# Advanced Multisystem Aquaponic with the Photovoltaic Solar Power Technology

**Mohamad Amiruddin Bin Ismail[1]*, Jiang Jiang[2], Irdayanti Mat Nashir[1] , Wan Nurlisa Wan Ahmad[1] , Lee Soyoung[3], Kazuma Sekiguchi[4]**

**[1]Jabatan Teknologi Kejuruteraan, Fakulti Teknikal dan Vokasional, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia**

**[2]Civil Engineering Department, Architecture and Civil Engineering College, Linyi University, 276000 Linyi, Shandong, CHINA**

**[3]Korean Armed Forced Nursing Academy, 78-502, Yuseong-gu, Daejeon, KOREA**

**[4]Department of Mechanical System Engineering, Tokyo City University, Tamazutsumi, 158-8557, Setagaya City, Tokyo, JAPAN**

***Corresponding Author**

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## ABSTRACT

This study aims Multisystem Aquaponic Model with a photovoltaic Solar power technology as a teaching aid for the topic of design technology subject in Malaysia. Specifically, the objectives of this study are to identify the needs and key elements for the development of the Multisystem Aquaponic Model with a photovoltaic Solar power technology as a teaching aid for the Aquaponic Design topic, to design the model, and to validate it for use as a teaching aid for the same topic. Solar technology is an integration system for the power efficiency to the Aquaponic system. Photovoltaic solar type suggested in this study. In other hand, study applies constructivism theory and is developed based on the ADDIE model. It also adopts a Design and Development Research (DDR) approach through qualitative methods, utilizing interviews with three experts who are Design and Technology subject teachers from a secondary school. An interview protocol inventory was used with the appointed experts. The findings indicate that the developed Multisystem Aquaponic Model with a photovoltaic Solar power technology is positively received and validated for use as a teaching aid for the Aquaponic Design topic. The findings indicate that the developed Multisystem Aquaponic Model with a photovoltaic Solar power technology is positively received and validated for use as a teaching aid for the Aquaponic Design topic.

**Keywords:** Aquaponic, Photovoltaic Solar power technology, Design and Technology Subject, Malaysian Education

## INTRODUCTION

Design and Technology was introduced in the Secondary School Standard Curriculum (KSSM) in 2017 to replace the Integrated Living Skills subject, which had been implemented since 1988 (KPM, 2016). This replacement aimed to equip students with skills that are more relevant to current needs, such as the ability to design, apply modern manufacturing technology, solve problems systematically, and develop innovative

projects (Zamri Sahaat & Nurfaradilla Mohamad Nasri, 2020). Additionally, design and technology emphasize communication skills, entrepreneurship, as well as critical and creative thinking in product development (KPM, 2016). KSSM design and technology is implemented for students from Form One to Form Three, covering various learning aspects such as an introduction to RBT, project management, the design process, sketching, technology applications, inventive problem-solving, product development, and business design. However, this study focuses on the design and technology syllabus, particularly on the topics of Inventive Problem-Solving and Technology Applications. One of the key subtopics in Technology Applications is Aquaponic Design with solar technology, which is the primary focus of this study in developing an effective Teaching Aid to enhance students' understanding (Mohd Zukhairi Abdul Rahman et al., 2017).

## Research Background

The topic of Aquaponic Design in design and technology introduces students to agricultural technology that integrates aquatic animal farming with plant cultivation using water as a medium (Mohd Shafik Mohd Samsi et al., 2022). Students are required to master eight subtopics, including understanding the concept of aquaponics, identifying components, sketching and constructing aquaponic system models, and proposing improvements (Mohd Zukhairi Abdul Rahman et al., 2017). One of the key aspects of this topic is Aquaponic System Design, which includes models such as the Raft System, Ebb & Flow, and NFT. Therefore, the use of Teaching Aids is crucial in enhancing students' understanding, as it helps them focus while stimulating creative and innovative thinking (Zainatul Fakih Zainon & Sharifah Juliana Yaakub, 2022; Hanin Falina Mohd Hashim, 2021). This study focuses on the development of a Multisystem Aquaponic Model as an integrating multiple aquaponic systems with Solar power.

## Problem Statement

Students continue to face difficulties in understanding the concepts and interactions within aquaponic systems due to the lack of effective Teaching Aids, resulting in learning that relies solely on text and verbal explanations. This reduces student engagement and limits practical applications in teaching and learning (Hanin Falina Mohd Hashim, 2020). Although teachers recognize the importance of teaching aids, its usage remains moderate (Nurul Ain Yaakop et al., 2024; Siti Aminah Sallehin & Fazlinda Ab Halim, 2018). The absence of teaching Aids leads to passive and unengaging teaching methods, negatively impacting student motivation and comprehension (Tyastya Chaeruna et al., 2023). Furthermore, the lack of appropriate Teaching Aids contributes to students' failure to fully grasp the subject matter, highlighting the importance of teachers' creativity in (Amirul Ismail et al., 2023; Siti Aishah Sumadi, 2021). Therefore, the development of a Multisystem Aquaponic Model with Solar technology as a teaching aid is necessary to enhance students' understanding through visualization and a more interactive learning experience.

## Research Objectives

This study is conducted to achieve the following objectives, to identify the requirements and key elements for designing the Multisystem Aquaponic Model as a teaching aid for the topic of Aquaponic Design, to integrated Solar technology design of the Multisystem Aquaponic Model and obtain validation for its use as a teaching aid for the topic of Aquaponic Design.

## Conceptual Framework

The development of the Multisystem Aquaponic Model design as a teaching aid serves as the independent affects the dependent variable, which is the validation level of the model for use as a teaching aid in the topic of Aquaponic Design with Solar Design. The following Figure 1.1 is the conceptual framework used in this study:

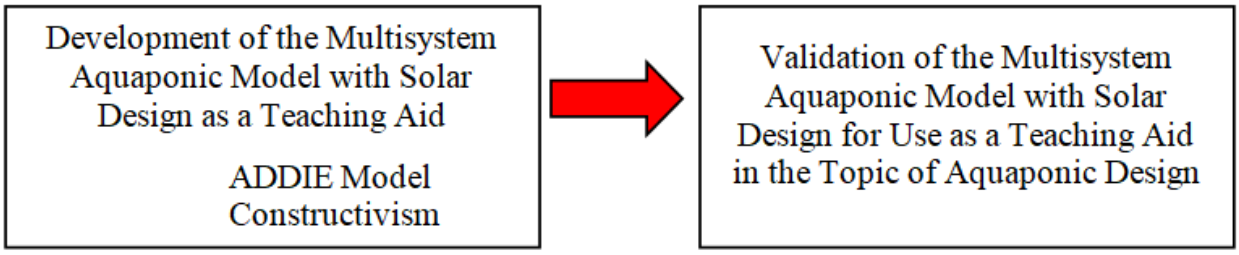


Figure 1.1: Conceptual Framework of the Study.

## LITERATURE REVIEW

Teaching Aids are learning media that help teachers deliver content more effectively, capture students' interest, and enhance their focus (Yanuardi et al., 2024; Farahana Nadirah Mahamad Nadzar, 2022). Studies show that interactive teaching aids can improve students' understanding and academic performance (Siti Sakinah Mohd Yusuf et al., 2018). Various types of teaching aids exist, including electronic and traditional methods. However, for the Aquaponic Design topic integrated with Solar Technology, physical models are more suitable as they allow students to observe and understand system structures directly (MA Ismail, 2024).

The Raft system allows plants to float directly on water using materials like polystyrene, enabling direct nutrient absorption for faster growth (Faizah Mohd Sharoum et al., 2016). However, it risks root rot and bacterial infections (Mohd Zukhairi Abdul Rahman et al., 2017). The Ebb & Flow system uses a siphon bell to regulate water flow in the planting medium, enhancing biofiltration but requiring continuous electricity and maintenance (Sudibyo Karsono et al., 2008). The NFT system, pioneered by Allen Cooper in 1965, circulates a thin nutrient film to plant roots, using minimal water but requiring additional filtration (Resh, 2013). Vertical aquaponics system combines fish farming with soil-free planting, optimizing space but sometimes producing less flavorful crops (Justin & Suwardana Winata, 2024). This study integrates the vertical system into the Multisystem Aquaponic Model to expose students to diverse aquaponic techniques beyond textbook knowledge (Muhammad Zukir & Yoana Nurul Asri, 2022). Figure 2.1 shows Photovoltaic Panel integrated to Aquaponic System (MA Ismail, 2024).

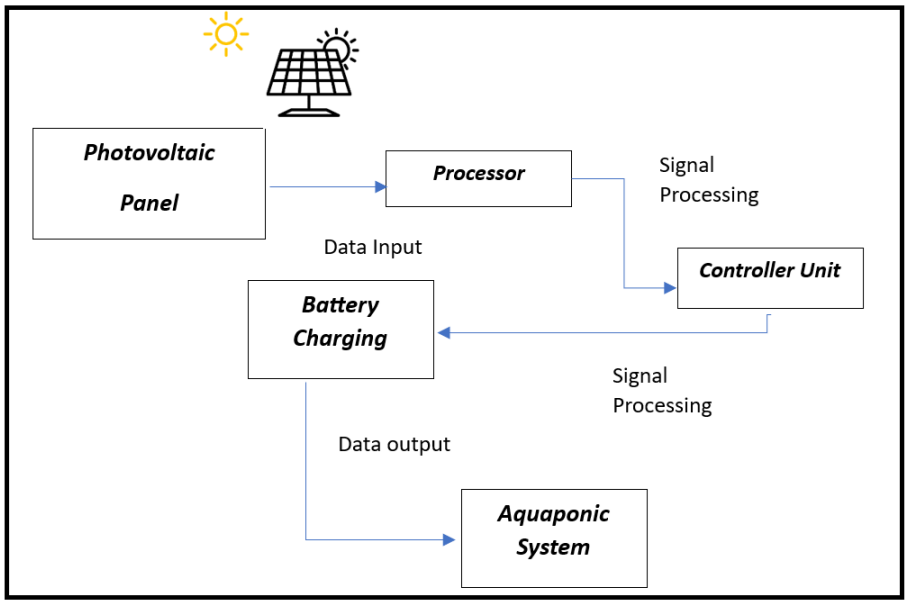


Figure 2.1: Photovoltaic Panel integrated to Aquaponic System

The Multisystem Aquaponic Model developed in this study integrates Raft, Ebb & Flow, NFT, and vertical systems on a small scale, featuring key components such as a fish tank, piping system, and planting media.

However, it is semi-functional, utilizing artificial fish and plants for learning purposes only. Figure 2.2 shows types of Aquaponic Systems with Solar Power.

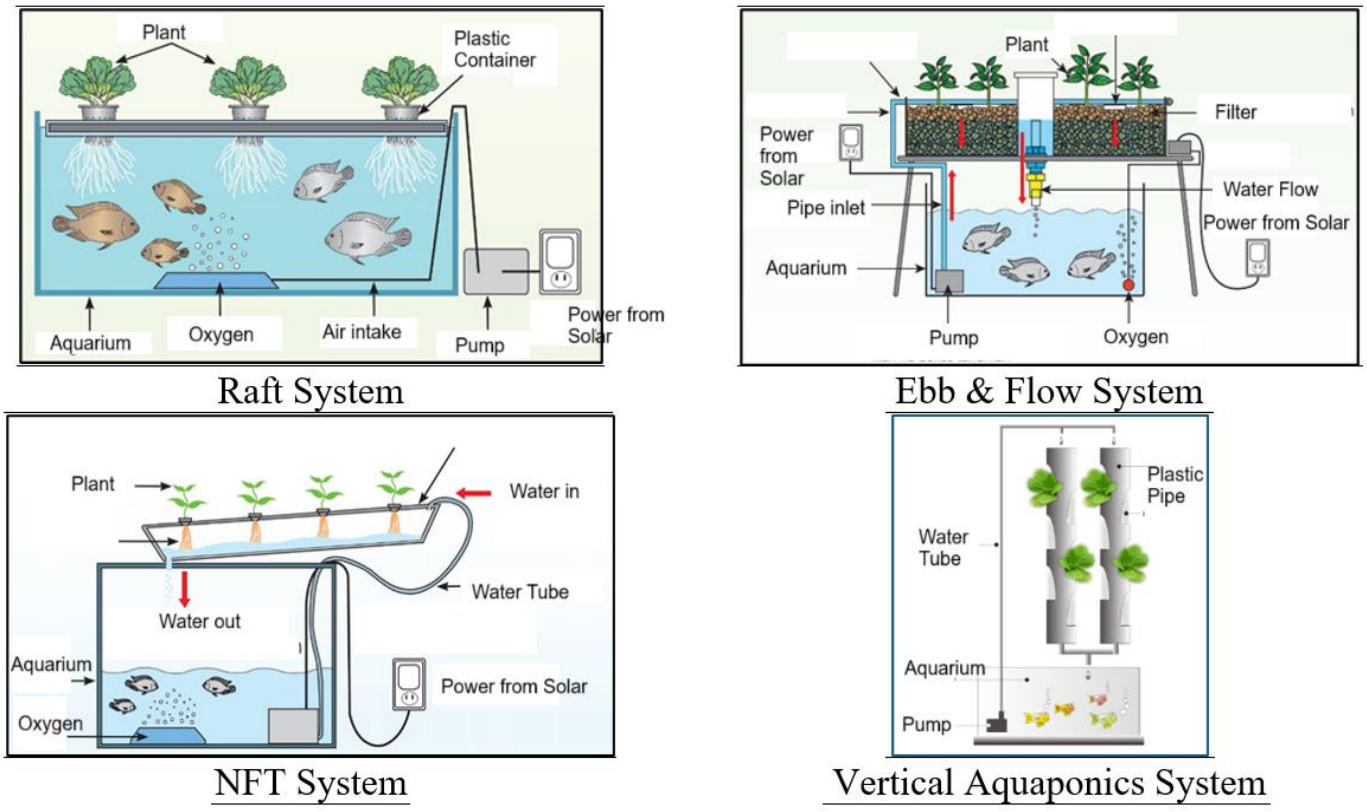


Figure 2.2: Types of Aquaponic Systems with Solar Power

This study uses the constructivist learning theory, which emphasizes the formation of knowledge through experience and social interaction, with learning occurring through guidance and active experience. In this study, the Multisystem Aquaponic Model is used as a teaching aid that supports students' Zone of Proximal Development (ZPD) in understanding Aquaponic Design and Solar system. Students can view the model directly, receive explanations from the teacher, and connect their prior experiences with fish farming and plant cultivation to understand the concept of aquaponics. This study also uses the ADDIE model, which consists of five phases: the analysis phase aims to identify the needs and key elements in developing the model; the design phase generates physical sketches based on the analysis; the development phase creates the model based on the sketches; the implementation phase tests the effectiveness of the model; and the evaluation phase assesses its suitability through expert interviews (Ibrahim Maulana Syahid et al., 2024; Halimaton Shamsuddin, 2021; Maswani Ismail, 2023).

## METHODOLOGY

This study uses the Design and Development Research (DDR) approach to create a Multisystem Aquaponics model as a teaching aid for the topic of Aquaponic Design using Solar technology. A qualitative approach with expert interviews is used to gather insights and validate the use of this model. Three experienced Design and Technology teachers were selected as respondents. The research instrument, in the form of an interview protocol inventory, was developed to collect information on the needs and validity of the model. Before the interviews were conducted, the protocol was validated by experts, namely lecturers from the Department of Engineering Technology at Sultan Idris Education University. Structured interviews were carried out to gather more detailed information regarding the key elements and validity of the model. The data collection process involved recording the interview sessions and transcribing them to ensure data accuracy. The collected data was analysed using thematic analysis to identify key themes related to the research objectives and to assess the validity of using the model as a teaching aid.

The process of building the Multisystem Aquaponic with Solar Technology model follows the ADDIE model, which consists of five phases: analysis, design, development, implementation, and evaluation. The analysis phase aims to understand the needs and key elements in the development of the teaching aid. The design phase involves planning the structure and function of the model, while the development phase focuses on constructing the physical model. The implementation phase involves testing the model and introducing it to teachers through usage demonstrations, and the evaluation phase ensures the validity of the model as a teaching aid based on feedback from the teachers. The entire process aims to create a model that is effective and meets educational needs.

## RESEARCH FINDINGS

The researcher explains the findings on the needs identified through interviews with three teachers and the product development process using the ADDIE model. Additionally, this section discusses the validity of using the Multisystem Aquaponics with Solar Technology model as a teaching aid based on interviews with the three teachers.

### Analyze Process

This section analyses the elements required to develop the design of the Multisystem Aquaponic model as a teaching aid for the topic of Aquaponic Design. The study findings include demographic data from three Design and Technology teachers, the need for teaching aids for this topic, and the elements required for model development. Additionally, this section addresses the first research objective, which is to identify the needs and key elements in the design of the model. The needs analysis involves 10 questions related to demographic data and the requirements for teaching aids. These findings serve as the foundation for building a more effective model. The findings from the interviews highlight several important elements in developing the design of the Multisystem Aquaponic model with Solar Technology as a teaching aid. The teachers recommended the use of clear and effective teaching aids, including basic elements such as fish, plants, piping systems, and water tanks. Some teachers suggested adding a vertical aquaponic system to introduce current systems not found in textbooks.

### Design Process

The design phase in the ADDIE model utilizes data from the analysis phase to plan and determine key elements in developing the Multisystem Aquaponic model as a teaching aid. This process includes selecting an appropriate design, choosing suitable materials, determining colour schemes, and defining the size and functionality of the model. To ensure precision and accuracy, the researcher uses AutoCAD software to create detailed 2D sketches and technical drawings. This allows for better visualization and refinement of components such as the piping system, water tank, and other essential elements. The finalized design serves as a structured guide for the model's construction, ensuring that it effectively facilitates students' understanding of the aquaponic system by providing a clear and comprehensive representation of its functions.

### Development Process

The development phase in the ADDIE model involves constructing the Multisystem Aquaponic model as a teaching aid for the Aquaponic Design topic. This process begins with the preparation of materials such as PVC pipes, plastic containers, and other suitable components to ensure the model is durable and easy to use. The model framework is built by cutting and connecting the pipes with adhesive according to the design sketches. Next, the system components are assembled by drilling holes in the NFT system, Ebb Flow system, vertical aquaponic system, and filtration tank to place plant containers and connect PVC pipes. Finally, the finishing process involves painting different parts of the model with distinct colours to differentiate each system, such as green for the NFT system, blue for the vertical aquaponic system, white-yellow for the Ebb Flow system, and red for the fish tank and filtration container.

### Implementation Process of the Model

The implementation phase in the ADDIE model involves several important steps to assess the suitability of the multisystem aquaponic model as a teaching aid. The first step is testing the model to ensure that its functions meet the construction objectives, including the stability of the structure and the effectiveness of the aquaponic system. Feedback from the testing is used for model improvements. Next, a user manual is provided to guide teachers on the functions and usage of the model. The final step is a model demonstration via a YouTube video for the teachers, offering explanations and the opportunity to provide feedback and evaluate the model's suitability as a teaching aid.

### Evaluation and Validation Process

The evaluation phase in the ADDIE model involves interviews with three experienced RBT teachers to gather feedback on their understanding, ease of use, and the potential of the multisystem aquaponic model as a teaching aid. The teachers provided critical insights and suggestions for improvements based on their experiences. The feedback analysis helps assess how well the model meets the established requirements and identifies any weaknesses that need to be addressed. A validity study was also conducted through 10 questions related to the model's design, suitability within the curriculum, and effectiveness as a teaching aid, which serves as a guide to enhancing its quality and usability before final validation.

The evaluation phase summary indicates that teachers have confirmed the Multisystem Aquaponic model as a suitable teaching aid for the Aquaponic Design topic. The model is recognized as safe, easy to use, and has an attractive design suitable for students. The use of color elements and labeling helps students understand different aquaponic systems, while the user guide facilitates teachers in mastering the model. Additionally, the model's design aligns with DSKP requirements and has a positive impact on learning. The validation obtained proves the success of the model’s development according to the research objectives and addresses its suitability as a teaching aid.

## FINAL RESULT

This study was conducted to identify the challenges faced by design and technology, teachers in teaching the topic of aquaponic design due to the lack of suitable teaching aids. Therefore, a multisystem aquaponic model was developed using the ADDIE model through five main phases. The analysis phase identified teachers' needs, followed by the design phase, which produced a 2D sketch using AutoCAD. The development phase involved material preparation, assembly, and finishing of the model, while the implementation phase included model testing, guide preparation, and a demonstration via a YouTube video. Finally, the evaluation phase confirmed the model's effectiveness in enhancing students' understanding and suggested improvements such as the provision of a user manual and the selection of more suitable materials to enhance visual comprehension in the teaching and learning process.

### Discussion of the Study

This section of the discussion emphasizes the importance of developing the multisystem aquaponic model as a teaching aid, especially in the context of Malaysia, where the lack of suitable teaching aids can hinder students’ understanding of complex topics like aquaponic design and solar technology. The study revealed that the model should effectively illustrate the aquaponic process, including the relationship between the aquaculture and hydroponic systems, as well as crucial components like fish, plants, piping systems, and drainage systems. In addition, the model must align with the learning levels outlined in the Malaysian’s syllabus curriculum to ensure it helps students grasp the fundamental concepts and functions of each system part. These findings underline the importance of appropriate teaching aids in enhancing student comprehension and the overall effectiveness of the teaching and learning process in Malaysia's educational system.

Furthermore, this section highlights the research findings on how the design of the multisystem aquaponic model was developed and validated as a teaching aid. The evaluation results indicate that the model meets the necessary criteria and has been validated by experts. The design and technology, teachers interviewed provided positive feedback on its design and functionality, noting that the model allows students to clearly understand the aquaponic process in an interactive manner. The model effectively includes key elements such as aquaculture systems, hydroponics, and their connection, while also enabling students to physically manipulate its components. Its compact and lightweight design makes it ideal for classroom use in Malaysian secondary schools. Experts suggested improvements such as adding a user manual and enhancing material durability for long-term use, ensuring that the model can be widely adopted in Malaysian education, supporting a more hands-on, engaging, and effective learning experience.

## RESEARCH RECOMMENDATIONS

Based on the study findings, several recommendations have been made to improve the effectiveness of teaching aids for the Aquaponic Design topic in Malaysia. The model should be easy to understand, interactive, and clear, with a focus on the relationship between aquaculture and hydroponic systems. Attractive, colourful materials should be used to enhance student focus. A detailed user manual for both teachers and students are necessary for effective usage. Durable materials and a modular design are recommended to ensure long-term use. Additionally, integrating digital technologies such as mobile apps or virtual reality (VR) can enrich the learning experience. These recommendations aim to make teaching and learning more engaging and effective in Malaysian schools, aligning with modern educational trends.

## CONCLUSION

In conclusion, the findings in this study indicate that the development of the Multisystem Aquaponic with Solar technology model as a teaching aid is a significant necessity to enhance students' understanding of the Aquaponic Design topic. This model has been validated by experts as an effective teaching tool that can help students understand aquaponic concepts both visually and practically. Key elements such as the use of fish, plants, piping systems, and a design that is easy to understand are crucial components that ensure the model is relevant and impactful in the learning process. Additionally, suggestions such as the selection of durable materials, the preparation of user manuals, and the integration of digital technology can add value to the model, making it more interactive and suitable for use in modern educational contexts. This study also recommends expanding the model's application to other topics and promoting its use across various educational levels. Thus, this study not only achieves the objectives set but also makes a significant contribution to the field of Design and Technology, while opening avenues for further research to ensure the continued relevance and sustainability of this teaching aid.

## REFERENCE

1. Advance Solar Design for Electric Vehicle Storage in Universiti Pendidikan Sultan Idris MA Ismail, WNW Ahmad, IM Nashir, L Soyoung, K Sekiguchi Journal of Technology and Humanities 5 (2), 13-20.
2. Design of magnetorheological suspension of c-class car segment using spencer model for education MAB Ismail, V Sethuprakash, K Sekiguchi, L Soyoung Central Asia and the Caucasus 23 (1), 3017-3023.
3. MAB Ismail, H Pratama, WNW Ahmad, IBM Nashir, L Soyoung (2024). An Innovation of Flap Design Energy Efficiency Lightweight Flying Vehicle, DESIGN, CONSTRUCTION, MAINTENANCE 4, 1-6.
4. Farahana Nadirah Mahamad Nadzar. (2020). Persepsi pelajar terhadap Penggunaan Alat Bantu Mengajar Sifir Pita Ukur dalam Membantu Kemahiran Membaca Tali Pita Ukur. *International Journal of Adanced Research in Future Ready Learning and Education, 27*(1), 30-42.

5. Halimaton Shamsuddin. (2021). *Pembangunan Perisian Pembelajaran M-SMAW bagi Kursus Teknologi Kimpalan di Kolej Vokasional Malaysia Zon Tengah.* [Tesis]. Universiti Pendidikan Sultan Idris.
6. Hanin Falina Mohd Hashim. (2021). Penggunaan Easy Learning Kit (ELK): Refrigerator System bagi Pelajar Sijil Teknologi Penyejukan dan Penyamanan Udara (SPU) di Kolej Komuniti Hulu Langat (KKHL). *International Journal of Humanities Technology and Civilization (IJHTC), 6*(S2), 50-55.
7. Ibrahim Maulana Syahid, Nur Annisa Istiqomah, & Khoula Azwary. (2024). Model Addie dan Assure dalam Pengembangan Media Pembelajaran. *Journal of International Multidisciplinary Research, 2*(5), 258-268.
8. Justin & Suwardana Winata. (2024). Pertanian Vertikal sebagai Respons Pedagang Pasar Tradisional di Kecamatan Kembangan terhadap Perubahan Pola Perdagangan dan Gaya Hidup Masyarakat. *Jurnal Sains, Teknologi, Urban, Perancangan, Arsitektur, 6*(1), 13-22.
9. Kementerian Pendidikan Malaysia. (2016, Mei*). Kurikulum Standard Sekolah Menengah Reka Bentuk dan Teknologi Dokumen Standard Kurikulum dan Pentaksiran Tingkatan 2*. https://anyflip.com/ spqkw/qufn/basic
10. Maswani Ismail. (2023). *Pembangunan Modul Sequin Topik Reka Bentuk Fesyen, Mata Pelajaran Reka Bentuk dan Teknologi Tingkatan Satu.* [Disertasi Kedoktoran]. Universiti Pendidikan Sultan Idris.
11. Magnetorheological suspension control using Matlab and Arduino PID controller for the Formula Malaysia Education Competition (Formula MEC). MA Bin Ismail, M Nashir, V Sethuprakash, K Sekiguchi, L Soyoung Central Asia & the Caucasus (14046091) 23 (1).
12. Mohamed Nor Azhari Azman, Nur Amierah Azli, Ramlee Mustapha, Balamuralithara Balakrishnan, & Nor Kalsum Mohd Isa. (2014). Penggunaan Alat bantu Mengajar ke Atas Guru Pelatih Bagi Topik Kerja Kayu, Paip dan Logam. *Sains Humanika, 3*(1), 77-85.
13. Mohd Shafik Mohd Samsi, Mohd Zuhaili Kamal Basir, & Norliza Gerunsin. (2022). Signifikan Penggunaan Sistem Akuaponik dari Perspektif Islam. *Al-Qanatir International Journal of Islamic Studies, 28*(2), 32-37.
14. Mohd Zukhairi Abdul Rahman, Mohd Ismail Abdul Rahim, Noorazzima Mohamad Nor, Sarifah Ab Rahman, & Zuraini Abdul Rashid. (2017). *Reka Bentuk dan Teknologi Tingkatan 2*. Sasbadi Sdn. Bhd.
15. Muhammad Zukir & Yoana Nurul Asri. (2022). Sistem Kontrol dan Monitoring Kadar Nutrisi pada Vertikal Akuaponik Berbasis Arduino Nano. *Jurnal Pendidikan Fisika dan Sains, 5*(2), 94-99.
16. Nurul Ain Yaakop, Aidah Mendolo, Mustaffa Kamal Ismail, Ahmad Hazim Muhamad, dan Nur Afifah Mazni. (2024). Penggunaan Alat Bantu Mengajar bagi Membandingkan Jumlah Arus Menggunakan Penunjuk LED. *APS Proceedings, 11*, 62-68.
17. Resh, Howard M. (2013). *Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower Seventh Edition.* CRC Press Taylor & Francis Group.
18. Siti Aisyah Sumadi. (2021). *Penilaian Unit Reka Bentuk Sistem Pertanian dalam Mata Pelajaran Reka Bentuk dan Teknologi Menggunakan Model CIPP: Sebuah Kajian Awalan* [Tesis]. Universiti Teknologi Malaysia. https://eprints.utm.my/99891/1/ SitiAishahSumadiMPP2021 .pdf.
19. Siti Aminah Sallehin, & Fazlina Ad Halim. (2018). Penggunaan alat bahan bantu mengajar berasaskan multimedia dalam pengajaran dan pembelajaran di Sekolah Menengah Zon Benut. *Online Journal for TVET Practitioners*.
20. Siti Sakinah Mohd Yusof et al (2018), penggunaan bahasa pengaturcaraan secara visual bagi Mengurangkan kesalahfahaman konsep pengaturcaraan Dalam kalangan pelajar.Unit Sains Komputer, Kolej Matrikulasi Perak,Page: 1-13, *Jurnal Penyelidikan Dedikasi jilid 14*.
21. Sudibyo Karsono, Sudarmodjo, Yos Sutiyoso, & Noraida Ilias. (2008). *Hidroponik Pertanian Skala Rumah. Synergy Media Books.*
22. Tyastya Chaeruna, Deni Setiawan, & Edi Waluyo. (2023). Pengaruh Media Articulate Storyline Dan Model Roleh Playing Untuk Peningkatan Keterampilan Berbicara Kata Sapaan Siswa Kelas II. *Journal Ilmiah Wahana Pendidikan, 9*(17), 642-649.

23. Yanuardi, Rachmat Destriana, Syepry Maulana Husain, Hengkin Rusdianto, & Andiny Layina. (2024). Perancangan Media pembelajaran Menggunakan Augmented Reality sebagai Alat Bantu Mengajar. *Jurnal Informatika*, *8*(2), 142-148.
24. Zainatul Fakih Zainon, & Sharifah Juliana Yaakub. (2022). Keberkesanan Penggunaan Alat Bantu Mengajar 4U Plexiglass Rack Server di dalam Pengajaran dan Pembelajaran bagi Pelajar Sistem Komputer dan Rangkaian, Kolej Komuniti Jelebu. *International Journal of Advanced Research in Future Ready Learning and Education, 27*(1), 9-16.
25. Zamri Sahaat, & Nurfaradilla Mohamad Nasri. (2020). Cabaran Pelaksanaan Mata Pelajaran Reka Bentuk dan Teknologi Sekolah Menengah. *Jurnal Pendidikan Malaysia, 45*(1), 51-59. https://journalarticle.ukm.my/15253/1/38454-126974-1-PB.pdf.