Momentum: Physics Education Journal
8 (2), 2024, 270-280
Available at: ejournal.unikama.ac.id/index.php/momentum
ISSN 2548-9127(print) | 2548-9135 (online)

Integration of physics learning content in the context of automatic machine design of fish feed throwers based on solar cells arduino IoT system

Rendy Wikrama Wardana[1]*, Yestilia Anggraini[2], M. Lutfi Firdaus[2], Fitri April Yanti[1], Elsi Adelia Fitri[3]

[1]Doctoral Education Study Program, FKIP, Universitas Bengkulu, Bengkulu, Indonesia, 38225
[2]Master Science of Education Study Program, FKIP, Universitas Bengkulu, Bengkulu, Indonesia, 38225
[3]Science of Education Study Program, FKIP, Universitas PGRI Palembang, Palembang, Indonesia, 30116
e-mail: rendywardana@unib.ac.id
* Corresponding Author.

Received: 5 February 2024; Revised: 11 May 2024; Accepted: 10 June 2024

Abstract: The utilization of aquaculture, especially in freshwater fish farming potential, is still not optimal. In general, fish feeding is still done manually and depends on human resources which is done simply. So an automatic fish feed thrower based on solar cells was designed to minimize the risk of delays in feeding fish. This innovation can be integrated in learning where it is adapted to physics content. This research uses a mix of methods with data collection techniques in the form of observations related to the surrounding environment and the learning process, documentation in the form of learning tools such as syllabus, lesson plans, curriculum, documentation, questionnaires, testing feed machine tools and literature studies. This research instrument is in the form of descriptive observation sheets, observation analysis sheets testing feed machine tools. Analytical techniques in this study use descriptive, qualitative and quantitative analysis techniques. The results of this research are in the form of content integration in physics learning in the context of designing a solar cell-based automatic fish feed throwing machine consisting of 6 physics contents that are adapted to the context of solar cell-based automatic fish feed throwing machines. The results of this study show that the application of the use of an automatic machine for throwing fish feed based on solar cells can be used as a source of learning, especially in physics subjects.
Keywords: automatic fish feed throwing machine, arduino, learning, physics content, solar cell.

How to Cite: Wardana, R. W., Anggraini, Y., Firdaus, M. L., Yanti, F. A., & Fitri, E. A. (2024). Integration of physics learning content in the context of automatic machine design of fish feed throwers based on solar cells arduino IOT system. *Momentum: Physics Education Journal*, *8*(2), 270-280. https://doi.org/10.21067/mpej.v8i2.9804

Introduction

The potential of fishery land in Indonesia is extraordinary, nationally estimated at 17.92 million ha consisting of freshwater aquaculture potential of 2.83 million ha, brackish water cultivation of 2.96 million ha and marine aquaculture of 12.12 million ha (Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, 2014). The utilization to date is only 11.32 percent for freshwater cultivation, 22.74 percent for brackish water aquaculture and 2.28 percent for marine aquaculture (Arrazy & Primadini, 2021). Some obstacles that are often faced by fish farmers in producing superior and quality products are the price of fish feed specifically for raw materials (fish meal) which continues to increase due to increasing demand (Hakim et al., 2020). In addition, constraints at the time of irregular fish feeding that cause inhibition of fish growth and breeding. In general, fish feeding is still done manually

DOI: 10.21067/mpej.v8i2.9804

and depends on human resources which is done simply by spreading fish feed directly into the pond. Sometimes when the cultivator has other activities in a long time so that feeding becomes delayed. Changes in the work system in all sectors today are inevitable, so the use of initially manual, mechanical then shifted to automation (Nulhakim, 2014). Automatic fish feed machine is one of the tools that can support fish production, with technological advances, this feed machine is made automatic. This automatic fish feed throwing machine can use Arduino Uno as a controlling brain. This machine can run and stop itself according to predetermined controls and programs.

Technology has a significant positive impact on education today (Sholeh et al., 2024). Technological innovations such as automatic fish feed throwing machines can be integrated into the world of education to support student skills where the skill aspect is one of the goals emphasized in the applicable curriculum in Indonesia. According to (Wahyuni, 2015) curriculum is the main tool used to achieve educational goals and as a reference for the educational process in Indonesia. The main curriculum used in Indonesia today is the 2013 curriculum but there are several driving schools initiated by the Ministry of Education, Culture, Research and Technology that are fostered to implement a special curriculum, namely the independent curriculum (Angga et al., 2022). Both the 2013 curriculum and the independent curriculum all complement each other to support the learning process.

The independent learning curriculum policy supports the world of education which aims to increase student creativity, problem solving and learning to be useful in the world of work (Firdaus et al., 2022). The application of a direct learning system that seems monotonous and boring, which has an impact on decreasing student learning motivation (Haryandi et al., 2024). In line with the objectives of the 2013 curriculum, namely to prepare Indonesian people to be productive, creative, innovative, and affective and able to contribute to community life (Sartika, 2019). Therefore, efforts to realize the objectives of the curriculum in schools that need to be developed, one of which is through the integration of physics learning content in the context of the design of automatic fish feed throwing machines based on solar cells, Arduino IoT systems. This activity is carried out in a trial or practicum. Where learning using practicum methods can increase students' understanding of concepts in understanding physics concepts (Renika et al., 2024).

The purpose of this study is to determine the form of integration of physics learning content in the context of the design of an automatic fish feed throwing machine based on solar cells Arduino IoT system which is expected to add information about physics learning content in the context of everyday life so as to supply the ability of students in community life.

Method

This study used the Mixed Method method (sequential explanatory designs). This type of research is divided into 3, namely sequential explanatory design, sequential exploratory designs, and concurrent triangulation designs (Sirnayatin, 2013). The population in this study is all 6th semester students at Bengkulu University for the 2022/2023 academic year. The subjects in this study were 52 6th semester students at Bengkulu University. Sampling in this study used purposive sampling techniques. The instrument trial was carried out on 26 6th semester students at Bengkulu University. Data collection techniques in the form of testing feed machine tools, observations related to the surrounding environment and learning process, documentation in the form of learning tools such as syllabus, lesson plans, curriculum, documentation, and literature studies. This research instrument is in the form of curriculum analysis observation sheets, feed machine tool testing observation sheets. Analytical techniques in this study use descriptive, qualitative, and quantitative analysis techniques.

Analysis of learning outcomes and learning materials

Analysis of the relationship between course learning outcomes (CLO) and solar cells in Applied Science learning, through semester learning plans. Based on the semester learning plan, the CLO that are considered the most relevant are Biodiesel material, Biogas and simple power plant technology.

Design of automatic feed thrower prototype

After knowing what material is suitable to be applied in this feeding machine, the next step is to design a prototype design of an automatic feed thrower. The design can be seen in the flowchart (Figure 1).

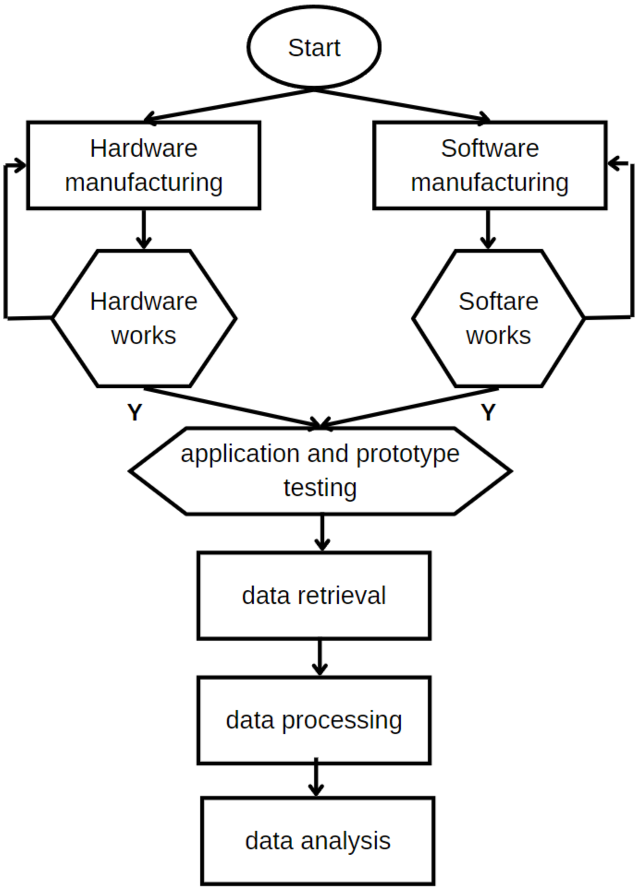

Figure 1. Flowchart Research Plan

This research plan starts from making hardware and software which will then be integrated with one another and will apply prototype testing then data collection, after the data is obtained it will be processed and analyzed.

Control System Testing

Analysis of this control system test is carried out to see the functioning of the tool and to ensure there is no possibility of troubleshooting the use process because it will greatly affect system performance.

Remote Operation Testing

This time and distance operation test aims to find out the time and distance of the feed throw.

Results and Discussion

Results of analysis of learning outcomes and learning materials

At this stage, an analysis is carried out related to the CLO used to achieve learning objectives. Furthermore, an analysis of the relationship between CLO and solar cells was carried out in Integrated Science learning, through a semester learning plan. Based on the semester learning plan, the CLO that are considered the most relevant are the simple power plant technology material illustrated in the Table 1.

Table 1. CLO and Applied Science Material

Course Learning Outcomes (CLO)	Material
• Students are able to analyze applied science studies in the context of Physics, Chemistry, Biology and Environment. • Students are able to collect and process the phenomenon of science concepts that can be applied in everyday life. • Students are able to make simple applications and practicum in integrating applied science in everyday life.	Biodiesel, Biogas and simple power generation technology.

The design result of the automatic feed thrower prototype

The results of the analysis of the design of the automatic feed thrower prototype are adjusted to the material of simple power plant technology that relies on solar cells as an alternative source of electrical energy. The prototype of the automatic feed thrower assembled in this study aims to be used as a learning medium, so that the learning carried out can be more contextual (Bossink, 2017). Therefore, the series and how to use are made as simple as possible so that students can understand. However, before assembling the tool components, software design was carried out on the arduino NodeMCU ESP8266 by coding in order to code the control system program which was continued in the ESP things application to set commands on automatic feed thrower control. Furthermore, the tool components will be assembled according to a predetermined circuit as in Figure 2.

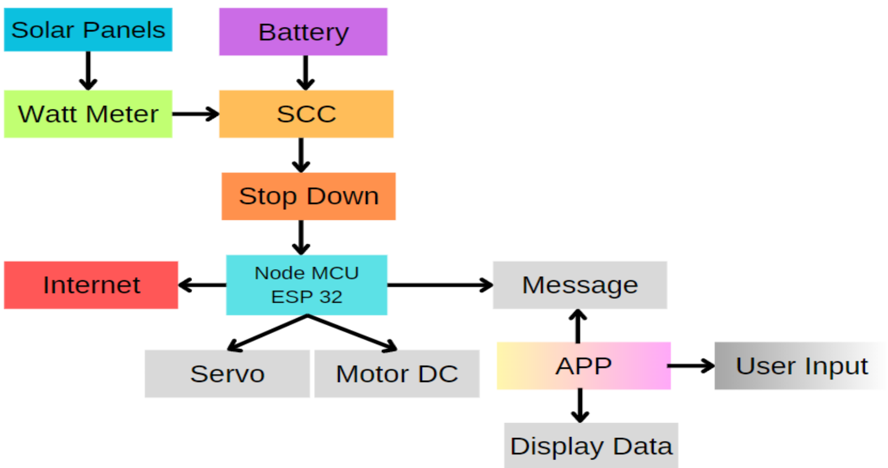

Figure 2. Prototype Series Design

This prototype design is sourced from solar panels where energy from solar panels will be flowed to the Solar Charger Controller (SCC) will be forwarded to step down and move the device to the Direct Current (DC) motor and servo to drive the feed machine after getting commands from the application using the internet network. Each component of the tool contained in the prototype design is designed as in Figure 3.

Figure 3. ***Automatic Feed Thrower Prototype***

Edaging research conducted by (Suryadi, 2021) entitled Design and Build Automatic Fish Feeding Machines Based on the Internet of Things and Solar Cells. In research conducted by suryadi, the automatic fish feeding machine still uses hardware in the form of Wimose D1 Mini which is the main controller. While the research conducted by researchers in this study is using the latest component, namely arduino NodeMCU ESP8266 which functions as a brain that regulates the control process, Arduino NodeMCU ESP8266 is directly connected to the internet network after being coded and adjusted all settings in the things Espressif Systems Platform (ESP) application and does not require additional components.

Tool component testing

Component testing on the tool is carried out to find out whether the measured parameters on each component work in accordance with the specifications and nameplates listed. In this measurement, the components measured are solar panels with variable current and voltage generated in 3 consecutive days. Data on voltage and current produced are recapitulated into a Table 2. Here are the data taken on December 15, 16 and 17, 2022:

Table 2. Tool Component Test Results

No.	Time	Day One		Day Two		Day Three	
		Ampere (A)	Voltage (V)	Ampere (A)	Voltage (V)	Ampere (A)	Voltage (V)
1	08.00	1.72	28.2	0.98	33.1	0.6	33.1
2	10.00	2.62	34.4	2.23	35.5	2.38	35.5
3	11.00	3.44	38.8	3.2	34.5	0.5	39.89
4	12.00	3.46	38.9	3.25	34.24	1.12	39.8
5	14.00	2.55	35.3	2.77	39.4	2.18	39.85
6	16.00	1.49	37.8	0.53	39.74	2.1	25.24
Average		2.55	35.57	2.16	36.08	1.48	35.58
Standard Deviation		0.83	4.06	1.2	2.8	0.84	6.47

Based on the table above, the test results of the components of the tool in the form of solar panels obtained the highest current at 12.00 with a current of 3.46 Amperes. The lowest current was obtained at 16:00 with a current of 1.49 Amperes. On the first day, the average current produced by solar panels at 08.00 to 16.00 is 2.55 Amperes. In addition, the highest voltage was obtained at 12.00 with a voltage of 38.9 Volts. The lowest voltage is obtained at 08.00 with a voltage of 28.2 Volts. On the first day, the average voltage produced by solar panels at 08.00 to 16.00 is 35.57 Volts. A relatively small standard deviation in current when compared to the resulting standard deviation in voltage. This is due to the difference in weather that is very different in the morning to noon, especially at 12:00 with the afternoon at 16:00 with the weather that is already covered by clouds. Unlike the case with voltage that has a low standard deviation when compared to the average voltage. This indicates that the electrical voltage produced by solar panels is not so affected by the weather (Bengtsson, 2011).

From the table on day 2 on the test results of tool components in the form of solar panels, the highest current was obtained at 12.00 with a current of 3.25 Amperes. The lowest current was obtained at 16:00 with a current of 0.53 Amperes. On the second day, the average current produced by solar panels at 08.00 to 16.00 is 2.16 Amperes. In addition, the highest voltage was obtained at 16.00 with a voltage of 39.74 Volts. The lowest voltage is obtained at 08.00 with a voltage of 33.1 Volts. On the second day, the average voltage produced by solar panels at 08.00 to 16.00 is 36.08 Volts. A relatively small standard deviation in current when compared to the resulting standard deviation in voltage. This is due to very different weather differences in the morning to noon, especially at 12:00 when the afternoon is at 16:00 with the weather that is already cloudy and covered by clouds. Unlike the case with voltage that has a low standard deviation when compared to the average voltage (Bell & Lowe, 2000). This indicates that the electrical voltage produced by solar panels is not so affected by the weather.

Furthermore, on the third day of the test results of the tool components in the form of solar panels, the highest current was obtained at 14.00 with a current of 2.18 Amperes. The lowest current is obtained at 11:00 with a current of 0.5 Amperes. On the third day, the average current produced by solar panels at 08.00 to 16.00 is 1.48 Amperes. In addition, the highest voltage was obtained at 11.00 with a voltage of 39.89 Volts. The lowest voltage is obtained at 16.00 with a voltage of 25.24 Volts. On the third day, the average voltage produced by solar panels at 08.00 to 16.00 is 35.58 Volts. A relatively small standard deviation in current when compared to the resulting standard deviation in voltage. This is due to the difference in weather that is very different in the morning which already shows that it will be cloudy until the afternoon and covered by clouds. Unlike the case with voltage that has a low standard deviation when compared to the average voltage. This indicates that the electrical voltage produced by solar panels is not so affected by the weather (Bates & Firestone, 2015).

From the results of testing the components of the 3-day diving equipment, it can be concluded that the absorption of solar energy is vulnerable from 11:00 to 14:00 is the optimal time for absorption. This is in line with (Nurdiansyah et al., 2020) stating that the sun is right above the daily solar circulation between 11.00-14.00 where at that time the absorption of solar energy is at optimal conditions. After analysis from the first, second and third days, it was found that the electric current generated by solar panels is influenced by weather, and makes the power generated vary, depending on the current generated. Because the weather is constantly changing, most solar cells do not function in ideal conditions (Singh et al., 2008). Many external influences determine the efficiency of PV energy conversion, including the reflectivity of light on the cell surface, which varies from one type to another. There is also an angle of fall of solar radiation on cells (Jeng et al., 2009; Chow et al., 2012). In addition, there are also other influencing factors, namely the wavelength of radiation that falls, due to the effectiveness of energy conversion due to changes in the spectrum of sunlight (Chakraborty et al., 2014; Skoplaki & Palyvos, 2009; Ndiaye et al., 2013; Chamoun & Chakroun, 2014). All research trials that have been conducted from (Singh & Ravindra, 2012; Dai & Ma, 2004) show higher temperatures are associated with increased intensity of solar radiation.

In addition, the voltage produced has a relatively small standard deviation, indicating that the electrical voltage produced by solar panels is not so affected by weather changes and time affects the level of light intensity that enters according to theory at 14:00 is the highest temperature on the surface of the earth (Chan et al., 2016; Codani et al., 2015).

Control system testing

Analysis of this control system test is carried out to see the functioning of the tool and to ensure there is no possibility of troubleshooting in the use process because it will greatly affect system performance. Here's the control system testing in Table 3.

Table 3. Control System Test Results

Types of I/O	Component	Attempt to - (Good/Not good)				
		1	2	3	4	5
Input	SCC	√	√	√	√	√
	Wattmeter	√	√	√	√	√
	DC Motor	√	√	√	√	√
Output	Network	√	√	√	√	√
	Relay Module	√	√	√	√	√
	Arduino	√	√	√	√	√

As seen in the table above, the results of testing on the control system on tool components as many as 5 experiments. This is done in order to find out whether the components of the device such as solar charger controller (SCC), watt meter and DC motor as input as well as network, relay module and Arduino used really function properly as planned, which can turn on automatically when connected to the internet network and can also be turned on manually (Boyd et al., 2013).

Based on the test table of the control system the results obtained during 5 experiments are good, meaning that the components of the tool used can function according to their respective functions.

Distance Operating Testing

This time and distance operation test aims to determine the time and distance of feed throwing which ranges from 7 cm -142 cm. The operating test results for throwing time and distance are in Table 4.

Table 4. Throwing Time and Distance Operation Test Results

Testing to-	Time(s)	Minimum Distance (cm)	Max Distance (cm)
1	5	7	92
2	10	8	120
3	15	10	131
4	20	12	142

Based on the table of test results and the operation of the time and distance of fish feed plates can be seen in the 1st test with a time of 5 seconds, a minimum distance of 7 cm and a maximum distance of 92 cm are produced. In the 2nd test with a time of 10 seconds, a minimum distance of 8 cm and a maximum distance of 120 cm was produced. In the 3rd test with a time of 15 seconds, a minimum distance of 10 cm and a maximum distance of 131 cm was produced. In the 4th test with a time of 20 seconds, a minimum distance of 12 cm and a maximum distance of 142 cm were produced. This means that it can be concluded that time affects the distance of throwing fish feed where the longer it takes to throw fish feed, the longer the distance to throw the fish feed and also the longer the time, the more fish feed bait will be produced (Bai et al., 2014).

Content Analysis in Physics learning in the Context of Solar Cell-Based Fish Feed Thrower Automatic Machine Design

The integration of physics learning content in the context of the design of an automatic fish feed thrower machine based on solar cells Arduino IoT system The concept of the tsunami disaster can be packaged into the form of learning as teaching materials that can be inserted in the context of the design of solar cell-based feed thrower automatic machines that are adjusted between basic competencies and physics content. The analysis is based on the 2013 Curriculum syllabus for physics subjects grade X, XI and XII. Based on the results of syllabus analysis related to the most relevant physics content to be integrated in the context of the design of an automatic feed throwing machine, namely as in the Table 5.

Table 5. of Physical Content Analysis in the Context of Feed Machine Design

No.	Basic Competencies	Physics Content Analysis	Analysis of Physical Content in the Design Context of Solar Cell-Based Fish Feed Throwing Automatic Machine
1	3.5. Analyzing parabolic motion using vectors, along with their physical meaning and application in everyday life 4.5. Presenting data on the results of parabolic motion experiments and their physical meanings	Parabolic motion: • Parabolic Motion • Utilization of Parabolic Motion in Daily Life	• Throwing feed produced from a feed throwing machine where the resulting trajectory is in the form of parabolic motion with a certain angle • Angular velocity of fish feed throwing • Centripetal force generated when the machine throws feed
2	3.1 Analyze the working principle of unidirectional electrical (DC) equipment and its safety in daily life 4.1 Conducting experiments on the working principle of direct electric circuits (DC) with scientific methods following the presentation of experimental results	Direct current circuit: • Electric current and its measurement • Ohm's Law • Electric current in a closed circuit • Bottleneck series • Combined sources of mains voltage • Energy and electrical power	• The use of current and voltage in automatic fish feed throwing machines • The electric current produced by solar panels and making the power generated varies, depending on the current generated. • Voltage generated from solar panels • Energy and power generated through solar panels by automatic fish feed throwing machines
3	3.2 Analyze electric charge, electric force, electric field strength, flux, electric potential, electric potential energy and their application to various cases 4.2 Conduct experiments following the presentation of the results of electrical experiments (e.g. charging and discharging capacitors) and their benefits in everyday life	Static Electricity (Electrostatics): • Static electricity and electric charge • Coulomb's law	• The potential energy of solar energy is converted into motion energy • Strong electric field generated from solar panels used to drive fish feed throwing machines
4	3.5 Analyzing alternating current (AC) circuits and their application 4.5 Presenting the working principle of the application of alternating current (AC) circuit in daily life	Alternating Current Circuit: • Alternating current and voltage • Alternating current circuit • Power on an alternating current circuit	• The current generated from solar panels is converted from DC current converted into AC Current • Voltage generated from solar panels
5	3.9 Explain the concept of data storage and transmission in analog and digital forms and their application in real information and communication technology in everyday life	• Digital technology : • Data storage • Data transmission • Application of digital technology in everyday life	• Applications of the use of solar cells as an alternative energy source • Utilization of fish feed disposal machine for daily life
6	3.11 Analyze the limitations of energy sources and their impact on life	Energy Sources: • Renewable and non-renewable energy sources	• Energy from solar cells is used as renewable energy

No.	Basic Competencies	Physics Content Analysis	Analysis of Physical Content in the Design Context of Solar Cell-Based Fish Feed Throwing Automatic Machine
		• Renewable and non-renewable power generation • Alternative energy	• Generation of electrical energy from solar cells •

The concept of science obtained from the design of this solar cell-based automatic fish feed throwing machine makes students closer to the daily environment so that in the learning process these concepts are also easier because they are in the surrounding environment. This is in line with (Yüzüak & Erten, 2022; Kasuga et al., 2022) that education has a dual function, which is not only to create changes towards a more innovative life but also to preserve a positive culture. The results of this study show that the application of the use of an automatic machine for throwing fish feed based on solar cells can be used as a source of learning, especially in physics subjects. This is expected to help and facilitate students in the learning process besides that it is also expected to foster students' scientific attitudes (Dewi et al., 2021; Bennett, 2016; Khusniati et al., 2023).

Conclusion

The conclusion of this study is the learning outcomes of the course (CLO) which is considered the most relevant is on the material Simple power plant technology. Content integration in physics learning in the context of the design of an automatic machine for solar cell-based fish feed throwers consisting of 6 physics content adjusted to the context of an automatic machine for throwing fish feed based on solar cells. In the form of parabolic motion, direct current circuits, static electricity, alternating current circuits, digital technology and energy sources. In addition, the prototype of a solar cell-based automatic feed thrower is a solution for farmers in automatic and regular feeding where the throwing time and distance produced in the solar cell-based automatic feed thrower prototype ranges from 5 seconds-20 seconds with a minimum throwing distance of 7 cm and a maximum distance of 142 cm. The results of this study show that the application of the use of an automatic machine for throwing fish feed based on solar cells can be used as a source of learning, especially in physics subjects.

References

Angga, A., Suryana, C., Nurwahidah, I., Hernawan, A. H., & Prihantini, P. (2022). Komparasi Implementasi Kurikulum 2013 dan Kurikulum Merdeka di Sekolah Dasar Kabupaten Garut. *Jurnal Basicedu*, *6*(4), 5877–5889. https://doi.org/10.31004/basicedu.v6i4.3149

Arrazy, M., & Primadini, R. (2021). Potensi Subsektor Perikanan Pada Provinsi-Provinsi Di Indonesia. *Jurnal Bina Bangsa Ekonomika*, *14*(1), 1–13.

Bai, L., Qiao, Q., Yao, Y., Guo, J., & Xie, M. (2014). Insights on the development progress of National Demonstration eco-industrial parks in China. *Journal of Cleaner Production*, *70*, 4–14. https://doi.org/10.1016/j.jclepro.2014.01.084

Bates, A., & Firestone, J. (2015). A comparative assessment of proposed offshore wind power demonstration projects in the United States. *Energy Research and Social Science*, *10*, 192–205. https://doi.org/10.1016/j.erss.2015.07.007

Bell, M., & Lowe, R. (2000). Energy efficient modernization of housing: A UK case study. *Energy and Buildings*, *32*(3), 267–280. https://doi.org/10.1016/S0378-7788(00)00053-0

Bengtsson, S. (2011). VVBGC demonstration plant activities at Värnamo. *Biomass and Bioenergy*, *35*(SUPPL. 1), 3–7. https://doi.org/10.1016/j.biombioe.2011.03.034

Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, *30*(3), 582–592. https://doi.org/10.1111/cobi.12681

Bossink, B. A. G. (2017). Demonstrating sustainable energy: A review based model of sustainable energy demonstration projects. *Renewable and Sustainable Energy Reviews*, *77*(April 2016), 1349–1362. https://doi.org/10.1016/j.rser.2017.02.002

Boyd, A. D., Liu, Y., Stephens, J. C., Wilson, E. J., Pollak, M., Peterson, T. R., … Meadowcroft, J. (2013). Controversy in technology innovation: Contrasting media and expert risk perceptions of the alleged leakage at the Weyburn carbon dioxide storage demonstration project. *International Journal of Greenhouse Gas Control*, *14*, 259–269. https://doi.org/10.1016/j.ijggc.2013.01.011

Chakraborty, S., Sadhu, P. K., & Pal, N. (2014). New location selection criterions for solar PV power plant. *International Journal of Renewable Energy Research*, *4*(4), 1020–1030.

Chamoun, R., & Chakroun, W. (2014). Cost-efficiency study of BIPV systems in Qatar residential houses. *International Journal of Renewable Energy Research*, *4*(3), 571–579.

Chan, S. H., Stempien, J. P., Ding, O. L., Su, P. C., & Ho, H. K. (2016). Fuel cell and hydrogen technologies research, development and demonstration activities in Singapore – An update. *International Journal of Hydrogen Energy*, *41*(32), 13869–13878. https://doi.org/10.1016/j.ijhydene.2016.05.192

Chow, T. T., Tiwari, G. N., & Menezo, C. (2012). Hybrid solar: A review on photovoltaic and thermal power integration. *International Journal of Photoenergy*, *2012*. https://doi.org/10.1155/2012/307287

Codani, P., Le Portz, P. L., Claverie, P., Perez, Y., & Petit, M. (2015). Coupling local renewable energy production with electric vehicle charging: A survey of the French case. *28th International Electric Vehicle Symposium and Exhibition 2015, EVS 2015*, *16*(1), 55–69.

Dai, H., & Ma, W. M. (2004). A novelty bayesian method for unsupervised learning offinite mixture models. *Proceedings of 2004 International Conference on Machine Learning and Cybernetics*, *6*, 3574–3578. https://doi.org/10.1109/icmlc.2004.1380410

Dewi, C. A., Erna, M., Martini, Haris, I., & Kundera, I. N. (2021). Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability. *Journal of Turkish Science Education*, *18*(3), 525–541. https://doi.org/10.36681/tused.2021.88

Firdaus, H., Laensadi, A. M., Matvayodha, G., Siagian, F. N., & Hasanah, I. A. (2022). Analisis Evaluasi Program Kurikulum 2013 dan Kurikulum Merdeka. *Jurnal Pendidikan Dan Konseling*, *105*(2), 79. Retrieved from https://core.ac.uk/download/pdf/322599509.pdf

Hakim, A. R., Handoyo, W. T., Fauzi, A., & Sarwono, W. (2020). Desain dan Kinerja Mesin Ekstruder Twin Screw untuk Pembuatan Pakan Ikan Terapung. *Jurnal Keteknikan Pertanian*, *7*(2), 129–136. https://doi.org/10.19028/jtep.07.2.129-136

Haryandi, S., Arlinda, R., Harto, M., & Muhammad, N. (2024). Bibliometric analysis : Trends of gamification in physics learning from 2019 to 2023, *8*(2), 181–193. https://doi.org/10.21067/mpej.v8i2.9877

Jeng, M. J., Lee, Y. L., & Chang, L. B. (2009). Temperature dependences of InxGa1-xN multiple quantum well solar cells. *Journal of Physics D: Applied Physics*, *42*(10). https://doi.org/10.1088/0022-3727/42/10/105101

Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of Problem-Based Learning on Developing Science Process Skills and Learning Achievement on the topic of Safety in Our Environment. *Journal of Turkish Science Education*, *19*(3), 872–886. https://doi.org/10.36681/tused.2022.154

Khusniati, M., Heriyanti, A. P., Aryani, N. P., Fariz, T. R., & Harjunowibowo, D. (2023). Indigenous science constructs based on Troso woven fabric local wisdom: a study in ethnoscience and ethnoecology. *Journal of Turkish Science Education*, *20*(3), 549–566. https://doi.org/10.36681/tused.2023.031

Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia. (2014). Performance Report of the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia 2014.

Ndiaye, A., Charki, A., Kobi, A., Kébé, C. M. F., Ndiaye, P. A., & Sambou, V. (2013). Degradations of silicon photovoltaic modules: A literature review. *Solar Energy*, *96*, 140–151. https://doi.org/10.1016/j.solener.2013.07.005

Nulhakim, L. (2014). Alat Pemberi Makan Ikan Di Akuarium Otomatis Berbasis Mikrokontroler Atmega16. *Tugas Akhir*. Retrieved from http://eprints.uny.ac.id/30002/1/Lukman Nulhakim 09506131021.pdf

Nurdiansyah, M., Sinurat, E. C., Bakri, M., & Ahmad, I. (2020). Sistem Kendali Rotasi Matahari Pada Panel Surya Berbasis Arduino UNO. *Jurnal Teknik Dan Sistem Komputer*, *1*(2), 7–12. https://doi.org/10.33365/jtikom.v1i2.14

Renika, J., Prima, E. C., & Amprasto, A. (2024). Kinematics analysis on accelerated motion using tracker video analysis for educational purposes. *Momentum: Physics Education Journal*, *8*(1), 23–31. https://doi.org/10.21067/mpej.v8i1.8883

Sartika, D. (2019). Pentingnya Pendidikan Berbasis STEM dalam Kurikulum 2013. *Jurnal Ilmu Sosial Dan Pendidikan*, *3*(3), 89–93. Retrieved from http://ejournal.mandalanursa.org/index.php/JISIP/index

Sholeh, M., Haryanto, Z., & Zulkarnaen, Z. (2024). Development of augmented reality-based physics learning media on magnetic field. *Momentum: Physics Education Journal*, *8*(1), 120–132. https://doi.org/10.21067/mpej.v8i1.8576

Singh, P., & Ravindra, N. M. (2012). Temperature dependence of solar cell performance - An analysis. *Solar Energy Materials and Solar Cells*, *101*, 36–45. https://doi.org/10.1016/j.solmat.2012.02.019

Singh, P., Singh, S. N., Lal, M., & Husain, M. (2008). Temperature dependence of I-V characteristics and performance parameters of silicon solar cell. *Solar Energy Materials and Solar Cells*, *92*(12), 1611–1616. https://doi.org/10.1016/j.solmat.2008.07.010

Sirnayatin, T. A. (2013). Penelitian Mixed Methods, 3–4.

Skoplaki, E., & Palyvos, J. A. (2009). On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. *Solar Energy*, *83*(5), 614–624. https://doi.org/10.1016/j.solener.2008.10.008

Suryadi, A. (2021). Rancang Bangun Mesin Pemberi Pakan Ikan Otomatis Berbasis Internet of Think dan Sel Surya. *Electrician*, *15*(3), 205–208. https://doi.org/10.23960/elc.v15n3.2213

Yüzüak, A. V., & Erten, S. (2022). Teachers' Views About Turkey's Zero Waste Project (TZWP). *Journal of Turkish Science Education*, *19*(1), 71–81. https://doi.org/10.36681/tused.2022.110