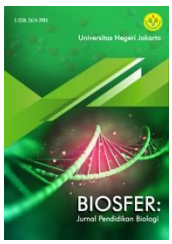
Biosfer: Jurnal Pendidikan Biologi

Beranda jurnal: http://journal.unj.ac.id/unj/index.php/biosfer



Analysis of student worksheets on compost making based on ESD-TPack to improve students' scientific attitudes in biology learning

Ainus Salsabila[1*], Suyono[1], Zainul Arifin Imam Supardi[1], Mosleh Habibullah[2]

[1] Science Education, Faculty of Mathematics and Natural Sciences, Surabaya State University, Indonesia
[2] English Language Education, Faculty of Tarbiyah, Madura State Islamic Institute, Indonesia

*Corresponding author: 24030795013@mhs.unesa.ac.id

ARTICLE INFO

Article history
Received: 07 January 2025
Revised: 24 March 2025
Accepted: 05 April 2025

Keywords :
Education for Sustainable Development
Science Attitude
TPACK

ABSTRAK

This research aims to develop teaching materials in the form of Student Worksheets based on ESD (Education for Sustainable Development) and TPACK (Technological Pedagogical Content Knowledge) that focus on improving students' scientific attitudes in biology learning. The identified problem is the lack of teaching materials relevant to sustainability issues and the suboptimal integration of technology in learning. This research uses the ADDIE development design, which includes needs analysis, design, development, implementation, and evaluation of teaching materials. Validation was conducted by media experts and education practitioners to ensure the product's validity. The validation results show that the ESD-TPACK-based student worksheet device has an average validity score of 0.96, categorized as very valid, and a reliability score of 0.98. This student worksheet trains four aspects of scientific attitudes, namely determinism, the belief that every problem has a solution, curiosity, and empathy towards human conditions. The application of this student worksheet is expected to enhance students' critical thinking skills and sense of responsibility towards environmental issues through project-based active learning. In conclusion, the ESD-TPACK-based student worksheets are valid and suitable for supporting sustainable learning and enhancing students' scientific attitudes in the context of biology education.

INTRODUCTION

Education for Sustainable Development (ESD) is a strategy to improve the quality of education for sustainability. (Matitaputty et al., 2022). Education for Sustainable Development (ESD) can develop several competencies that foster a sustainable mindset by delving into crucial issues (Salam & Hamdu, 2022). Education that adopts ESD is an education that can be applied to address current global challenges. (Purnamasari et al., 2021). Issues in ESD are all related to the environment. ESD facilitates learners in developing attitudes, skills, and knowledge related to social, economic, and environmental life (Purwianingsih et al., 2022). Thus, environmental education is an important part of developing students' character to care for nature. Through ESD, life will achieve better sustainability amidst the limitations of nature, by maintaining the balance of life in social, economic, and of course, environmental aspects (Kuhlman & Farrington, 2010).

During this technological era, education must keep pace with technological advancements to produce students with globally competitive skills. Education is not just limited to ESD but must also incorporate technology (Purwianingsih et al., 2022) and perfect learning that integrates technology (Rohman et al., 2024), a term often referred to as TPACK. As an analytical and creative framework, TPACK learning has the potential to produce a deeper construction of knowledge about ICT integration (Koh et al., 2015). Technology, Pedagogy, Art, Content, Knowledge (TPACK) is a very complex development in learning, not just limited to technology, but the integration of TPACK in learning will accelerate the achievement of learning objectives. To support the integration of TPACK, appropriate teaching tools are needed; these teaching tools must be innovative, TPACK-based for the local context, and of course, support sustainable education.

TPACK learning aims to create interactive learning (Pulungan et al., 2024). The use of TPACK with ESD is expected to enhance interactive capabilities for sustainable education. In its application, a scientific attitude is required, because a scientific attitude is one of the important aspects in science education. The main function and objective in science education is to cultivate a scientific attitude (Istikomah et al., 2010). A scientific attitude is an attitude that must be possessed by all scientists and academics. Scientific attitude has two meanings: attitude toward science, which refers to an attitude that pertains to science, and attitude of science, which is the attitude that emerges after studying science (Ulfa., 2018). This research focuses on teaching materials designed to enhance the attitude toward science. There are 20 scientific attitudes according to determinism, a belief that problems have solutions, a thirst for knowledge, an intellectual drive, and Empathy for the human condition. The enhancement of the four scientific attitudes supports TPACK-oriented ESD learning. The application of the attitude of science is implemented in biology education (Mustain et al., 2021).

Biology is a science with a set of facts, concepts, and principles about natural phenomena obtained through scientific processes and attitudes (Ulfa, 2018). Biology learning ideally pays attention to all aspects of products, attitudes, processes, and technology, specifically based on the nature of science (Amira Balqis, 2021; Sudarisman, 2015). Therefore, educators should prepare learning experiences for students that emphasize the aspects of products, processes, attitudes, and their relevance to everyday life. The implementation of education with technology can produce competent human resources that are globally competitive (Widiadnyana et al., 2014). With the support of relevant learning tools, students' curiosity will increase, allowing education to make a positive contribution to sustainability. Therefore, teachers play a crucial role in this matter.

Science learning tends to use an expository approach where the teacher only provides definitions of a concept and rarely allocates time for observation or experimentation (Dwi Apriliani et al., 2019). Thus, there is still a limited availability of teaching materials relevant to sustainability and technology issues in the context of Indonesian education. There is a gap between theory and practice in sustainability-based learning. One way to develop a scientific attitude is by creating active learning and considering students as young scientists, so that students become active. A scientific attitude requires a process of implementing concepts, theories, principles, and laws with facts and evidence (Fitriansyah et al., 2021). According to Agustina et al., (2021) students' scientific attitudes are still low due to several factors, one of which is the lack of supporting teaching materials.

This research will develop biology teaching materials for compost making. The presentation of student worksheets uses the PjBL model. The use of PjBL helps students become curious, flexible in their thinking, critical thinkers, and sensitive in solving environmental problems (Gunada et al., 2023). Project-based problem learning will construct students' knowledge according to their capacity

(Pratama et al., 2020). The selection of the composting problem is because this material supports learning for sustainable education. In previous research, composting was only used to train student activity (Andriani, 2021), the development of student worksheets for environmental change (Lestari, 2017), teaching materials for local waste processing (Dewi & Sari, 2024), and the improvement of composting skills (Zurhalena et al., 2021). Which of these studies has not yet developed a scientific attitude based on TPACK-ESD for students. Previous research has also developed student worksheets based on scientific attitudes, but the indicators used were general and did not employ the TPACK-ESD approach (Widiyarini & Wilujeng, 2015). It is hoped that the presentation of compost-making integrated with TPACK will be the right combination to enhance students' scientific attitudes, especially in improving their scientific attitudes. Determinism, a belief that problems have solutions, a thirst for knowledge, and empathy for the human condition. The combination of ESD with TPACK will result in the development of innovative teaching materials with a focus on enhancing scientific attitudes through sustainability-based learning activities. This study aims to analyze the validity of the developed teaching materials to ensure they are suitable for improving students' scientific attitudes.

METHODS

Research Design

This research is a development study that produces a product in the form of a TPACK-ESD student worksheet teaching device. The development model refers to the ADDIE model (Tegeh & Kirna, 2013) , which consists of five stages: the analysis stage, the planning stage, the development stage, the implementation stage, and the evaluation stage (Branch, 2009). The research stages were conducted by observing students' problems in education and the quality of education to see if they align with sustainable education that keeps up with the times. The research results will produce student worksheets integrated with TPACK-ESD, which are planned to be implemented in grade X SMA/MA in Indonesia. Before the student worksheets are used in the learning process, the worksheets are validated by media experts and high school Biology education practitioners to assess the validity of the product created by the researcher. The validation data were processed using Aike V (1985), then analyzed and presented descriptively and quantitatively. Quantitative descriptive analysis is an analysis method using statistics to provide a systematic overview and is interpreted more easily (Aziza, 2023).

Participation

The participants used in the student worksheet analysis research are students from class X-A. The sample used was specifically for compost making, selected purposively. The validators used are 2 teachers and 1 lecturer.

Instrument

The data collection technique used is the content analysis guidelines of student worksheets/expert validation sheets based on ESD and TPACK criteria to train students' scientific attitudes. The scientific attitudes that will be trained are 4, namely; (Determinism, A belief that problems have solutions, A thirst for knowledge, and Empathy for the human condition). The scientific attitudes were adopted from modifications by Bronowski (1978), Diederich (1967), and Whaley & Surratt (1967). The analysis guidelines have been validated by two experts in the field, and the student worksheets that were analyzed have also been validated by two experts and deemed suitable and reliable for use in teaching. The validation sheet instrument used to measure students' scientific attitudes is a questionnaire containing statements with a 1-5 Likert scale, but the 3 scale is not used (Seung Youn (Younnie), Chyung; Roberts, Katherine; Swanson, Leva; Hankinson, 2017). The research results will be analyzed descriptively and quantitatively based on the validation results.

Procedure

This research uses the ADDIE development design. The stages in the ADDIE model are 5, namely; analysis stage, planning stage, development stage, implementation stage, and evaluation stage (Branch, 2009). The analysis stage is the initial phase in research related to observing problems in biology learning. In the planning stage, researchers create a design related to the design and content as well as the layout of student worksheet devices. In the development stage, the student worksheet devices that have been developed are tested with reviews and validations in terms of content feasibility, construct

feasibility, and language. In this stage, it is expected to develop a valid student worksheet teaching device that has been validated and revised based on critiques and suggestions from experts, making the device suitable for use. Then, the next stage is implementation and evaluation. However, this research is limited to the development of TPACK-ESD student worksheet devices to train students' scientific attitude skills. The ADDIE development model can be seen in Figure 1.

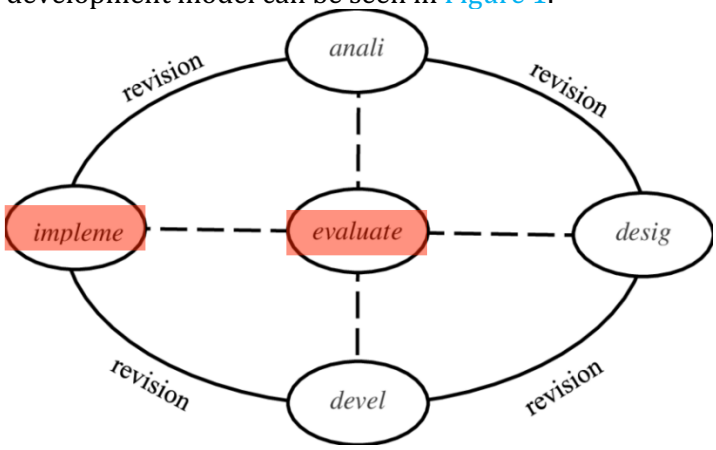


Figure 1. Development Stage of the ADDIE Student Worksheet device (Branch, 2009)

Data Analysis Techniques

There are two types of data that will be presented, namely quantitative data from the results of statistical validation calculations and descriptive data to clarify the meaning of the presented statistical data. The validity and reliability of the student worksheet devices are presented using a 1-5 Likert scale, but the 3 scale is not used (Seung Youn (Younnie), Chyung; Roberts, Katherine; Swanson, Leva; Hankinson, 2017). The validity analysis uses the Aiken formula (1985) in (An Nabil et al., 2022). It is said to be valid if the calculated V value ≥ the Aiken table V value (1985). Then, reliability is calculated using the Alpha Cronbach formula (Sudijono, 2011). If the reliability coefficient obtained from the calculation is greater than the coefficient found in the critical value table (R > r table), it is considered reliable, and vice versa (Sudijono, 2011).

RESULTS AND DISCUSSION

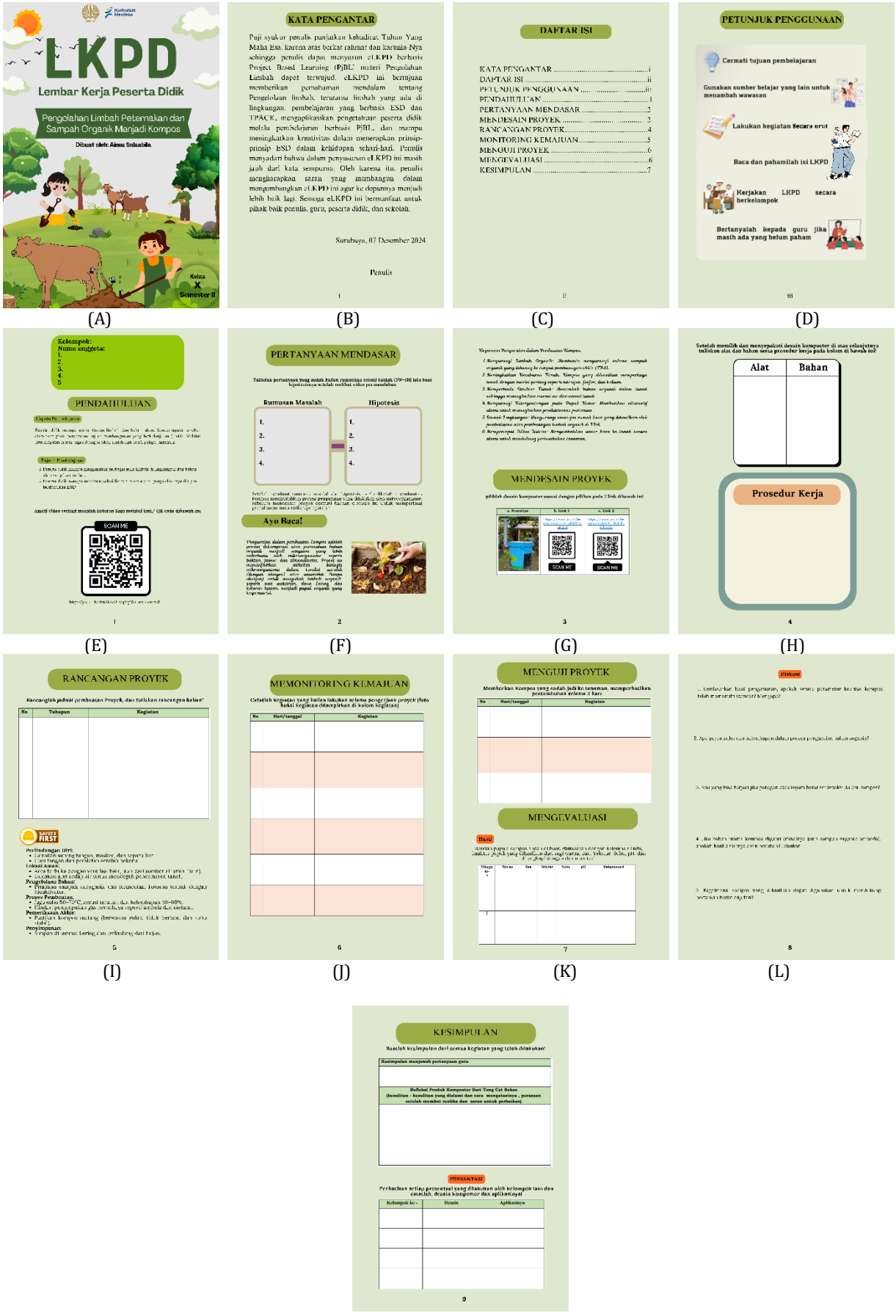
1. Analysis

The results of the analysis stage in the device development process were obtained from the needs analysis, which showed that teachers and students still use biology learning that tends to be conventional. This is due to a lack of time and uncreative teachers, resulting in the learning devices used being merely theoretical without any direct practical follow-up. The learning conducted is also limited to theoretical material without being connected to phenomena and problems in the surrounding environment (Rachmawati et al., 2024).

Biology teachers are lacking in guiding students for education for sustainable development (ESD), and the teaching materials used are still not suitable for training the skills needed in this technological advancement. The teaching materials used also do not fully utilize the natural potential and issues present in the students' environment. Moreover, students' science attitude skills are still not being developed, because the teachers do not even understand what is included in science attitude.

2. Design

At this stage, the researcher is developing teaching materials that combine TPACK based on ESD to train students' science attitudes. Indicators in the student worksheet devices are linked to learning outcomes in the independent curriculum on the main topics of environmental issues and efforts to address them with the subtopic of waste management. The material achievement to be reached is "the utilization of waste and natural resources, all efforts are directed towards achieving sustainable development goals (SDGs)." Through process skills, a scientific attitude and the Pancasila student profile are also developed. The selection of materials is adjusted according to the learning objectives, student characteristics, and time allocation (Fogarty & Pete, 2009). The design of student worksheet devices integrated with TPACK-ESD to cultivate science attitudes in project-based learning (PjBL) is shown in Figure 2.



(A) (B) (C) (D)

(E) (F) (G) (H)

(I) (J) (K) (L)

(M)

Figure 2. (A) Cover, (B) Foreword, (C) Table of Contents, (D) Filling Instruction, (E) Introduction, (F) Basic Questions, (G) Designing the Project, (H) Designing the Project, (I) Project Design, (J) Monitoring Progress, (K) Testing the Project and Evaluating, (L) Discussion Questions, (M) Conclusion and Presentation.

The completion of the teaching module is done online by scanning the QR code provided by the teacher in picture 3.

Figure 3. QR Code for Student Worksheet Completion

3. Development

After the development of the teaching device is completed, testing of the created teaching device is conducted with a review and validation in terms of concept/content, construct, and language presentation, as well as ease of use by students, teachers, or education experts. The review process is conducted during the preparation of the student worksheet devices, taking into account input and suggestions from experts. After that, the student worksheet device was validated by two expert validators. Based on the expert validation results, it was concluded that the device is valid and suitable for use. The purpose of this expert validation is to assess the content and presentation based on the measured variables (Salsabilla et al., 2023). There are 22 aspects in the student worksheet device validation sheet (Table 1), and the results of the validity of Aiken V for each aspect can be seen in Figure 3.

Table 1.
Aspects of device validation instruments

No	Aspect
1	The material in the student worksheet is in accordance with the Learning Achievements and Learning objectives that must be achieved by students.
2	Material that contains facts, concepts, principles, laws and theories regarding waste processing (Making Compost from Livestock Waste and Organic Waste).
3	The material presented is in accordance with the needs of students to support the completion of student worksheet.
4	Materials supporting steps PJBL learning designed in student worksheet.
5	The material in the student worksheet directs students to identify and examine problems in case studies.
6	The material in student worksheet directs students to be able to find solutions to a problem.
7	The material in student worksheet directs students to carry out projects and analyze data.
8	Include the learning objectives you want to achieve.
9	Questions in the student worksheet are formulated clearly and show integration.
10	student worksheet includes steps according to PJBL learning steps.
11	Learning objectives are in accordance with the steps in the student worksheet.
12	student worksheet is able to train scientific attitude determinism.
13	student worksheet is able to train scientific attitude A belief that problems have solutions.
14	student worksheet is able to train scientific attitude A thirst for knowledge, an "intellectual drive."
15	student worksheet is able to train scientific attitude Empathy for the human condition.
16	student worksheet supports ESD.
17	student worksheet is made using TPACK aspects.
18	student worksheet is written using good and correct Indonesian language rules according to PUEBI (General Guidelines for Indonesian Spelling).
19	Suitability of sentences to the level of thinking, reading ability and age of high school students.
20	The sentences used in student worksheet are clear, unambiguous, and easy to understand.
21	The language used is simple and does not use terms that are difficult to understand without explanation.
22	The language in each section of the student worksheet feels integrated and supports the flow of students' thinking from one section to another.

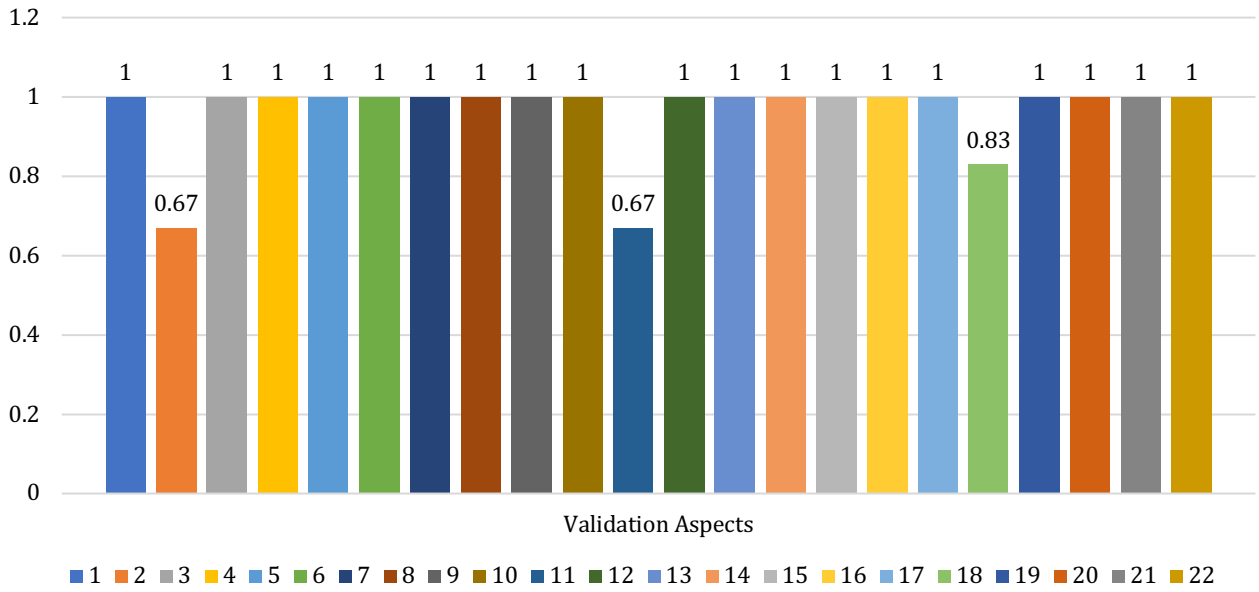


Figure 4. Aiken V Validity Results for each aspect

An average of 0.96 is categorized as valid because the V table value is 0.77, which is smaller than the calculated V value. The lowest aspect results are in aspects 2 and 11. For the validation results of the aspects related to science attitude, a perfect score has been achieved.

The score from the first validator was 92, and the score given by the second validator was 93. It can be concluded that the student worksheet device is suitable (Aji & Budiyanto, 2022) for improving science attitude. The reliability value for each aspect was obtained at 0.98, which is greater than the R table value, thus it can be said that the student worksheet devices are reliable and valid (Putriadi et al., 2020). Descriptive analysis of 4 science attitudes as follows:

1. The "Determinism" aspect

Determinism is an action taken that will cause an effect, and this effect will not occur without a cause (Restianty, 2018). Or it can be said that determinism is "cause and effect" (Kabir, 2019). The consequences in the context of determinism do not occur immediately after the action, but the consequences can appear now or on another day (Rational Enquire, 1989).

The aspect of determinism is evident in the student worksheet section that emphasizes that composting requires systematic and predictable steps. For example, the process of decomposing organic matter is explained in detail regarding the needs of temperature, humidity, and the role of microorganisms. This shows that the student worksheets teach students to understand that natural phenomena have predictable and measurable causes and effects. The smell from waste and organic garbage can cause environmental pollution and lead to disease outbreaks (Ekawandani & Anzi Kusuma, 2018) . From this issue, students can conclude that every effect has a cause.
Example in the student worksheet:

" Manufacturing Process: Maintain a temperature of 50–70°C, regular aeration, and humidity of 40–60%."
" Final Inspection: Ensure the compost is mature (dark in color, odorless, and at a stable temperature)"

2. Aspect "A Belief That Problems Have Solutions"

The belief that all problems have solutions. This attitude should be possessed by students in the science process (Janah et al., 2018). In the concept of this aspect, problems from the biggest to the smallest can all be solved and resolved. Although it is not easy, it is very likely that this problem will be resolved and will pass.

The main part of the student worksheet is to help students find solutions to the problem of organic waste. The impact of the odor caused by organic waste can disrupt breathing due to the presence of ammonia compounds in the organic waste (Azmin et al., 2022). The composting project is evidence that environmental problems, such as livestock waste and organic waste, can be addressed in a practical and

measurable way (Iswadi et al., 2023; Saputra & Zulham, 2024). Students are asked to design, monitor, and evaluate their projects, reinforcing the belief that every problem has a scientific solution.
Example in the document:

" Students can create waste solutions and management methods based on ESD."
"Write down the tools and materials as well as the work procedure in the column below."

3. "A Thirst for Knowledge" aspect

The learning process must encourage students to be eager for intellectual knowledge (Sukmawati et al., 2024). In this aspect of the concept, the more puzzles given to students, the more interesting the learning will be, and it will encourage learners to actively seek proof of gaps and incomplete explanations. This student worksheet encourages students to delve deeper into the scientific process behind composting (Sairoh et al., 2025). Instructions to watch videos, conduct observations, and formulate hypotheses indicate that students are encouraged to actively explore new knowledge. Additionally, the project design and evaluation process encourages students to continuously learn from their experiences.

Example in the document:
"Watch the video related to the cow dung issue through the link/QR code below."
"Write the problem statement and hypothesis after watching the problem video."

4. "Empathy for the Human Condition" aspect

In line with the goal of creating student worksheets oriented towards sustainable education. The aspect of empathy towards humans is very much needed, because only humans can protect and restore nature, so students must have a sense of concern for the environment, especially for sustainability (Sairoh et al., 2025). In its application in education, practices that do not incorporate these attitudes and values in the scientific process will result in inaccurate science.

The aspect of empathy is evident in the main goal of the composting project, which is to reduce the impact of waste on the environment and support sustainable agriculture. By understanding the impact of waste on soil and water, students are encouraged to care about environmental conditions and community welfare. The production of compost has dual benefits, namely reducing waste effectively and increasing the market value of the waste (Shitophyta et al., 2021).

Example in the document:
"Reducing Organic Waste: Helping to reduce the volume of organic waste sent to landfills (TPA)."
"How can the produced compost be used to support sustainable agriculture?"

The TPACK aspect consists of 3 interrelated main elements: technological knowledge (TK), pedagogical knowledge (PK), knowledge about teaching strategies, and content knowledge (CK), and knowledge about teaching materials (Unaida & Fakhrah, 2022). In the student worksheets, technology (TK) is utilized with the completion of the worksheets online and the content of the worksheets using videos and QR codes to facilitate students in finding learning resources. The use of this technology makes students more interactive and easily access information digitally (Pasaribu et al., 2024), thereby making the understanding of the composting concept more engaging and contextual. The PK element used is project-based learning (PjBL), a model that is an effective pedagogical strategy to encourage students to actively think critically and solve problems. PjBL is an innovative learning model that encourages students to use their creativity in problem-solving (Fadiyah Andirasdini & Fuadiyah, 2024). PjBL invites students to gain knowledge through the experiences they undertake, making the learning process more meaningful (Ayu, 2023). The CK element is the main material used, "Management of organic waste into compost." The selection of this material is relevant to the curriculum and can contribute to ESD learning.

Education for Sustainable Development (ESD) is an educational approach aimed at developing skills, values, and attitudes that support sustainable development (Umar et al., 2024). This student worksheet covers several key principles of ESD, namely: first, Environmental Responsibility. In the composting activity designed in the student worksheet it teaches students to manage waste in an

environmentally friendly manner, a process that reduces greenhouse gas emissions because it is eco-friendly. This process also introduces students to the concept of the circular economy, which is the utilization of waste for beneficial product outcomes. The second is Social Responsibility. ESD teaches students to consider the social impact of their actions. This student worksheet encourages learners to think about finding solutions that can have a positive impact on their surroundings and support local agriculture. The third ESD principle, Future-Oriented Thinking, this student worksheet instills the concept of long-term thinking with the importance of problem-solving for sustainability. This approach is capable of fostering a proactive attitude in facing environmental challenges.

This research is only at the development stage, so further research is needed to determine the effectiveness of using the validated student worksheets. The student worksheets developed based on the ADDIE development model are already based on TPACK-ESD. Then, providing student worksheets using QR codes will reduce paper usage (Wijayanto et al., 2022) , thereby correlating with sustainable education and helping students use them more flexibly (Indiana et al., 2024).

CONCLUSION

This student worksheet has successfully integrated TPACK and ESD elements to improve students' science attitude skills. The use of digital technology, project-based learning methods, and content relevant to sustainable development shows that this student worksheet can be an effective instrument in supporting ESD-based science learning.

ACKNOWLEDGMENT

The author would like to thank the school and the expert validators who have provided assessments and the experts who have provided criticism and suggestions until this student worksheet device was completed and suitable for use.

REFERENCES

Agustina, P., Saputra, A., Anif, S., Rayana, A., & Probowati, A. (2021). Analisis Keterampilan Proses Sains Dan Sikap Ilmiah Siswa Kelas Xi Ipa Sma Pada Praktikum Biologi. *Edusains*, *13*(1), 1–7. https://doi.org/10.15408/es.v13i1.11015

Aji, G. S., & Budiyanto, M. (2022). Peningkatan Hasil Belajar Peserta Didik Kelas VII dengan Menerapkan Pembelajaran Inkuiri Terbimbing. *Jurnal Pendidikan Sains*, *10*(3), 367–373. https://ejournal.unesa.ac.id/index.php/pensa/article/view/45423/41476

Amira Balqis. (2021). *Kajian Sikap Ilmiah Peserta Didik Pada Praktikum Biologi Dan Korelasinya Terhadap Keterampilan Proses Sains Kelas X Ipa Di Sma Negeri 1 Sukoharjo*.

An Nabil, N. R., Wulandari, I., Yamtinah, S., Ariani, S. R. D., & Ulfa, M. (2022). Analisis Indeks Aiken untuk Mengetahui Validitas Isi Instrumen Asesmen Kompetensi Minimum Berbasis Konteks Sains Kimia. *Paedagogia*, *25*(2), 184. https://doi.org/10.20961/paedagogia.v25i2.64566

Andriani, L. (2021). Pemanfaatan Lingkungan Sekitar Sebagai Sumber Belajar Siswa Pada Mata Pelajaran Ipa Di Masa Pandemi. *Journal of Chemical Information and Modeling*, *53*(February), 2021. https://repository.unja.ac.id/id/eprint/19295

Ayu, R. (2023). Efektivitas Lembar Kerja Peserta Didik Berbasis Model Pembelajaran Project Based Learning (Pjbl) Terintegrasi Tpack Terhadap Hasil Belajar Siswa SMA. *Jurnal Biogenerasi*, *8*(1), 385–388. https://doi.org/10.30605/biogenerasi.v8i1.2254

Aziza, N. (2023). Metodologi penelitian 1 : deskriptif kuantitatif. *ResearchGate*, *July*, 166–178.

Azmin, N., Irfan, I., Nasir, M., Hartati, H., & Nurbayan, S. (2022). Pelatihan Pembuatan Pupuk Kompos Dari Sampah Organik Di Desa Woko Kabupaten Dompu. *Jompa Abdi: Jurnal Pengabdian Masyarakat*, *1*(3), 137–142. https://doi.org/10.57218/jompaabdi.v1i3.266

Branch, Robert Maribe. (2009). Instructional Design: The ADDIE Approach. New York: Springer Science-Business Media.

Dewi, A. F., & Sari, T. M. (2024). *Pengembangan Bahan Ajar Mikrobiologi Berbasis Pengelolaan Limbah Lokal Development*. *9*(1), 9–22. https://doi.org/10.37058/bioed.v9i1.3986

Dwi Apriliani, N. M. P., Wibawa, I. M. C., & Rati, N. W. (2019). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Hasil Belajar IPA. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *3*(2), 122. https://doi.org/10.23887/jppp.v3i2.17390

Ekawandani, N., & Anzi Kusuma, A. (2018). Pengomposan Sampah Organik (Kubis Dan Kulit Pisang)

Dengan Menggunakan EM4. *Tedc*, *12*(1), 38–43. https://osf.io/preprints/inarxiv/3gt26_v1
Fadiyah Andirasdini, I., & Fuadiyah, S. (2024). Pengaruh Model Pembelajaran Problem Baseed Learning Terhadap Keterampilan Berpikir Kreatif Peserta Didik Pada Pembelajaran Biologi : Literature Review. *Biodik*, *10*(2), 156–161. https://doi.org/10.22437/biodik.v10i2.33827
Fitriansyah, R., Werdhiana, I. K., & Saehana, S. (2021). Pengaruh Pendekatan STEM dalam Model Inkuiri Terbimbing Terhadap Sikap Ilmiah dan Kerja Ilmiah Materi IPA. *Jurnal Ilmiah Pendidikan Fisika*, *5*(2), 225. https://doi.org/10.20527/jipf.v5i2.3598
Fogarty, R., & Pete, B. M. (2009). Haw To Interate the Curricula. *Corwin A SAGE Company*, LB1570.F655 2009 375—dc22, 2008056034.
Gunada, I. W., Wahyudi, W., Ayub, S., Taufik, M., & Busyairi, A. (2023). Validitas Perangkat Model Project Based Learning Berbasis STEM pada Pokok Bahasan Perubahan Energi untuk Meningkatkan Sikap Ilmiah. *Empiricism Journal*, *4*(1), 134–144. https://doi.org/10.36312/ej.v4i1.1287
Indiana, S., Pd, M., Dr. Hj. Nurrohmatul Amaliyah, M. P., & Dr. Tri Isti Hartini, M. P. (2024). Hubungan Antara Kemampuan Berpikir Kritis dan Kemampuan Berpikir Kreatif Dengan Penguasaan Konsep Dasar Ipa Pada Siswa Kelas V Di SDN Gugus 2 Kecamatan Cipayung Kota Depok. *Pedagogi: Jurnal Penelitian Pendidikan*, *11*(1), 86–104. https://doi.org/11.25134/pedagogi.v11i1.8507
Istikomah, H., Hendratto, S., & Bambang, S. (2010). Penggunaan Model Pembelajaran Group Investigation Untuk. *Jurnal Pendidikan Fisika Indonesia*, *6*(1), 40–43. https://doi.org/10.15294/jpfi.v6i1.1101
Iswadi, H., Ahmad, M. S., & Ramadhanny, R. (2023). Pembuatan Kompos. In *Teknik Pengolahan Limbah*.
Janah, M. C., Widodo, A. T., & Kasmui. (2018). Pengaruh Model Problem Based Learning Terhadap Hasil Belajar Dan Keterampilan Proses Sains. *Jurnal Inovasi Pendidikan Kimia*, *12*(1), 2097–2107. https://doi.org/10.15294/jipk.v12i1.13301
Kabir, S. F. (2019). Kejahatan Dan Hukuman: Tantangan Filosofis Determinisme-Kausal Terhadap Pertanggungjawaban Pidana. *Jurnal Hukum & Pembangunan*, *49*(2), 279. https://doi.org/10.21143/jhp.vol49.no2.2003
Koh, J. H. L., Chai, C. S., & Lee, M. H. (2015). Technological Pedagogical Content Knowledge (TPACK) for Pedagogical Improvement: Editorial for Special Issue on TPACK. *Asia-Pacific Education Researcher*, *24*(3), 459–462. https://doi.org/10.1007/s40299-015-0241-6
Kuhlman, T., & Farrington, J. (2010). What is sustainability? *Sustainability*, *2*(11), 3436–3448. https://doi.org/10.3390/su2113436
Lestari, Y. (2017). Pengembangan Lembar Kegiatan Siswa (Lks) Berbasis Contextual Teaching and Learning (Ctl) Pada Materi Perubahan Lingkungan. *BioEdu*, *6*(3), 250133. https://ejournal.unesa.ac.id/index.php/bioedu/article/view/20878/19151
Matitaputty, J. K., Ufie, A., Ima, W., & Pattipeilohy, P. (2022). Implementasi Education for Sustainable Development (Esd) Melalui Ekopedagogi Dalam Pembelajaran Di Smp Negeri 8 Ambon. *Budimas : Jurnal Pengabdian Masyarakat*, *4*(1), 1–8. https://doi.org/10.29040/budimas.v4i1.3532
Mustain, M. N., Hirza, B., & A Siroj, R. (2021). Analisis Korelasi Sikap Ilmiah dan Hasil Belajar Biologi. *Biodik*, *7*(4), 115–126. https://doi.org/10.22437/bio.v7i4.14438
Pasaribu, J., Sari, N. F., & Riswanto, R. (2024). Penerapan Model Problem Based Learning (Pbl) Untuk Meningkatkan Literasi Digital Siswa Berbasis Tpack Pada Pembelajaran Biologi Siswa Sma. *Jurnal Mahasiswa Pendidikan*, *5*(1), 38–43. https://doi.org/10.36987/jmapen.v5i1.6015
Pratama, A. T., Limiansi, K., & Anazifa, R. D. (2020). Penggunaan STEM (Science, Technology, Engineering, and Mathematics) Terintegrasi Pembelajaran berbasis Proyek untuk Mahasiswa. *Biosel: Biology Science and Education*, *9*(2), 115. https://doi.org/10.33477/bs.v9i2.1627
Pulungan, T. N., Kuswantara, H., & Hadi, D. (2024). *Studi Implementasi Pendekatan Pembelajaran Berbasis TPACK untuk Meningkatkan Kompetensi Murid*. *3*(1), 139–151. https://doi.org/10.69630/jm.v4i1.49
Purnamasari, S., Fitri Azkia Fahmi Suhendi, & Zulfah, N. L. N. (2021). Implementasi Education for Sustainable Development (ESD) dalam pembelajaran IPA di Kabupaten Garut: sebuah studi pendahuluan. *JKPI: Jurnal Kajian Pendidikan IPA Program Studi Pendidikan IPA*, *1*(2), 69–75. https://doi.org/10.52434/jkpi11573
Purwianingsih, W., Novidsa, I., & Riandi, R. (2022). Program for Integrating Education for Sustainable Development (Esd) Into Prospective Biology Teachers' Technological Pedagogical Content Knowledge (Tpack). *Jurnal Pendidikan IPA Indonesia*, *11*(2), 219–228.

https://doi.org/10.15294/jpii.v11i2.34772
Putriadi, D. N., Suastra, I. W., & Adnyana, P. B. (2020). Pengembangan Asesmen Kinerja Pada Praktikum Ipa Berbasis Pendekatan Saintifik Dalam Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas Vii Smp. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, *14*(2), 1858–0629. https://doi.org/10.23887/wms.v14i2.16120
Rachmawati, R. N., Rohman, F., Novianti, V., Education, B., Science, N., & Malang, U. N. (2024). *Biosfer : Jurnal Pendidikan Biologi*. *17*(2), 406–420.
Rational, Enquire. (1989). Twenty Science Attitudes: Modified from Bronowski (1978), Diederich (1967) and Whaley & Surratt (1967). Taken from The Kansas School Naturalist, Vol. 35, No. 4, April 1989.Issues are availabile free of charge by writing to: The Kansas School Naturalist Division of Biological Sciences Emporia State University Emporia, Kansas, 66801-5087.
Restianty, A. (2018). Literasi Digital, Sebuah Tantangan Baru Dalam Literasi Media. *Gunahumas*, *1*(1), 72–87. https://doi.org/10.17509/ghm.v1i1.28380
Rohman, F., Novianti, V., Biologi, P., Pengetahuan, I., & Malang, U. N. (2024). *Machine Translated Biosfer : Jurnal Pendidikan Biologi by Google*. 406–420.
Sairoh, L., Ainulhaq, N., & Muharomah, D. robiatun. (2025). *Praktikum Pembuatan Kompos Cair Sebagai Metode Pembelajaran Kontekstual Dalam Materi Daur Ulang Sampah Organik Untuk Meningkatkan Keterampilan Berpikir Kritis*. *10*(2), 928–939. https://doi.org/10.30605/biogenerasi.v10i2.5134
Salam, A., & Hamdu, G. (2022). Penerapan Education for Sustainable Development (ESD) dalam Media Pembelajaran Elektronik di Kelas V Sekolah Dasar: Perspektif Guru. *PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *9*(1), 161–172. https://doi.org/10.17509/pedadidaktika.v9i1.53129
Salsabilla, N. L., Mahrudin, M., & Rezeki, A. (2023). Validitas Booklet Keanekaragaman Jenis Semak di Kawasan Mangrove Desa Pagatan Besar. *JUPEIS : Jurnal Pendidikan Dan Ilmu Sosial*, *2*(2), 1–8. https://doi.org/10.57218/jupeis.vol2.iss2.561
Saputra, A. S., & Zulham, M. (2024). Implementasi Program Ekopesantren dalam Mewujudkan Pondok Pesantren Ramah Lingkungan (Studi kasus: Pondok Pesantren Salafiyah Darunnajah Braja Selebah, Lampung). *Himmah: Jurnal Kajian Islam Kontemporer*, *8*(1), 857–876. https://doi.org/10.47313/jkik.v8i1.3817
Seung Youn (Younnie), Chyung; Roberts, Katherine; Swanson, Leva; Hankinson, A. (2017). Evidence-Based Survey Design: The Use Of a Midpoint On The Likert Scale. *Performance Improvement*, *56*(10), 15–23. https://doi.org/10.1002/pfi
Shitophyta, L. M., Amelia, S., & Jamilatun, S. (2021). Pelatihan Pembuatan Pupuk Kompos Dari Sampah Organik Di Ranting Muhammadiyah Tirtonirmolo, Kasihan, Yogyakarta. *Community Development Journal : Jurnal Pengabdian Masyarakat*, *2*(1), 136–140. https://doi.org/10.31004/cdj.v2i1.1405
Sudarisman, S. (2015). Memahami Hakikat Dan Karakteristik Pembelajaran Biologi Dalam Upaya Menjawab Tantangan Abad 21 Serta Optimalisasi Implementasi Kurikulum 2013. *Florea : Jurnal Biologi Dan Pembelajarannya*, *2*(1), 29–35. https://doi.org/10.25273/florea.v2i1.403
Sudijono. (2011). Pengantar Statistik Pendidikan. Jakarta: Rajawali Pers
Sukmawati, S., Halim, A., & Beddu, M. J. (2024). Upaya Guru Pendidikan Agama Islam dalam Penguatan Multi Intelegensi di SMP Swasta Nurul Jadid Batam. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(3), 1095–1105. https://doi.org/10.53299/jppi.v4i3.677
Tegeh, I. M., & Kirna, I. M. (2013). Pengembangan Bahan Ajar Metode Penelitian Pendidikan dengan ADDIE Model. *Jurnal IKA*, *11*(1), 16. https://ejournal.undiksha.ac.id/index.php/IKA/article/view/1145
Ulfa, S., W. (2018). Mentradisikan Sikap Ilmiah dalam Pembelajaran Biologi. *Jurnal Biolokus*, *1*(1), 1–10.
Umar, M. F., Bariroh, G., Dewi, N., Jannah, K., Rahmat, A., Education, B., Education, N. S., & Indonesia, P. (2024). *JPBIO (Jurnal Pendidikan Biologi)*. *9*(2), 157–170.
Unaida, R., & Fakhrah, F. (2022). Studi Evaluasi Kemampuan Tpack (Technologycal, Pedagogical, and Content Knowledge) Guru Biologi Sma/Ma Kecamatan Dewantara. *Prosiding Seminar Nasional Biotik*, *9*(2), 77. https://doi.org/10.22373/pbio.v9i2.11599
Widiadnyana I W, Sadia I W, & Suastra I W. (2014). Pengaruh Model Discovery Learning Terhadap Pemahaman Konsep IPA dan Sikap Ilmiah Siswa SMP. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, *4*(2). https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/1344/1036

Widiyarini, A., & Wilujeng, I. (2015). Pengembangan LKS IPA Berbasis Scientific Approach untuk Mengoptimalkan Learning Outcome Siswa MTs Kelas VII. *Jurnal Pendidikan Matematika Dan Sains*, *3*(2), 169–181. https://staf.uny.ac.id/upload/132051059/penelitian/Asli%20Artikel%20ke%2021.pdf

Wijayanto, A., Siahaan, J., Tantri, A., Juditya, S., Bangun, S. Y., Ardha, M. A. Al, Kodrat, H., Dewi, R., Miskalena, Rozy, F., Akhmad, I., Fitriady, G., Widyaningsih, H., Ningsih, Y. F., Sinulingga, A., Kamal, M., Zainuddin, M. S., Nurkadri, Sucipto, A., … Artanty, A. (2022). *Teknologi Metaverse dalam Ilmu Keolahragaan*.

Zurhalena, Z., Wiskandar, W., & ... (2021). Peningkatan Keterampilan Siswa SMK Asy'ariyah Desa Ibru Kecamata Mestong Kabupaten Muaro Jambi Melalui Pembuatan "Trichokompos Plus" Berbahan Organik …. *Jurnal Karya Abdi …*, *5*(1), 91–99. https://doi.org/10.22437/jkam.v5i3.17007