JPII 12 (4) (2023) 590-597

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

THE EVALUATION OF A TECHNOLOGY-EMBEDDED SOLAR ENERGY STEM (SESTEM) MODULE: A PILOT IMPLEMENTATION OF MODERN TEACHING TOOL FOR DIPLOMA SCIENCE STUDENTS

F. L.Supian*[1], S. W. Tho[2], Y. Y. Wong[3], M. S. Mohd Azmi[4], N. J. Hosman[5], Ratnawulan[6], A. F. Al Naim[7]

[1,2,3,4,5]Department of Physics, Faculty of Science and Mathematics,
Sultan Idris Education University, Malaysia
[6]Department of Physics, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Padang, Indonesia
[7]Department of Physics, College of Science, King Faisal University, Saudi Arabia

DOI: 10.15294/jpii.v12i4.43994

Accepted: April 19th, 2023. Approved: December 29th, 2023. Published: December 31st 2023

ABSTRACT

Utilising an excellent teaching tool is vital for students' education nowadays. In contrast to the traditional teaching way, Technology-Embedded Solar Energy STEM (SESTEM) module was created as a modern teaching tool for physics subject. In order to develop and evaluate the students' perception towards the complete SESTEM module, developmental research and technology acceptance model (TAM) were applied in this research study. 52 randomly selected diploma students from Sultan Idris Education University (UPSI) were involved as respondents in this work. After the development of the SESTEM module using the analysis, design, development, implementation and evaluation (ADDIE) model, the perceptions of students as respondents towards this module were evaluated based on the TAM via questionnaire. Based on the responses from the respondents, the majority of the respondents demonstrated positive attitudes and behaviour intention, as well as agreed that the SESTEM module was useful as a teaching tool. Besides, the respondents showed a positive technological acceptance towards SESTEM module. The respondents' acceptance was contingent on the employment of technology for educational purposes in the future. Consequently, SESTEM module could be utilised by educators as a contemporary tool for enhancing student learning for future benefits.

Keywords: ADDIE; module; STEM education; teaching tool

INTRODUCTION

In the 21st century, the traditional teaching method is no longer relevant for creating an effective learning environment (Liu & Wang, 2021; Rusydiyah et al., 2021; Malikovna et al., 2022; Purba et al., 2022). Moreover, science, technology, engineering, and mathematics (STEM) as vital factors in the modern world should be used in education to help students integrate information across topics through flipped learning and by encouraging them to think more logically and holistically (Li et al., 2019; Rifandi & Rahmi, 2019; Wicaksono, 2020; Laine et al., 2020; Chu et al., 2022; Nurlina et al., 2022; Chu et al., 2023). To accommodate the mastery of 21st century abilities, it is crucial to invent teaching aids that align with this contemporary trend. The use of effective teaching tools in the education system is crucial to boost the effectiveness of teaching for educators and the learning performance of students (Tho et al, 2019; Ong et al., 2020; Eltahir et al., 2021; Shurygin et al., 2022; Zakaria et al., 2022).

***Correspondence Address**
E-mail: faridah.lisa@fsmt.upsi.edu.my

On the other hand, Physics is recognised as one of the most abstract subjects in the science stream (Istiyono et al., 2019; Kurniawan et al., 2019; Berge et al., 2020; Kurniawati & Ermawati, 2020). Renewable energy, such as solar energy, is one of the subtopics of Physics (Rajagukguk et al., 2020; Chien et al., 2021; Malavoloneque & Costa, 2022). Education about solar energy can promote awareness and social acceptance of solar systems for diverse purposes. The inclusion of solar energy education in scientific and technical courses in higher education may provide a deeper understanding of solar technologies, boost research and development, and generate innovations for the use of solar energy to solve local or regional issues (Ciriminna et al., 2016; Malik & Ayop, 2020). However, current teaching practice on a solar issue in higher education focuses primarily on traditional lectures that fail to connect the theories to their environment. Thus, the development of a teaching tool for the topic of solar energy is a significant step in making the learning process more engaging and fostering student creativity (Hosman et al., 2022).

In contrast to the conventional teaching way, a modern teaching tool, named Solar Energy STEM (SESTEM) module was created and its evaluation in the context of students' perception was carried out in this work. This module incorporates STEM concepts and applies them to the study of solar energy by students. The evaluation of the students' perceptions of this module was focused on this work since the SESTEM module was effectively built based on our prior report (Hosman et al., 2022).

Despite the fact that there have been a number of previous studies concerning the developed STEM module with TAM implementation, the use of STEM module in the study of solar energy is still considered to be a novel implementation (Mutambara & Bayaga, 2021; Mater et al., 2022; Mutambara & Chibisa, 2022; Zhao et al., 2022). Some earlier research only addressed renewable energy in general, not solar energy specifically (Huenteler et al., 2016; Gu et al., 2019; Al-Janabi et al., 2020; Wang et al., 2019). The SESTEM module of this work incorporates the utilisation of technology and solar energy within the STEM framework. Using TAM questionnaires, an attempt was made to ascertain the perceptions of the respondents regarding the SESTEM module to comprehend their technology acceptability (Ghani et al., 2019; Naruetharadhol et al., 2021; Kholifah & Fudhla, 2023).

METHODS

This study employed a developmental research method using ADDIE model in the form of questionnaires to evaluate the SESTEM module as a teaching aid. Two essential aspects were involved in this research, which were the SESTEM module manual and a questionnaire. These module and questionnaire were reviewed and evaluated by a panel of research experts with science and education related background to ensure face and content validity as well as the language used. Then, a pilot test was administered to 10 diploma students who have not been involved in the study. The Cronbach's alpha reliability coefficient for each construct of the questionnaire survey is ranged 0.769 to 0.841. The components of the SESTEM module was illustrated in Figure 1 (Creswell & Clark, 2017; Hosman et al., 2022).

(a) (b) **(c)**

Figure 1. The Components of the SESTEM Module, Consisted of (a) Solar Car, (b) Solar Windmill, (c) Solar Puppy, and Their QR Codes, Respectively

As reported in our previous work, the ADDIE model (Figure 2) and TAM were adapted and applied to develop the SESTEM module (Abidin & Tho, 2018; Tho et al. 2019; Hosman et al., 2022). All of the innovative activities given in the SESTEM module used modern technology with QR codes made available to students. Dey et al. (2022) mentioned that the QR codes facilitated learning and the exchange of knowledge. In this work, students were provided with video clips as a resource for the activities by scanning the QR codes. As the final activity, students were encouraged to construct a solar park using their creativity. Another instrument, which was the questionnaire was adapted based on previous research. The development of the SESTEM module was considered very successful based on the feedback of the respondent as mentioned in our previous work. The perception of students towards the SESTEM module was collected for the evaluation part based on the TAM (Hosman et al., 2022).

The population for this study was the diploma science students from the Faculty of Science and Mathematics in UPSI. A survey via questionnaire was implemented in two diploma classes from Semester 1, 2, and 3. The sample's criteria are based on the diploma students who have taken the Basic Physics course due to the necessity of understanding basic solar energy knowledge. The cluster sampling method was applied to ensure that the respondents were randomly sampled, which was the main advantages of using this sampling method. The respondents were divided into several groups and selected at random (Bhardwaj, 2019; Etikan & Babatope, 2019; Berndt, 2020; Mahmud et al., 2020). In this work, 52 participants were recruited at random as participants.

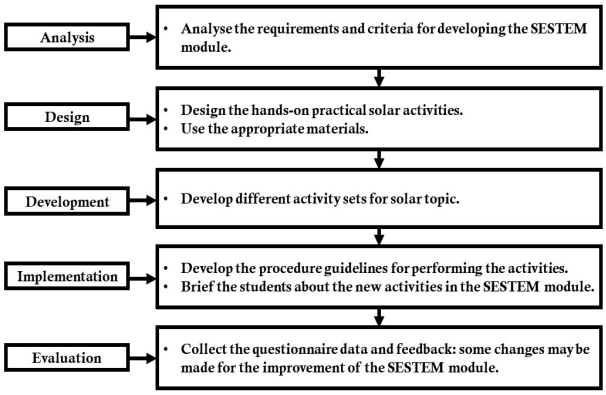

Figure 2. ADDIE Research Process

RESULTS AND DISCUSSION

In this paper, the evaluation of the SESTEM module is reported in detail based on the feedback of respondents via four main constructs consisted in the questionnaire, including perceived usefulness, perceived ease of use, attitude towards the use of SESTEM, and behavioural intention. Based on the data obtained via student activities (refer Figure 3) and questionnaire using the Likert scale from a scale of 1 to 5 ranging from "strongly disagree" to "strongly agree", the central tendencies measurement including the mean, standard deviation (SD), and mean ranking are listed in Table 1, Table 2, Table 3, and Table 4 for each of the constructs, respectively.

Figure 3. Student Activities During the Use of SESTEM

The respondent's responses on the first construct, which was the perceived usefulness of using the SESTEM module, are tabulated in Table 1. The mean value ranged from 3.42 to 3.33. The mean ranking of the first item was the highest, at 3.42. This indicated that the majority of respondents agreed that SESTEM would enhance their learning ability. The item with the lowest mean score was the last item, with a value of 3.33. Nevertheless, respondents acknowledged that adopting SESTEM may improve their learning performance. Based on the central tendency measurement of each item, the majority of the respondents agreed regarding the perceived usefulness of using the SESTEM module. The preference of respondents stated that their learning skills, productivity, and learning performance would be improved by using the SESTEM module as a teaching tool in their study. This was in congruence with the prior research regarding the utilisation of educational aid in learning process (Kumar et al., 2015; Ong et al., 2020; Castro & Tumibay 2021; Kalid et al., 2022).

Table 1. Central Tendencies Measurement of Perceived Usefulness

	Items	Mean (SD)	Mean Ranking
1.	Using SESTEM will improve my learning skill.	3.42 (0.499)	1
2.	Using SESTEM will increase my productivity.	3.40 (0.495)	2
3.	I find SESTEM as a useful tool in my study.	3.35 (0.520)	3
4.	I could enhance my effectiveness by using SESTEM. (Effectiveness: increase my learning performance)	3.33 (0.474)	4

Responses from respondents about the second construct, which was the perceived ease of use of the SESTEM module, are stated in Table 2. The range of mean values was between 3.33 and 3.08. The first item showed the highest ranking with a mean of 3.33. This suggested that the vast majority of respondents agreed that SESTEM was easy to use. With a mean value of 3.08, the final item has the lowest mean value. Moreover, it was determined that the respondents did not exert a great deal of mental effort when interacting with the SESTEM module. Based on the central tendency measurement, the majority of the respondents agreed regarding the perceived ease of use for the SESTEM module. The respondents' preference indicated that the usage of the SESTEM module was easy, clear, understandable, and did not require a lot of mental effort. This was consistent with previous research studies conducted regarding the importance of a user-friendly educational tool in the teaching and learning process (Abidin & Tho, 2018; Tho et al., 2019; Zubair & Folorunso, 2020; Chu et al., 2022).

Table 2. Central Tendencies Measurement of Perceived Ease of Use

	Items	Mean (SD)	Mean Ranking
1.	I find it easy to use the SESTEM module.	3.33 (0.585)	1
2.	My interaction with the SESTEM module is understandable.	3.29 (0.498)	2
3.	Interacting with the SESTEM module does not require a lot of mental effort.	3.08 (0.763)	3

Responses of the respondent to the third construct, which was the attitude towards the use of the SESTEM module, are tabulated in Table 3. The range of the mean value was 3.56 to 3.38. The average position of the first item was the highest, at 3.56. This demonstrated that the majority of respondents agreed that SESTEM made the learning experience more interesting. The item with the lowest mean score was the last one, which received a mean of 3.38. The respondents were looking forward to the learning approaches that required them to use QR codes and videos. Based on the central tendency measurement, the majority of the respondents demonstrated a positive attitude towards the use of the SESTEM module

with promising acceptance. The respondents showed that the SESTEM module made the learning process interesting and fun. Furthermore, they liked to use the SESTEM module and accepted the learning method with the implementation of QR codes and videos. This was in congruent with the previous research project regarding the use of an educational tool that created interesting learning surrounding (Nachiappan et al., 2017; Tho et al., 2019; Zaki et al., 2020; Kee et al., 2021).

Table 3. Central Tendencies Measurement of Attitude towards the Use of SESTEM

	Items	Mean (SD)	Mean Ranking
1.	The SESTEM module makes the learning process more interesting.	3.56 (0.502)	1
2.	Learning with the SESTEM module is fun.	3.48 (0.577)	2
3.	I like using the SESTEM module.	3.38 (0.491)	3
4.	I look forward to the learning method that requires me to use QR codes and videos.	3.38 (0.565)	4

The respondent's feedback on the final construct, which was the behavioural intention, is tabulated in Table 4. The mean value ranged from 3.29 to 3.21. The mean ranking of the first item was the highest, at 3.29. This showed that the majority of respondents were interested in utilising the SESTEM module in the future. The lowest mean value was 3.21 for the last item. Nonetheless, respondents would use the SESTEM module frequently if it were simple to use. Based on the central tendency measurement, the majority of the respondents showed a positive behavioural intention toward the use of the SESTEM module as a teaching tool in the future. The respondents' awareness indicated the potential use of the SESTEM module in the coming days, which was in accord with the findings of the study conducted by prior researchers regarding the future application of teaching aids (Neilson & Reeves, 2019; Mirna et al., 2020; Zin et al., 2021).

Table 4. Central Tendencies Measurement of Behavioural Intention

	Items	Mean (SD)	Mean Ranking
1.	I will use the SESTEM module in the future.	3.29 (0.457)	1
2.	Whenever possible, I intend to use the SESTEM module for learning and teaching in the future.	3.27 (0.448)	2
3.	Given that I can use the SESTEM module easily, I predict that I would use it often.	3.21 (0.457)	3

All items comprising the constructs revealed positive answers from respondents concerning the usage of the SESTEM module as a teaching tool incorporating STEM and technology. As discussed in the previous section, this was consistent with the prior research regarding the use of STEM and technology teaching tools, which were considered relative and effective to enhance the teaching and learning process. In general, the findings corresponded with those of a number of earlier studies, which found that the application of the SESTEM module in learning led to better outcomes for students.

CONCLUSION

The development of the SESTEM module with STEM application for the study of solar energy was successful. Using a questionnaire, the perceptions of students towards this module were evaluated holistically. In general, respondents had a favourable attitude toward the employment of the SESTEM module as a teaching tool for the study of solar energy, indicating a good reception. Consequently, this could be viewed as the key to incorporating SESTEM into the lecture for more insightful learning. The results may serve

as a guide for the development of STEM-implemented teaching aid in the near future, which is crucial for the improvement of the teaching and learning process for both students and teachers. Future works are needed to explore the qualitative feature for more meaningful findings by interviewing students' attitude and motivational level towards the technology-embedded solar energy STEM module in learning science. For instance, the respondent feedback can be collected via the interview to obtain in-depth qualitative data on the implementation of the SESTEM module. Moreover, an experimental design with large sample size is needed to enhance teaching and learning in science by focusing on important variables such as STEM literacy, science literacy, technological literacy, mathematics literacy, and science process skills.

ACKNOWLEDGEMENTS

This study was supported by the Sultan Idris Education University (UPSI) Research Management and Innovation Centre (RMIC) through the University Research Grants GPU (2018-0056-107-01). All parties engaged in this work are acknowledged with appreciation by the authors.

REFERENCES

Abidin, N. Z., & Tho, S. (2018). The development of an innovative resonance experiment using smartphones with free mobile software applications for tertiary education. *International Journal of Education and Development using ICT*, *14*(1).

Al-Janabi, S., Alkaim, A. F., & Adel, Z. (2020). An Innovative synthesis of deep learning techniques (DCapsNet & DCOM) for generation electrical renewable energy from wind energy. *Soft Computing*, *24*(14), 10943-10962.

Berge, M., Danielsson, A., & Lidar, M. (2020). Storylines in the physics teaching content of an upper secondary school classroom. *Research in Science & Technological Education*, *38*(1), 63-83.

Berndt, A. E. (2020). Sampling methods. *Journal of Human Lactation*, *36*(2), 224-226.

Bhardwaj, P. (2019). Types of sampling in research. *Journal of the Practice of Cardiovascular Sciences*, *5*(3), 157.

Castro, M. D. B., & Tumibay, G. M. (2021). A literature review: Efficacy of online learning courses for higher education institution using meta-analysis. *Education and Information Technologies*, *26*, 1367-1385.

Chien, S. I., Su, C., Chou, C. C., & Wang, H. H. (2021). Research insights and challenges of secondary school energy education: A dye-sensitized solar cells case study. *Sustainability*, *13*(19), 10581.

Chu, W. W., Mohd Hafiz, N. R., Mohamad, U. A., Ashamuddin, H., & Tho, S. W. (2023). A review of STEM education with the support of visualizing its structure through the CiteSpace software. *International Journal of Technology and Design Education*, *33*(1), 39-61.

Chu, W. W., Ong, E. T., Ayop, S. K., Mohd Azmi, M. S., Abdullah, A. S., Abd Karim, N. S., & Tho, S. W. (2022). The innovative use of smartphone for sound STEM practical kit: A pilot implementation for secondary classroom. *Research in Science & Technological Education*. Advance online publication.

Ciriminna, R., Meneguzzo, F., Pecoraino, M., & Pagliaro, M. (2016). Rethinking solar energy education on the dawn of the solar economy. *Renewable and Sustainable Energy Reviews*, *63*, 13-18.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage Publications.

Dey, S., Saha, S., Singh, A. K., & McDonald-Maier, K. (2022). SmartNoshWaste: Using blockchain, machine learning, cloud computing and QR code to reduce food waste in decentralized web 3.0 enabled smart cities. *Smart Cities*, *5*(1), 162-176.

Eltahir, M. E., Alsalhi, N. R., Al-Qatawneh, S., AlQudah, H. A., & Jaradat, M. (2021). The impact of game-based learning (GBL) on students' motivation, engagement and academic performance on an arabic language grammar course in higher education. *Education and Information Technologies*, *26*, 3251-3278.

Etikan, I., & Babatope, O. (2019). A basic approach in sampling methodology and sample size calculation. *Med Life Clin*, *1*(2), 1006.

Ghani, M. T. A., Hamzah, M., Ramli, S., Ab, W., Daud, A. W., Romli, T. R. M., & Mokhtar, N. N. M. (2019). A questionnaire-based approach on technology acceptance model for mobile digital game-based learning. *Journal of Global Business and Social Entrepreneurship (GBSE)*, *5*(14), 11-21.

Gu, G. H., Noh, J., Kim, I., & Jung, Y. (2019). Machine learning for renewable energy materials. *Journal of Materials Chemistry A*, *7*(29), 17096-17117.

Hosman, N. J., Supian, F. L., Wei, T. S., Mohamad, S. A. M. S., Azmi, M. S. M., & Mohtar, L. E. (2022). Development of Technology-Embedded Solar Energy STEM (SESTEM) Module among Universiti Pendidikan Sultan Idris (UPSI) diploma science students. *Journal of Physics: Conference Series*, *2309*(1), 012076.

Huenteler, J., Niebuhr, C., & Schmidt, T. S. (2016). The effect of local and global learning on the cost of renewable energy in developing countries. *Journal of Cleaner Production*, *128*, 6-21.

Istiyono, E., Mustakim, S. S., Widihastuti, W., Suranto, S., & Mukti, T. S. (2019). Measurement

of physics problem-solving skills in female and male students by physteprоss. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 170-176.

Kalid, K. S., Ahmad, W. F. W., Amar, M. S. S., Sulisworo, D., Fitrianawati, M., & Subrata, A. C. (2022). An internet of things-based e-learning implementation to support collaborative learning in science subject. *Platform: A Journal of Science and Technology*, *5*(1), 43-53.

Kee, K., Hashim, H., & Ainil Sulaiman, N. (2021). The use of technology in teaching of writing among Malaysian ESL secondary school teachers. *Arab World English Journal (AWEJ) Special Issue*(7), 314-330.

Kholifah, W., & Fudhla, N. (2023). Technology acceptance model (TAM) of magic book augmented reality by hippo as a reading medium for junior high school students in Padang: A study of students' perception. *Journal of English Language Teaching*, *12*(2), 425-434.

Kumar, M., Saxena, I., Kumar, J., Kumar, G., & Kapoor, S. (2015). Assessment of lecture strategy with different teaching aids. *Journal of clinical and diagnostic research: JCDR*, *9*(1), CC01.

Kurniawan, D. A., Astalini, A., & Sari, D. K. (2019). An evaluation analysis of students' attitude towards physics learning at senior high school. *Jurnal Penelitian dan Evaluasi Pendidikan*, *23*(1), 26-35.

Kurniawati, D. M., & Ermawati, F. U. (2020). Analysis students' conception using Four-Tier diagnostic test for dynamic fluid concepts. *Journal of Physics: Conference Series*, *1491*(1), 012012.

Laine, E., Veermans, M., Gegenfurtner, A., & Veermans, K. (2020). Individual interest and learning in secondary school STEM education. *Frontline Learning Research*, *8*(2), 90-108.

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research*, *2*, 93-104.

Liu, J., & Wang, X. (2021). Plant diseases and pests detection based on deep learning: a review. *Plant Methods*, *17*, 1-18.

Mahmud, M. S., Huang, J. Z., Salloum, S., Emara, T. Z., & Sadatdiynov, K. (2020). A survey of data partitioning and sampling methods to support big data analysis. *Big Data Mining and Analytics*, *3*(2), 85-101.

Malavoloneque, G., & Costa, N. (2022). Physics education and sustainable development: A study of energy in a glocal perspective in an Angolan initial teacher education school. *Frontiers in Education, 6*, 639388.

Malik, S. A., & Ayop, A. R. (2020). Solar energy technology: Knowledge, awareness, and acceptance of B40 households in one district of Malaysia towards government initiatives. *Technology in Society*, *63*, 101416.

Malikovna, K. R. N., Mirsharapovna, S. Z., Shadjalilovna, S. M., & Kakhramonovich, A. A. (2022). Types of interactive methods in teaching english to students. *Texas Journal of Multidisciplinary Studies*, *14*, 1-4.

Mater, N. R., Haj Hussein, M. J., Salha, S. H., Draidi, F. R., Shaqour, A. Z., Qatanani, N., & Affouneh, S. (2022). The effect of the integration of STEM on critical thinking and technology acceptance model. *Educational Studies*, *48*(5), 642-658.

Mirna, M., Dwina, F., & Khairani, K. (2020). Students' characteristics, learning outcomes and needs of geometry media tools in junior high school at Padang. *Journal of Physics: Conference Series*, *1554*(1), 012051.

Mutambara, D., & Bayaga, A. (2021). Determinants of mobile learning acceptance for STEM education in rural areas. *Computers & Education*, *160*, 104010.

Mutambara, D., & Chibisa, A. (2022). Rural STEM preservice teachers' acceptance of virtual learning. *International Journal of Learning, Teaching and Educational Research*, *21*(2), 155-175.

Nachiappan, S., Rahim, S. A. A., Othman, M., & Balakrishnan, V. D. (2017). Usage of teaching aids in increasing cognition among slow learners through art lessons. *Journal of Research, Policy & Practice of Teachers and Teacher Education*, *7*(1), 12-20.

Naruetharadhol, P., Ketkaew, C., Hongkanchanapong, N., Thaniswannasri, P., Uengkusolmongkol, T., Prasomthong, S., & Gebsombut, N. (2021). Factors affecting sustainable intention to use mobile banking services. *Sage Open*, *11*(3), 21582440211029925.

Neilson, S. J., & Reeves, A. (2019). The use of a theatre workshop in developing effective communication in paediatric end of life care. *Nurse education in practice*, *36*, 7-12.

Nurlina, N., Marisda, D. H., Riskawati, R., Sultan, A. D., Sukmawati, S., & Akram, A. (2022). Assessment on digitalization of basic physics courses: Need analysis on the use of digital-based assessment. *Jurnal Pendidikan IPA Indonesia*, *11*(4), 531-541.

Ong, E. T., Keok, B. L., Yingprayoon, J., Singh, C. K. S., Borhan, M. T., & Tho, S. W. (2020). The effect of 5e inquiry learning model on the science achievement in the learning of "Magnet" among year 3 students. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 1-10.

Purba, R., Herman, H., Purba, A., Hutauruk, A. F., Silalahi, D. E., Julyanthry, J., & Grace, E. (2022). Improving teachers'competence through the implementation of the 21st century competencies in a post-covid-19 pandemic. *Jurnal Masyarakat Mandiri*, *6*(2), 1486-1497.

Rajagukguk, R. A., Ramadhan, R. A., & Lee, H. J. (2020). A review on deep learning models for forecasting time series data of solar irradiance and photovoltaic power. *Energies*, *13*(24), 6623.

Rifandi, R., & Rahmi, Y. L. (2019). STEM education to fulfil the 21st century demand: A literature

review. *Journal of Physics: Conference Series*, *1317*(1), 012208.

Rusydiyah, E. F., Indarwati, D., Jazil, S., Susilawati, S., & Gusniwati, G. (2021). Stem learning environment: Perceptions and implementation skills in prospective science teachers. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 138-148.

Shurygin, V., Ryskaliyeva, R., Dolzhich, E., Dmitrichenkova, S., & Ilyin, A. (2022). Transformation of teacher training in a rapidly evolving digital environment. *Education and Information Technologies*, *27*, 3361-3380.

Tho, S. W., Lee, T. T., Baharom, S., Supian, F. L., Abdullah, N. S. Y., & Zainal Abidin, N. A. S. (2019). The pilot implementation using an adapted technology acceptance model to evaluate an innovative use of smartphone for scientific investigation programme in tertiary education. *Proceedings of the 27th International Conference on Computers in Education*, 429-434.

Wang, H., Lei, Z., Zhang, X., Zhou, B., & Peng, J. (2019). A review of deep learning for renewable energy forecasting. *Energy Conversion and Management*, *198*, 111799.

Wicaksono, A. G. (2020). Penyelenggaraan pembelajaran IPA berbasis pendekatan STEM dalam menyongsong era revolusi industri 4.0. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, *10*(1), 54-62.

Zakaria, N. A., Supian, F. L., & Darus, M. M. (2022). Developing an energy band gap model and its usability from the perspective of physics undergraduate students. *Journal of Physics: Conference Series, 2309*(1), 012099.

Zaki, N. A. A., Zain, N. Z. M., Noor, N. A. Z. M., & Hashim, H. (2020). Developing a conceptual model of learning analytics in serious games for STEM education. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 330-339.

Zhao, J., Wijaya, T. T., Mailizar, M., & Habibi, A. (2022). Factors influencing student satisfaction toward STEM education: Exploratory study using structural equation modeling. *Applied Sciences*, *12*(19), 9717.

Zin, T. T., Thant, S., Pwint, M. Z., & Ogino, T. (2021). Handwritten character recognition on android for basic education using convolutional neural network. *Electronics*, *10*(8), 904.

Zubair, A. R., & Folorunso, S. S. (2020). Education during covid-19 lockdown and social distancing: Programmable teaching aid for amplitude modulation theory as a case study. *International Journal of Computer Applications*, *175*(33), 11-29.