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Development of the Acid-Base Module Based on Problem Based Learning with Ethnochemisty to Improve Students Science Literacy Ability

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Abstract: This study aims to produce an acid-base module based on ethnochemical problem-based learning to improve students' scientific literacy skills, analyze the validity and practicality of the module and analyze the effectiveness of the acid-base module based on ethnochemical problem-based learning to improve students' scientific literacy skills. The type of research used is Research and Development (R&D) with a 4-D development model. The 4-D development model consists of 4 stages of development, namely define, design, develop and disseminate. The research instruments used are interview sheets, questionnaires, validation instruments, practicality instruments and effectiveness instruments. The validity test uses the Aiken's V formula. The results of the construct and content validity tests were 0.88 and 0.89 with a valid category. The results of the module practicality test carried out by teachers and students were 91.25% and 90.65% with a very practical category. The effectiveness test of the module was carried out using the N-Gain test and obtained a result of 0.71 in the high category. The results of the study indicate that a valid, practical and effective acid-base module based on ethnochemical problem-based learning has been obtained in improving students' scientific literacy skills.

Keywords: Acid base; Etnochemistry; Problem base learning; Science literacy

Introduction

The very rapid development of technology has resulted in foreign cultures entering and starting to displace local culture (Gutiawati et al., 2022). This has implications for the development of local culture which is influenced by foreign culture (Aris et al., 2023). Therefore, schools need to include learning content that contains local wisdom by linking learning material with cultural elements. Ethnochemistry is a branch of science that studies the combination of chemical studies with cultural anthropology in the form of studying the application of cultural technology to a particular community group (Jofrishal et al., 2020). Ethnochemistry can be integrated into learning, for example through the Problem Based Learning (PBL) model. The PBL model is a learning model designed so that students have the ability to participate in teams (Ardiansyah et al., 2021). The PBL model can be implemented in an independent curriculum (Hartatik, 2023). The PBL model can also help students to improve their ability to solve contextual problems (Priscylio et al., 2019).

The demands of the 21st century make education play an important role in creating human resources which include critical thinking, creativity, innovation, collaboration, communication and scientific literacy (Redhana, 2019). Scientific literacy ability is the ability to understand scientific concepts and processes and utilize science to solve problems in everyday life (Sutrisna, 2021). A survey conducted by PISA (Program for

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International Student Assessment) showed that the average score for scientific literacy skills in Indonesia in 2018 was 396, placing Indonesia in 74th place out of 79 participating countries. Based on data obtained, around 40% of students in Indonesia reached Level 2 in the ability to recognize the correct explanation for known scientific phenomena and can use this knowledge to identify, in simple cases (OECD, 2019). Efforts to improve scientific literacy skills can be done through the use of PBL-based acid-base modules with ethnochemical nuances in the learning process.

Problem-based learning can be applied through group discussions, namely at the research and investigation group stage, at this stage, it can train students to exchange ideas between individuals and their group of friends in order to solve the problems they face. Through a process of discussion, question and answer, and exchanging ideas with their group friends, they are able to build their knowledge about the material being taught (Prabasari et al., 2021). The role of material in chemistry learning is very close to daily activities so that learning in schools should involve the application of this material (Wibowo et al., 2020). One thing that can support the application of the PBL model in learning is through teaching materials. Teachers are required to be able to design teaching materials that can motivate and make it easier for students to learn (Suprihatin et al., 2020). One of the teaching materials used in learning activities at school is a module. Modules are teaching materials with the aim that students can learn independently and can be used as a facility for delivering material in the learning process (Hidayat et al., 2019). The use of modules can support a student-centered learning process (Suryani et al., 2020).

Based on the results of interviews with chemistry teachers at SMAN 1 Cerenti and SMAN 1 Kuantan Mudik, several problems were found. First, the teaching materials used do not facilitate students in applying the concepts they have for solving contextual problems. Second, they have never applied teaching materials on acid-base material which is connected to culture and chemistry (ethnochemistry) to improve students' scientific literacy skills. Third, acid-base material is one of the chemical materials that is still considered difficult by students because it is abstract (Aprilli et al., 2023). Acid-Base material consists of factual, conceptual and procedural knowledge (Oktarina et al., 2021). According to the chemistry teacher, it is necessary to develop problem-based modules with ethnochemical nuances to improve students' scientific literacy skills which can make students more familiar with local culture related to chemistry material, and can apply concepts in everyday life, so that students' scientific literacy abilities can improve trained in accordance with the demands of the 21st century.

The demands of the 21st century make education play an important role in creating human resources which include critical thinking, creativity, innovation, collaboration, communication and scientific literacy (Redhana, 2019). Scientific literacy ability is the ability to understand scientific concepts and processes and utilize science to solve problems in everyday life (Sutrisna, 2021). Scientific literacy is important for students to understand the environment, modern society, technology, health and economics. However, in reality, currently students' scientific literacy abilities are still very low (Nuryanti et al., 2023). According to the Program for International Student Assessment (PISA), scientific literacy is the ability to apply scientific knowledge, identify questions, and determine conclusions based on scientific evidence to understand and make decisions regarding nature and its changes due to human activities (Robertson, 2021).

The development of an acid-base module based on PBL with ethnochemical nuances is one of the teaching materials that has great potential to be developed in improving students' scientific literacy skills and it is hoped that students will be more active. Previous research conducted by Asda et al. (2023) examined "Development of Buffer Solution Students Worksheet Based on Problem Based Learning with Ethnochemistry to Improve Students Science Literacy Ability". Based on the research that has been carried out, the results show that the buffer solution worksheet based on problem based learning with ethnochemistry is valid, practical and effective in significantly improving students' scientific literacy skills. Then previous research conducted by Wibowo et al. (2020) examined "Science Literacy Abilities in High School Students Using Ethnoscience-Based Chemistry Learning".

The aim of this research is to produce an acid base module based on problem based learning with an ethnochemical nuance to improve students' scientific literacy skills, analyze the validity and practicality of an acid base module based on problem based learning with an ethnochemical nuance and analyze the effectiveness of an acid base module based on problem based learning with an ethnochemical nuance students' scientific literacy.

Method

This type of research is Research and Development (R&D) with a 4-D development model (Sugiyono, 2018). This 4-D model consists of four development stages, namely definition, design, development and deployment (Arkadiantika et al., 2020). The first stage consists of 5 parts, namely front end analysis, student analysis, task analysis, concept analysis and formulation

of learning objectives. The second stage is design, namely designing an acid-base module based on problem-based learning with ethnochemical nuances. The third stage is development, activities carried out at the development stage are testing validity, practicality and effectiveness.

The validity test consists of two parts, namely construct and content validity. The validity test was carried out by 3 lecturers and 2 chemistry teachers with the aim of revealing the validity of the acid-base module being developed. Criticism, input and suggestions from validators become material for revising the module being developed. The assessment given by the validator to each statement is analyzed using the Aiken's V formula shown in Equation 1.

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

Information:
r = value given by the validator
c = highest validity score
lo = lowest validity value
s = r- Io
n = number of expert validators

The practicality test was carried out by giving practicality test questionnaires to 2 chemistry teachers and 32 students. The data generated from the practicality test is analyzed using the formula as shown in Equation 2 (Arikunto, 2021).

$$p = \frac{f}{N} \text{ x } 100\ \% \quad (2)$$

Information:
p = final value
f = score obtained
N = maximum score

The effectiveness test was carried out using a Pre-Experimental Design research design with the type "One Group Pretest-Posttest" and the sampling technique used was Random Sampling, where the samples used for the experimental group were taken randomly from a certain population (Sugiyono, 2018). The research design can be seen in Table 1.

Table 1. Pre-Experimental Design Research Design (Sugiyono, 2013)

Pretest	Treatment	Posttest
O1	X	O2

Information:
O1 = Pretest value
O2 = Posttest value
X = The treatment is a PBL-based acid-base module ethnochemical nuances given to the experimental group

The effectiveness of the module is seen by comparing the results of the pretest and posttest of students' scientific literacy abilities which are then analyzed using the N-Gain test as shown in Equation 3 (R. Hake, 1999).

$$\text{N- Gain} = \frac{\text{posttest score} - \text{pretest score}}{100 - \text{pretest score}} \quad (3)$$

The results of the average N-Gain calculation can be seen in Table 2.

Table 2. N-Gain Criterion (R. R. Hake, 2002)

Limitation	Criterion
g ≥ 0.70	Tall
0.70 > g > 0.30	Currently
g ≤ 0.30	Low

The final stage is deployment. This stage is the stage of using devices that have been developed on a wider scale, for example in other classes, in other schools, or by other teachers.

The instruments used in this research were teacher interview sheets, student questionnaires, validity questionnaires, practicality questionnaires. Meanwhile, effectiveness is carried out using an essay question instrument which has been tested for its effectiveness in measuring students' scientific literacy abilities.

Result and Discussion

Definition

Based on the front-end analysis stage, the results showed that in explaining acid-base material, no one has used an approach that links the material to local culture or ethnochemistry. Ethnochemistry-based learning can help students understand and apply chemical concepts in everyday life. Then, students still have difficulty understanding acid-base material. Acid-base material is one of the chemical materials studied by students in phase F in SMA/MA. This material generally requires a deep understanding of concepts and applying these concepts in everyday life, because the concepts in acid-base material are closely related to everyday life. Then, the teaching materials used in schools have not been able to support the achievement of students' scientific literacy skills because they have not met all the components of scientific literacy. Scientific literacy skills are the ability to understand scientific concepts and processes and utilize science to solve problems in everyday life (Sutrisna, 2021).

At the student analysis stage, the results showed that students still had difficulty understanding acid-base material and students did not know ethnochemical-based learning. Then students need learning resources based on ethnochemical nuances that make it easier to understand acid-base material.

At the analysis stage, the task that has been carried out is to analyze learning outcomes in the acid-base material. The learning outcomes analyzed are phase F learning outcomes where students are required to be able to use the acid-base concept in everyday life. Meanwhile, the learning objectives are to compare the acid-base theory according to Arrhenius, Bronsted-Lowry and Lewis and its application in everyday life, identify several acid-base solutions with natural indicators and artificial indicators and calculate the degree of acidity (pH), degree of ionization and acid equilibrium constant base. The concept analysis stage is carried out based on the learning objectives that have been set.

Planning

Based on the problems that were discovered at the definition stage, an acid-base module based on problem-based learning with ethnochemical nuances was produced. The design created is the module cover, instructions for using the module, competencies to be achieved, supporting information, student worksheets. Student worksheets are made based on PBL model-based learning steps which consist of stages of student orientation to problems. At this stage, students read discourse and listen to audio that has been presented containing contextual problems regarding acid and base material related to local culture.

The next stage is organizing students to learn. At this stage, students collect information related to acid-base material, so that students get facts related to the problem that was presented in the previous stage. Stages of guiding individual and group investigations. At this stage, students collect data by conducting investigations or experiments to find solutions to problems that have been presented in the previous stage. The next stage is developing and presenting the results of the work. At this stage, students present work that is in accordance with the results of problem solving in the form of filling in answers on the student's worksheet. The final stage is analyzing and evaluating the results of problem solving. At this stage, students evaluate the investigation and processes used in problem solving.

Development

Validity test

Module validation to see the validity of a product being developed. Validation of learning modules that by expert lecturers have carried material to determine the validity of the module is measured based on the aspects that are assessed (Yustinaningrum et al., 2019). The construct validity test consists of content components, linguistic components, presentation components and graphic components. Meanwhile, the content validity test consists of the suitability of the module content with problem based learning syntax and the suitability of the module content with chemistry. Based on the results of construct validity data analysis, an average value of 0.88 was obtained in the valid category and content validation obtained an average value of 0.89 in the valid category. So it can be concluded that the acid-base module developed is valid in terms of construct and content by five validators and get responses that meet the validity criteria this is in line with the opinion of Ariesta et al. (2018). Apriliyana et al. (2012) explains that the product is said to be valid if the product developed is adequate and all components produced are consistently related to each other. A superior product cannot be produced by one person, but is produced through the collaboration of many parties. Therefore, the collaboration of several people or units is very important to produce a superior product or said to be valid (Irman et al., 2020). In line with the opinion of Asri et al. (2022), construct validity is the validity of how far the impact of measurement results is able to reflect the theoretical construction underlying the development of an instrument or product (Asri et al., 2022). The results of the construct validity test can be seen in Table 3 and content validity can be seen in Table 4.

Table 3. Construct Validity Analysis Results

Rated aspect	V value	Validity category
Content components	0.84	Currently
Linguistic components	0.91	Valid
Presentation components	0.86	Currentyly
Graphic components	0.92	Valid
Average V value	0.88	Valid

Table 4. Content Validity Analysis Results

Rated aspect	V value	Validity category
Conformity of content to PBL syntax	0.87	Valid
Suitability of module content chemistry	0.91	Valid
Average V value	0.89	Valid

Practicality Test

The practicality test of the PBL-based acid-base module with ethnochemical nuances was measured by providing a practicality questionnaire to 2 chemistry teachers and 32 students. Practicality analysis based on ease of use, efficiency of learning time, and benefits. It was found that the average practicality score for the acid base module by teachers and students was 91.25% and

90.65% in the very practical category. These results indicate that the acid-base module developed is valid and practical for use as teaching material in chemistry learning on acid-base material and can then be tested for its effectiveness in improving students' scientific literacy skills. Practicality can be generated from the scores obtained from the implementation of learning, student activities, and student responses which contain aspects that become benchmarks in obtaining scores that can be used as a benchmark for whether or not the module developed in the learning process is practical. In line with Gita et al. (2018) as an activity of organizing or arranging the environment as well as possible and connecting it with students so that the learning process occurs, this environment in this sense is not only the learning space, but also includes teachers, teaching aids, libraries, laboratories and so on that are relevant to student activities. According to Handayani et al. (2022) that the factors that need to be considered when conducting an evaluation are the available time allocation and the time required. These results are in accordance with research conducted by Sakolan (2021) which states that a sign of the practicality of printed teaching materials is that they can be easily used in the teaching and learning process by teachers and students.

The results of the module practicality data analysis can be seen in Table 5.

Table 5. Results of Module Practicality Data Analysis by Teachers and Students

Rated aspect	Teacher	learners	Practicality category
Easw of use	95.00%	90.39%	Very Practical
Study time effciency	87.50%	91.40%	Very Practical
Benefit	91.25%	90.18%	Very Practical
Average value	91.25%	90.65%	Very Practical

Effectiveness Test

This stage aims to determine the level of effectiveness of the module being developed by comparing the pretest and posttest results of students' scientific literacy abilities. Research data was obtained after conducting research at SMAN 1 Kuantan Mudik in class XI. 1 as a sample class. Pretest questions are given to students before learning begins to determine students' initial abilities. Then they were given treatment using an acid base module based on problem based learning with ethnochemical nuances in learning and then given posttest questions using the same questions. A comparison of the pretest and posttest results of students' scientific literacy abilities can be seen in Table 6.

Based on the results of the average pretest and posttest scores, it can be seen that there was an increase in students' scientific literacy abilities after being given treatment in the form of an acid base module based on problem based learning with ethnochemical nuances in learning with a difference of 55.55. Then the students' scientific literacy abilities were analyzed using the N-Gain test. The results of the N-Gain analysis can be seen in Table 7.

Table 6. Comparison of Pretest and Posttest Results of Students' Scientific Literacy Ability

Results	**X**
Pretest	21.61
Posttest	77.16

Table 7. Sample Class N-Gain Analysis Results

N-Gain	Category
0.71	Tall

Based on the analysis results, data obtained that the N-Gain value in the sample class was 0.71 at high criteria. The increase in scientific literacy skills was due to students who studied with the acid-base module based on Problem Based Learning with ethnochemical nuances (Siregar, 2014).

The Problem Based Learning model is a learning model that is designed so that students gain the ability to solve contextual problems and have the ability to participate in teams (Ardiansyah et al., 2021). Learning using the Problem Based Learning model can help students build their knowledge based on the problems presented. The increase in students' scientific literacy skills is also influenced by teaching materials with ethnochemical nuances. Local wisdom makes learning more applicable because it prioritizes the usefulness of concepts owned by students and is reinforced by scientific discoveries related to local culture (Asda et al., 2023).

Deployment

The deployment stage was carried out at SMAN 1 Kuantan Mudik with the number of modules distributed being 2 expells. It is hoped that the distribution of this module will enable teachers and students to utilize the module that has been developed to improve students' scientific literacy skills.

Conclusion

Acid-base module based on Problem Based Learning with ethnochemical nuances to improve the science literacy skills of class XI MIPA 1 students at SMAN 1 Kuantan Mudik which was produced through research and development with a 4D development model. The acid-base module based on PBL with ethnochemical nuances that was developed has been

valid with a construct validity level of 0.88 and a content validity of 0.89. The results of the module's practicality test carried out by teachers and students obtained 91.25% and 90.65% with a very practical category. The effectiveness test of the module was carried out using the N-Gain test and obtained a result of 0.71 in the high category. The results of the study indicate that the acid-base module based on Problem Based Learning with ethnochemical nuances is valid, practical and effective in improving students' science literacy skills.

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Creating research instruments, guiding the research process, and writing articles, P. P and A.; validation the module, Y. H. and O. S.

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Conflict of interest
The authors declare no conflict of interest.

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