Gravity: Jurnal Ilmiah Penelitian dan Pembelajaran Fisika

http://jurnal.untirta.ac.id/index.php/Gravity

ISSN: 244-515x; e-ISSN: 2528-1976

Vol. 10, No. 2, Aug 2024, Page 151-162

Development of an Internet of Things control solution (IoT consol) learning program in the physics learning media course

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(Received: 18 August 2024; Accepted: 22 August 2024; Published: 30 August 2024)

ABSTRACT

This research focuses on developing an Internet of Things control solution (IoT consol) learning program in physics learning media courses. This study uses the Research and Development (R&D) method with the Thiagarajan 4D development model consisting of four stages: Define, Design, Develop, and Disseminate. The learning program products include semester learning plans, student worksheets, learning modules, and assessment sheets. Data collection techniques include product feasibility test sheets and student response questionnaire sheets. The feasibility test data for the learning program is analysed descriptively based on the feasibility test criteria for product development, referring to the Likert scale 1-7. The results of the product development research obtained a feasibility value with overall feasibility criteria for learning device elements with a value of 93% in the very good category, and the results of student responses obtained a value of 77.77% in the good category. The developed IoT consol learning program was feasible for physics learning media courses based on data analysis.

Keywords: IoT consol, learning program, physics learning media

DOI: 10.30870/gravity.v10i2.25393

INTRODUCTION

The use of digital and new technology in the 21st century is one of the characteristics of the world of education, which is developing very massively today. Sarah et al. (2021) stated that the learning process must be integrated with technology in the era of the Industrial Revolution 4.0. In other words, teachers need optimal competence to incorporate technology into learning by considering learning materials. The ability to apply technology to the learning process can be identified through Technological Pedagogical Content Knowledge (TPACK), namely the combined ability that includes the dimensions of technological and pedagogical integration knowledge in content development. (Erlangga et al., 2024; Fakhriyah et al., 2023;

Utami & Guntara, 2021). TPACK skills are essential for educators, and students as prospective teachers also need to practice TPACK skills to be ready to face learning disruptions(Sholihah et al., 2016). Research by Nasution (2018) and Agusta & Sa'dijah (2021) states that teachers must be able to use technology as a fundamental skill in presenting creative learning. Research by Sastria (2023) noted that the TPACK ability of pre-service science teachers in Indonesia obtained the lowest score compared to the score of in-service science teachers with an average score of the Technological Knowledge (TK) ability dimension of 19.8, Technological Content Knowledge (TCK) of 16.6, Technological Pedagogical Knowledge (TPK) of 9.5, and Technological Pedagogical Content Knowledge (TPACK) of 3.5. The study's results showed that the absence of training in using ICT-based learning media resulted in science teachers being unable to optimise technology in learning. In addition, not all pre-service science teachers can use the features available in new technology, so they are not used to integrating technology in creating learning media (Nasar & Daud, 2020). Ideally, science teachers must have professional teaching skills that are linear with knowledge of technology, pedagogy, and content.

The Internet of Things (IoT) is defined as modern technology developing massively and is the basis of various human activities today. IoT is defined as a design where an object can be connected to the internet so that it is possible to communicate with each other automatically (Adani & Salsabil, 2019). The implementation of IoT has developed in several fields, such as industry, transportation, health, agriculture, and education, which is a potential field for developing IoT technology. However, research by Hala & Arifin (2020) states that teacher readiness to apply IoT technology in learning is still not optimal. In addition, Apriyanto (2019) research states that IoT in education, especially physics, is still limited and requires media for its application.

In physics learning, theory and practice are two important components determining how physics learning is carried out. Physics can provide hands-on experience in practical learning to improve students' skills (Safarati et al., 2022). Physics learning media is important for conveying knowledge in the learning process through practicums (Firmadani, 2020). Thus, to maximise the learning process, prospective physics teachers must be able to design and create learning media using alternative tools if teaching aids or practicum tools as learning media are still limited. However, in reality, Sundaygara et al. (2018) and Herman et al. (2023) stated that the ability of physics teachers to create and carry out physics practicum activities in schools is still not optimal due to the unavailability of practicum tools.

Physics students' skills in designing learning media are developed through physics learning media courses, with the output of physics students as prospective physics teachers being able to create physics learning media in making simple physics practical instruments for several school physics materials such as valuable tools for uniform, straight motion, temperature measurement, renewable energy and other physics materials. The results of interviews with physics education students show that the skills required to develop physics learning media using IoT technology are still rare and limited. In addition, interviews were also conducted with lecturers in charge of physics learning media courses. The results of the interviews showed that currently, there has been no development of IoT technology learning materials in physics learning media courses, so a learning program is needed to support IoT-based physics learning media courses, namely by developing lecture learning devices, including lesson plan, student worksheet, modules, and assessment sheets. Based on the information that

has been submitted, the researcher conducted a study entitled "The Development of an Internet of Things Control Solution (IoT consol) Learning Program in the Physics Learning Media course".

RESEARCH METHODS

This research uses the Research and Development (R&D) method with Thiagarajan's 4D development model approach. The model stages include the definition, design, development, and dissemination. The initial stage, namely define, includes needs analysis, curriculum analysis, material analysis, and specification of learning objectives. The purpose of the definition stage is to determine learning needs, which are then continued at the design stage. The design stage focuses on preparing learning programs that are developed according to the format based on the references used, including the preparation of higher education curriculum formats. Furthermore, the development stage is carried out to obtain the final product that has passed the feasibility test, product revision, and product trial. At the dissemination stage, the research product in the form of an IoT consol learning device is disseminated after the development and revision process, which considers suggestions and comments from experts.

The data collection instruments in this study consisted of a product feasibility test sheet addressed to two material expert validators to determine the assessment of the development product and a student response questionnaire sheet for the developed learning program. Data analysis of the feasibility test sheet and student response questionnaire through a Likert scale is presented in Table 1.

Table 1. Guidelines for assessing the feasibility of learning programs

Scale	Score
Very agree	7
Agree	6
A little agree	5
Neutral	4
A little disagree	3
Disagree	2
Very disagree	1

To calculate the validity of the developed learning program product, the following formula is used:

$$NP = \frac{n}{N} \times 100\% \quad (1)$$

Where NP is the percentage value of eligibility (%), n is the value obtained for each aspect, and N is the total value of each aspect.

To process data from the results of expert validation tests, descriptive analysis techniques are used to help analyse the assessment scores of the learning devices that have been developed. The criteria for determining product eligibility refer to the standards presented in Table 2.

Table 2. Product eligibility criteria

Score	Criteria
86% - 100%	Very worthy

72% - 86%	Good
57% - 72%	A little worthy
43% - 57%	Fair
29% - 43%	A little not worthy
15% - 29%	Not worthy
15%	Very not worthy

RESULTS AND DISCUSSION

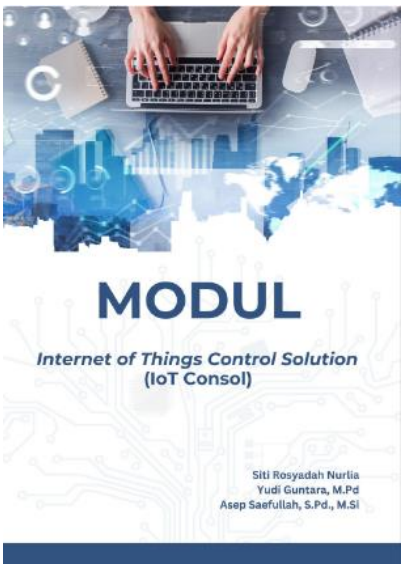
This study presents the results of the development of the IoT consol learning program in the physics learning media course for each stage as follows:

Define Stage

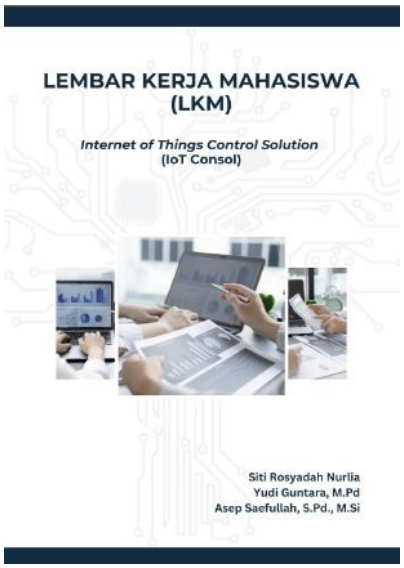
This stage includes several processes, namely needs analysis, curriculum, materials, and specifications of learning objectives. The results of the needs analysis are based on the results of interviews with lecturers and physics education students at Sultan Ageng Tirtayasa University, and information was obtained that existing learning devices have never integrated IoT technology as an ICT-based physics learning media, limited practical tools and no development of IoT-based physics learning media. In addition, based on the results of the student response questionnaire to determine students' initial knowledge of the introduction of IoT technology in physics learning media, data was obtained that 94.2% of students did not know and had never created IoT-based physics learning media using the Blynk IoT platform. Furthermore, curriculum analysis was carried out by identifying the course's learning outcomes and sub-learning outcomes in the physics learning media course according to the 2022 curriculum used by the physics education study program at Universitas Sultan Ageng Tirtayasa University. Material analysis was carried out by identifying the main materials from IoT that will be taught so that they are arranged systematically. Meanwhile, the specifications of learning objectives are placed in more detail based on the learning objective of the physics learning media course.

Design Stage

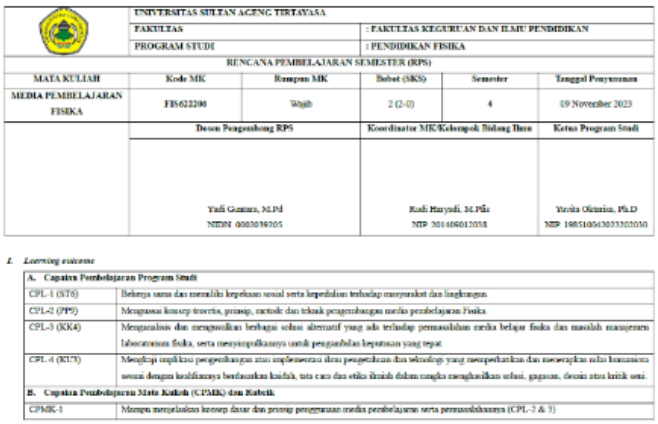
This stage includes designing the initial format of the learning program in the form of lesson plans, modules, student worksheets, and assessment sheets. The lesson plans and assessment sheets have been adjusted to the 2022 curriculum format. The learning module consists of 3 primary materials, namely: 1) an introduction to IoT technology, 2) an introduction to Arduino IDE, Wemos D1 R1 (ESP8266), and C programming, and 3) an introduction to types of sensors. Meanwhile, the student worksheets developed consist of 5 worksheets, namely: 1) control system practicum with Arduino IDE and Wemos D1 R1, 2) automatic control system practicum on the Blynk IoT platform, 3) control and monitoring system practicum with the Blynk IoT web dashboard, 4) control and monitoring system practicum with Blynk mobile apps, and 5) IoT-based physics learning media smart device development project. The results of the IoT Consol learning device design can be seen in Figure 1.



(a)



(b)



	UNIVERSITAS SULTAN AGENG TIRTAYASA				
	FAKULTAS		: FAKULTAS KEGURUAN DAN ILMU PENDIDIKAN		
	PROGRAM STUDI		: PENDIDIKAN FISIKA		
RENCANA PEMBELAJARAN SEMESTER (RPS)					
MATA KULIAH	Kode MK	Rumpun MK	Bobot (SKS)	Semester	Tanggal Penyusunan
MEDIA PEMBELAJARAN FISIKA	FIS622206	Wajib	2 (2-0)	4	09 November 2023
	Dosen Pengembang RPS		Koordinator MK/Kelompok Bidang Ilmu		Ketua Program Studi
	Yudi Guntara, M.Pd NIDN 0003039205		Rudi Haryadi, M.Pfis NIP 201409012038		Yuvita Oktaviia, Ph.D NIP 198510063033303030

I. Learning outcome

A. Capaian Pembelajaran Program Studi	
CPL-1 (ST6)	Bekerja sama dan memiliki kepekaan sosial serta kepedulian terhadap masyarakat dan lingkungan
CPL-2 (PP9)	Menguasai konsep teoretis, prinsip, metode dan teknik pengembangan media pembelajaran Fisika
CPL-3 (KK4)	Menganalisis dan merumuskan berbagai solusi alternatif yang ada terhadap permasalahan media belajar fisika dan masalah manajemen laboratorium fisika, serta menyimpulkannya untuk pengambilan keputusan yang tepat
CPL-4 (KU5)	Mengkaji implikasi pengembangan atau implementasi ilmu pengetahuan dan teknologi yang memperhatikan dan menerapkan nilai humaniora sesuai dengan keahliannya berdasarkan kaidah, tata cara dan etika ilmiah dalam rangka menghasilkan solusi, gagasan, desain atau kritik seni.
B. Capaian Pembelajaran Mata Kuliah (CPMK) dan Kaitelk	
CPMK-1	Mampu menjelaskan konsep dasar dan prinsip penggunaan media pembelajaran serta permasalahannya (CPL-2 & 3)

(c)

Figure 1. a) Design of IoT consol learning device b) Student worksheet, c) Semester learning plan and Assessment sheet

The lesson plans designed in this study use the 2022 curriculum—lesson plans designed by adding IoT learning materials to the physics learning media course. According to the 2022 curriculum format, several components in the lesson plans contain information in the form of learning objectives, ability mapping, syllabus, learning programs and attachments (assessment techniques and rubrics). Learning modules are created as learning resources that students can use independently and in groups in learning activities and are adjusted to the learning objectives. Meanwhile, a student worksheet is designed as a learning medium to assist students in carrying out practicums that are adjusted to learning objectives. The preparation of worksheets consists of several parts that are adjusted to the research of Wulandari et al. (2020), namely containing the cover section, experimental objectives, work safety, tools and materials, experimental steps, and assignments. Recent research shows that using worksheets in practicums can increase learning effectiveness and students' practical skills. Research by Nurmaningsih & Wijaya (2021) found that well-designed worksheets can help students follow practicums more systematically, achieve better learning outcomes, and make it easier to understand the practical concepts taught. In implementing the practicum, students in groups

design a simple IoT project, starting with assembling sensor components, designing programming codes, and configuring devices for the Blynk IoT platform and application.

Development Stage

The product that has been made at this stage is tested for its feasibility by two material experts in their fields. In conducting the feasibility test, an instrument is used in the form of a feasibility test sheet filled out by the experts so that the learning program being developed can be measured for its feasibility. The feasibility test assessment sheet used modifies the research (Araina et al., 2023). The assessment aspects in the validation of material experts include the suitability of the material with learning objectives, the truth of the content or material, and the adequacy of the references used. The results of the feasibility test on the development product are presented in Table 3.

Table 3. Product development feasibility analysis by material experts

No	Assessment Aspect	Percentage	Category
1.	Compliance of materials with learning objectives	100%	Very worthy
2.	The truth of the content of the material (presentation of the material by existing definitions)	86%	Worthy
3.	Accuracy of material (presentation of actual material by current developments)	93%	Very worthy
4.	Adequacy of the references used	93%	Very worthy
Average		93%	Very worthy

The assessment of the material on the IoT consol learning program in terms of the truth of the material content has a lower percentage than the other three aspects. This is because there needs to be an addition and simplification of the material presented in the learning device so that the researcher can make the material for product revision even better with this deficiency. Although the truth of the material content has the lowest value, the assessment criteria are still declared feasible with a percentage value of 85.71% according to the interpretation of feasibility (Sugiyono, 2013). In terms of the suitability of the material with learning objectives, it obtained the highest value, reaching 100%, because the material in the learning device met the learning objectives criteria. The other two aspects, namely material accuracy and the adequacy of references used, each aspect received a percentage value of 92.86% in the very feasible criteria. Based on the feasibility results of all aspects, an average value of 93% was obtained in the very feasible criteria. The IoT Consol learning program in the physics learning media course is viable and can be used by students because it is correct by learning objectives, the presentation of the material is by existing definitions, the presentation of actual material is by applicable developments, and the feasibility of the references used. The learning device resulting from the feasibility test that has gone through a revision process based on expert input and received an assessment in the very feasible category can be used or tested (Muslina et al., 2017; Yudha et al., 2023). The results obtained also align with the research of Makhrus et al. (2020) who

concluded that development products that have received an assessment of the appropriate criteria can be used as teacher reference material.

After the learning program was declared feasible and revised, a product trial was conducted on 45 4th semester physics education students who taught the physics learning media course. The results of student responses to implementing the IoT consol learning program in the physics learning media lecture are presented in Figure 2.

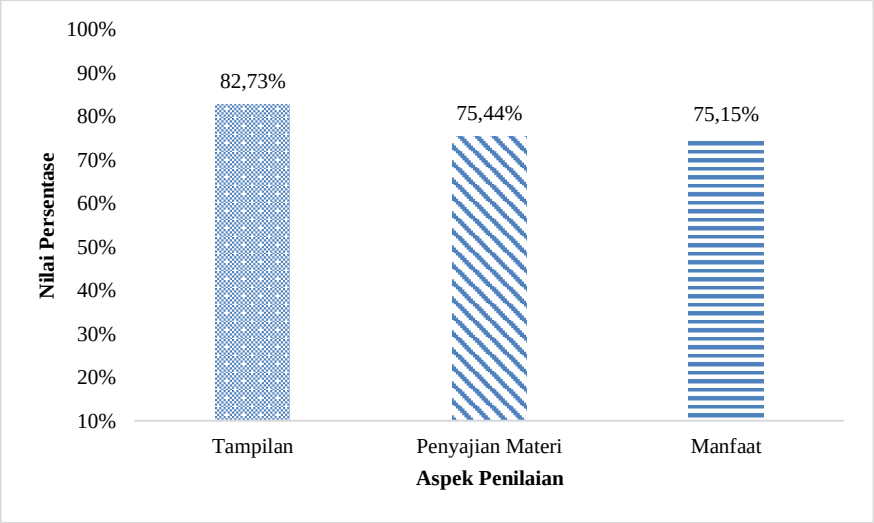


Figure 2. Student response results on the IoT consol learning program

Based on Figure 2, it can be seen that the three aspects have a range of values that are not far apart, namely, the highest value in the display component reaches 82.73%, the material presentation component reaches 75.44%, and the benefits component reaches 75.15%. In its implementation, several students still experience obstacles in completing project assignments, such as errors in assembling tools, using programming languages, the WiFi configuration process from devices caused by unstable networks so that several devices cannot be connected to Blynk IoT, and the factor of student limitations in designing real IoT-based practical projects as learning references. Although the lowest aspect is in the benefits aspect and the highest is in the appearance aspect, all three aspects are in the good category. This is because the IoT consol learning program contains new learning materials in the physics learning media course and provides real experiences for students in the form of practicums where each practicum requires students to create a project design as learning to develop IoT-based physics learning media.

The IoT consol learning program has significant advantages in physics learning media courses because it introduces new learning materials that are relevant to current technological developments. One of the main aspects of this program is providing students with in-depth practical experience. Through this practicum, students learn theory and directly engage in practical applications of the materials studied. Each practicum requires students to design a project as part of the learning. This project focuses on developing physics learning media based on IoT technology. This assignment allows students to apply their knowledge in real contexts and develop practical skills in designing and using IoT-based learning media. This experience is very valuable because it deepens students' understanding of the material and provides them with skills relevant to industry needs and current technological developments. This project also encourages students to think creatively and innovatively in overcoming challenges they may

face in developing learning media and preparing them for the application of advanced technology in education.

The application of IoT technology in this learning provides a practical and modern context that aligns with the latest technological trends and prepares students to face future challenges and opportunities. This aligns with several recent studies that emphasise the importance of technology integration in education. For example, research by Alvendri et al. (2023) shows that applying technology such as IoT in education can improve students' practical skills and the relevance of learning materials (Journal of Educational Technology). In addition, a study by Khairun et al. (2023) found that using IoT-based media can enrich the learning experience by providing opportunities for students to interact directly with the technology they are learning. International research by Kassab et al. (2020) also supports these findings, showing that integrating IoT in education increases student engagement and facilitates a more adaptive and innovative learning approach. The use of lecture devices that have been developed can provide real practical knowledge and experience for students to support the achievement of competencies as prospective physics teachers (Made Astra & Rahma Fitri, 2017; Pratiwi et al., 2024; Sari & Wulanda, 2019).

Dissemination Stage

Dissemination is an essential stage in the research and development process that aims to introduce, implement, and utilise research results or products developed to a wider audience (Mesra, 2023). This stage involves disseminating products as an IoT consol learning program in the physics learning media course to lecturers and students through the Sultan Ageng Tirtayasa University campus. The results of the product dissemination are presented in Figure 3.

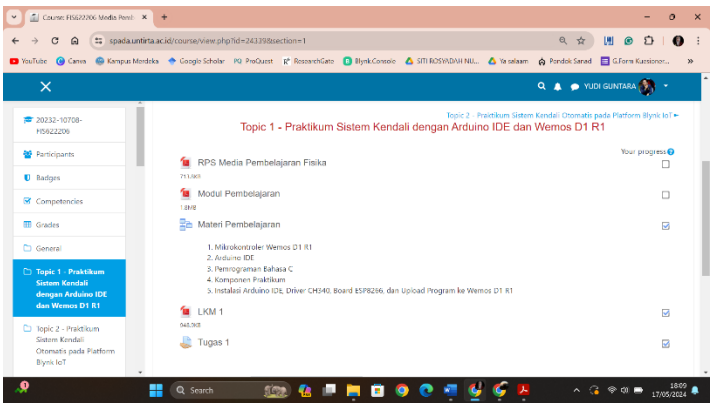


Figure 3. View of the learning material for physics courses

Based on Figure 3, the IoT consol learning device on the spada page of Sultan Ageng Tirtayasa University is loaded into the physics learning media course consisting of 5 learning topics as detailed in the lesson plans. Each learning topic contains modules, sub-learning materials, student worksheets, and assignments. The spada page for the learning media course can be accessed at the following link: https://spada.untirta.ac.id/course/view.php?id=24339.

The IoT consol learning device implemented on Spada UNTIRTA page assists in the physics learning media course. Each topic is equipped with a learning module that presents the primary material sub-material that divides the topic into more specific parts. The integration of

IoT technology in this learning is in line with the latest research findings that emphasise the importance of technology in improving the effectiveness of education. For example, research by El-Haggar et al. (2023) shows that applying technology such as IoT in learning can increase student engagement and the efficiency of the teaching and learning process. In addition, a study by Forkosh-Baruch et al. (2021) revealed that IoT-based devices can enrich the learning experience by providing access to more interactive and relevant resources. Research by Kumar & Al-Besher (2022) also emphasises that integrating technology into the educational curriculum can improve learning outcomes and facilitate a more adaptive learning approach. Thus, the IoT consol learning device at Spada provides a comprehensive learning structure and supports innovation in the educational process based on the latest technological developments.

CONCLUSION

This research has developed a product in the form of an Internet of Things control solution (IoT consol) learning program in the physics learning media course. The learning program that has been developed includes lesson plans, modules, student worksheets, and assessment sheets. The results of this study indicate that the learning program developed is considered to have met the overall eligibility standards, reaching a percentage value of 93%, which is a very good criterion. The results of student responses obtained a percentage of 77.77% in the good category. The data interpretation results conclude that the IoT consol learning program is feasible to be used in physics learning media courses.

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https://doi.org/10.29303/jwd.v5i2.228