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STEM ISCIT Learning Tools to Improve Integrative Scientific Thinking

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ABSTRACT

Learning in the era of the new university regulations experienced a revolution in students' learning style and teachers' teaching style because this situation caused many changes in the learning system. Different types of learning alternatives are carried out to achieve learning that meets these conditions. Integrative STEM was selected as one of the learning models in the new order era. However, inclusive STEM learning is difficult to do without support or learning tools, especially in distance learning. Based on these needs, this research was carried out to develop support devices for the integrative STEM model in university physics class students. This research is research and development (R&D). The development model used uses a 4D development model. The 4D model is synonymous with definition, design, development, and dissemination. In this study, an assistive device model was developed in an integrative MINT learning device. The analysis results show that the development of integrative learning tools based on STEM for students is rated as good, with an average of 80%.

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I. Introduction

Covid19 has become widespread, so the government decided to close schools and universities by switching to distance education [1]. Several initiatives have been taken to ensure that learning activities continue. The sudden shift from classroom teaching to distance education at home also indicates the need for increased teaching skills [2], [3]. One type of PJJ is online learning. The online learning system is a learning system without direct contact between teachers and students, but online through the Internet [4]. This condition also requires teachers to innovate in learning [5], to be more creative in the design of learning that can be implemented online to foster students' independence and thinking skills [6].

The implementation of innovative, pedagogical, and communicative learning can be done by selecting the learning methods used and optimizing technology, pedagogy and content. To achieve the learning objectives according to the level of difficulty of the material, the teacher tries to implement different learning models [7]. Most of the learning models that are attempted are student-oriented learning models. One of the models some teachers focus on is a learning model that builds science, technology, engineering, and math (STEM) content.

According to Li et al. [8], an interesting learning model to examine the integration of TPC is the MINT approach since this MINT-based learning method can solve phenomena through the simultaneous application of knowledge and skills. Research suggests that the MINT learning model focuses the educational process on solving real everyday problems by developing various aspects of attitudes, knowledge, and skills and increasing critical thinking and the ability to form logic [9]. Another study found that the STEM learning model could empower students to solve problems and stated that the STEM learning model could empower children to get used to finding solutions [10]. In addition, it can stimulate the ability to convey information easily, have patience, teamwork, and various mental skills that can be applied to individuality and daily life. Another benefit of STEM is that STEM-based learning empowers students' thinking skills. However, the cause of STEM learning was not optimally achieved because teachers still failed to gain full student engagement and critical thinking and promote communication skills [11], [12]. Furthermore, literacy among students in understanding concepts and facts remains limited.

Furthermore, inclusive learning prepares students to recognize their abilities and make appropriate decisions [13]. Deep knowledge of science, technology, and mathematics is a prerequisite for making the right decisions, good analytical skills, accurate data collection methods, and excellent communication skills [14]. The analysis results suggest that the future needs of teacher training candidates include the integration of mastery of pedagogical and professional competencies, mastery of TPC skills in the presentation of learning materials, and the ability of students to perform well. Critical thinking skills, proper decision-making, and competition in Mediation require data. Based on preliminary studies and studies, it is interesting to study studies on the development of STEM learning models to improve pedagogical and professional skills [12], [15].

Additionally, researchers will also work with Integrative Scientific Thinking (ISCIT) in STEM learning. Then the STEM Integrative Scientific Thinking (STEM ISCIT) learning model is developed. During STEM learning, learning tools are needed to support the learning process. Building on the importance of devices in STEM learning, this study was conducted to develop integrated STEM-based learning tools in universities for physics students.

II. Theory

STEM

STEM education means providing practical strengthening of education in STEM fields separately and further developing an educational approach that integrates physics, technology, engineering, and mathematics by focusing the educational process on solving real problems in everyday life or professional life [12]. STEM will aid education in Indonesia since both education and STEM aspire to enhance students' higher-order thinking skills, such as creative and critical thinking. STEM is an integrated learning approach that connects real-world applications with classroom learning that includes four disciplines: natural sciences (physics), technology, engineering results, and mathematics.

The STEM approach connects learning with four teaching components: Science, Technology, Engineering, and Mathematics [16]. In line with this, the STEM approach can be implemented at the level of formal education/in the classroom and at the level of non-formal units/outside the classroom. STEM in recent years has been widely applied in several countries, such as in Taiwan. In Indonesia, STEM has also been used in recent years [10]. Learning using the STEM approach is expected to be able to build and develop Physics Education students so that they not only memorize concepts but are also guided to be able to integrate Physics, technology, engineering, and mathematics so that they can improve critical thinking skills in Physics Education students towards learning materials. to be applied to teach science, especially physics because studying physics does discuss not only mathematical formulas but also uses other components, such as technology and engineering to understand the material. Students in Physics Education may benefit from a STEM approach that aims to improve skills, such as problem-solving and investigational skills. [17]–[19]. These skills are important to help improve human resources.

Learning Media

Learning tools are items that teachers must prepare before conducting instruction [20]. Learning is a process or method of causing people to learn [21]. Devices are tools or equipment, but learning is a process or method of causing people to learn. Learning devices are tools or equipment that allow instructors and students to carry out processes to carry out learning activities. Teachers can use learning tools to help them carry out learning in the classroom, laboratory, or outside the classroom. The preparation of learning resources is part of learning planning, according to Permendikbud No. 65 of 2013 concerning Standards for Primary and Secondary Education. A syllabus and lesson plans that conform to topic standards are used to plan to learn. Learning scenarios and the production of learning media and resources, assessment tools, and learning scenarios are all part of the learning planning process [22].

III. Method

The development procedure needs to involve product testing, and research implementation is carried out systematically to achieve an expected result. Therefore, this research development procedure uses 4D [23]. The following is a research flow chart shown in Figure 1.

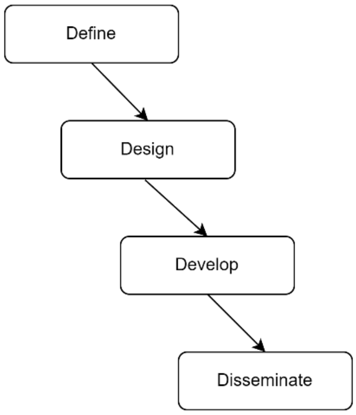

Figure 1. Research Flowchart

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Define

This step is carried out to determine and define development needs. This definition analyzes development needs, research, and models suitable for product development and product development tailored to user needs. Analysis can be done through literature searches or preliminary studies [24].

Design

The design stage (planning) makes the initial product (prototype). The prototype is the initial model (pre-model) developed during development. The development stage aims to produce a supporting device for the ISCIT STEM learning model. The development of learning support devices begins with designing a model supporting device. The device developed is a supporting device for the ISCIT STEM learning model. The device was developed based on syntax (stages), namely a description of the implementation of the model in the field in teaching and learning activities. The syntax can be described as a systematic process of learning activities related to the implementation of the model.

Develop

The development stage can be divided into evaluation by experts and development testing [24]. Assessment by experts is a method for validating or evaluating the feasibility of a product design. Experts in each field assess these activities. The suggestions are used to improve the teaching materials and prepare learning designs. The validation results are used to improve the product. After the product is repaired, it is retested to achieve effective results.

Disseminate

The dissemination stage can be divided into three activities: verification testing, packaging, dissemination, and recruitment. The product modified in the development stage is deployed to the actual target in the validation testing stage. The implementation also measures the achievement of goals. This measurement is carried out to ensure the validity of the developed product. After the product is implemented, the developer must see the results of achieving the goals. The last activities in the development stage are packaging and distribution. This procedure is done to make the product available to others. The field test at the disseminate stage involved 60 Physics Education students. In this test, research is carried out using products that have been developed and refined.

IV. Results and Discussion

Define

Preliminary Analysis

Based on the literature study carried out, the initiative is carried out to ensure that the activity takes place. The change from face-to-face methods in the classroom to distance learning at home indicates the need to increase teaching capacity [1], [2]. one type of PJJ is bold learning. The bold learning system is without direct face-to-face interactions between teachers and students, but online using the internet network [3]. This condition also requires teachers to make innovations in learning [4], to be more creative in designing learning that can be applied boldly to foster student independence and thinking skills [5]. Based on the importance of students' critical thinking and the need for students to be associated with science, technology, mathematics, and engineering in learning, the application of STEM learning in Higher Education is carried out [5], [6]. Learning devices are needed to support the learning process in the STEM learning process.

Task Analysis

Task analysis is carried out to analyze the main tasks that the subject must master to achieve minimum competence. The analysis is done by making achievement indicators for each competency improved. The indicators created are product feasibility indicators and user responses.

Concept Analysis

Conceptual analysis consists of a concept map that is used to achieve a certain ability to determine the main parts of the study material systematically. From the results obtained, the material that will be used to develop Integrative STEM learning devices on magnetic material and electromagnetic induction with the product to be made is an integrative STEM learning device.

Formulation of Learning Objectives

Analysis of learning objectives is carried out to determine material analysis and curriculum analysis indicators. Based on the material analysis and curriculum analysis, the manufacture of Integrative STEM learning tools on magnetic material and Electromagnetic Induction is carried out.

Design

The design stage (planning) makes the initial product (prototype). The product developed is an Integrative STEM learning tool. Planning is done by making a draft for further validation and testing on the subject. The design is made using a microscope office.

Development

The development stage is divided into two activities, namely: expert evaluation and development testing. Expert evaluation is a technique to verify or evaluate the feasibility of a product design. The evaluation is carried out by experts in their respective fields. The suggestions given are used to improve the teaching materials and designs that have been prepared. Development testing is a product design testing activity aimed at the actual target object.

Based on expert test data analysis, it can be seen that the product produced through this research has been declared very feasible, with several suggestions for improvement (see Figure 2).

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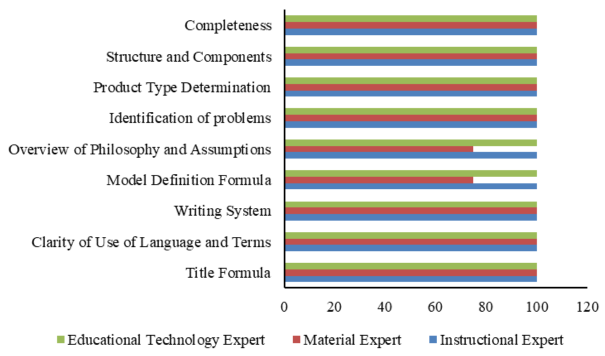

Figure 2. Summary Graph of Expert Consensus on Integrative STEM Learning Tools

Based on Figure 2, the Integrative STEM learning device developed is very feasible. Validation data were obtained from three experts: Physics education experts, Instructional experts, and Learning Technology experts. From the aspect of title formulation, it can be seen that the average obtained is 100% that the model book made in the aspect of title formulation has an effective and efficient short title formulation, does not cause double interpretation, the display is legible (size and typeface are appropriate), and the suitability of the color composition selection already well.

From a review of aspects of language clarity and terminology/components, it can be seen that the level of expert consensus on the feasibility of the book model has reached 100%. This shows that the experts agree that the clarity of language and terminology is suitable for formulating the developed book model. Clarity of language and terminology are terms used in simple, clear models, will not cause misunderstanding and can be understood by readers, as well as the use of common foreign languages and applicable terms of use.

In addition, in terms of the systematic aspects/components of the model, the level of expert consensus on the developed Integrative STEM learning tools has reached 100%. This means that experts agree that the system model compiled is suitable for being used as part of the Integrative STEM learning tool. Expert opinion is based on evaluation, showing that the documents developed in the model book: systematics according to indicators that are consistent and interesting to the reader (readability), systematics according to consistency between projects, systematics according to intervention design, and systematics based on research and theory development (basic equipment).

Another aspect is the formulation of the definition of the expert consensus model, which reaches the 75% level, indicating that the student activity designs that have been prepared are feasible to use. This feasibility is based on evaluation results showing that the toolkit has: clear and understandable sources, current or contemporary (containing visionary elements), comprehensive compilation, and elements that fit the model and definition. They are prepared comprehensively, objectively, and decisively. Among the four experts, only the material expert gave an unworthiness rating or percentage (75%) in this regard, and the other two experts gave a very good level of consensus. This is because the material experts are of the opinion that the model book in the definition section of the development model is not following the development model. Furthermore, the model book was improved based on input from material experts to be further validated without being reassessed.

Judging from the formulation and hypotheses of the philosophical review, it can be seen that the average consensus level of experts has reached 88%, which indicates that the planned teaching activity plan is declared feasible as part of the teaching activity. Philosophical comments and hypotheses are used. This level of consensus is based on the evaluation results, namely that the developed model book has considered the formulation and assumptions of philosophical comments as useful. The breadth and depth of the philosophical hypotheses and commentaries are drawn up with cultural backgrounds in mind. The formulation of philosophical and hypothetical reviews is designed according to the context of life and the development of science and technology. The formulation of philosophical reviews and hypotheses is generalized to specific (already coherent). As in the formulation of the model definition, in the formulation of hypotheses and this philosophical review, the material also provides the least appropriate level of consensus (50%), while the other three experts think it is very feasible. Because, according to material experts, both the breadth and depth of philosophical interpretation need to be slightly improved. Furthermore, the model book was improved based on input from material experts to be further validated without being reassessed.

From the following aspects, namely problem identification, the consensus of experts has reached an average level of 100%, which indicates that the evaluation system designed is considered very suitable as part of the problem identification system. This feasibility is based on the evaluation results which show that the resulting model book covers the existing problems, namely the demands of the world of education and identification of problems based on the needs of the development of science and technology. As the dynamics of the world of work, problem identification is based on the need to improve the efficiency and effectiveness of the education/learning process, and problem identification is based on a comprehensive needs analysis. Another aspect of the Expert's evaluation of the effectiveness of the model book is the determination of the type of product. From this aspect, it can be seen that the consensus of the experts has reached 100% which indicates that it is very suitable as an expert.

The way to do a field trial is to test the product made on 60 Physics Education students. The results obtained have a good perception of 45.55 from a score of 56 and a percentage of 79% of the developed framework. Based on Figure 2, it can be concluded that the developed framework is categorized as good. Rationality, supporting theory, social system, reaction principle, support system, instructional impact, accompaniment impact, instructional implementation instructions, learning environment, management tasks, and assessment are among the characteristics that are evaluated.

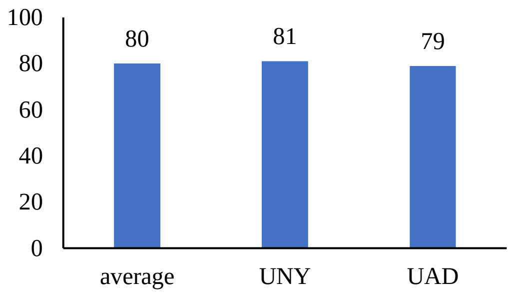

Figure 3. Student response data to the Integrative STEM Learning Tool

This study was used to determine the feasibility of STEM ISCIT products used in distance learning. In addition, it can be used as reference material in learning about magnetic electricity. This product is equipped with teaching materials, learning media, lesson plans, and learning evaluations

V. Conclusion

The STEM ISCIT learning tool to improve Integrative Science Thinking has been created. The results of the data obtained show that this device is suitable for supporting the STEM ISCIT model in the new normal era. This study has limitations, namely that it is only used to determine the effectiveness of the ISCIT STEM learning device to improve Integrative Scientific Thinking on magnetic electricity. Suggestions for further research are to conduct expanded research and add learning tools to other materials.

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