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Development Of Chemistry Supplement Book with Ethno-Socio-Scientific Context on The Sub-Topic of Alcohol to Improve Students' Cognitive Learning Outcomes

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Abstract

This study aims to develop a valid, practical, and effective ethno-socioscientific supplementary book on the topic of alcohol to enhance students' cognitive learning outcomes. Employing a Research and Development methodology, the study utilizes the 4D development model, limited here to three stages: Define, Design, and Development. Research instruments included validation sheets, response questionnaires, and effectiveness test sheets. Validation results indicate the book is highly valid, with an average Aiken score of 0.91. The practicality test, involving 27 students, yielded a score of 96%, categorized as very practical. The effectiveness test, based on N-gain results, produced an average score of 0.61, categorized as moderate. The presentation of contextual phenomena in the ethno-SSI supplement book to deepen their understanding of chemistry concepts and broaden their cultural horizons. In conclusion, the ethno-socioscientific Sikka culture chemistry supplement book is valid, practical, and effective in improving students' cognitive learning outcomes on the subtopic of alcohol.

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INTRODUCTION

Chemistry learning in schools today needs to be supported by contextual learning resources to help students understand chemistry concepts in a meaningful way. The textbooks used by students in schools generally present foreign cultural contexts, making it difficult for students to understand complex chemistry material. Supplementary learning books serve as companion books that help students explore and clarify concepts through contextual examples that are relevant to their lives (Salsabila & Sari, 2024). Supplementary books can be developed in accordance with learning objectives with attractive and adaptive presentations to help students deepen their understanding of concepts (Rizal & Suryani, 2024; Azmi et al., 2023; Novia et al., 2023). In addition, the existence of supplementary books supports the role of teachers as facilitators. In addition, the existence of supplementary books could help students with varying learning styles learn independently. Contextual chemistry learning can be designed by integrating local wisdom that is related to science.

One approach that can be used to integrate chemical concepts and local wisdom is ethnochemistry. Ethnochemistry is the practice of local wisdom in community life that is related to chemical concepts (Wahyudiati & Fitriani, 2021; Singh & Chibuye, 2016). In addition, local wisdom as part of community life is inseparable from social polemics that can be studied scientifically. The existence of socio-scientific issues in learning encourages students to engage in discussion, reflection, and problem-solving, which leads to critical thinking skills (Rahayu, 2019; Eilks et al., 2018). The integration of ethno-socioscientific learning can improve students' scientific process skills and creative thinking skills (Khoiri et al., 2022; Khoiri et al., 2024).

Sikka Regency, East Nusa Tenggara, has a wealth of local wisdom that can be integrated into learning. Moke is an alcoholic beverage produced from the traditional distillation of palm sap. The stages of the moke production process are a learning resource for students related to the concept of alcohol. Meanwhile, from a cultural perspective, moke is a traditional drink that serves as a symbol of brotherhood. However, the integration of moke's chemical concepts into chemistry learning has never been done. Previous researchers have identified scientific concepts in Sikka culture, including the identification of physics concepts in the moke-making process (Harra et al., 2021). The integration of laka wae culture in the concept of changes in the form of substances (Helvina et al., 2024), a study of chemical concepts in the activities of chewing betel nut and Sikka ikat weaving (Putri et al., 2022). Unfortunately, the identified concepts have not been fully integrated into learning in a systematic manner.

Based on the results of interviews, teachers stated that the cultural potential of Sikka has not been fully utilized in learning due to limited references and learning media. Another problem is the lack of supporting facilities such as laboratories, which causes students to be less involved in scientific exploration. In fact, the empowerment of local culture can be a natural laboratory for students to learn contextually. In fact, culture-based learning becomes a bridge for students in building concepts related to science that support constructivist and sociocultural learning theories (Slavin, 2006). Based on these conditions, the purpose of this study is to develop an integrated Ethno-socioscientific chemistry supplement book, specifically in the process of making moke, as a relevant pedagogical solution to improve student learning outcomes.

METHODS

This research is a development study with the output being a Chemistry Supplement Book containing Sikka ethno-socioscientific culture. The development of the supplement book refers to the 4D model (define, design, develop, and disseminate) according to Thiagarajan et al. (1974). However, this study is limited to three stages of development, namely define, design, and develop. This study was designed as a small-scale pilot test to measure the feasibility of the developed supplement book. The define stage involved observation and interviews with teachers and students regarding product development needs. Interviews were also conducted with moke farmers to learn about the process of making Sikka moke. The design stage included selecting a book template and designing the supplement book using the Canva application. The development stage involved testing the feasibility of

the supplementary book, including validity, practicality, and effectiveness tests. The product trial after validation was conducted at SMA Negeri 1 Waigete in the 12th-grade science class. The dissemination stage was not carried out due to the relatively small sample size and the limited small-scale trial.

Research data analysis includes:

Product validity test

The product validation data obtained from subject matter, media, and language experts were then analyzed using the Aiken formula shown in equation 1 (Putri et al., 2022).

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

V = validator agreement index
s = score assigned by the validator minus the lowest score in the category used (s = r-1)
n = number of validators
c = number of categories selected by the validator.

The results of the product validity calculation are then interpreted using the Aiken index categories in Table 1.

Table 1. Validation Category

Validation Result Interval	Category
$0.80 < V \leq 1.00$	Very Valid
$0.60 < V \leq 0.80$	Valid
$0.40 < V \leq 0.60$	Sufficiently Valid
$0.00 < V \leq 0.40$	Not Valid

Product Practicality Test

The practicality level of the product is measured based on the results of the student response questionnaire using equation 2.

$P = f/N \times 100$ ..... (2)

P = final score
F = score obtained
N = maximum score

The results of the user response questionnaire calculations are then interpreted based on the criteria in Table 2.

Table 2. Criteria for Practicality

Interval	Category
$80\% < x \leq 100\%$	Very Practical
$60\% < x \leq 80\%$	Practical
$40\% < x \leq 60\%$	Fairly Practical
$0\% < x \leq 40\%$	Not Practical

Effectiveness Test

The effectiveness of the supplement book was tested using the one-group pretest-posttest design technique. The effectiveness of the book was measured by comparing the pretest and posttest scores, which were analyzed using the N-Gain test shown in equation 3 (Hake, 1999).

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

The results of the calculation were then categorized based on the criteria in Table 3 (Pebrianti et al., 2024).

Table 3. N-Gain Category

N-Gain Score	Category
$g \geq 0.70$	High
$0.70 > g > 0.30$	Medium
$g \leq 0.30$	Low

The final stage of development is the large-scale use of supplementary books, such as their use in several schools. However, this study focuses on a small-scale test at one school in Sikka Regency.

Research objectives

This research was conducted at SMA Negeri 1 Waigete with a sample of students from Grade XII Science.

RESULTS AND DISCUSSION

Initial analysis found that teachers had not integrated the local cultural context into chemistry lessons, which had an impact on low student learning outcomes. The concept of alcohol is a difficult topic for students to understand because the manufacturing concepts described generally refer to foreign cultures, such as the processes of making beer and wine. Integrating the moke manufacturing process in Sikka culture is a relevant solution for students learning the concept of alcohol. The relationship between chemical concepts and the moke manufacturing process is presented in Table 4.

Table 4. Study of Chemical Concepts in The Moke Making Process

The Stages of Moke Production	Chemistry Concepts	Pictures
The Process of Tapping Palm Sap a) *Pikut* The process of pinching the palm flower with a tool called a *pikut*. The male palm flower is pinched gently so that it does not break, with the aim of producing more palm sap. *b) Kare Tua* The process of cutting the palm flower to produce sap. *c) Tere Tua* The process of tapping the sap produced into a prepared container. The container can be made of bamboo or jerry cans.	• Nira is a liquid obtained from the male flower of the lontar palm tree (Irmayuni et al., 2018) • Aren sap/Nira contains carbohydrates (in the form of sucrose, glucose, fructose); protein; water (H_2O), fat; minerals such as calcium (Ca) and iron (Fe); phosphorus (P), copper (Cu), and vitamins such as ascorbic acid (vitamin C) and vitamin B complex (Sarkar et al., 2023). • Fresh nira obtained from tapping contains about 2.32% alcohol with a pH below 6 (Khadka, 2024).	
Storage of Nira Nira is stored in a closed container for 2-4 days.	• Fermentation is the process of breaking down glucose by microorganisms into alcohol and carbon dioxide (Kaur et al., 2019). • Microorganisms act as biocatalysts in accelerating the breakdown of sugar. • Microorganisms such as Saccharomyces cerevisiae produce the enzymes zymase and invertase, which play a role in breaking down sugar into alcohol (Kurniawan et al., 2014).	
Heating Nira *(Api Tua*) Fermented nira is cooked on a stove using firewood. The steam from heating the nira passes through a series of Mangun and wewur bamboo until it condenses. The droplets from heating are collected in a lo'un.	• The heating process is carried out by cooking the nira liquid in a pot (unu tana). The nira at the bottom will receive heat first so that its molecular density and mass decrease. As a result, the nira molecules at the bottom of the unu tana will move towards the surface of the solution (Paramita et al., 2021; Harra et al., 2021). • The purpose of heating is to separate compounds with different boiling points. The alcohol contained in the sap will evaporate first because the boiling point of ethanol is lower than that of the solution. • The vapor produced by heating the sap then interacts with the cold surface of the bamboo trunk, causing condensation or a change in	

The Stages of Moke Production	Chemistry Concepts	Pictures
	state from gas to liquid. The result is drops of *moke* that are collected in a container (Harra et al., 2021).	
Moke Product	Distilled alcohol contains ethanol with varying levels depending on the length of fermentation of the sap (Sondakh et al., 2022).	

The results of the chemical concept study in Table 4 were then developed into a chemistry learning supplement book. The developed book contains several points, including the meaning of moke for the Sikka community (cultural aspects), a study of chemical concepts in the moke-making process, an ethno-socioscientific study of the moke context, and the structure and characteristics of alcohol compounds. The book is equipped with several features, such as a chemistry dictionary, science information, and practice questions. In addition to studying chemical concepts, researchers also integrated controversial issues related to moke. The socio-scientific study related to moke is the danger of alcohol consumption to the body and air pollution due to incomplete combustion from the nira heating process. The integration of moke production into chemistry learning is a strategy for implementing deep learning. Deep learning emphasizes the relevance of the topics studied to the cultural context, social aspects, and daily lives of students (Ministry of Primary and Secondary Education, 2025).

The book validated by two experts in subject matter and one language expert. The validation results are presented in Table 5.

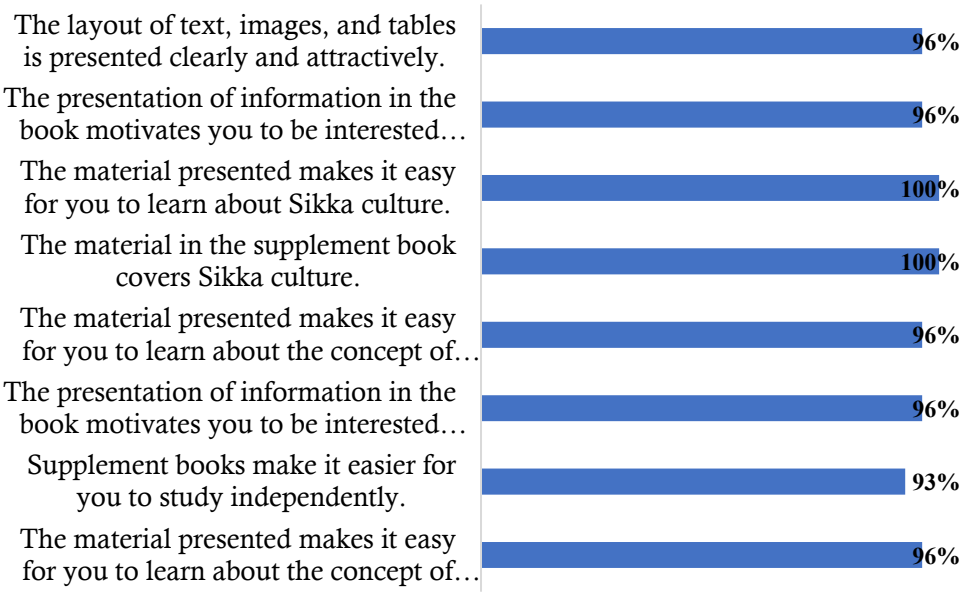
The validation results show that the developed supplement book is valid in terms of language and presentation, with an average Aiken validity score of 0.89, which is classified as highly valid. The language presented is communicative, easy to understand, and attractively presented (Khoiroh & Azizah, 2021). Andayani et al. (2024) state that the language aspect emphasizes the use of simple language, free of ambiguity, and concise so that students can easily understand the concepts.

Table 5. Results of Construct Validation of the Supplement Book

Aspects Assessed	Aiken's Score	Category
Content Components	0.96	Very Valid
Linguistic Components	0.85	Very Valid
Layout and Graphic Components	0.94	Very Valid
Average	0.91	Very Valid

Practicality Test

The practicality of the book was reviewed based on ease of use, effectiveness, and the benefits of the book for users. This is in line with the statement by Nieveen et al. (2013), which states that practicality testing emphasizes the aspects of ease of use and efficiency of use of products that are relevant to the development objectives. The practicality of the supplement book in this study was reviewed based on the results of an analysis of the book usage response questionnaire completed by 27 students after participating in the learning process. The data is presented in Picture 1.



Picture 1. Result of the Students Response

In general, students stated that the supplementary book developed made it easier for them to understand concepts and learn about Sikka culture. The percentage of respondents in general was >90% in the very practical category. These results indicate that the supplementary book developed is easy to use, provides benefits, and is relevant to the development objectives. This is in line with research conducted by (Pebrianti et al., 2024), which reviewed the practicality of the modules developed based on ease of use and the benefits obtained by respondents.

Effectiveness Test

This stage aims to measure the effectiveness of using supplementary books to improve students' cognitive learning outcomes. The effectiveness of the product is assessed based on a comparison of students' pretest and posttest scores. Data on the results of the trial use of supplementary books are presented in Table 6.

Table 6. Comparison of Student Learning Outcomes

Results	Average Score	N-Gain Score	Category
Pre-Test	34.07	0.61	Medium
Post-test	73.70		

The results of the N-gain analysis show that there is an increase in the cognitive learning outcomes of students in the moderate category. The increase in students' cognitive learning outcomes is the result of using ethno-ssi context-based supplementary books during learning on the sub-topic of alcohol. The supplementary book developed explains the study of chemical concepts involved in each stage of moke production from raw materials, the microorganisms involved, the reactions that occur, the distillation process, to the alcohol product produced. This makes it easier for students to observe the alcohol production process more closely, thereby strengthening their understanding of the concepts. This is in line with constructivist learning theory, which states that students form their knowledge through interaction with their surroundings. This is in line with research (Dewi et al., 2024) that e-modules with ethnochemistry content present comprehensive information, making it easier for students to relate concepts and contextual phenomena. The presentation of contextual phenomena related to local culture strengthens students' science literacy so that they are able to provide holistic scientific explanations (Pebrianti et al., 2024). In addition, the nuances of ethnochemistry make learning more in-depth, enjoyable, and interesting to study (Rahmawan, 2023). Learning with a local cultural theme trains

students to apply their knowledge to find solutions in their surroundings.

In addition to cultural aspects, studying controversial issues helps students analyze an issue from various perspectives. The inclusion of controversial issues stimulates students to seek solutions to the problems presented. In this study, the issues presented were the dangers of alcohol to health and the legality of alcohol use in the Sikka district. This makes science learning not only concept-oriented but also hones critical thinking skills, trains argumentation skills, and shapes students' character (Saija et al., 2023). The integration of local cultural aspects and social issues broadens students' knowledge and perspectives on complex phenomena in everyday life. The application of ethno-socioscientific contextual learning not only attracts students' interest in learning science but also improves their creative thinking skills to find solutions to the issues presented (Khoiri et al., 2024).

The improvement in cognitive learning outcomes among students in the moderate category was also due to the lack of time for conducting the research and the students' readiness to participate in the learning process. Ethno-socioscientific learning had never been implemented by teachers before, so it required thorough preparation by both teachers and students. Learning readiness needed to be established before the learning process was implemented due to the varying levels of prior knowledge among students. In addition, each student's learning style and learning challenges are not the same, which has an impact on the differences in students' cognitive learning outcomes (Yadav, 2025).

CONCLUSION

The ethno-socioscientific chemistry supplement book has been proven to be valid, practical, and effective in improving students' cognitive learning outcomes. The study of Sikka culture in the concept of alcohol helps teachers prepare contextual chemistry lessons and serves as a supporting reference for standard school textbooks. The supplement book helps students learn to explore scientific concepts, strengthen their understanding of local culture, and become aware of social issues. This study is still limited in improving student learning outcomes, thus providing an opportunity for future researchers to use relevant learning models to measure critical thinking and scientific argumentation skills.

RECOMENDATION

This study is limited to improving students learning outcomes, but it has not measured other student thinking skills such as critical thinking, argumentation skill and scientific literacy. This provides an opportunity for future researchers to use relevant learning models to measure student thinking skills.

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