solving skills in students, especially in colloidal material because there is still a lack of application of e-modules by teachers in the learning process (Napoles, et al., 2022; Komikesari, et al., 2020 & Maksum & Purwanto, 2022). This e-module is arranged according to the syntax of the problem based learning model where the process of learning activities is more centered on students (Zhang, et al., 2022) and encourage learners in science thinking skills (Serevina, et al., 2018). By learning using e-modules, students become interested and more active and understand the material quickly and effectively improve their knowledge (Logan, et al., 2020; Amini & Usmeldi, 2022 & Mulyadi, et al., 2019) and e-module is also very simple to use it (Mahmudah, et al., 2022) Because it can be accessed via mobile or laptop and makes it easy to access anytime and anywhere. In addition, this e-module is designed attractively because colloidal material is integrated with ethnoscience that connects with typical foods from South Kalimantan, so learning is more meaningful. According to Syafitri, et al. (2022), students’ knowledge can grow when using this ethnoscience-integrated problem based learning model since it draws from a variety of learning resources. Furthermore, learning that integrates ethnoscience increases student engagement because it is student-centered, which means that students learn more (Hidaayatullaah, et al., 2021 & Nurcahyani, et al., 2021) than they would if it were only teacher-centered or even if ethnoscience were not included. As a result, it is crucial to development of e-modules to improve student’s problem solving abilities on ethnoscience integrated colloidal material with problem based learning model also ensuring that the e-modules are valid, practical, and effective.

Methods

This research is a type of research "Research & Development". A product is created and tested for efficacy using the research process known as research and development (R&D) (Fikri, et al., 2019) also to be tested for validity, practicality, and effectiveness (Sholahuddin, et al., 2021). The development model used to develop e-modules is the ADDIE model. This model is more detailed and more rational when compared to other models based on the stages of product development (Yuliana, et al., 2023). The steps of the ADDIE model are analysis, design, development, implementation, and evaluation. The ADDIE model is suitable for designing learning systems (Hastuti, et al., 2020).

Test instruments and non-test instruments (validation sheets, readability questionnaires, response questionnaires, observation sheets) are used in data collection procedures. A descriptive analysis of the data was conducted. The electronic module (E-module) that was created is the end product. Five experts or validators review the e-module. Trials were then conducted on an individual, small group, and limited group basis. Three subjects participated in individual trials, while ten participants from class XI MIPA 4 SMAN 2 Banjarmasin participated in small group trials. In the meantime, 33 participants from class XI MIPA 5 SMAN 2 Banjarmasin participated in the limited group experiment.

Data is derived from the findings of previous studies. It is then examined to evaluate the e-module's efficacy, usefulness, and validity. Based on the answers to validation sheets completed by five validators, data analysis is performed to assess the e-module's validity. The following formula is used to determine the validator assessment result:

$$\rho(\%) = \frac{\text{score}}{\text{score max}} \times 100\%$$  \hspace{1cm} (1)

For the validity category of e-modules using the value principle in Table 1.
**Table 1.** Validity criteria

<table>
<thead>
<tr>
<th>Validity criteria (%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho \leq 20$</td>
<td>Invalid</td>
</tr>
<tr>
<td>$20 &lt; \rho \leq 40$</td>
<td>Less valid</td>
</tr>
<tr>
<td>$40 &lt; \rho \leq 60$</td>
<td>Quite valid</td>
</tr>
<tr>
<td>$60 &lt; \rho \leq 80$</td>
<td>Valid</td>
</tr>
<tr>
<td>$80 &lt; \rho \leq 100$</td>
<td>Very valid</td>
</tr>
</tbody>
</table>

(Source: Asri & Dwiningsih, 2022)

The results of readability tests, observation sheets on the application of learning and teachers' media usage skills, and teacher and student reaction questionnaires were used to gauge the practicality of the e-module. Likert scales with a 1-4 score were employed in the questionnaires. The more practical the e-module develops, the higher the score. To use the following formula to determine the practicality result:

$$ \text{Practicality score} (x) = \frac{\text{Total scored}}{\text{Total scored maximum}} \times 100\% $$  \hspace{1cm} (2)

Following the evaluation of the observer, the assessment results are transformed into qualitative scale data in Table 2.

**Table 2.** Practicality Criteria

<table>
<thead>
<tr>
<th>Practicability criteria (%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$80 &lt; x \leq 100$</td>
<td>Very Practical</td>
</tr>
<tr>
<td>$60 &lt; x \leq 80$</td>
<td>Practical</td>
</tr>
<tr>
<td>$40 &lt; x \leq 60$</td>
<td>Quite Practical</td>
</tr>
<tr>
<td>$20 &lt; x \leq 40$</td>
<td>Less Practical</td>
</tr>
<tr>
<td>$x \leq 20$</td>
<td>No Practical</td>
</tr>
</tbody>
</table>

(Source: Isnaini, et al., 2022)

To measure the effectiveness of the e-module in terms of test results consisting of 10 number questions on colloidal material. These questions are made based on indicators of problem-solving ability put forward by Polya. Before being given to learners, the test instrument must be valid and reliable. The Pretest is administered prior to the start of the learning activities, and the Posttest is administered when the learning process done to determine whether the students' capacity for problem-solving has increased. This formula can be used to determine the score on the problem-solving abilities test.

$$ \text{Score} = \frac{\text{Total scored}}{\text{Total Scored Maximum}} \times 100\% $$  \hspace{1cm} (3)

The category of assessment of students' problem-solving ability in Table 3.
Table 3. Problem Solving Ability Category

<table>
<thead>
<tr>
<th>Interval</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 &lt; score ≤ 100</td>
<td>High</td>
</tr>
<tr>
<td>55 &lt; score ≤ 65</td>
<td>Fair</td>
</tr>
<tr>
<td>score ≤ 55</td>
<td>Low</td>
</tr>
</tbody>
</table>

(Source: Fatmawati & Murtafiah, 2018)

The improvement in learning outcomes before and after therapy is then calculated using N-Gain (posttest vs. pretest). It is possible to compute the increase in students’ problem-solving skills using the normalcy gain (g) formula. The formula is stated by Arisa, et al. (2020):

$$g = \frac{\text{skor posttest} - \text{skor pretest}}{\text{skor ideal} - \text{skor pretest}}$$

(4)

The N-Gain scores are categorized in Table 4.

Table 4. N-Gain category

<table>
<thead>
<tr>
<th>N-Gain (g)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>g &gt; 0.7</td>
<td>High</td>
</tr>
<tr>
<td>0.3 ≤ g ≤ 0.7</td>
<td>Fair</td>
</tr>
<tr>
<td>g &lt; 0.3</td>
<td>Low</td>
</tr>
</tbody>
</table>

(Source: Ramdhani, et al., 2020)

The effectiveness of N-Gain is then interpreted based on the N-Gain value, which may be computed using the formula in number 5.

$$G = \frac{g}{g_{\text{max}}} \times 100\%$$

(5)

Remark:
G : N-Gain effectiveness
g : N-Gain score
g_{\text{max}} : N-Gain score maximum

The categories of interpretation of the effectiveness of N-gain (Nawir, et al., 2019) are presented in Table 5.

Table 5. Interpretation of N-Gain Effectiveness

<table>
<thead>
<tr>
<th>N-Gain Effectiveness (%)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>G &gt; 76</td>
<td>Effective</td>
</tr>
<tr>
<td>55 &lt; G ≤ 76</td>
<td>Quite Effective</td>
</tr>
<tr>
<td>40 &lt; G ≤ 55</td>
<td>Less Effective</td>
</tr>
<tr>
<td>G &lt; 40</td>
<td>No Effective</td>
</tr>
</tbody>
</table>

(Source: Nawir, et al., 2019)
Results and Discussion

The ADDIE model are analysis, design, development, implementation, and evaluation, is used in this study (Hamzah, et al., 2022). During these phases, a number of research findings are generated, such as colloidal e-module products and information on the efficacy, viability, and validity of e-modules.

Analysis

Analysis is the first stage in developing an e-module. This step is done to identify the problem and solutions to overcome the problem (Pribadi, 2021). The analysis carried out is as follows:

a. Initial needs analysis

The primary goal of the needs analysis is to determine whether the generated product meets the needs of teachers and pupils. 33 grade XI MIPA 5 SMAN 2 Banjarmasin students provided field data for this study. Based on interviews with a single chemistry instructor and pupils from class XI MIPA 5 SMAN 2 Banjarmasin, the findings of this preliminary needs analysis can be stated descriptively.

The first requirements analysis yielded the following results: e-modules that use the problem based learning model to enhance students' problem-solving skills on ethnoscience integrated colloidal material were needed. This is evident from the instructor's agreement to construct the e-module. Furthermore, based on the pupils' comments, it is known that they are interested in using the e-module.

b. Student analysis

According to interviews conducted with chemistry teachers at SMAN 2 Banjarmasin, the use of e-modules and other teaching media in chemistry instruction is still relatively low. Problem based learning model are also rarely applied to help students become better problem solvers; instead, the learning model that is currently in use is still conventional. According to the findings of student interviews, the majority of students disliked chemistry since they found it challenging to comprehend chemical substances.

c. Material analysis

In terms of matter, almost abstract chemicals include colloidal matter. If explained by the method of teaching lectures alone, then students are unable to achieve learning objectives to understand the material and its role in real-life problems. Thus, the development of this e-module is urgently needed to be developed, implemented, and tested for feasibility.

Design

The next stage is to design an e-module by compiling materials along with research tools and instruments to help collect and recapitulation of data quantitatively during research. The results of this stage are in the form of learning media, namely e-modules that are ready to be developed along with research tools (Pribadi, 2021).

Implementation

At this stage, researchers develop e-modules with the help of heyzine.com website so that they can be converted into an e-module that can be accessed easily via a link or barcode scan. Furthermore, five validators conducted an e-module validation test throughout the development phase to see if employing the created e-module would be feasible. E-modules that are prepared for testing and usable research tools are the end products of this phase.

a. Results of e-module development

The results of the development in this study are the e-modules using the problem based learning model on ethnoscience integrated colloidal material taught to grade XI MIPA
5 SMA Negeri 2 Banjarmasin students in the even semester of the 2022/2023 academic year. These modules use the problem based learning model on ethnosciences integrated colloidal material. The QR code scan that follows will enable you to access the e-module.

Figure 1. QRcode e-module

Display of e-module on desktop shown in Figure 2.

Figure 2. Display e-module on desktop

b. Validity

Evaluators validate e-modules in order to assess their viability prior to moving on to the deployment phase (e-module trials). To perform this validation, multiple experts or seasoned specialists are asked to evaluate an e-module (Sugiyono, 2022). The aspects assessed in the validation of this e-module are aspects of content, language, and media. The results of the validity test of the developed e-module are presented in Figure 3.
The practicality test is the next level of testing that occurs after the validator team declares the validated e-module to be valid. Questionnaires categorized as (1) readability; (2) student response; (3) teacher response; (4) observation sheets on learning implementation; and (5) observation sheets on teacher abilities using e-modules are used to administer this practicality test to students, teachers, and observers. But at this point in its development, it only tests the readability of e-modules on individuals and small groups.

Three students of XI MIPA 4 SMAN 2 Banjarmasin were given individual trials to evaluate the e-module and offer comments and ideas (Syahmani, et al., 2022). The researchers will use these as raw data to revise the e-module. The results of this stage will be continued at the next stage. In individual trials, students gave suggestions so that the material in the e-module was arranged more neatly and corrected some mistyped words. As for the small group trial, 10 people in class XI MIPA 4 SMAN 2 Banjarmasin were carried out to determine the readability of the e-modules developed in assessing the practicality of e-modules that have gone through the revision stage and individual trials. At this stage, assessments, suggestions, and comments are used as material for revision at the next stage. In small group trials, there were suggestions in the form of improving the layout of buttons to slide the e-module on the screen so that the display of the e-module when opened on a mobile phone was not too small. Furthermore, limited group or field trials are carried out at the next stage, namely at the implementation stage.

**Implementation**

At this stage, e-modules and research tools that have been validated and revised based on suggestions or comments from experts or validators along with individual and small group readability test results are used in the implementation stage.

a. Readability test results

After passing the previous stages, namely individual and small group trials, the next is field trials or limited trials carried out on 33 students of grade XI MIPA 5 SMAN 2 Banjarmasin. The results of the readability test can be seen in Figure 4.
The comment of students in the limited group trial of the e-module developed was to add a button feature to the table of contents page on the e-module. Suggestions and comments at this stage become an evaluation for research to be revised and produce practical e-modules in a readable manner so that they can be disseminated and used in chemistry learning.

b. Results of student responses

This response questionnaire is given to learners to assess their response to the e-module. The difference between readability questionnaires and response questionnaires lies in the purpose of data collection. The readability questionnaire is useful for assessing whether the e-module can be read clearly, while the response questionnaire is useful for measuring the response of students to the e-module developed. Response questionnaires were given to as many as 33 people after conducting a posttest. The response of students to the developed e-module can be seen in Figure 5.

Based on Figure 5, the response of students to the developed e-module has a percentage of 85.68% with the category very practical. The comments of students who finished using the e-module gave a positive response, including being very helpful in learning and interested in learning using the e-module.

c. Results of teacher response

In addition to measuring student responses, researchers also measured teacher responses through questionnaires given to teachers who used e-modules. The teacher's response to the e-module developed can be seen in Figure 6.
Figure 6. Results of teacher response

Remark:
1. Colloidal material has been described precisely and clearly.
2. Colloidal material in accordance with learning objectives can provide additional reference materials in the learning process.
3. E-modules can provide additional reference material in the learning process.
4. Practice questions according to the material and purpose.
5. Images and explanations make it easier for students to understand the subject matter.
6. Learning using this e-module can increase student motivation.
7. Learning using this e-module can improve students' problem-solving skills.
8. Learning using this e-module facilitates the thought process to solve problems.
9. Learning using this e-module provides more knowledge about technology.
10. Learning using this e-module makes students have more knowledge because it is related to ethnoscience in everyday life.

Based on Figure 6, it shows that the teacher's response to the e-module with an average percentage for all aspects is 95% with the category very practical. The teacher's suggestions and comments on the e-module are writing words according to PUEBI, adding information related to ethnoscience, and including practice questions for students.

d. Observations of the application of learning

The purpose of this learning implementation test is to assess the teacher's comprehension of the material, classroom management skills, and application of learning syntax. The outcomes of observation sheets completed by three observers over the course of two meetings are used to evaluate how well the learning was implemented. Figure 7 displays the findings of the observers' evaluation on how learning was put into practice.
e. Results of observations of teachers' abilities using e-modules

Observation sheets are used not only for learning implementation, but also to assess teachers' proficiency with the created e-module. In the same way as two meetings' worth of learning were observed, this test was evaluated by three observers as well. The findings of the observations made about the teachers' proficiency with e-modules are shown as follows in Figure 8.

f. Recapitulation of practicality test results

Based on the explanation of the practicality components, a recapitulation of the practicality of the e-module as a whole is presented in Table 7.

<p>| Table 7. Practicality Recapitulation |
|-----------------------------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Component</th>
<th>Practicality criteria(%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Module Readability</td>
<td>83.41</td>
<td>Very Practical</td>
</tr>
<tr>
<td>Student Response</td>
<td>85.68</td>
<td>Very Practical</td>
</tr>
<tr>
<td>Teacher Response</td>
<td>95.00</td>
<td>Very Practical</td>
</tr>
<tr>
<td>Learning Implementation</td>
<td>82.25</td>
<td>Very Practical</td>
</tr>
<tr>
<td>Teacher's Ability to Use E-Modules</td>
<td>84.25</td>
<td>Very Practical</td>
</tr>
<tr>
<td>Mean</td>
<td>86.12</td>
<td>Very Practical</td>
</tr>
</tbody>
</table>
g. Effectiveness test results

Following individual and small group trials and validation, the e-module is put into use in the classroom. Prior to instruction, students take a pre-test to determine their baseline understanding of the colloidal content covered in the e-modules. Students take a post-test at the conclusion of their education to gauge their level of problem-solving proficiency following their use of e-modules. Thirty-three students from grade XI MIPA 5 SMAN 2 Banjarmasin took this test.

The data obtained in the pre-test and post-test is an effectiveness test analyzed through the N-Gain value. The results of the effectiveness test in this study are as follows.

1) Effectiveness test results based on students

Data on student problem-solving ability test results based on the average percentage of pretest and posttest scores in limited trial classes can be seen in Figure 9.

![Figure 9. Distribution of pre-test and post-test](image)

Based on Figure 9, it shows that students' problem-solving ability increased from an average of 26.06 with the low category to 91.59 with the high category after using the e-module using the problem based learning model on ethnoscience integrated colloidal material. Data from effectiveness tests can be processed into data distribution to determine the frequency of students in certain categories. The distribution of pretest and posttest data can be seen in Table 8.
Table 8. Distribution of problem-solving ability test results

<table>
<thead>
<tr>
<th>Interval</th>
<th>Category</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 &lt; score ≤ 100</td>
<td>High</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>55 &lt; score ≤ 65</td>
<td>Fair</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>score ≤ 55</td>
<td>Low</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on Table 8, when the pretest obtained problem-solving ability in the low category. Otherside, at posttest, it was in the high category. The increase in students' problem-solving ability can be measured by N-Gain (g), as seen in Table 9, showing that as many as 33 students experienced an increase in students' problem-solving ability in the high category and 2 students experienced moderate improvement.

Table 9. N-Gain value of problem-solving ability test

<table>
<thead>
<tr>
<th>N-Gain (g)</th>
<th>Category</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>g &gt; 0.7</td>
<td>High</td>
<td>31</td>
</tr>
<tr>
<td>0.3 ≤ g ≤ 0.7</td>
<td>Fair</td>
<td>2</td>
</tr>
<tr>
<td>g &lt; 0.3</td>
<td>Low</td>
<td>0</td>
</tr>
</tbody>
</table>

The data obtained during the pretest and posttest are tests of the effectiveness of e-modules with N-Gain percentages and are categorized in Table 10.

Table 10. Interpretation of the effectiveness of n-gain

<table>
<thead>
<tr>
<th>N-Gain Effectiveness Criteria</th>
<th>Interpretation</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>g &gt; 76</td>
<td>Effective</td>
<td>30</td>
</tr>
<tr>
<td>56 &lt; g ≤ 76</td>
<td>Quite Effective</td>
<td>3</td>
</tr>
<tr>
<td>40 &lt; g ≤ 56</td>
<td>Less Effective</td>
<td>0</td>
</tr>
<tr>
<td>g &lt; 40</td>
<td>No Effective</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on Table 10 shows that the e-module is effective, which is mostly from the result shows effective.

2) Effectiveness test results based on indicators

It is possible to interpret pre- and post-test result data using markers of problem-solving proficiency. At Figure 10 shows the outcomes of improving student knowledge based on indicator of problem-solving skills by Polya (Supardi, 2020) with N-Gain.

Figure 10. Comparison of pre-test and post-test scores
Based on Figure 10, the most significant increase is the indicator (4) Looking back from 15.91 (pre-test) to 95.45 (post-test) by having the highest N-Gain value compared to other competencies, which is 0.95. In the second order, namely indicator (2) Divising a plan with N-Gain of 0.90. In the third order, namely indicator (3) Carrying out the plan amounted to 0.86. Finally, indicator (1) Understanding the problem by 0.82. All competencies are in the high improvement category that shown in Table 11.

**Table 11. Interpretation of the effectiveness of n-gain based on indicator**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Score</th>
<th>N-Gain</th>
<th>Category</th>
<th>Effectiveness (%)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the problem</td>
<td>50.75</td>
<td>0.82</td>
<td>High</td>
<td>81.54</td>
<td>Effective</td>
</tr>
<tr>
<td>Divising a plan</td>
<td>38.64</td>
<td>0.90</td>
<td>High</td>
<td>90.12</td>
<td>Effective</td>
</tr>
<tr>
<td>Carrying out the plan</td>
<td>11.55</td>
<td>0.86</td>
<td>High</td>
<td>86.30</td>
<td>Effective</td>
</tr>
<tr>
<td>Looking back</td>
<td>15.91</td>
<td>0.95</td>
<td>High</td>
<td>94.59</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Based on Table 11 shows that all indicators of problem solving ability are in the high category and the developed e-modules are effective to increase the problem solving ability of students.

3) Effectiveness test results based on question items

In addition to indicators, further data processing is reviewed based on question items. In 4 indicators of problem-solving ability are reduced to 10 question points. This data processing is carried out to determine the level of understanding of students with the specified indicators and analyze the improvements that occur. The improvement of students' problem-solving ability and the effectiveness of e-modules based on each question item is presented in Figure 11.

![Figure 11. Comparison of pre-test and post-test based on question items](image-url)
The categories of learners' problem-solving ability levels are presented in Table 12.

**Table 12. Score of pre-test and post-test based on question items**

<table>
<thead>
<tr>
<th>No</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Post-Pre</th>
<th>pre-test Ideal</th>
<th>N-Gain</th>
<th>Category</th>
<th>N-Gain effectiveness (%)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68.18</td>
<td>95.45</td>
<td>27.27</td>
<td>31.82</td>
<td>0.86</td>
<td>High</td>
<td>85.71</td>
<td>Effective</td>
</tr>
<tr>
<td>2</td>
<td>33.33</td>
<td>86.36</td>
<td>53.03</td>
<td>66.67</td>
<td>0.80</td>
<td>High</td>
<td>79.55</td>
<td>Effective</td>
</tr>
<tr>
<td>3</td>
<td>12.12</td>
<td>91.67</td>
<td>79.55</td>
<td>87.88</td>
<td>0.91</td>
<td>High</td>
<td>90.52</td>
<td>Effective</td>
</tr>
<tr>
<td>4</td>
<td>68.18</td>
<td>100.00</td>
<td>31.82</td>
<td>31.82</td>
<td>1.00</td>
<td>High</td>
<td>100.00</td>
<td>Effective</td>
</tr>
<tr>
<td>5</td>
<td>9.09</td>
<td>87.88</td>
<td>78.79</td>
<td>90.91</td>
<td>0.87</td>
<td>High</td>
<td>86.67</td>
<td>Effective</td>
</tr>
<tr>
<td>6</td>
<td>6.82</td>
<td>87.88</td>
<td>81.06</td>
<td>93.18</td>
<td>0.87</td>
<td>High</td>
<td>86.99</td>
<td>Effective</td>
</tr>
<tr>
<td>7</td>
<td>24.24</td>
<td>98.48</td>
<td>74.24</td>
<td>75.76</td>
<td>0.98</td>
<td>High</td>
<td>98.00</td>
<td>Effective</td>
</tr>
<tr>
<td>8</td>
<td>9.85</td>
<td>85.61</td>
<td>75.76</td>
<td>90.15</td>
<td>0.84</td>
<td>High</td>
<td>84.03</td>
<td>Effective</td>
</tr>
<tr>
<td>9</td>
<td>11.36</td>
<td>96.21</td>
<td>84.85</td>
<td>88.64</td>
<td>0.96</td>
<td>High</td>
<td>95.73</td>
<td>Effective</td>
</tr>
<tr>
<td>10</td>
<td>17.42</td>
<td>86.36</td>
<td>68.94</td>
<td>82.58</td>
<td>0.83</td>
<td>High</td>
<td>83.49</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Based on Tabel 12, it shows that all question items have improved with the category "effective" which means stating that the e-module used effectively improves students' problem-solving abilities on colloidal material.

When the pretest falls into the low group, all students receive scores with an average score is 26.06. The inability to accurately recognize questions and respond to questions mentioned on the question sheet is the root cause of this poor problem-solving abilities. Furthermore, some students fail to respond to specific queries because they lack the necessary information. According to Iriani, et al. (2020), the foundational thinking skill of higher order thinking skills is the capacity for analysis (C4). Because of their poor analytical abilities, students need to learn things that can help them become more proficient in this area, including the problem based learning's paradigm (Triwahyuningtyas, et al., 2020).

The post-test results conducted after treatment had a significant increase in problem-solving ability in all students, with a mean is 91.59 in the high category. This increase is due to the treatment carried out in the study, namely the use of e-modules of colloidal material integrated with ethnoscience with the problem based learning model that trains students to be able to solve problems in the learning process. E-modules integrated with ethnoscience are able to improve problem-solving skills in students. This is because the learning material presented by linking ethnoscience is easier to understand and learning becomes real because it is related to daily life or culture in society (Syahmani, et al., 2022). This opinion is similar to Sholahuddin, et al. (2021), the learning process of connecting traditional ethnoscience-based foods helps students to build an understanding of abstract colloidal concepts to be more real so as to provide meaningful learning. So that students more easily connect the concept of colloids with traditional foods that they often encounter and make it easier to solve a problem in colloidal material.

The integration of ethnoscience facilitates easy comprehension of the subject matter (Hikmawati, et al., 2020). As a result, learning colloidal content through e-modules that integrated ethnoscience is a good way to connect with the chemical and helps students comprehend it better (Wati, et al., 2021) include connecting with colloidal material (Rusmansyah, et al., 2023). Furthermore, the problem based learning approach of instruction has an impact on how well students can solve problems. This is due to the fact that the learning phases make use of problem based learning, in which students are trained to solve problems in everyday activities using science by starting with a problem orientation and integrating ethnoscience throughout the learning process (Iriani & Indah, 2019).

According to Iriani, et al. (2019) that the use of modules with the problem based learning model makes students able to solve problems because learning is faced directly with real problems around them so that it is more meaningful and remembered easily. When looking at a problem, they can develop the knowledge they already have to overcome
the problem. By using this model, in addition to being taught cognitive knowledge is also taught related to strategies to overcome problems that create meaningful learning.

**Evaluation**

The step that is completed at every prior stage is the evaluation stage. Put another way, an assessment is done at every stage of development, for example, during the implementation stage, in order to make improvements to the e-module based on feedback and recommendations from students and validators. Subsequently, assessment is conducted upon the conclusion of each phased procedure or study project. This is so that the e-module, which has been tested on a sample, can be refined and made ready for eventual widespread distribution and ongoing usage in chemistry education.

**Conclusion**

The research findings indicate that the e-module was classified as highly valid, practical, and effective, receiving sequential scores of 96.59%, 86.12%, and 88.63%. With an N-Gain of 0.89, the students' problem-solving ability increased from the low category (26.06) in the pretest to the high category (91.59) in the post-test.

**References**


Triwahyuningtyas, D., Ningtyas, A.S., & Rahayu, S. 2020. The problem-based learning e-module of planes using Kvisoft Flipbook Maker for elementary school students. *Jurnal Prima Edukasia*, 8(2):199–208. [https://doi.org/10.21831/jpe.v8i2.34446](https://doi.org/10.21831/jpe.v8i2.34446)


