RESEARCH ARTICLE

Developing e-modules based on scientific literacy in bamboo ethno-taxonomy

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Abstract: The development of e-module materials for the classification of living things based on scientific literacy and bio-ethnotaxonomy issues is still very limited. This study aims to develop e-modules for the classification of living things based on scientific literacy and bamboo ethnotaxonomy that are valid and suitable for use in learning. This research and development was carried out using a 4D model by Thiagarajan. This study involved three material expert validators, three media expert validators, and three language expert validators. The instruments used include questionnaires and interview sheets. Development trials are carried out in small-scale trials and large-scale trials. A total of 24 students were involved in the trial with a division of 5 students in the small-scale trial, and 19 students in the large-scale trial. The results showed that there were four species of bamboo found in Sungai Krawang Village, including *Bambusa vulgaris, Bambusa multiplex, Gigantochloa apus*, and *Gigantochloa atroviolacea*. The results of material and linguistic validation show that the product developed has fulfilled four and six indicators with a score of >80% (very valid). Furthermore, the validation results of media experts are classified as very valid on three indicators including media size, cover design, and overall design with successive scores of 90.00, 83.33, and 84.76. These results indicate that the e-module of bamboo ethnotaxonomy is appropriate for use in learning about the classification of living things.

Keywords: contextual-based; e-module; ethno-taxonomy; students' scientific literacy

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Introduction

Many research results report that the scientific literacy level of Indonesian students is still not satisfactory (Ahied et al., 2020; Suryawati et al., 2018). It is indicated that this will have an impact on the nation's competitiveness if it is not resolved immediately (McFarlane, 2013; Turiman et al., 2012). Furthermore, many efforts have been made by educators and researchers in Indonesia to increase students' scientific literacy levels (Febriasari & Supriatna, 2017; Hudha et al., 2017; Kusumaningrum, 2018; Nofiana & Julianto, 2018; Suwono, 2016). The results of the PISA survey show that from 2012 to 2018, the literacy scores of Indonesian students have increased closer to the average scientific literacy score (OECD score average) (OECD, 2012, 2018, 2019). However, as a whole, continuous and consistent efforts are needed to improve the quality of students' scientific literacy (Awwad, 2013; Serrat et al., 2014). The four components of scientific literacy as measured by PISA are indicated to be the basis for the quality of human development (Virtič, 2022), so that literacy development is something that needs to be carried out on an ongoing basis. Several studies report that scientific literacy is influenced by various factors, one of which is the selection of learning resources (Aiman et al., 2020; Bahri et al., 2020; Saribas, 2015; Sholahuddin et al., 2021). In the science learning process, teachers and students need learning resources as teaching materials in the learning process (Leasa et al., 2021; Viro et al., 2020).

Modules are one of the teaching materials that can be used to create interesting and fun learning (Halim et al., 2021; Serrat et al., 2014). Modules can be used as main or supporting teaching materials to complement the deficiencies of commonly used teaching materials (Rosli et al., 2015). In the latest technological developments, modules are not only written in printed form but also developed in electronic form (e-modules). In general, the development of e-modules places more emphasis on ease of access which is expected to increase the scientific literacy of its users (Budiarti et al., 2016; Serevina et al., 2018).

Research on the development of e-modules in the field of science so far has a lot of monodisciplinary material or contexts and is still at a general level, not yet at a contextual level (Astra et al., 2020; Baeng et al., 2022; Rochsun & Agustin, 2020). In fact, the contextualization of material and concepts is also a form of scientific literacy (Pursitasari et al., 2019; Yuliana et al., 2021). Contextualization of material with phenomena in everyday life, according to many researchers, is also an effective effort in increasing students' scientific literacy (Anstey, 2017; Tawfik, 2017).

As a country with high biodiversity (Kusmana & Hikmat, 2015), studies related to the diversity of living things in Indonesia are very important to do. Furthermore, this diversity issue can also be used as a learning resource for science learning such as taxonomy, utilization, to issues related to culture and ethnicity (ethnoscience) (Parmin et al., 2016; Sholahuddin et al., 2021; Yuliana et al., 2021). On the other hand, Indonesia is also known as a high producer of bamboo products (Shah et al., 2021; Sharma et al., 2018). This cannot be separated from the large population of bamboo in Indonesia. For Indonesian people, bamboo is very close to their daily lives (Abdullah et al., 2017; Utami & Pradnyawathi, 2017). However, studies related to the ethnotaxonomy of bamboo in Indonesia are still limited, especially those used in learning (Hirota & Tsuji, 2021; Sujarwo, 2018; Utami & Pradnyawathi, 2017).

This study aims to develop an ethnotaxonomy e-module based on scientific literacy that is valid and can be used in learning. The ethnotaxonomic study in this study is based on the results of the ethnotaxonomic study of bamboo that has been carried out. The development of an ethnotaxonomy-based e-module based on scientific literacy is expected to increase students' understanding of preserving local community wisdom in classifying existing bamboo species.

Method

The e-module development in this study uses the 4D model by Thiagarajan (Thiagarajan et al., 1976). The deep definition stage includes student-beginning-end analysis, bamboo ethnotaxonomy analysis, material analysis, and formulation of learning objectives. The design phase includes the preparation of test references, questionnaire preparation, format selection, and the initial design of the e-module. The develop stage in this study includes expert validation and trials. This expert validation includes three material expert validators, three media expert validators, and three language expert validators.

Development trials were carried out at Junior High School (JHS) 7 of Batu Ampar, Kuburaya Regency, West Borneo. Technically, development trials were carried out twice, including small-scale trials and large-scale trials. The small-scale trial involved five students in seventh graders, while the large-scale trial involved 19 students, in different class.

Data collection techniques in this study included e-module validation, student questionnaires, and teacher interviews. E-module validation was obtained using validation instruments by experts, while student questionnaires were used to obtain data on student responses to the developed e-module. Interviews were conducted using unstructured interview techniques. In this interview, the researcher asked science teachers and students directly.

To measure the level of validity of the e-module material classification of living things based on scientific literacy and bamboo ethnotaxonomy using the following Formula (1):

$$P = \frac{\sum X}{\sum X_1} \text{ x } 100\% \quad (1)$$

Information:
P = Validity value in percentage form
$\sum x$ = Number of answers of all respondents in one aspect
$\sum x_1$ = Number of ideal answers in one aspect
100% = Constant

Meanwhile, as a basis for decision-making to revise teaching materials, the following assessment criteria are used as a Table 1. As a follow, the analysis of student responses to the e-module aims to measure the percentage of student responses as described at Table 2. The calculating of students' response are follow the Formula (2):

$$\%NRS = \frac{\sum NRS}{NRS\ Maksimum} X\ 100\% \quad (2)$$

Information:
%NRS : Percentage of student response scores
$\sum$NRS : Total score of student responses
Maximum NRS : n x best choice score

Table 1. E-module validity criteria

Scoring Scale (%)	Criteria	Notes
81-100	Very valid	No revision
61-80	Valid	No revision
41-60	Valid enough	Revision
21-40	Invalid	Revision
0-20	Totally invalid	Revision

Table 2. Students' response criteria

NRS (%)	Category
0 ≤ NRS < 25	Very less
25 ≤ NRS < 50	Less
50 ≤ NRS < 75	Good
75 ≤ NRS ≤ 100	Very good

Results and Discussion

Define Stage

The define stage is intended for product specifications that will be developed according to user needs. At this stage, the need for e-modules in the digital learning era is one of the reasons why this module was developed. The focus of e-module development is based on the ethnotaxonomy of bamboo in Indonesia. We carry out five steps in the define stage, as described in Table 3.

Table 3. Results of the define stage

Step	Result
Initial final analysis	Teaching materials used in science learning are limited to student worksheets and textbooks. There are no contextual and innovative teaching materials yet, so additional references are needed to support the learning process.
Student analysis	Students have difficulty solving questions. This arises because often the material tested in the questions does not correlate with what has been learned and vice versa.
Bamboo ethnotaxonomy analysis	There are four types of bamboo in Sungai Krawang Village, Batu Ampar District, i.e: 1) Yellow Bamboo (*Bambusa vulgaris*) 2) Pagar Bamboo (*Bambusa multiplex*) 3) Tali Bamboo (*Gigantochloa apus*) 4) Black Bamboo (*Gigantochloa atroviolacea*).
Material analysis	The material presented in the e-module is the classification of living things with a discussion of the characteristics and groupings of living things, in this case the grouping of bamboo plants based on an ethno-taxonomy
Formulating goals	The planned learning objectives can be achieved through two activities, including: 1. First activity: explaining the characteristics of living things, explaining the differences between living things and non-living things, observing various living things around, and explaining the characteristics of the living things around them. 2. Second activity: classifying living things based on classification principles, presenting the results of observations, identifying and communicating the results of their observations, and making group dichotomies and making key determinations.

The initial and final analysis steps were carried out to obtain the fundamental problems encountered in the science learning process, so it is necessary to innovate and develop teaching materials in electronic form. In a learning process, teaching materials have a very fundamental function as a study that will be discussed by students through plans that have been developed by the teacher (Bahri et al., 2016; Sutarto et al., 2021). It can be understood that the role of a teacher in designing or compiling teaching materials greatly determines the success of the learning process and learning through teaching materials (Irmita & Atun, 2018; Parmin et al., 2016). Other researchers say that teaching materials can be interpreted as any form of material that is arranged systematically which allows students to learn independently and is designed according to the applicable curriculum (Lin & Wu, 2016; Pursitasari et al., 2019).
Ethnotaxonomic analysis of bamboo was carried out by interviewing Javanese, Sundanese and Malay people in Sungai Krawang Village with an age range of 25 to 50 years. Before the binomial nomenclature naming system in the classification of living things was known and used globally, humans had grouped

various living things that were found around them (Patel et al., 2020; Wang et al., 2019). The grouping is done based on identical characteristics that are owned and named using the local language. In a literature review, this is called ethnotaxonomy (Hidayati et al., 2018; Hirota & Tsuji, 2021; Sholahuddin et al., 2021). Ethnotaxonomy as a branch of science from ethnobiology can be a fairly accurate tool in solving problems around the types of living things that are very important for certain ethnic groups but are taxonomically problematic (Hidayati et al., 2021).

Bamboo plays an important role in human life. Bamboo sticks have strong properties, and bamboo bark is easy to shape. Bamboo morphology such as the number of bamboo reeds, length of bamboo reeds, bamboo clumps, number of bamboo clumps, color of bamboo leaves, shape of bamboo leaves, and color of bamboo shoots (Tavita & Herawatiningsih, 2022). There are four types of bamboo found in Sungai Karawang Village, namely *Bambusa vulgaris, Bambusa multiplex, Gigantochloa apus*, and *Gigantochloa atroviolacea* (Table 4).

Table 4. Kind of Bamboo species found at Sungai Krawang village

No	Kind of bamboo species	Javanese	Sundanese	Malays
1	*Bambusa vulgaris*	*Preng kuneng*	*Awi koneng*	*Buluh kuning*
2	*Bambusa multiplex*	*Preng pager*	*Awi leutik*	*Buluh jambang*
3	*Gigantochloa apus*	*Preng apus*	*Awi tali*	*Buluh tali*
4	*Gigantochloa atroviolacea*	*Preng ulong*	*Awi hideung*	Black bamboo

The naming of bamboo plants by the community is based on the uniqueness of each type. Usually, each name consists of two words. The first word refers to the name of bamboo with the name of each region, while the second word has a variety of names and special meanings related to the unique morphological characteristics and uses of each bamboo (Aptoula & Yanikoglu, 2013; Clark et al., 2015).

Design Stage

It is the second stage in e-module product development. The mapping results at the first stage are the basis for the e-module design. The results of the mapping show that the problem of scientific literacy is important to solve by implementing it in the e-module. Furthermore, the design development carried out included format selection, initial design, and preparing a reference test questionnaire (Table 5).

Table 5. Results of the design stage

Step	Result
Format selection	The developed e-module format consists of three main parts. The initial part includes the cover page, preface, table of contents, core competencies, basic competencies, learning objectives, instructions for use, and introductions. The content section includes the title of the material, description of the material, assignments, and summary. Meanwhile, the last section contains a bibliography.
Initial design	The initial design of the e-module is in accordance with a predetermined format. Scientific literacy studies discuss the classification of bamboo from an ethno-taxonomic perspective. In particular, the ethno-taxonomic view is based on the view of the three tribes, including Javanese, Sundanese, and Malay.
Compilation of reference test questionnaires	The developed test questionnaire includes e-module validation guidelines based on three aspects, namely language, material, and media. In addition to validation guidelines, a student response questionnaire was also prepared based on aspects of convenience and assistance in the learning process.

The cover design was designed with a bamboo theme to reflect the content discussed therein. The bamboo illustration on the cover of the e-module serves as an attraction and explanation of the contents of the e-module and forms the characteristics of the contents of the e-module (Fisher, 2016; Utomo et al., 2020). The description of the material is the main component in designing this e-module, because it contains the concept of ethno-taxonomy (Hidayati et al., 2018). Material descriptions are packaged to confirm student activity.

Develop Stage

This stage aims to validate the product so that it is suitable for use in learning through a series of validations and trials. Expert validation is in the form of an overall assessment and input on the product being developed, both in terms of material, design, and language (Nawawi, 2017; Rofieq et al., 2021). Expert validation aims to determine the feasibility of the learning media developed. In addition, expert validation aims to get suggestions, and criticism is used as input to revise learning tools so that the resulting products can be categorized as good and suitable for use in field trials (Nurrohmah et al., 2018; Suprianti, 2020).

Material expert validation focuses on the appropriateness and correctness of the material contained in the product. In addition, it also reviews the systematics of preparing material. The validation results by

material experts show that the percentage of the average score obtained is very valid (>80) on the four assessment indicators, including conformity of material, up-to date material, strengthening of curiosity, and scientific literacy) as described in Table 6. These results indicates that the content in the e-module can be used in learning. However, improvement is still needed on the material accuracy indicator. Furthermore, material experts stated that the e-module had been prepared quite well and the development of this e-module made learning more active and easier for students to understand. Suggestions from e-module material experts require a little improvement on the functional substance and included questions (Ardan, 2016; Leow & Neo, 2014).

Table 6. Material expert validation assessment results

No	Indicator of Assessment	Results of Validation			Average Score	Maximum Score	(%)	Criteria
		1	2	3				
1	Conformity of material with KI and KD	12	15	12	13.00	15	86.67	Very Valid
2	Material accuracy	27	28	28	27.67	35	79.05	Valid
3	Up-to date material	8	9	8	8.33	10	83.33	Very Valid
4	Encourage curiosity	8	8	8	8.00	10	80.00	Very Valid
5	Scientific literacy	16	17	16	16.33	20	81.67	Very Valid

Furthermore, the results of media expert validation (Table 7) also show that the average percentage of each assessment indicator is above 80% with very valid criteria. These results indicate that in terms of quality, the developed e-module design has fulfilled the required elements, both from size, cover design, to the overall module design. However, expert validators still provide suggestions for improvement for product perfection. Some notes that can be made in developing e-modules include the use of a sans serif font type and size, color consistency that refers to the theme, and image labels.

Table 7. Results of media expert validation assessment

No	Indicator Assessment	Results of Validation			Average Score	Maximum Score	(%)	Criteria
		1	2	3				
1	Media size	7	10	10	9.00	10	90.00	Very Valid
2	Cover design	19	30	26	25.00	30	83.33	Very Valid
3	Design of media	26	35	28	29.67	35	84.76	Very Valid

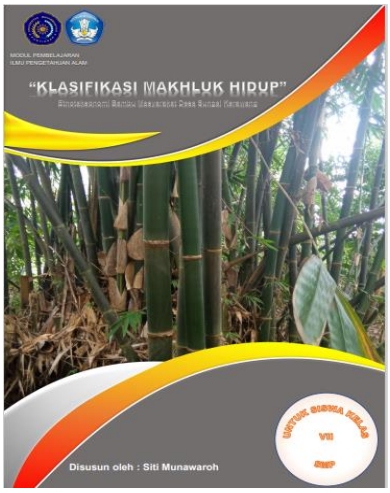
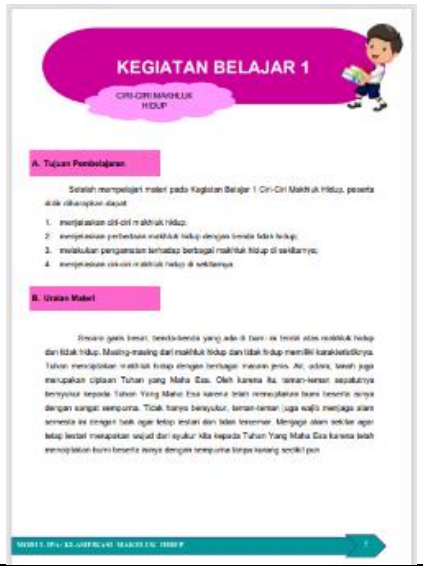
The writing quality and language of the e-module are also very good. The six components of language assessment measured in the e-module include straightforward, communicative, interactive and dialogic, suitability for students' intellectual level, linguistics, and use of symbols and icon (Table 8). The four indicators of which obtain an average percentage of 86.67% (very valid). Furthermore, the communicative and dialogic interaction indicators obtain an average score of 80.00%. Even though it is still very valid, these two indicators are areas of further improvement for this e-module. Notes from the linguist are corrections to the language/spelling used, corrections to the grammar of Indonesian writing, use of proper diction, and consistency in the use of terms.

Table 8. Results of linguistic validation assessment

No	Indicator Assessment	Results of Validation			Average Score	Maximum Score	(%)	Criteria
		1	2	3				
1	Straightforward	15	12	12	13.00	15	86.67	Very Valid
2	Communicative	4	4	4	4.00	5	80.00	Very Valid
3	Dialogic and interactive	4	4	4	4.00	5	80.00	Very Valid
4	Confirmity with the students intellectual development	5	4	4	4.33	5	86.67	Very Valid
5	Linguistic	10	8	8	8.67	10	86.67	Very Valid
6	Use of terms and symbols/icons	10	8	8	8.67	10	86.67	Very Valid

The improvement suggestions by the expert validators are embodied in development steps with the aim of improving product quality. Improvements made include cover design, material structure, assignments, scientific literacy activities, and the concept of ethno taxonomy on bamboo. The repairs made are as described in Table 9.

Table 9. Five parts of e-module development

No	E-module section	Picture
1	Cover	
2	Material	
3	Task	

No	E-module section	Picture
4	Examples of science literacy	
5	Bamboo Ethnotaxonomy	

Many researchers state that teaching materials used in learning must meet didactical, constructional, and technical requirements (Anstey, 2017; Fatimah et al., 2018; Iriti et al., 2016; Vieira et al., 2017). Didactic requirements were met through validation by material experts (Serrat et al., 2014), construction requirements were met through validation by linguists (Hidayati et al., 2018), and technical requirements through validation by media experts (Kundariati & Rohman, 2020). Didactic requirements are reviewed from the suitability of learning objectives, basic competencies, correct concepts, and completeness of components (Himschoot, 2012; Sari et al., 2019). The construction requirements are the use of language, sentence structure, language politeness, and sentence meaning (Baram-Tsabari & Lewenstein, 2013). These technical requirements are related to the clarity of writing and images, the selection of letters and numbers, and the attractiveness of the display (Carleton-Hug & Hug, 2010). The media is said to be valid if the percentage reaches a rating range of ≥61% with valid criteria. Thus proving that the resulting e-module media is valid based on the assessment of material experts, media experts, and linguists. The advantage of the e-module being developed is that there is material covering the four aspects of scientific literacy, as well as material regarding the types of bamboo in Sungai Krawang Village. Furthermore, the developed e-module can be accessed without using a network (offline).

Student Response Results

Small-scale trials were carried out by purposive sampling by taking into account the level of student's academic abilities, including high, medium, and low academics. Students are asked to adjust the learning experience gained while using the e-module based on the ten statements given (Table 10). The results of this small-scale trial showed that the student responses were very positive. Positive criteria are shown in the results of small-scale trials of 78% (very good).

Table 10. Student response results

Statement	Small-scale Trial (n = 5)		Large-scale Trial (n = 19)	
	%	Criteria	%	Criteria
1. I am interested in learning activities for the classification of living things using e-module learning media based on scientific literacy and ethnotaxonomy	80	Very Good	82.11	Very Good
2. I am bored when the teacher explains the classification of living things material using e-module learning media based on scientific literacy and ethnotaxonomy	48	Less	72.63	Good
3. The language used in the learning media e-module learning media based on scientific literacy and ethnotaxonomy makes it easier for me to understand the material classification of living things	76	Very Good	85.26	Very Good
4. E-module learning media based on scientific literacy and ethnotaxonomy on classification of living things does not help me when studying	76	Very Good	80	Very Good
5. Writing and pictures in e-module learning media based on scientific literacy and ethnotaxonomy on classification of living things make me more motivated in learning	84	Very Good	83.16	Very Good
6. Writing and pictures in e-module learning media based on scientific literacy and ethnotaxonomy on classification of living things are presented clearly and easily understood	88	Very Good	85.26	Very Good
7. E-module learning media based on scientific literacy and ethnotaxonomy on classification of living things using an unattractive appearance	76	Very Good	70.53	Good
8. The practice questions presented in the e-module learning media based on scientific literacy and ethnotaxonomy do not support my understanding of the classification of living things	88	Very Good	72.63	Good
9. I am not interested in studying material on the classification of living things using e-module learning media based on scientific literacy and ethnotaxonomy	80	Very Good	80	Very Good
10. The appearance of the e-module media based on scientific literacy and ethnotaxonomy is very interesting so I like studying material on the classification of living things using e-module learning media based on scientific literacy and ethnotaxonomy	78	Very Good	82.11	Very Good
Total	**78**	**Very Good**	**79.37**	**Very Good**

Large-scale trials were carried out after small-scale trials received positive results. As with small-scale trials, large-scale trials also show positive criteria. The average student response on the large-scale test (Table 10) is 79.37% (very good). Student responses are said to be positive criteria if the categories obtained are good or very good (Astuti et al., 2018). On small-scale and large-scale trials, the e-module received an assessment in the very good category. The very good category shows a positive response from students towards the e-module that has been developed. This shows that the developed e-module can be used for learning media in the teaching and learning process.

Conclusion

The results of the study show that the development of the ethno-taxonomy module is classified as very valid and can be used in learning. The results of validation by material experts showed that the developed e-module met the five established assessment criteria, four of which even exceeded it (> 80%). Likewise, from the point of view of media and language development, three and six assessment indicators have been fulfilled respectively.

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Conflicts of Interest

The researcher declares that there is no conflict of interest regarding the writing of this article.

Author Contributions

S. Munawaroh: Methodology; data analysis; write article manuscripts; review and editing. **A. Sunandar:** Manuscript writing; review; searching for references and editing. **M. Qurbaniah:** Writing articles, review; and editing.

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