Interactive E-Module of Integrated Science with Connected Type as Learning Supplement on Energy Topic

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Abstract. Development of an interactive e-module of integrated science with the Connected type on energy topic for Junior High School (SMP) aims to develop an interactive e-module of integrated science that includes biology, physics, and chemistry concepts an interrelate unity in energy topics. That expected to strengthen the student concept knowledge. The Research and Development (R & D) design with the Plomp model was employed. Collection data procedures used validation sheets and user responses questionnaires by the validator team, teachers, and students. Assessments involved material substance, learning design, display (visual communication), and software utilization. Data analysis results showed the validation percentage from the material and media experts are 94.99% and 96.96%, with very valid criteria. Through the teacher's responses, obtain 95.00% (very good practicality criteria). The 92.45% on the one and one test and 92.71% on the small group test, both on very interesting criteria from students. Its means, the interactive e-module has been valid and suitable for use in the learning process.

1. Introduction
In this 21st century, the development of science, technology, and information is rapidly and full of competition [1]. Towards the 21st century, students require to learn that is no longer just traditional academic learning but education that offers learning services that renew them to collaborate, communicate and solve problems, think critically, creatively, and innovatively [2]. The ability of the 21st century is an essential factor in facing future careers and success [3]. Moreover, students have to have higher-order thinking to solve new-world problems [4] [5] by way of a combination of e-learning and face-to-face, known as Blended Learning [6]. The use of technology as a learning tool refers to the ability of students to learn [7] and produce products [8] by using appropriate information, communication, and technology [9].

The Blended Learning model requires the optimization of technology as an educational aid to produce creative, innovative, and competitive creation to face the era of industrial revolution 4.0. Syamsuar & Reflianto (2019) argue that Indonesia needs to immediately improve human resources’ capabilities and skills through education to achieve high competitiveness and productivity [10]. With the industrial revolution, teachers must improve their quality that can lead them to become teachers who can produce higher quality human resources [11]. A teacher is a critical point in improving the quality of education. Therefore, teachers must supervise and professional guidance as part of professional teachers' empowerment [12].
The era of the industrial revolution 4.0 requires teachers to make changes in the field of education both in terms of learning models, learning methods, and learning resources [13] [14]. “Making Indonesia 4.0” is the government's commitment to enter the industrial revolution 4.0 era. In preparing for that, educational actors can change schools' learning methods: 1) Changing the nature and mindset, 2) Sharpening and developing talents, and 3) Changing the learning model according to the times' needs. In preparation, teachers can expand students' competence to apply new technology, which will help students develop about changes in society [15]. The integration of technology in the learning process is crucial in today's digital era so that educators not only have content and pedagogical knowledge components but must also support by the ability to integrate these two components with technology [16] [17] [18].

The quality and achievement of learning objectives are strongly influenced by learning methods and teaching materials [19]. Today's learning methods are still verbal and tend to use a blackboard and a lack of effort to conduct demonstrations/experiments [20] [21]. Based on the pre-research, the teaching materials commonly used were printed teaching materials in textbooks, student worksheets, photocopies of questions, and digital teaching materials in Powerpoint Text (PPT).

Science learning in schools is one of the compulsory curriculum contents, which aims to make students able to live life with a positive, honest, and open attitude; with critical, creative, and innovative thinking; and collaborating, based on the nature of natural science [6] [22]. It can also understand the impact of natural science development in an integrated manner on the development of technology and human life in the past, present, and potential future effects on themselves, others, and the environment [23].

Science learning in Junior High School (SMP) packaged in an integrated science lesson. Science learning integrates various science branches related to using an intra-disciplinary approach [24] [25]. Integrated science Junior High school (SMP) in Indonesia itself is under one science curriculum that combines the fields of biology, physics, chemistry, earth and space sciences, as well as technology and society [26] [27]. In science learning so far, it tends to be teacher-centered [28] [29], students are in the low-level domain [30], students are not used to high-level thinking [31]. But it was created like robots that can only enter numbers and memorize. The essence contained in science learning itself does not enter the memory of students. Not expected of science learning itself and is not following the central view of the 2013 Curriculum that science learning in students tends to study science as a product, memorizing concepts, theories, and laws [32] [33]. In this current situation, the learning process is more oriented to exam tests. Science, as a result, process, attitude, and application are not touched in the learning process. This situation requires teachers to always innovate in learning and preparing teaching materials such as modules [34].

The results of observations and interviews with science teachers from several schools found several facts: 1) The learning outcomes of students, especially students' mastery of concepts in science subjects, energy material for the 2019/2020 academic year at SMPN 1 Bangkinang Kota showed only 71% of those who achieve the Minimum Completeness Criteria (KKM) with the KKM in science subjects are 72 on a scale of 100 and at SMPN 1 Kampar only 70% who reach the KKM with 73 on a scale of 100, and 2) Science were given to students, namely integrated science, while teachers complained about their lack of knowledge about integrated science and the teaching materials provided did not fully cover integrated science. In line with research by As’ari et al. (2017) and Novitasari et al. (2016), the reality is that science teachers in Junior High School (SMP) have not taught science in an integrated manner. Science is still taught separately between physics, chemistry, and biology [34] [35]. Many obstacles have resulted in teachers not implementing science in an integrated manner, namely: 1) Teachers come from educational backgrounds in physics, chemistry, and biology, there are even non-science teachers who have to teach science, 2) Books provided by the government have not fully presented science in an integrated manner, and 3) The limited ability of teachers to design integrated science teaching materials [36]. Stephen (2015) conducted that teachers do not have the skills and strategies in developing teaching materials to hinder the learning and teaching process [37].
Energy is one of the lesson topics from integrated science study materials for Junior High School (SMP), which are a continuation of integrated science learning materials for Primary School (SD) [38]. Setiyawati (2011) generalizes the Connected type on energy topics in physics, chemistry, and biology as a concrete relationship and can be held spontaneously or planned [39]. Specifically, the physics concept in the energy topic discusses the first law of thermodynamics [40]. The biological concept discusses the transformation of energy through body metabolism, and the chemical concept discusses chemical reactions during the body's metabolic processes.

The connectedness of concepts in the energy topic can outline in an interactive e-module. Integrated science has an urgency to improve students’ mastery of concepts and insights to achieve the competency demands of the 2013 Curriculum as a whole [41] [42]. Also, conceptual mastery is an essential element for solving problems [43]. Linda et al. (2020) implemented an interactive chemistry e-module based on Kvisoft Flipbook Maker on stoichiometry to determine the effect of student self-learning using interactive e-module as teaching material [44]. While the other topic, chemical equilibrium, was done by Wahyuni et al. (2018) [45]. The ease of mastering the concepts presented provides more contextual and meaningful situations and conditions [46]. Therefore, students do not memorize concepts but master the concepts and apply them in everyday life.

2. Methodology
The research was conducted at the Postgraduate Science Education Program, FKIP, Universitas Riau in Pekanbaru, with tests at SMPN 1, SMPN 2 in Bangkinang Kota and SMPN 1 in Kampar. The interactive e-module of integrated science with the Connected type on energy topic developed using an R & D design with the Plomp model [47]. This model consists of an initial investigation phase (which consists of analysis, namely the front end, students, material and competence and characteristics of teaching materials [48]), the design phase, the realization/construction phase, and the validation, trial, and revision phase and the implementation phase [49]. But, this research objective was limited to obtaining a valid interactive e-module output based on aspects of material substance, learning design, display (visual communication), and software utilization [44] [45], and has not yet implemented the interactive e-module. To collect the data of validity and user responses from interactive e-module was obtained in the validation, trial, and revision phases [45]. The research instruments used were validation sheets and user responses questionnaires (teachers and students). The validation sheets by media and material experts refers to Panduan Praktis Penyusunan E-Modul [50]. The evaluation was carried out to three media experts and three material experts [45].

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The data collected was analyzed using relevant analytical techniques [36] [45] [48]. The validity analysis used a Likert four-choice scale with scoring guidelines in Table 1 [51].

| Statement of Attitude  | Score |
|-----------------------|-------|
| Strongly agree        | 4     |
| Agree                 | 3     |
| Less disagree         | 2     |
| Disagree              | 1     |

Table 1, the calculation of the percentage of the validity score, uses the formula [51]:

\[ P = \frac{n}{N} \times 100\% \] (1)
Conversion to the qualitative value of the interactive e-module uses a percentage calculation that refers to the validity criteria as in Table 2 [36].

| Percentage (%) | Criteria                      |
|----------------|-------------------------------|
| 81-100         | Very valid (no need for revision) |
| 61-80          | Valid (no need for revision)   |
| 41-60          | Less valid (need for revision) |
| 21-40          | Invalid (need for revision)    |
| <20            | Very invalid (need for revision) |

Meanwhile, the analysis of students' attractiveness is converted by referring to Table 3 [36].

| Percentage (%) | Criteria         |
|----------------|------------------|
| 81-100         | Very interesting |
| 61-80          | Interesting      |
| 41-60          | Quite interesting|
| 21-40          | Unattractive     |
| <20            | Not attractive   |

3. Results and Discussion
This development produces an interactive e-module of integrated science with the Connected type on energy topic for the Junior High School (SMP). This interactive e-module can access via electronic media such as computers, laptops [34] [36] [47], Androids, iPhones, iPads [44] [45], and various other gadgets both online and offline [45] [47]. Teachers and students can use this interactive e-module during the learning process in the classroom or as independent teaching materials [45].

Through the R & D research design with the Plomp model, in the initial investigation phase; carried out the front-end analysis and student analysis through literature review, interviews, and observations [49], and it knows that the teaching materials used in schools are still in printed form, namely textbooks, student worksheet, and photocopies of questions and digital teaching materials in the form of Powerpoint Text (PPT). Then, the teacher realized his lack of integrated science, while the available teaching materials provided did not fully cover integrated science. Students' learning outcomes, especially the mastery of students' concepts on the energy topic for the 2019/2020 school year, show that only 72% have achieved the Minimum Completeness Criteria (KKM). Then, the competency and material analysis perform to the syllabus of integrated science for Junior High School (SMP), then study the relevant energy concepts with Competency Achievement Indicators (GPA) and learning objectives and connect the interdisciplinary science energy topics. This analysis informed that the energy topic is at Basic Competency (KD) 3.5 and 4.5 for class VII [23], and the concept map presents according to Figure 1.
Figure 1. Energy concept map

In the design phase, a prototype design and research instrument were obtained [49]. The prototype design shows that the interactive e-module contains: 1) Cover page, 2) Foreword, 3) Table of contents, 4) Instructions for use, 5) Position map, 6) Concept map, 7) Learning; includes a) Basic Competence b) Competency achievement indicators, c) Learning objectives, d) Description of the material; where composed of perceptions, learning materials, summaries, exercises, assignments and follow-up, 8) Evaluation, 9) Answer keys, 10) Glossary, 11) Authors and 12) Bibliography [50] [53]. In this phase, tools and materials in the form of text, images, audio, video, animation, flash, links, and software that support the prototype are also collected [54]. The research instrument's design was a validation sheet by the media and material experts, the rubric, and the teacher and student response questionnaires [51].

After passing the design phase, followed by the realization/construction phase of the designed prototypes and instruments. The realization results of designed prototypes and instruments then enter the validation, trial, and revision phases to get the assessment and suggestions of the prototypes constructed [23] [55] (the interactive e-module).

Validation carried out by the validator team using the validation sheet and rubric provided. Validation was carried out twice for each validator [55]. The material and media experts’ percentage validity diagrams are presented in Figures 2 and 3, respectively.
Based on Figure 2, the percentage of all aspects from material experts is 94.99%, indicating that criteria are very valid. According to the three material experts, the highest percentage (96.67%) is in the display (visual communication) aspect. The interactive e-module is according to the e-module eligibility criteria included in Panduan Praktis Penyusunan E-Modul [50]. The interactive e-module also collaborated with intermezzo and age-appropriate pictures of students to not feel bored when reading it. Reinforced by Serevina et al. (2018) showed that material experts’ validation of the overall aspects obtained 82.20% (very feasible of validity criteria). In contrast, the lowest percentage was in the material substance’ aspect (93.33%). According to the material experts’ assessment, the interactive e-module still lacks the clarity of instructions for use, collaboration with other knowledge insights, language used, and intermezzo [54].

In Figure 3, the percentage of all aspects from media experts is 96.96% which means it is very valid. The highest percentage (98.33%) is in material substance and display (visual communication). The interactive e-module has the clarity of user instructions, the complete content, the systematic material structure, using simple language, harmonious between cover illustration with page and content image, the proportional size among content and page space, the font type used, the exciting presentation of image, video, narration, and layout. This result is in line with Komikesari et al. (2020), which obtained 82.00% to become 89.10% from media validation after revision (very good validity criteria) [36]. With the consistency of illustrations [38] and colours display [53], this can affect students’ emotions and thoughts when viewing content [28] in the interactive e-module. Students’

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**Figure 2.** The validation diagram by material experts

**Figure 3.** The diagram of validation by media experts
simple language and age-appropriate will attract their attention, so they don’t get bored quickly reading the interactive e-module [32] [47]. Figure 4 presents the display of the interactive e-module.

![Interactive e-module display](image)

(a) Cover and (b) Learning materials

Figure 4. Interactive e-module display (a) Cover and (b) Learning materials

After a valid declaration and did not need revision, conducted the test to determine the practicality from teachers and students’ attractiveness [55]. The first test conduct on nine integrated science teachers in three different schools. The result is 95.00% with very good practicality criteria. Percentage diagram of practicality presents in Figure 5.

![Percentage diagram of practicality](image)

Figure 5. Percentage diagram of practicality according to teacher responses

The practicality indicates the interactive e-module is very practical to use as teaching material in the learning process. According to the teacher’s response, the interactive e-module will significantly support the learning process because following the demands of the 2013 Curriculum, the explanation of the material is up to date, easy to understand, and equipped with animations, videos, and images that can match the appearance that is on the gadget well. This result is in line with Komikesari et al. (2020), which received teacher responses of 85.96% with very good criteria [36]. Also, Serevina et al. (2018) obtained 86.31% with very practical criteria for independent teaching materials [54]. There are clear and straightforward instructions that can make students do not need to ask many questions so that the teachers also do not need to explain too much (facilitator) [31] [ 47]. Also, the learning contents equipped application examples based on real conditions. It provides an innovation that can add new and up-to-date insights to students and improve their understanding [6] [32].

Meanwhile, the results are very interesting criteria for the attractiveness of interactive e-module from student responses obtained from the 2-step test phase. The one and one test step received 92.45%
from nine students in three different schools, and the small group test carried on thirty students with 92.71%. Figure 6 presents the diagram percentage of attractiveness.

![Student Responses](image)

**Figure 6.** Percentage diagram of attractiveness according to student responses

Therefore, the interactive e-module is practical and interesting to use in the learning process because the learning objectives can complete within the estimated time. Also, the illustrations and multimedia are beneficial to understanding [45] the concept of energy. The size and font type are easy to read. Then, the interactive e-module is practical to use in gadgets [55]. These results are in line with the research of Wahyuni et al. (2018) and Saraswati et al. (2019). So, it can access anytime and anywhere. Student responses from Serevina et al. (2018) obtained 80.78% on very good criteria. It indicates the quality of e-module content, presentation techniques, and e-module completeness consider to be used as independent teaching materials [54]. The same result means this interactive e-module can implement on a broader scale. The aim is to know the significance effect besides that advantages as alternative and innovative teaching materials in integrated science learning on energy topic in Junior High School (SMP).

4. **Conclusion**

The interactive e-module of integrated science with the Connected type on energy topic for Junior High School (SMP) developed successfully with Plomp's R & D model design. This interactive e-module obtained very valid criteria from material and media experts, respectively 94.99% and 96.96%. Through the teacher's and students' responses, successively results of 95.00% (very good practicality criteria) and very interesting criteria for students in the one and one test (92.45%) and the small group test (92.71%). It means the interactive e-module can implement on a broader scale in Junior High School (SMP) on energy topics in the integrated science lesson.

5. **Acknowledgments**

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