DOI: https://doi.org/10.33487/edumaspul.v9i1

EDUMASPUL
JURNAL PENDIDIKAN

Vol 09 No. 01 (2025) page 236-241

p-ISSN 2548-8201 | e-ISSN 236-0469
https://ummaspul.e-journal.id/maspuljr/

Validation of Educational Robotic-Based Work and Energy Learning Module using Structured Inquiry Model to Improve Students' Concept Comprehension

Astri Juwita Siregar[1*]; Wawan Kurniawan[2]; Cicyn Riantoni[3]; Hebat Shidow Falah[4]
Department of Physics Education, FKIP, Universitas Jambi[1,2,3,4]
astrijuwita363@gmail.com

Receive: 20/06/2025	*Accepted: 20/07/2025*	*Published: 01/10/2025*

Abstrak

Rendahnya pemahaman konsep siswa terhadap materi Usaha dan Energi mengakibatkan kesulitan siswa dalam menghubungkan teori dengan praktik nyata, serta kurangnya kemampuan siswa untuk mengaplikasikan konsep usaha dan energi dalam pemecahan masalah. Selain itu, penggunaan teknologi berupa *robotic* dapat meningkatkan keterlibatan siswa dalam proses pembelajaran dan membantu siswa memahami konsep-konsep abstrak melalui pengalaman praktis Pengembangan ini bertujuan untuk menghasilkan produk berupa modul pembelajaran Usaha dan Energi berbasis *Educational Robotics* dengan model Inkuiri Terstruktur sebagai solusi dari permasalahan tersebut. Tujuan dari penelitian ini adalah untuk mengetahui studi awal dan kevalidan modul. Model yang pengembangan yang digunakan adalah model pengembangan ADDIE. Teknik analisis data yang digunakan adalah metode spiral dan analisis statistik deskriptif kuantitatif. Berdasarkan data yang telah dianalisis terdapat dua hasil penelitian. Pertama, pada tahap analisis kebutuhan dilakukan wawancara dengan pendidik. Kedua, hasil validasi oleh ahli media sebesar 87,05% dengan kategori sangat valid dan hasil validasi oleh ahli materi sebesar 90,35% dengan kategori sangat valid. Hasil penelitian ini menyimpulkan bahwa modul pembelajaran Usaha dan Energi berbasis *Educational Robotic* dengan model Inkuiri Terstruktur valid digunakan dalam pembelajaran.

Kata Kunci: Model ADDIE; *Educational Robotic*; Modul Pembelajaran Usaha dan Energi; Inkuiri Terstruktur; Pemahaman Konsep

Abstract

Students' poor understanding of the concepts of work and energy leads to students' difficulties in connecting theory to practice, as well as students' lack of ability to apply the concepts of work and energy in problem solving. In addition, the use of robotic technology can increase student involvement in the learning process and help students understand abstract concepts through practical experience. This development aims to produce a product in the form of an Educational Robotics-based Work and Energy learning module using a Structured Inquiry model as a solution to these problems. The purpose of this research is to determine the initial study and validity of the module. The development model used is the ADDIE development model. The data analysis technique used is the spiral method and quantitative descriptive statistical analysis. Based on the data analysed, there are two research findings. Firstly, interviews were conducted with educators at the needs analysis stage. Secondly, the results of validation by media experts were 87,05% with a very valid category and the results of validation by material experts were 90,35% with a very valid category. The results of this study conclude that the Educational Robotics-based Work and Energy learning module with the Structured Inquiry model is valid for use in learning.

***Keywords**: ADDIE model; Educational Robotic; Work and Energy learning module; Structured Inquiry; Concept Comprehension.*

Introduction

Work and energy are fundamental concepts in understanding the application of physics to a variety of human activities as well as the transformation of objects into finished products known as technological results (Lusiani et al., 2021). This concept serves as an important foundation for the development of technology, as every piece of technology produced requires a work to produce energy to support its operation. A deep understanding of this concept is necessary to master the basic principles that govern the interaction of energy and motion in everyday life and in various technological applications. A strong understanding will prepare students for the technological challenges of the future.

Concept comprehension of work and energy is very important in strengthening students' physics knowledge base and increasing interest and motivation to learn (Eliza et al., 2022). Research shows that students with good comprehension tend to have higher learning outcomes. In addition, this understanding is also related to self-efficacy, where belief in one's own abilities can increase motivation to learn and solve more complex physics problems (Fatonah, 2024). Thus, a strong concept comprehension of work and energy not only improves academic performance but also builds a positive attitude towards learning.

Based on the results of interviews with science teachers at SMP Xaverius 1 Kota Jambi, it shows that students' understanding of work and energy still needs to be improved, especially in basic concepts such as displacement speed and force. Current learning methods, such as PhET simulations, discussions, and lectures, are quite effective, but still require additional interactive approaches. Teachers are interested in Educational Robotic-based modules as a new innovation that can enhance students' learning experience. The learning model varies, but the inquiry model is considered the most suitable for this material, and teachers believe the integration of Educational Robotic will be well received by students.

Previous research shows various effort to improve concepts comprehension of work and energy through the development of e-modules. Berutu & Ginting (2023) research about developed an Edmodo-based e-module that proved effective in improving student understanding through an interactive approach. In addition, the research of Ni & Widodo (2022) showed that the PhET-assisted structured inquiry model effectively improved students' concept comprehension of electricity concepts as well as developing critical thinking and problem-solving skills. This approach can be adapted in modules with the addition of Educational Robotic to enrich the learning experience and encourage innovative use of technology at the SMP level.

To support interactive learning, systematically designed modules are required. Modules are printed teaching materials that are systematically designed with language that is appropriate for the level of understanding and age of learners, so that they can be used for independent learning with little guidance from educators (Bustomi, 2018). The learning module structure includes material description, learning objectives, benefits, and competencies achieved. The module is also equipped with interactive materials, exercises, assignments, case studies, reflections, and evaluations to measure learning achievement (Kosasih, 2020). The learning module developed based on Educational Robotic stimulates systematic and structured thinking in solving a problem.

Educational Robotic is a device that combines mechanical and electronic units, as well as the ability to detect data through sensors and provide responses according to the code written. This robot is used to create an interactive learning environment and software that supports robot programming (Bilgi et al., 2023). To program the robot, the mBlock software is required. mBlock is a programming software developed from Scratch, specifically designed to facilitate programming for beginners using graphical blocks (Chin et al., 2019). With features such as support for various Arduino boards and the ability to integrate advanced technologies, mBlock facilitates the understanding of programming concepts and the application of process control in an intuitive and interactive way.

The integration of a structured inquiry model in the learning module enables students to learn science facts and concepts in depth (Soleh, 2018). This model allows students to conduct exploration and investigation with clear guidance from the teacher, so that students can construct their own understanding through directed activities (Zulfiani et al., 2016). The structured inquiry model follows systematic and purposeful steps, involving problem identification, hypothesis formulation, experiment design and execution, data analysis, and conclusion formulation and presentation (Wijayanto, 2019).

Through this approach, students not only understand the material conceptually but also practice critical thinking and problem-solving skills that are essential in science learning.

The Educational Robotic-based Work and Energy learning module using structured inquiry model helps students' concepts comprehension through real problems. This research is needed to develop teaching materials that are interesting and interactive in the learning process. The interactive process is needed because it can clarify the material taught through an interesting robot. This research aims to develop and test the validity of Educational Robotic-based interactive learning modules on the subject of Work and Energy.

Method

The development model used is the ADDIE development model (*Analysis*, *Design*, *Develop*, *Implementation and Evaluation*). The ADDIE development model cycle according to Mariam & Nam (2019) is:

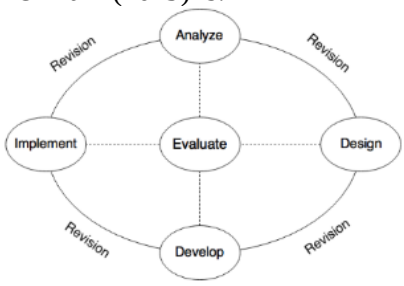

Figure 1 ADDIE's Cycle

The first stage of this research is a needs analysis in the form of curriculum and material analysis, and analysis of the results of interviews with educators. The second stage is design in the form of designing an Educational Robotic-based Work and Energy learning module. The learning module is designed in printed form. The learning module is designed with a structured inquiry model. The structure of the learning module is cover, preface, table of contents, table of tables, introduction, introduction of Roblock device, introduction of mBlock device, learning objectives, benefits and relevance, competencies achieved after using the module, main part, and cover. The design of this learning module will be made interactive such as providing illustrations and videos that can be accessed through links and barcodes. The third stage of this research is develope in the form of module content development based on the design that has been made. Furthermore, making module prototypes in printed format in accordance with the components that will be contained in the module. This prototype will go through a module prototype validation test which includes material and media validation with the aim of ensuring that the module is appropriate in content, clear in its delivery, and visually appealing. The fourth stage is evaluation which is carried out at each stage, namely at the analysis, design and development stages. Evaluation aims to ensure the quality and success in achieving the set goals.

The analysis technique in this research uses the spiral method and quantitative descriptive analysis. The spiral method is used to analyze the results of the module needs interview. While quantitative descriptive analysis is used to analyze the results of the module validation questionnaire by material experts and media experts. In addition, the module validity value category based on the percentage and module assessment criteria ranges from 0% to 20% in invalid criteria, 21% to 40% in the less valid category, 41% to 60% in the moderately valid category, 61% to 80% in the valid category and 81% to 100% in the very valid category (Anggraini & Nelmira, 2023).

Result and Discussion

Needs Analysis

The first needs analysis is in the form of curriculum and material analysis which focuses on the independent curriculum, in order to find out the learning outcomes and learning objectives demanded by the curriculum in science subjects, especially on the material of work and energy. Furthermore, material analysis is carried out to assess the depth and breadth of work and energy material taught in class VIII SMP, so that the module can be adjusted to the level of student understanding. Researchers used literature study techniques to collect secondary data related to previous research, the depth and breadth of work and energy material, as well as curriculum information used from various written sources such as books, scientific articles, proceedings and curriculum documents from the Kemendikbud related to module development.

The second needs analysis was in the form of interviews with science teachers at SMP Xaverius 1 Kota Jambi using the spiral method using the attached semi-structured interview sheet with 10 indicators, namely indicators of student understanding, learning methods and tools, integration of technology and robotics, potential learning innovations, learning media,

challenges in learning, student responses, readiness and expectations, further participation and educator background. The results of the needs analysis with the spiral method are described in the following table:

Table 1 Interview results with the spiral method

Stage	Activity	Main Categories
Data Collection	Interview	Student comprehension difficulties
Data Organization	Categorizing interview data based on main themes	Use of technology and robotics
Reading and Decoding Data	Finding patterns from teachers' answers regarding challenges in learning	Challenges in learning methods
Interpretation and Reflection	Making interpretations of the data that has been parsed, then formulating hypotheses based on the main relationships	Support for robot-based interactive learning

The hypotheses built based on the category relationship are as follows:

1. Hypothesis 1: If the Educational Robotic-based module is applied in learning work and energy, it will help students recall the concept of quantities that are often forgotten, because learning is based on direct practice.
2. Hypothesis 2: The use of interactive technology such as robots in the inquiry module will increase the interest of students who have been less interested in virtual technology such as PhET, because robots offer a more interesting practical experience.
3. Hypothesis 3: Educational Robotic-based inquiry learning can overcome the challenges of traditional learning methods that have been perceived as less effective, by increasing students' active involvement in finding solutions and conducting hands-on experiments.

Description of Educational Robotics-based Work and Energy Learning Module using Structured Inquiry Model

The next research result is product description. The product developed is the Educational Robotics-based Work and Energy Learning module using Structured Inquiry Model to improve students' concept comprehension. The module is designed based on the module writing structure. The following is the result of the module cover which can be seen in Figure 2.

Figure 2 Module's Cover

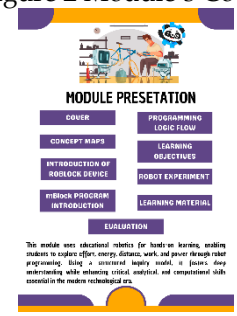

Figure 3 Module's Preset

On the cover of the module there is the Merdeka curriculum logo, the Kemendikbud logo, title, author, and class. This teaching material is provided for SMP in Class VIII semester 2. The appearance of the module is made as attractive as possible by balancing colors and providing animations that describe the contents of the module. On the cover of the module there is a picture of a robot that helps humans in doing work. The picture represents the material of Work and Energy that will be studied. The module contains a preface, table of contents, table of tables, introduction, introduction of Roblock device, introduction of mBlock device, learning objectives, benefits and relevance, competencies achieved after using the module, main part, and cover. In addition, the integration of robots in learning is in the form of experiments that can explain the concepts of effort and energy. The robot is programmed with mBlock software according to the experimental steps contained in the module. The following is an example of visualisation and robot programming to explain the concept of Work:

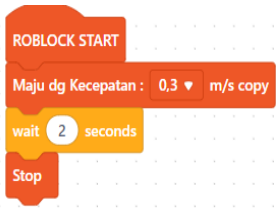

Figure 4 Block Programming

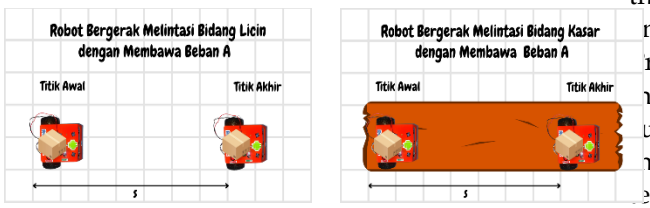

Figure 5 Programming visualisations

In Figure 4 there is a 'Roblock Start' block that serves as a sign of programming to begin. Followed by the 'Maju dg Kecepatan 0.3 m/s and Wait 2 seconds' block signifies that the robot will move forward at that speed for 2 seconds. Finally, the 'Stop' block stops the robot's movement. Based on the arrangement of these blocks, the robot will move according to the programming visualised in Figure 5. In this experiment, students were asked to program the robot and measure the distance travelled by the robot during the specified time interval and speed. This experiment helps students to program and run the robot directly so that they can see the concept of effort in real life with the help of robots.

The integration of the structured inquiry model in the module can be seen in the experiments using robots that follow the syntax of structured inquiry where in this approach, students are guided through each step of the experiment, starting from initial observations to drawing conclusions based on the data obtained. By utilizing the robot as a direct experimental tool, students not only strengthen their understanding of the theory, but also develop critical thinking skills, creativity, and problem-solving abilities.

Validity of Educational Robotics-based Work and Energy Learning Module using Structured Inquiry Model

The results of the validation of the Educational Robotics-based Work and Energy Learning module using Structured Inquiry Model to Improve Student Concept Comprehension were carried out by 3 lecturers with very valid criteria. The aspects assessed in material validation are aspects of content feasibility, aspects of presentation feasibility and aspects of language feasibility. Content feasibility is a test of content or material validity, including the suitability of the material with CP (Learning Outcomes), the accuracy of the material, the currency of the material, encouraging curiosity, finding and explaining strategies in solving problems, expressing ideas through oral or written, evaluating arguments, nd solving a problem in various ways. resentation feasibility is a validity test that ncludes presentation techniques, presentation upport and coherence and conciseness of nought flow. Language feasibility is a validity est which includes straightforward, communicative, dialogical and interactive, conformity with language rules and the use of notation and symbols.

The aspects assessed in media validation are aspects of content feasibility and development components. Content feasibility is a validity test that includes the composition of the module in accordance with the objectives, the use of proportional text and graphics, the attractiveness of layouts, the selection of attractive colors, the harmony of text and graphics, the product helps develop the reader's knowledge, the product is informative to the reader, and over all the module product fosters the reader's curiosity. The development component is a validity test which includes consistency of systematic presentation in chapters, logicality of presentation and conciseness of concepts, coherence of substance between chapters, balance of substance between chapters, suitability and appropriateness of illustrations with material, suitability of images and captions, and the existence of reference sources. The validation results can be seen in tables 2 and 3 below:

Table 2 Module Validation Results by Material Experts

Aspects assessed	Validity Result (%)	Category
Content Feasibility	90,63	Very Valid
Presentation Feasibility	86,67	Very Valid
Language Feasibility	93,75	Very Valid
Total average	90,35	Very Valid

The overview of the table above, it can be concluded that the three aspects of assessment on the validity of the material can be described as

follows: 1) Content feasibility of 90,63% very valid category, 2) Presentation feasibility with a score of 86,67% very valid category, and 3) Language feasibility with a score of 93,75% very valid category. So that the overall average is 90,35% in the very valid category.

Table 3 Module Validation Results by Media Expert

Aspects assessed	Validity Result (%)	Category
Content feasibility	81,25	Very Valid
Development Components	92,85	Very Valid
Total Average	87,05	Very Valid

The overview of the table above, it can be concluded that the three aspects of assessment on media validity can be described as follows: 1) Content feasibility of 81,25% very valid category, and 2) Presentation component with a score of 92,85% very valid category. So that the overall average is 87,05% in the very valid category. So that the combined results between the media validation table and material validation can be seen the validity of the Work and Energy learning module is 88,7% in the Very Valid category.

Conclusion

ADDIE development research model that produces teaching materials in the form of Work and Energy learning modules. Based on the research that has been done, it can be concluded that the Educational Robotics-based Work and Energy learning module using Structured Inquiry Model to Improve Students' Concept Comprehension which was tested to media expert validators obtained a score of 87,05% with a very valid category, material expert test 90,35% with a very valid category, so that the final score of validation of the Educational Robotics-based Work and Energy learning module using Structured Inquiry Model with a score of 88,7% very valid category. Based on this, the Educational Robotics-based Work and Energy learning module using Structured Inquiry Model is suitable for use in science subjects in class VIII SMP.

References

Anggraini, S., & Nelmira, W. (2023). Validitas Media E-Modul Pembuatan Gaun Pesta untuk Siswa Kelas XI di SMKN 3 Kota Solok. *Jurnal Pendidikan Tambusai*, *7*(1), 1168–1172. https://doi.org/10.31004/jptam.v7i1.5403

Berutu, Y. N., & Ginting, E. M. (2023). Pengembangan E-Modul Berplatform Edmodo Pada Materi Usaha dan Energi di Kelas X Semester II SMA Negeri 7 Medan T.P 2020/2021. *Jurnal Ikatan Alumni Fisika*, *8*(3), 50. https://doi.org/10.24114/jiaf.v8i3.32696

Bilgi, Ö., Düşünme, İ., Etkisi, B., & Küçük, D. K. (2023). The Use of Educational Robots in Coding Education for Special Skilled Students. *Journal of Ahmet Kelesoglu Education Faculty*, *5*, 1536–1555.

Bustomi, A. H. (2018). Pengembangan Modul Pembelajaran Fisika Sma Berbasis Contextual Teaching And Learning Pada Materi Suhu, Kalor Dan Perpindahan Kalor Untuk Meningkatkan Hasil Belajar Siswa. *Seminar Nasional Fisika 2018*, *3*, 2527–5917.

Chin, W. C., Su, Y. H., & Meng, H. W. (2019). Use Arduino and the Mblock as the Process Control of Innovation Study Tool: Case Study of freshmen of University. *International Journal of Trend in Scientific Research and Development*, *4*(1), 774–779.

Eliza, N., Tandililing, E., & Hidayatullah, M. M. S. (2022). Analisis Kemampuan Pemahaman Konsep Fisika Terhadap Minat Dan Motivasi Belajar Peserta Didik Pada Materi Usaha Dan Energi Kelas X Di Sma Negeri 6 Pontianak. *Jurnal Inovasi Penelitian Dan Pembelajaran Fisika*, *3*(1), 43. https://doi.org/10.26418/jippf.v3i1.49183

Fatonah, U. (2024). *Pengaruh Efikasi Diri Dan Motivasi Siswa Sma Terhadap Pemahaman Konsep Pada Materi Usaha Dan Energi*. Universitas Jambi.

Kosasih, E. (2020). *Pengembangan Bahan Ajar* (B. S. Fatmawati (ed.)). PT. Bumi Aksara.

Lusiani, Muliawan, A., Ratnadewi, Satria, E., Taba, H. H. T., Tanwir, Siregar, J., Yani, A., Nugraha, A. S. A., & Widyastuti, H. (2021). *Fisika Terapan*. Zahir Publishing.

Ni, M., & Widodo, W. (2022). Penerapan Model Pembelajaran Inkuiri Terstruktur Berbantuan Virtual- Laboratory phET Untuk Meningkatkan Pemahaman Konsep Listrik Dinamis. *Pendidikan Sains*, *10*(2), 296–304.

Soleh, R. (2018). Pengaruh Penerapan Model Pembelajaran Inkuiri Terstruktur Terhadap

Keterampilan Proses Sains Dan Hasil Belajar Siswa Pada Materi Jaringan Tumbuhan Di Kelas XI MAN 3 Bireuen. *JESBIO*, *VII*(1), 13–16.

Teguh Wijayanto. (2019). Implementasi Model Pembelajaran Inkuiri Terstruktur untuk Meningkatkan Kemampuan Scientific Explanation Siswa SMA. *Jurnal Integrasi Pendidikan, Sains, Dan Teknologi Dalam Mengembangkan Budaya Ilmiah Di Era Revolusi 4.0*, *4*(1), 265–270.

Zulfiani, Z., Octaviana, H., & Miranto, S. (2016). Perbedaan Keterampilan Generik Sains Antara Siswa Yang Menggunakan Model Pembelajaran Inkuiri Terstruktur Dengan Siswa Yang Menggunakan Model Pembelajaran Inkuiri Terbimbing Pada Konsep Sel. *Edusains*, *7*(2), 185–190. https://doi.org/10.15408/es.v7i2.1405

Anggraini, S., & Nelmira, W. (2023). Validitas Media E-Modul Pembuatan Gaun Pesta untuk Siswa Kelas XI di SMKN 3 Kota Solok. *Jurnal Pendidikan Tambusai*, *7*(1), 1168–1172. https://doi.org/10.31004/jptam.v7i1.5403

Berutu, Y. N., & Ginting, E. M. (2023). Pengembangan E-Modul Berplatform Edmodo Pada Materi Usaha dan Energi di Kelas X Semester II SMA Negeri 7 Medan T.P 2020/2021. *Jurnal Ikatan Alumni Fisika*, *8*(3), 50. https://doi.org/10.24114/jiaf.v8i3.32696

Bilgi, Ö., Düşünme, İ., Etkisi, B., & Küçük, D. K. (2023). The Use of Educational Robots in Coding Education for Special Skilled Students. *Journal of Ahmet Kelesoglu Education Faculty*, *5*, 1536–1555.

Bustomi, A. H. (2018). Pengembangan Modul Pembelajaran Fisika Sma Berbasis Contextual Teaching And Learning Pada Materi Suhu, Kalor Dan Perpindahan Kalor Untuk Meningkatkan Hasil Belajar Siswa. *Seminar Nasional Fisika 2018*, *3*, 2527–5917.

Chin, W. C., Su, Y. H., & Meng, H. W. (2019). Use Arduino and the Mblock as the Process Control of Innovation Study Tool: Case Study of freshmen of University. *International Journal of Trend in Scientific Research and Development*, *4*(1), 774–779.

Eliza, N., Tandililing, E., & Hidayatullah, M. M. S. (2022). Analisis Kemampuan Pemahaman Konsep Fisika Terhadap Minat Dan Motivasi Belajar Peserta Didik Pada Materi Usaha Dan Energi Kelas X Di Sma Negeri 6 Pontianak. *Jurnal Inovasi Penelitian Dan Pembelajaran Fisika*, *3*(1), 43. https://doi.org/10.26418/jippf.v3i1.49183

Fatonah, U. (2024). *Pengaruh Efikasi Diri Dan Motivasi Siswa Sma Terhadap Pemahaman Konsep Pada Materi Usaha Dan Energi*. Universitas Jambi.

Kosasih, E. (2020). *Pengembangan Bahan Ajar* (B. S. Fatmawati (ed.)). PT. Bumi Aksara.

Lusiani, Muliawan, A., Ratnadewi, Satria, E., Taba, H. H. T., Tanwir, Siregar, J., Yani, A., Nugraha, A. S. A., & Widyastuti, H. (2021). *Fisika Terapan*. Zahir Publishing.

Ni, M., & Widodo, W. (2022). Penerapan Model Pembelajaran Inkuiri Terstruktur Berbantuan Virtual- Laboratory phET Untuk Meningkatkan Pemahaman Konsep Listrik Dinamis. *Pendidikan Sains*, *10*(2), 296–304.

Soleh, R. (2018). Pengaruh Penerapan Model Pembelajaran Inkuiri Terstruktur Terhadap Keterampilan Proses Sains Dan Hasil Belajar Siswa Pada Materi Jaringan Tumbuhan Di Kelas XI MAN 3 Bireuen. *JESBIO*, *VII*(1), 13–16.

Teguh Wijayanto. (2019). Implementasi Model Pembelajaran Inkuiri Terstruktur untuk Meningkatkan Kemampuan Scientific Explanation Siswa SMA. *Jurnal Integrasi Pendidikan, Sains, Dan Teknologi Dalam Mengembangkan Budaya Ilmiah Di Era Revolusi 4.0*, *4*(1), 265–270.

Zulfiani, Z., Octaviana, H., & Miranto, S. (2016). Perbedaan Keterampilan Generik Sains Antara Siswa Yang Menggunakan Model Pembelajaran Inkuiri Terstruktur Dengan Siswa Yang Menggunakan Model Pembelajaran Inkuiri Terbimbing Pada Konsep Sel. *Edusains*, *7*(2), 185–190. https://doi.org/10.15408/es.v7i2.1405

Curriculum Vitae

The author is a student at Universitas Jambi, Indonesia. The author research focuses on science and educational technology. The author is actively involved in writing and developing innovative learning modules aligned with the current curriculum and is interested in integrating technology to support interactive and effective learning processes.