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Development of Adaptive Digital Module in Integrated Science Course for Natural Education Students

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Abstract

Course modules must be adapted to the existing Lesson Plan. In the Integrated Science Course of the Natural Science Education Study Program, Universitas Negeri Semarang, there is already a course module but it needs to be adapted to the Lesson Plan in the Odd Semester of 2024/2025. This study aims to develop adaptive digital modules for the Integrated Science course for Science Education students. The research was conducted at the Science Education Study Program, Universitas Negeri Semarang in the Odd Semester of the 2024/2025 Academic Year. The research method used is R&D with Four-D Design. Data collection techniques using questionnaires and observations. Data analysis using quantitative and qualitative analysis. The results of the study show that the Adaptive Digital Module has been developed according to student characteristics and can be used in lectures.

INTRODUCTION

Integrated Science courses are courses that must be taken by students of the Science Education Study Programme. This course can be taken by students in the odd semester starting in semester three. Course Learning Outcome (CLO) of this course are: (1) Students are able to apply TPACK knowledge (Technological, Pedagogical, Content Knowledge) to design, conduct, and evaluate integrated science learning, (2) Students are able to apply knowledge of the basics of science, integrated science and interdisciplinary science (A2, K1, GS2), and (3) Students are able to design, conduct, and evaluate integrated science learning. Teaching materials used in this course are modules, books, journals and various other relevant sources that can be accessed by students independently.

Modules are a set of materials that are arranged systematically and used to achieve learning objectives (Kelana & Pratama, 2019). Systematic module usually consists of at least instructions for use, material, evaluation, and feedback. The requirements for good module are: (1) self instructional, (2) self contained, and (3) user friendly. Self instructional is that module must be able to teach students themselves, for example by including clear instructions for using modules (Tsani & Saptono, 2023). Module can be used by students themselves even without the help of lecturers. Self contained means that the content of the material in the modules is complete according to achieving learning objectives. User friendly means that module are easy to use by students.

Integrated Science Module in Natural Science Education Study Program have been created in 2022, but needs to be adjusted to the latest Lesson Plan prepared in 2024. The existing Integrated Science Module is based on the odd semester Lesson Plan for the 2022/2023 academic year. This module does not match the Lesson Plan used for the 2024/2025 academic year because there are differences in several lecture topics. In addition, the module also needs to be adjusted to current technological developments.

Students said that the current Integrated Science module need to be completed. Based on a survey given to 25 students, the results showed that 11 students said that the modules were adequate and 14 students said that the module were inadequate to be used as teaching materials in Integrated Science lectures. A total of 13 out of 25 students said that they had difficulty in learning the material. 24 out of 25 students conveyed that they need structured modules that help in understanding Integrated Science material.

Module is a type of teaching material that allows students to learn a competency in a coherent, systematic, and intact manner (Famulaqih & Nukman, 2024, p. 2). Modules consist of printed modules and digital modules or electronic modules (e-modules) (Lastri, 2023, p. 1140, Kurniawan & Kuswandi, 2021, Puspitasari, 2019, p. 18). According to Humairah et al (2024, p. 27), digital modules are learning resources that can help teachers present material in class, help students understand the material, and use it flexibly and interactively. Interactive learning media can be displayed in digital modules (Astuti & Haryati, 2019, p. 34). The use of digital modules can change the tendency of conventional learning to innovative learning (Triyono, 2021, p. 8). This digital module can facilitate student needs with structured and technology-based material content.

Adaptive digital modules are digital modules developed based on student characteristics. In terms, adaptive means adjusting to conditions and situations. Adaptive modules are modules that are designed according to the conditions and needs of students (Saleh, et al., 2010; Murtadhlo, Praherdhiono, & Wedi, 2022;

Tianda, Wulandari & Tunip, 2025). Adaptive modules are a form of learning material that adapts to the needs, level of understanding, and learning styles of students individually (Normalita, 2024).

Adaptive modules are designed using adaptive learning principles to enable dynamic content delivery based on student interactions with their learning resources (El-Sabagh, 2021; Taylor, Yeung, & Bashet, 2021). Al Fadilah & Akbar (2024) said that adaptive learning supported by digital technology allows students to adjust learning materials to their abilities, learning styles, and speeds. This adaptive learning allows for a more personal and effective learning experience.

Adaptive digital modules are a solution to meet the current need for teaching materials which cannot be separated from technological developments. Integration of novel technologies in the area of higher education, including modules innovation, is extremely promoting the traditional way of teaching (Sodiqi, Widiyatmoko, & Amelia, 2024; Bdiwi et al., 2019; Putri & Ngabekt, 2021). The success of students in achieving a learning goal cannot be separated from the contribution of various supporting factors such as instructional modules (Perdana et all, 2021, p. 263). Integrated science modules need to be integrated with technology in this digital era.

This research aims to develop course modules that are in accordance with the characteristics of students, namely adaptive digital modules. Adaptive digital modules are developed in Integrated Science courses for Science Education students. The adaptive digital module that will be developed has novelty by integrating the latest technology such as animated videos and AI (Artificial Intelligence). The adaptive digital module is also integrated with the Learning Management System (LMS), called ELENA, used in lectures at Universitas Negeri Semarang.

METHOD

The research method used is R&D with 4D Design (Four D-Design). The first stage, Define, conducted a preliminary analysis, namely curriculum analysis and student analysis. This define stage is done to explore students' needs for the module. In the second stage, Design, the initial design of the module is made based on preliminary analysis. At the third stage, Develop, at this stage a feasibility assessment and module testing were carried out. The fourth stage, Disseminate, is the dissemination of the developed module.

The research was conducted at the Science Education Study Program at Universitas Negeri Semarang. The research was conducted in the Spring Semester 20224/2025, September-December 2024. The research population was 3rd semester students who took Integrated Science courses. The research sample consisted of 25 students taken using simple random sampling.

Data collection techniques using questionnaires and observations. The instruments used were questionnaires and observation sheets. The questionnaire sheet was used to explore students' needs for the module, assess the feasibility of the module and assess the readability of the module. The module feasibility assessment questionnaire instrument consists of 10 questions with a Likert scale format of 1-5 and 2 open questions. The module readability assessment questionnaire instrument consists of 12 questions with a Likert scale format of 1-4 and 2 open questions. The observation sheet was used during the module trial. This is to ensure that the items are in accordance with the indicators being measured. The observation sheet instrument consists of 6 open-ended questions. The validity and reliability of the

questionnaire and observation sheet instrument are carried out through expert judgment. Based on the validity and reliability tests, the instrument was declared valid and reliable so it was used for research.

Data analysis used quantitative and qualitative analysis. Quantitative analysis in the form of module feasibility assessment analysis and module readability analysis. Qualitative analysis in the form of analysis of student needs for the module and input for module improvement.

Data from the needs analysis was obtained through a questionnaire in the form of a google form given to students and analyzed descriptively. Data analysis of module feasibility assessment was carried out using the average assessment score obtained from two experts. The experts who evaluate the adaptive digital module are experts with experience in the field of Natural Science learning.

Interpretation of expert assessment is based on the average score and the interpretation is shown in Table 1.

Table 1. Interpretation of module feasibility assessment

Score Range	Criteria
$4.206 < \overline{X}$	Very feasible
$3.402 < \overline{X} \leq 4.206$	Feasible
$2.598 < \overline{X} \leq 3.402$	Moderate feasible
$1.794 < \overline{X} \leq 2.598$	Less feasible
$< \overline{X}\ 1.794$	Very less feasible

(Source: Sukardjo, 2009; Sugiyono, 2019)

Table 2. Interpretation of module readability assessment

Score Range	Criteria
$3.094 < \overline{X}$	Very good
$2.698 < \overline{X} \leq 3.094$	Good
$2.302 < \overline{X} \leq 2.698$	Quite good
$1.906 < \overline{X} \leq 2.302$	Less good
$< \overline{X}\ 1.906$	Very poor

(Source: Sukardjo, 2009; Sugiyono, 2019)

The data analysis of the learner response questionnaire was carried out by calculating the average total score of each aspect and providing an assessment interpretation based on the score obtained. The interpretation of the assessment is divided into five criteria. The learner response assessment criteria are shown in Table 2.

RESULT AND DISCUSSION

The development in this research is a digital module that suits the characteristics of students and is used in Integrated Science Courses. The module was then called an Adaptive Digital Modules in Integrated Science Course. This research was conducted with four stages of development, namely: define, design, develop, and disseminate.

Define

In this define stage,: (1) curriculum analysis, and (2) student analysis. Curriculum analysis was conducted by reviewing the lesson plan used this year. Based on the curriculum analysis, it is known that there are several new materials in the Lesson Plan in 2024 and have not existed in the previous year, namely regarding: “Keterampilan Proses Sains” (Science Process Skills), “Literasi Sains” (Science Literacy), “Pengetahuan TPACK” (TPACK Knowledge), and “Perencanaan, Pelaksanaan, dan Evaluasi Pembelajaran IPA Terpadu” (Planning, Implementation, and Evaluation of Integrated Science Learning).

Student analysis was conducted by providing a survey through google form to find out the characteristics and needs of students for the module. The results of the student needs survey can be seen in Figure 1, Figure 2, and Figure 3. Based on the survey, it is known that students use various digital learning resources because they are easily accessible. Students learn Integrated Science materials from journals (google scholar), YouTube, AI (chat gpt, perplexity, juva.ai),

and so on. In addition to requiring structured reading materials, students also need videos to clarify lecture material.

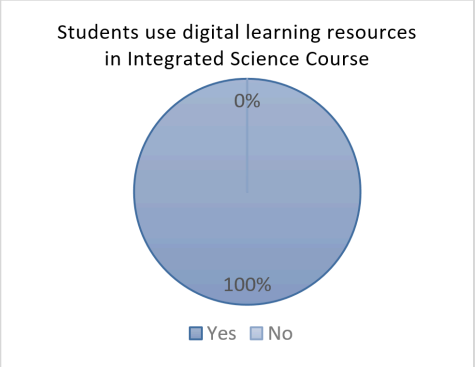

Figure 1. Percentage of students using digital learning resources in the Integrated Science Course

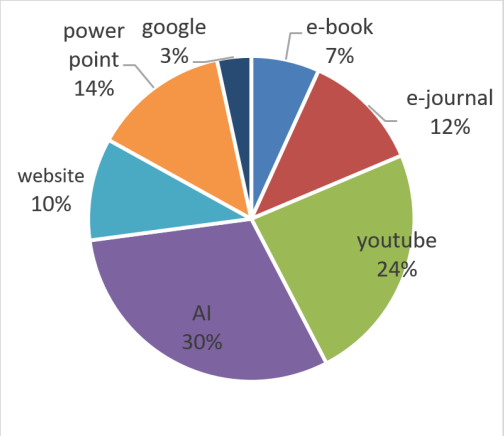

Figure 2. Learning resources that need to be provided in Integrated Science courses according to students

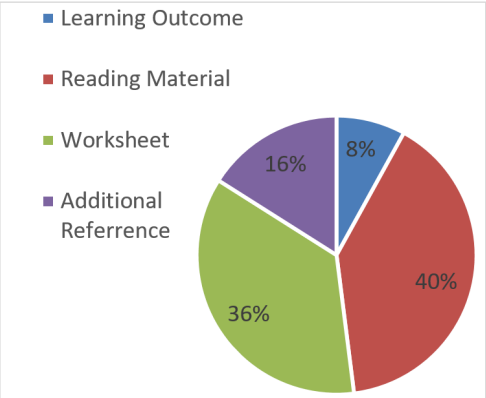

Figure 3. Important components in the Integrated Science learning module according to students

Design

At the Design stage,: (1) media selection and (2) format selection. The media chosen to develop the modules consisted of several software, namely Canva to design the overall layout and typography of the content, flipbook, and Website 2 APK Builder to make into applications (.aps). The Modules format consists of the initial part, the core part, and the final part. The initial part consists of a cover page, preface, table of contents, instructions for using modules, and learning outcomes. The core section contains lecture material consisting of 10 chapters. The final section contains a bibliography and glossary.

Develop

The Develop stage conducted: (1) feasibility assessment and (2) module readability testing. Feasibility assessment by experts showed that: (1) the module can be used as teaching material in Integrated Science Lectures in the Science Education Study Program, (2) the module is interesting and in accordance with student needs, (3) the content of the learning module material is quite complete because it is accompanied by additional information barcodes, videos, and exercise questions along with discussions in each chapter, and (4) the appearance of the module is attractive and easy to use. Input from experts is to add direct links to each chapter in the table of contents. Data on the results of the feasibility assessment can be seen in Table 3.

Table 3. Data from the module feasibility assessment

Component	Average	Category
Curriculum	4.50	Very feasible
Content	4.48	Very feasible
Display	4.45	Very feasible
User friendly	4.45	Very feasible

Language	4.54	Very feasible

Table 4. Readability test result data

Component	Average	Category
Content	3.01	Very good
Display	2.94	Good
Language	3.12	Very good

Module readability testing was conducted during lectures. The test results showed that: (1) All students stated that the Digital Learning Module can be used as teaching material in Integrated Science lectures. (2) Most students stated that the Digital Learning Module can be motivated in Integrated Science lectures. (3) Most students stated that the appearance of the Integrated Science Digital Learning Module was attractive. (4) Most of students stated that the Integrated Science Digital Learning Module can be read clearly, and (5) Notes given by students related to improvements that can be made to digital learning modules, namely: (a) The appearance of the module on the cover is added with more colorful colors and (b) The module is made in pdf version.

Based on the notes during the pilot test, the module was improved according to the feedback. The final module can be seen in Figure 4. The module was also made in pdf form, but some features cannot be accessed offline.

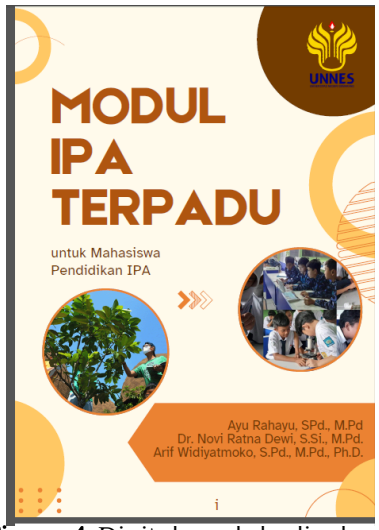

Figure 4. Digital module display

Disseminate

At the Disseminate stage, the dissemination of the developed module is carried out. Dissemination is carried out on a limited basis. The developed module is reported to the science education coordinator and can be used for the following year's lecture.

Adaptive digital modules are one of the innovations in science education that utilize technology to adapt teaching materials to the individual needs of students. In the context of Integrated Science lectures, the development of adaptive digital modules can increase learning effectiveness (Kurnia, et al, 2021; Astuti & Hayati, 2019; Zhao, 2025).

The adaptive digital module developed has characteristics: self instructional, self contained, and user friendly In the module there are instructions for using the module. The adaptive digital module developed allows students to learn independently according to their needs. Students can study the module outside of lectures at their own pace. Students have full control over their learning process, including in setting goals, choosing strategies, and evaluating their own learning outcomes. Research by Kusmaharti and Yustitia (2022) and Martin, Chen, Moore, & Westine (2020) shows that digital modules can even improve students' critical thinking skills and are effective in supporting independent learning. Thus, the developed adaptive digital modules not only provide teaching materials that suit the individual needs of students, but also encourage them to be active in managing and evaluating their own learning process, thereby increasing the effectiveness of learning in Integrated Science courses.

The adaptive digital modules of Integrated Science is self contained, which means that the material is quite complete. The material contains various references to the latest journal articles, video material, and

various learning activities that allow students to explore various references. The adaptive digital modules of Integrated Science is user friendly, because it can be accessed online in the form of a flipbook or offline by being installed on each cellular phone device. Adaptive digital modules allow students to access material through various formats, such as text, audio, and video according to the individual needs of students.

CONCLUSION

The results showed that the Integrated Science Modules has been developed according to student characteristics and can be used in lectures. The adaptive digital modules have been developed based on students' needs for technology by integrating with various videos and Artificial Intelligence (AI) learning resources. The material in the module is in accordance with the Lesson Plan for Integrated Science Courses in the odd semester of the 2024/2025 academic year. The module can be used by students independently and is easy to use both online and offline. The adaptive digital modules of Integrated Science is self instructional, self contained, and user friendly.

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