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Development of Ethnoscience-Based Organic Chemistry Practicum e-Module to Improve Students' Problem-Solving Ability

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Abstract

This study aims to develop an ethnoscience-based organic chemistry practicum e-Module, determine the feasibility of the developed e-Module, and test its effectiveness in improving the problem-solving abilities of Chemistry Education students. The development procedure in this research is adapted from Thiagarajan (4D), which consists of Defining, Designing, Developing, and Disseminating. The e-module trial involved Chemistry Education students at Lambung Mangkurat University, consisting of five people for individual trials, 10 for small group trials, and 19 for field trials. Data was collected using response questionnaires and learning achievement tests. The feasibility test shows that the e-Module is in the very good category based on the assessment of media experts (88%), material experts (90%), and Education experts (89%). Student responses to using e-Modules were also very positive. There is a significant difference between the student's pretest and post-test after using the e-Module with sig <0.05 and experiencing a high increase in students' problem-solving abilities with an N-gain value of 0.77.

1. INTRODUCTION

The main component of the Society 5.0 era is that humans can create new values through innovation from technological developments born in the era of the Industrial Revolution 4.0 (Farana et al., 2021; Pereira et al., 2020). Information technology is a field experiencing rapid development and influences various aspects, including education. In education, the development of information technology was very beneficial when the COVID-19 pandemic occurred, where learning was carried out online and using various learning media to carry out the learning process (Komalasari, 2020; Tang et al., 2023). However, quality learning media is needed so that learning takes place well (Riady, 2021; Sausan et al., 2020). One of the learning media that can be used to facilitate students in the independent learning process is the e-module (Laili et al., 2019).

Electronic modules or e-Modules are learning media that are packaged in the form of digital books, where apart from containing learning material, there are also images, animations, or videos

that can facilitate students' understanding (Aryawan et al., 2018). Using e-Modules as a substitute for printed books can reduce paper use and support green chemistry principles. Research on the development of e-Module assembly shows an increase in student performance: learning outcomes (Imansari & Sunaryantiningsih, 2017), problem-solving abilities (Utami et al., 2018), scientific literacy (Kimianti & Prasetyo, 2019), and learning motivation (Kurniawati, 2020). Learning materials related to practicum and using tools and chemicals are beneficial with the learning videos in the e-Module. Learning videos can increase a more meaningful understanding and improve students' laboratory skills in practicum activities (Aliyyah et al., 2021).

Practicum is an activity that aims to improve competence in using scientific tools, materials, and procedures to solve a problem (Fajarianingtyas & Hidayat, 2020). In chemistry, practicum activities are needed to provide students with research experience on a small scale. Chemistry practicum activities can also improve and strengthen students' conceptual understanding of the material. Chemistry is the study of matter, its properties, structure, changes/reactions, and the energy accompanying these changes. Various studies say that chemistry is a material that is considered difficult by most students. To eliminate this assumption, of course, through an approach that brings students close to chemistry, for example, chemical material is connected to materials often encountered or used in everyday life so that students feel close to chemistry (Rizki et al., 2016). For example, in South Kalimantan, where there are many swamp areas, learning is done by integrating with materials from swamp ecosystems or wetlands.

The province of South Kalimantan, which geographically has many wetlands or swamp areas, has several plant species that can be used as traditional medicines, which are often used by the local community (Radam et al., 2017). This natural wealth can be integrated into chemistry learning so that students feel close to their environment and develop high curiosity. Phytochemical screening of wetland plants and identification of chlorophyll of wetland plants are examples of chemicals that can be integrated with surrounding natural materials. Learning by integrating local culture and potential is often called ethnoscience (Syahmani et al., 2022).

Ethno learning is a method of education that uses the culture of the studied area as its subject. Students' affection for their country of origin is also cultivated by introducing them to local culture and providing more insight and knowledge. Children develop character through what they constantly see, hear, and do (Arfianawati et al., 2016). Children who grow up in a supportive atmosphere will consistently develop positive character traits. A teaching strategy known as ethnoscience enables pupils to learn by connecting concepts and the local culture in their surroundings. For students, ethnoscience-based learning is enjoyable and fulfilling. Students' memory during the learning process can be improved using proper learning tools (Anwar et al., 2017; Sudarmin et al., 2017). Integrating ethnoscience into chemistry learning can improve students' problem-solving abilities (Syahmani et al., 2022). This type of instruction can increase students' interest in and excitement for the subject matter.

Based on the description above, developing digital teaching materials in chemical practicum activities integrated with the surrounding environment is necessary. This research will develop an ethnoscience-based Organic Chemistry Practicum e-Module, test its feasibility, and determine the effectiveness of the e-Module in improving students' problem-solving abilities.

2. METHOD

This research and development adapt the Thiagarajan development model (Thiagarajan et al., 1974), 4D: Define, Design, Develop, and Disseminate.

The research was conducted at the Chemistry Education Study Program at Lambung Mangkurat University. Subjects for individual trials of five students, small group trials of 10 students, and field trials of 19 students were carried out in the Organic Chemistry Laboratory. A media expert, a material expert, and an Education expert from a Chemistry Education lecturer at Lambung Mangkurat University conducted the e-Module Feasibility Test.

The data collection instrument used an e-Module validation sheet and a student response questionnaire to the e-Module. E-Module media assessment includes material, language, presentation, and graphic aspects. The instrument for testing the effectiveness of the e-Module in improving problem-solving skills is with pretest and post-test sheets.

The data analysis technique used to determine the feasibility of the e-Module uses a Likert scale. The score obtained is converted into a percentage to determine the eligibility level of the media. The score conversion table into media eligibility categories (Table 1.) refers to Purwanto (2012).

Table 1. Conversion of Media Eligibility Score

Percentage (%)	Criteria
81 – 100	Very good
61 – 80	Good
41 – 60	Enough
21 – 40	Bad
0 – 20	Very Bad

Data analysis techniques to determine the effectiveness of e-Modules in improving students' problem-solving abilities in organic chemistry practicums use the N-gain value. To calculate the value of N-gain, use the following equation 1 (Hake, 1998).

$$\text{N gain} = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \text{ …….. (1)}$$

Information:
S_{post} : average post-test score
S_{pre} : average pretest score
S_{max} : maximum score

The N-gain value is used to determine the increase in problem-solving ability. The interpretation of the N-gain value for increasing e-Module effectiveness is according to Table 2.

Table.2 N-Gain Category

N-gain Score (g)	Category
$g > 0.7$	High
$0,3 \leq g \leq 0.7$	Moderate
$g < 0.3$	Low

3. RESULTS AND DISCUSSION

This development research adapts the Thiagaragan development model, 4D, which consists of defining, designing, Developing, and Disseminating.

Define

The define stage consists of problem analysis, student analysis, material analysis, and learning objectives analysis. Problem analysis was conducted in the Chemistry Education Study Program at Lambung Mangkurat University. The results of the analysis show that an electronic book/module is needed to integrate wetlands or ethnoscience. The results of interviews with the Head of the Science Education Department and the Chemistry Education Study Program Coordinator at Lambung Mangkurat University confirmed it. Student analysis was conducted to determine student interests and interests in the learning process. The results of observations and interviews with students showed that students wanted e-module media with pictures and videos that could be accessed easily on smartphones or laptops/computers. Material analysis is carried out to determine the material to be developed according to the surrounding environment. The results of interviews with organic chemistry lecturers are required to integrate organic chemistry practicum materials with local characteristics. The research was conducted in Banjarmasin, so the local characteristics were a wetland environment. It aims to make learning more interesting because it is integrated with materials related to the environment around the wetlands and local culture according to the geographical characteristics of Lambung Mangkurat University students.

Design

The design or design phase is carried out by preparing material, taking pictures of supporting material, making learning videos, and selecting software for e-Modules.

The preparation stage considers materials that can be integrated from wetland environments. Materials developed and integrated with wetlands include Phytochemical Methods for Wetland Plants, Identification and Determination of Chlorophyll Content for Wetland Plants, and Synthesis of Salicylic Acid from Wintergreen Oil. In preparing the material, pictures that support practicum learning are needed so that the pictures of practicum tools are taken at the Organic Chemistry Laboratory.

They made learning videos as practical tutorials on phytochemical material and chlorophyll identification. The results of the learning videos are included in the developed e-Module. The existence of videos that support material explanations can make it easier for students to understand learning material. The software for developing this e-Module uses Sigil, and the resulting format is epub. The choice to use Sigil in developing this media is because the resulting e-Module output can be made interactive (can be filled with videos, animations, images, and sound directly in the e-Module product) and can be run on many platforms, both computers or smartphones (Alperi, 2020).

Develop

The develop or development stage consists of creating an e-Module with the Sigil application. The Sigil application has several advantages, including e-Modules created with the Sigil application that can be accessed offline. The application can add images, videos, and audio, which can be directly accessed in Sigil-based E-Modules and accessed via various devices, be it smartphones, PCs, and soon (Rahmida et al., 2023). Creating an e-Module with the Sigil application uses an HTML writing format to produce the e-Module layout as expected (Figure 1).

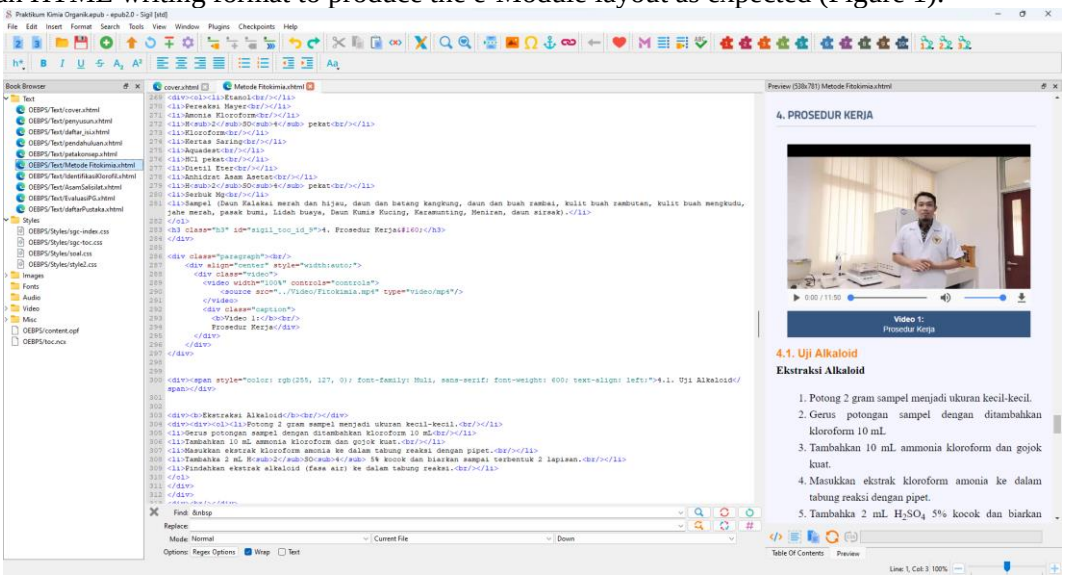

Figure 1. View of the Sigil Application

The resulting E-Modules include Start Pages, Learning Materials, Learning Videos, and Evaluation. The start page contains the Title, Table of Contents, Module Identity, and Concept Maps. Learning Material pages consist of practical procedures for the phytochemical method of wetland plants, identification and determination of chlorophyll content in wetland plants, and synthesis of salicylic acid from wintergreen oil. The e-module files generated from the Sigil application have an epub format that can be run on multiple platforms: Windows, Mac, or Android (Dalu et al., 2023). Figure 2 shows screenshots of the resulting Ethnoscience-Based Organic Chemistry Practicum e-Module.

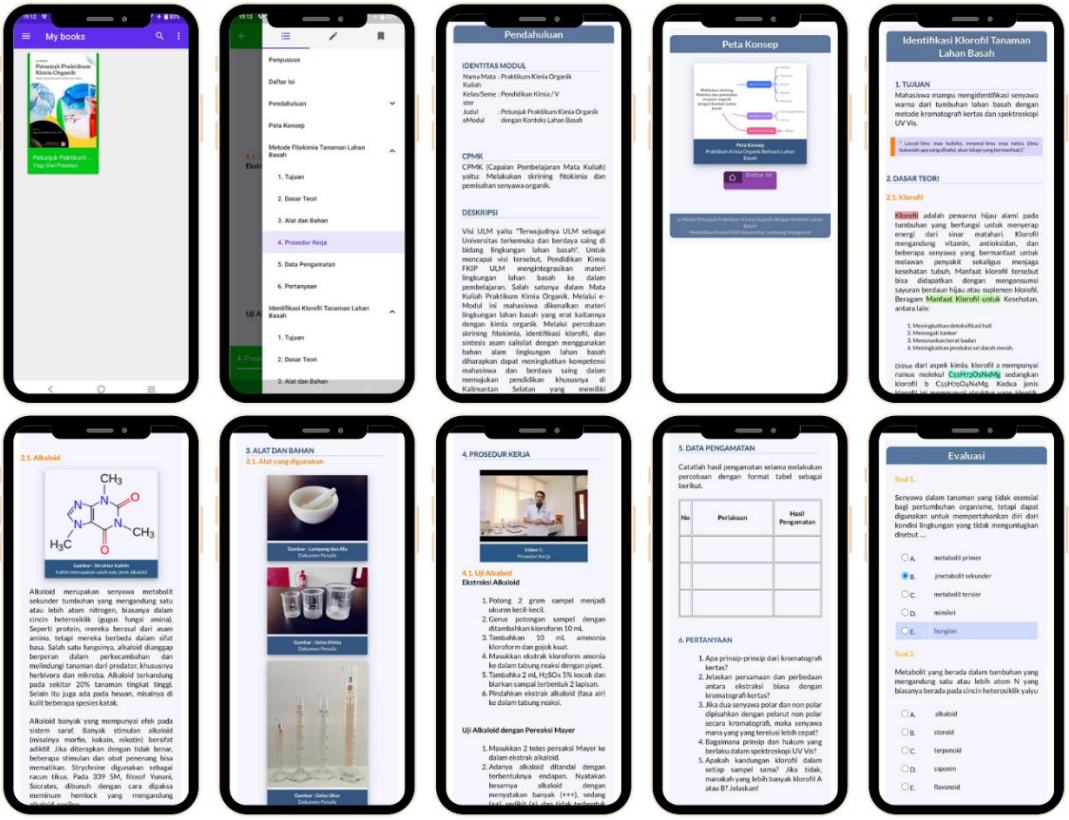

Figure 2. Screenshot of Ethnoscience-Based Organic Chemistry Practicum e-Module

Furthermore, the resulting e-modules are validated by a media expert, material expert, and education expert to determine the feasibility of the resulting media. The aspects assessed include Material Aspects, Linguistic Aspects, Presentation Aspects, and Graphical Aspects. The average results of expert validation can be seen in Table 3.

Table 3. Assessment and Validation by Expert

No	Aspects	Average Percentage of Assessment		
		Media Expert	Material Expert	Educational Expert
1	Material	84 %	92 %	88 %
2	Linguistic	85 %	90 %	90 %
3	Presentation	90 %	90 %	86.67 %
4	Graphical	92 %	88 %	92 %
Overall Percentage Average		88 %	90 %	89 %

The material aspect consists of five indicators with an average percentage of scores in the very good range (81 – 100%) (Purwanto, 2012), in the assessment of media expert (84%), material expert (92%), and education expert (88%)). The material in this e-Module integrates the local wisdom of wetlands (ethnoscience), thus making the material accessible for students to accept because it relates to everyday life. The linguistic aspect, which consists of four indicators, is also in the very good category from the assessment of the three experts. The assessment of media experts, material experts, and education experts on linguistic aspects are, respectively, 85, 90, and 90%. The presentation aspect includes six indicators. The e-Module assessment of the Presentation aspect is also in the very good category with scores from media, material, and education experts, namely 90, 90, and 86.67%. The graphical aspect includes five indicators, with the average percentage of indicators based on expert judgment in the very good category. The scores obtained from media, material, and education experts on graphical aspects were 92, 88, and 92%, respectively. Overall,

media, material, and education experts' assessment of the feasibility of the resulting e-Module is very good, with an average percentage score of 88, 90, and 89%, respectively.

After being declared feasible or very good in the expert validation, five students followed it with an individual test. The results of individual tests of the e-Module obtained an average percentage value of 90.93% and were in the very good category. Then, a small group test was carried out with ten students. The results of the small group trial obtained an average percentage of 89.73% and were in the very good category. These individual and small group trials assessed material, linguistic, presentation, and graphical aspects. Input and suggestions from small group trials are used to improve the e-Module before field trials. Improvements were made to some writing that still needed to be corrected and navigation in the e-Module that did not work correctly.

An ethnoscience approach is integrated into the created e-Module. The reason for this is that learning using an ethnoscience method can benefit from a variety of potentials, characters, and local content (Hadi et al., 2019; Walid et al., 2022) and enhance cognitive features like self-improvement, as well as self-awareness and culture (Kasi et al., 2020). The ethnoscience approach can also help students care about and preserve local wisdom (Lestari & Fitriani, 2016), learning outcomes, critical thinking abilities, and students' scientific thinking skills in local culture (Fadilah et al., 2019; Hidaayatullaah et al., 2021). However, the effectiveness of the ethnoscience-based e-module produced in this study was seen from the increase in students' problem-solving abilities.

Disseminate

The e-Module product dissemination stage is carried out using a link drive. The link is disseminated via WhatsApp social media to chemistry education students at Lambung Mangkurat University to be used in Organic Chemistry Practicum activities. At this stage, field trials were also carried out to test the effectiveness of the e-Modules, which were developed to increase students' problem-solving abilities.

Field trials were conducted with 19 students. This stage is carried out to determine student responses to the use of e-Modules and to determine the effectiveness of e-Modules in improving student problem-solving abilities. Student responses to the use of e-Modules can be seen in Table 4.

Table 4. Student Responses to the Use of e-Modules

No	Aspect	Average (%)	Criteria
1	Material	89.12	Very Good
2	Language	88.68	Very Good
3	Presentation	89.21	Very Good
4	Graphics	86.84	Very Good

Table 4 above shows that the average percentage of each aspect of the e-Module is in the very good category based on student responses. Overall, the average percentage obtained is 88.42%. Student testimonials on the use of e-Modules are very positive, including interesting e-Modules because there are learning videos explaining experimental procedures, more e-Modules need to be developed (other subjects), and the use of e-Modules makes it more environmentally friendly because it reduces the usage of paper.

The effectiveness of using e-Modules in improving problem-solving skills can be seen from the results of the pretest and post-test. Pretest and post-test data were normally distributed and homogeneous. Normality and homogeneity data can be seen in Table 5 and Table 6.

Table 5. Normality Test with Kolmogorov-Smirnov

Test	Statistic	df	Sig.	Criteria	Result
Pretes	0.121	19	0.200*	0.05	Normal
Post-test	0.115	19	0.200*	0.05	Normal

Table 6. Homogeneity Test

Tes	Statistic	df1	Sig.	Criteria	Result	Sig.
Based on Mean	0.064	1	36	0.802	0.05	Homogenous
Based on Median	0.055	1	36	0.816	0.05	Homogenous

The t-test results showed a significant difference between student scores before and after treatment with the e-Module with t count > t table and a significance value of 0.000 <0.05. The results of the t-test can be seen in Table 7.

Table 7. T-test Results

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	*pretest - postest*	-39.947	11.740	2.693	-45.606	-34.289	-14.832	18	.000

Furthermore, N-gain analysis is performed on value data. The results of the analysis obtained an N-gain value of 0.777, which means that there was a high increase (g > 0.7 (Hake, 1998)) in students' problem-solving abilities. This study's results align with the research of Panggabean Purba (2021), which states that e-Modules can improve students' problem-solving skills. The ease of access to e-Modules is a distinct advantage because it can be used anywhere and anytime (Padwa & Erdi, 2021). In addition, the e-Module format is in epub format, which can accommodate the addition of videos that can be accessed without an internet connection. It can make it easier for students to study independently without worrying about no internet access.

One of the weaknesses of the developed e-Module is the large file size. It happens because the video integrated into the e-Module file has a large file size. Its problem can be anticipated with a flash drive. The e-Module file can be saved in a flash drive and opened on a smartphone via an OTG connection. Apart from that, e-Modules can also be used in a laptop/PC to run because it was developed with the Sigil application, have an epub format, and can be run on various platforms, be it Windows, Mac, or Android (Dalu et al., 2023).

4. CONCLUSION

The ethnoscience-based Organic Chemistry Practicum E-Module has been developed using the 4D development model (Define, Design, Develop, and Disseminate). The developed e-module was declared valid in the very good category based on the assessment of media, material, and education experts with an average percentage of 88, 90, and 89%, respectively. The test results show that the e-Module can improve the problem-solving skills of chemistry students with an N-gain of 0.777.

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