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Development of An Environmental Chemistry Module Based on Green Chemistry Principles Through Project Activities

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A B S T R A C T

This research developed an environmental chemistry module based on green chemistry principles through project activities. The study aimed to describe the development process, validate the product, and assess its effectiveness in teaching. The development followed Lee and Owens' four-step process. Qualitative data from expert feedback informed revisions, while quantitative data from questionnaires were collected. The subjects were 40 chemistry education students. Validation by material experts in two rounds showed scores of 80.76% and 85.38% (valid), improving to 100% and 90.76% (very valid) in the second stage. Design validation by three experts yielded initial scores of 83.4%, 86.7%, and 73.4% (valid), which improved to 100%, 93.3%, and 96.7% (very valid) in the second stage. Student responses rated the module as 84.68% (practical). The Wilcoxon signed ranks test for effectiveness showed a significant p-value of 0.000, indicating improved argumentation abilities and science process skills, which averaged 83.25% (excellent).

Keyword: *Environmental chemistry, green chemistry principles, module, project activities*

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INTRODUCTION

Presenting environmental problems as examples of phenomena presented in learning, students must be directly involved in observing and studying environmental phenomena around them to foster environmental sensitivity (Mandler et al., 2012). One factor that can support learning to instill social attitudes is the availability of teaching materials integrated with environmental problems (Setyowati et al., 2013). Minister of Education and Culture Regulation No. 3 of 2020 concerning national educational standards. Learning is a process of student interaction with lecturers and learning resources in a learning environment.

Modules are printed materials for learning organized so that students may study

them without the direct presence of a teacher. Modules are said to be good and interesting if they meet the following characteristics: complete material, instructions for use, easy to learn independently, and up-to-date (Depdiknas, 2008). By using modules, students are expected to be able to carry out complete independent learning. In order to achieve these goals, an appropriate module should be self-instructional (can be used independently), self-contained (contains entire content), stand-alone (stands alone), adaptable (adapted to advancements), and user-friendly (easily used) (Daryanto, 2013).

Green Chemistry is a philosophy or concept that encourages the design of a product or process that reduces or eliminates the use and production of hazardous substances (Mitarlis et al., 2018). Green chemistry aims to develop chemical processes and products that are environmentally friendly and follow sustainable development (Prabawati & Wijayanto, 2015). Green Chemistry Education (GCE) incorporates green chemistry principles, new concepts, contents, and pedagogical approaches across (Jovero & Picardal, 2022). Considering the concept and approach of green chemistry to prevent pollution due to chemicals that can damage the environment and health, it is necessary to think about how to apply these green chemistry concepts and ideas in chemistry learning at universities in Indonesia.

Through the learning module, students are guided to solve the problems presented in this environmental chemistry course module and build their knowledge through the material by providing students with insight into protecting the environment and discussing important issues in world climate change such as global warming, acid rain, various polluted compartments in the water, air, and soil environment in terms of chemistry and chemical transformation processes that take place in the environment from various activities which cause a decline in environmental quality (Minarni, 2022)

Based on observations by Supriyanto et al., (2021) from an interview with the Head of the Brebes Regency Environmental Office, he explained that the effect of pesticide use on the soil was that as a result of the very high use of pesticides in Brebes, damage to approximately 50% of shallot vegetable land in Brebes is characterized by a decrease in land fertility, the soil becoming more dense, soil microbes decreasing. There are many other examples of environmental quality degradation, one of the causes of which is a lack of public awareness about this.

According to Haatainen & Aksela, (2021), project-based learning has much potential to improve 21st-century skills and engage students in real-world tasks. The abilities expected of students in the 21st century are 4C: creative (creative thinking), collaborative (working together), communication (communicating), and critical (critical thinking) (Hidayatullah et al., 2021). Following Rini & Cholifah, (2020), The project-based learning media or learning materials developed effectively increase students' motivation and critical thinking. PjBL is a significant problem, focusing on the learning goal, engagement in activity, collaboration among students, and between students and instructors, and use of technology for creating real results (Suradika et al., 2023). The project-based learning model is student-centric, allowing students to learn and try new things (Khoiri et al., 2023).

Science process skills are the physical and mental skills that scientists possess to acquire and develop knowledge (Juwita, 2022). Science process skills can be assessed

when conducting experiments or activities that can be observed (Tauhidah & Farikha, 2022). Science process skills are a learning approach oriented towards the science process, which contains not only a collection of knowledge but four things: process/method, content/product, technology, and attitude (Cahya et al., 2023).

Argumentation is a logical and rational conversation that aims to find a relationship between an idea and the evidence used to support the concept (Ramadani et al., 2023). Module development was carried out by (Widiastiningsih et al., 2022). The module was developed based on argumentation patterns in acid-base material, the results obtained were based on validation from media experts and material experts, the module was categorized as suitable for testing, and the module was classified as very good based on teacher assessment and student responses. In another study by (Al Idrus et al., 2020) The developed environmental chemistry practicum module based on green chemistry is very suitable for implementation in environmental chemistry learning, as seen from the assessment of chemistry lecturers in the "very good" category with an average score above 3.4. Student responses show that the practicum module is efficient, with positive responses with an average for each aspect above 0.49. Research (Sudarmin et al., 2023) on chemistry project-based learning in Secondary metabolite courses in essential oils and terpenes and learning tools with an Ethno-STEM approach are feasible and effective for improving students' conservation and entrepreneurial character.

RESEARCH METHODS

This research follows a Research and Development (R&D) approach, utilizing the media development principles of William W. Lee and Diana L. Owens. The process consists of four stages: (1) developing a framework for tools, specifications, and standards; (2) creating media components based on the framework; (3) reviewing and refining the product; and (4) implementing the final product.

This development framework uses a model developed by (Haryanto et al., 2018) consisting of eight learning components, followed by experimental research to determine the product's effectiveness. Researchers use the development framework of (Haryanto et al., 2018) for several reasons, namely (1) this development framework has simple but interactive stages to produce competent products, (2) the development framework has systematic and efficient stages, making it easier for researchers to study, (3) the development framework specifically designed for green chemistry-based environmental chemistry learning, so that it is following the main research topic, namely developing green chemistry-based environmental chemistry learning modules to improve student learning outcomes.

The research subjects were chemistry education students, teaching, and education faculty at Jambi State University. The sampling technique uses cluster random sampling. There are qualitative and quantitative data in the form of responses, suggestions, and input from experts/experts from material and design experts, which will then be used for product revisions and improvements. Data obtained from other assessment questionnaires will be processed using a quantitative approach.

The scores obtained based on the results of the gradation of answer choices are then converted into a five-point Likert scale, which ranges in intervals (Sugiyono., 2018). The effectiveness test in this research was

conducted to determine the module's effectiveness in improving student learning outcomes in environmental chemistry material. Analysis in this study was carried out using the Wilcoxon signed-rank test using the Social Package for Social Science (SPSS) software. If the value is <0.05, then the hypothesis is accepted: the module can improve student learning outcomes in environmental chemistry material.

RESULTS AND DISCUSSION

The steps in developing William W. Lee and Diana L. Owens learning tools consist of four stages, namely (1) developing a framework for tool development, development of specifications and standards; (2) developing parts of the media that have been adapted to the framework; (3) review and improve the product; (4) implement the final product. This development framework uses a model developed by Haryanto et al. (2018) consisting of eight learning components, followed by experimental research to determine the product's effectiveness.

Researchers use the development framework of (Haryanto et al., 2018) for several reasons, namely (1) this development framework has simple but interactive stages to produce competent products, (2) the development framework has systematic and efficient stages, making it easier for researchers to study, (3) the development framework specifically designed for green chemistry-based environmental chemistry learning, so that it is in line with the leading research topic, namely developing green chemistry-based environmental chemistry learning modules to improve students' argumentation skills. In this research, researchers only carried out the small group evaluation stage.

1) Inputs

The initial step is a needs analysis accompanied by data collection. At the needs analysis stage, data was obtained from a Google form distributed to students—initial analysis by analyzing students' initial abilities regarding green chemistry. The analysis was conducted on 40 students: 10 during the small group test and 30 during the significant group test in the chemistry education study program, Faculty of Teacher Training and Education, Jambi State University. Based on the results of the student characteristics questionnaire in Table 5.1, it was found that students' responses to learning environmental chemistry in class were 40% answered normal, 32.5% answered it was fun, and 27.5% answered it was difficult. Based on this, half of the students already think learning environmental chemistry is fun. However, half of the students still think that learning environmental chemistry is ordinary and complex. For this reason, lecturers need to use learning tools in the learning process so that students can be more interested in learning Environmental Chemistry. It is in line with the results of the student questionnaire, where 87.5% of respondents agreed that using teaching materials in learning would make learning more fun (not dull). Respondent's response to understanding the principles of green chemistry was, 27.5% answered yes, and 72.5% answered no. It is suggested that 72.5 percent of respondents still need to comprehend green chemistry fundamentals, but 27.5% do. Based on this, it is necessary to provide additional teaching materials to overcome students' difficulties in studying environmental chemistry with a green chemistry orientation by implementing project-based learning.

2) Process

After the needs analysis is complete, it continues designing module teaching materials for environmental chemistry according to needs. This development stage produces several product designs in material determination, cover design, and evaluation design. Module design using the Canva application. The design of the product developed by researchers is as follows:

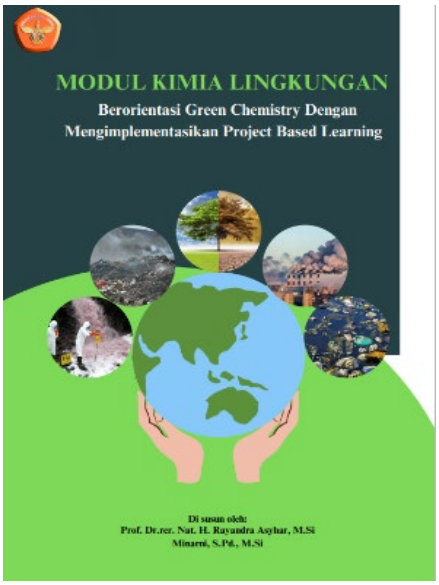

Figure 1. Module Cover Design

In material design, developers adapt to the needs and learning objectives they want to achieve by determining the material content they want to include in the module.

Figure 2. Table of Contents of Environmental Chemical Materials

Figure 3. Example in Assignment

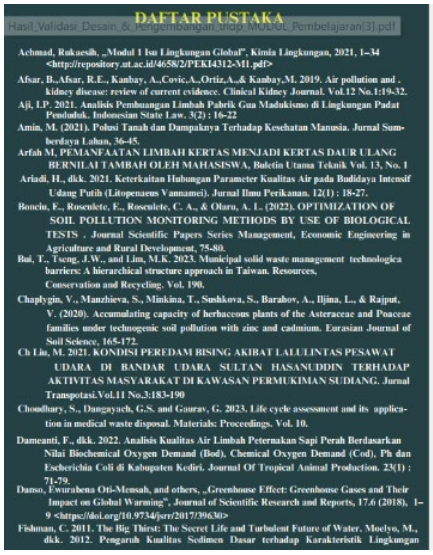

Figure 4. List of References Used in the Module

The initial draft produced is then reviewed, and the module is revised so that it is based on input from material experts and media experts. It validated the environmental chemistry learning module with a green chemistry approach. Validation was carried out in 2 rounds by each validator, design expert, and material expert.

A material expert, Mrs. Dr. Dra. Zurweni, M.Si, and Prof. Dr. rer. nat. H. Muharram, M.Si, carried out the expert validation. After the material expert saw and read the learning module in the green chemistry-oriented environmental chemistry

course by implementing project-based learning. Next, the material expert assesses the material contained in the learning tool by providing an assessment on a questionnaire and providing comments and suggestions regarding environmental chemistry material. After the learning module is revised according to comments and suggestions, the learning tool is shown again to the material expert to see the revised results. Material validation by material experts was carried out two times. Dr. Dra. Zurweni obtained the results of material validation in the first stage, M.Si got 80.76%, and Prof. Dr. rer. nat. H. Muharram, M.Si obtained 85.38% with valid criteria or can be used with minor revisions. The results of material validation in the second stage were obtained by Dr. Dra. Zurweni, M.Si, who got 100%, and Prof. Dr. rer. nat. H. Muharram, M.Si, who obtained 90.76%. So that the results obtained are "very good" or do not need revision.

The second expert validation was carried out by a design expert, Dr. Dra. Zurweni, M.Si, Prof. Dr. rer. nat. H. Muharram, M, and Siti Raihan, S.Pd., M.Pd. After the design expert has seen and developed the module, the design expert then provides an assessment regarding the design of the learning tools by assessing the questionnaire and providing comments and suggestions on the green chemistry-oriented environmental chemistry course module by implementing project-based learning. After the learning tools are revised according to comments and suggestions, the learning tools are shown back to the design expert to see the revised results. Design validation by design experts was carried out two times. Dr. Dra. Zurweni obtained the results of the design validation in the first stage, M.Si obtained 83.4%, Prof. Dr. rer. nat. H. Muharram, M. Si achieved 86.7%, and Siti achieved 73.4%, S.Pd., M.Pd. So, the results obtained are in the 'valid' category or require revision. Dr. Dra. Zurweni obtained the results of the design validation in the second stage, M.Si got 100%, Prof. Dr. rer. nat. H. Muharram, M. Si achieved 93.3%, and Siti achieved 96.7%, S.Pd., M.Pd. So, the results are in the 'very valid' category or without revision.

Based on the data from expert validation results by material experts and design experts above, it can be concluded that the environmental chemistry course module oriented towards green chemistry by implementing project-based learning meets the validity criteria. It is very valid or can be tested at a later stage.

3. Output

Draft 3 is ready to be implemented or tested on students in the chemistry education study program, teaching, and education faculty at Jambi State University in environmental chemistry. The trial results used a questionnaire distributed via Google Forms to obtain data on student responses to product use. Student responses were carried out in small-group trials with ten respondents and large-group trials with 30 respondents. The student results were obtained with a percentage of 87.2%. Based on the practical percentage interpretation criteria, small group evaluations (student responses) were obtained using practical or feasible criteria/no need for revision. The student response results were obtained with a percentage of 84.68%. Based on the practical percentage interpretation criteria, the extensive group evaluation (student responses) was obtained using practical or feasible criteria/with no need for revision.

Pretests and posttests were carried out to test the product being developed. Product testing was given to 40 students in the chemistry education study program at the Faculty of Teacher Training and Education,

Jambi State University. The purpose of this pretest and posttest is to determine the effectiveness of the module product in improving student learning outcomes. Testing was carried out using the one-group pretest-posttest design method; this method compares the conditions before and after treatment.

Based on this data, the provision of environmental chemistry course modules oriented towards green chemistry by implementing project-based learning is adequate. Data can be seen in Table 1 below;

Table 1 *Wilcoxon Signed Rank Test calculation*

Ranks

		N	Mean Rank	Sum of Ranks
Post-test - Pre-test	Negative Ranks	0[a]	,00	,00
	Positive Ranks	40[b]	20,50	820,00
	Ties	0[c]		
	Total	40		

a. Post-test < Pre-test
b. Post-test > Pre-test
c. Post-test = Pre-test

Table 1 shows the pretest and posttest results, which were tested on 40 samples, showing positive results. These results show that in the 40 students who were examined by providing green chemistry-oriented environmental chemistry course modules by implementing project-based learning, all research subjects experienced increased learning outcomes.

Table 2. Wilcoxon Signed Rank Statistical Test

Test Statistics[a]

	Post-test - Pre-test
Z	-5,527[b]
Asymp. Sig. (2-tailed)	,000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Based on Table 2, it can be seen from the results of statistical tests carried out on 40 students in the chemistry education study program, Faculty of Teacher Training and Education, Jambi State University, that the p-value obtained from the pretest and post-test results is 0.000. Based on the hypothesis, if the p-value is < 0.05, the hypothesis is accepted, implying that the green chemistry-oriented environmental chemistry course module, implemented through project-based learning, can improve student learning outcomes in the chemistry education study program at Jambi State University's Faculty of Teacher Training and Education.

The PjBL learning model can improve learning habits and motivate students to think initially in solving real-life problems (Kisworo et al., 2021). In the field of chemistry education itself, green chemistry can be applied as learning modules. Minimize dangerous product designs and chemical processes. Applying the 12 principles of green chemistry can empower student teachers to overcome environmental problems.

The green chemistry approach in studies in the field of chemistry education is still in a relatively new category with a focus on the application of chemical principles in designing, using, or producing chemicals to reduce the use or production of hazardous materials that can disrupt the health of living creatures and environmental preservation (Al Idrus et al., 2021). A more environmentally friendly learning process can only be achieved with the skills and talents of teachers. According to Inayah et al., (2022), Environmental issues are closely related to the green chemistry movement. Using the 12 principles of green chemistry, we can overcome urgent environmental problems such as pollution, energy shortages, waste management, and workplace safety and security. Green Chemistry wants to achieve the goal of emphasizing environmentally and health-friendly chemicals and products. Students' problem-solving abilities, critical thinking skills, and scientific work can be realized and improved through green chemistry-oriented education by contributing to the use of environmentally friendly and resource-saving chemical products and processes.

The results prove that a viable product has been validated and tested to become an effective product used to improve learning outcomes in environmental chemistry material. Using project-based learning, Pretest, and post-test analysis are used to measure and analyze the effectiveness of green chemistry-oriented environmental chemistry course modules. Based on the Wilcoxon signed ranks test calculation results, the average ranking value is 20.50, with a total ranking value of 820.00. Furthermore, no negative ranking was found in the effectiveness test. The p-value obtained is 0.000 based on the hypothesis made; if the p-value is <0.05, then the green chemistry-oriented environmental chemistry course module can improve learning outcomes by implementing project-based learning.

It aligns with research conducted by Al-Idrus et al., (2020), developing a Green Chemistry-based environmental chemistry practicum module that students can use as a guide for implementing safe and environmentally friendly practicums in the Environmental Chemistry course. This research method is Research and Development (R&D), with the principles of media development according to William W. Lee and Diana L. Owens. The target of this research is the feasibility of the practicum module based on expert assessments (Chemistry lecturers) and student responses. The research results were analyzed using quantitative descriptive analysis methods. Data analysis shows that the chemistry lecturer's assessment is in the "very good" category, with an average score above 3.4. Student responses show that the practicum module is efficient, with positive responses with an average for each aspect above 0.49. So, the green chemistry-based environmental chemistry practicum module developed is very suitable for implementation in environmental chemistry learning.

There are five levels of argumentation ability in the assessment; namely, level 1 students can provide simple arguments in the form of simple statements or opinions, level 2 students can provide arguments consisting of opinions and are supported by good data, reasons or assumptions, but do not contain any objections, level 3 students can provide arguments with a series of 99 opinions or statements with data, reasons, or assumptions that are sometimes accompanied by weak rebuttals, level 4 students can provide arguments with an opinion with a refutation that can be identified. This argument may also have several claims and reasons, but it is not mandatory, and level 5 students can

provide arguments composed of long statements with more than one rebutta (Ramadani et al., 2023).

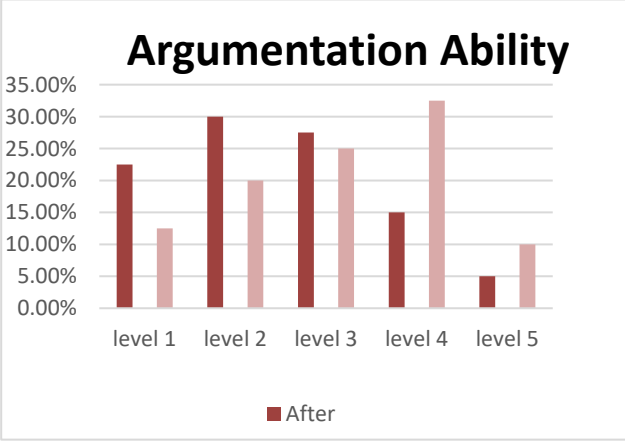

Figure 5. Graph of Argumentation Ability

It can be seen in the picture that the distribution of argumentation abilities before and after implementing the module. At level 1, 22.5% after implementation, students with argumentation skills at level one decreased by 12.5%. At level 2, it was 30% before the module was implemented and 20% after. There was a visible decrease in the number of students with argumentation skills at level 2. At level 3, it was 27.5% before and 25% after the implementation. At level 4, as much as 15% before implementation and 32.5% after implementation, there was an increase in students' skills in arguing. At level 5, it was 5% before, and after implementation, it increased by 10%. Based on the data obtained, students' argumentation abilities can be seen in the distribution at levels three and four.

Science process skills obtained in the aspect of observing 85%, skills in planning experiments 82%, skills in using tools and materials 84.5%, communication skills 83.5%, grouping skills average 87.5%, skills in applying concepts 84.5%, interpretation skills 88%, question asking skills 86.5%, hypothesizing skills average 88.5%, and prediction skills 90. Students' science process skills are at an average of 83.25 in the excellent category. Skills in the categories' forecasting/predicting, hypothesizing, and interpretation aspects are excellent.

CONCLUSION

The environmental chemistry course modules, focused on green chemistry principles and implemented through project-based learning, underwent validation by material and design experts. Initial material validation yielded "valid" results, improving to "very valid" in the second stage. Similarly, design validation progressed from "valid" to "very valid" across stages. Student feedback indicated practicality at 84.68%. The Wilcoxon signed ranks test confirmed significant effectiveness ($p < 0.05$) in enhancing learning outcomes. Science process skills, averaging 83.25%, demonstrated substantial improvement post-module implementation.

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Author Contributions

All authors contribute to the process of completing research and writing articles.

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Conflicts of Interest

The funders had no role in the design of the study, in the collection, analyses, or

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REFERENCES

Al Idrus, S. W., Purwoko, A. A., Hadisaputra, S., & Junaidi, E. 2020. Pengembangan Modul Praktikum Kimia Lingkungan Berbasis Green Chemistry Pada Mata Kuliah Kimia Lngkungan. *Jurnal Pijar Mipa*, *15*(5), 541–547.

Cahya, N. N., Saridewi, N., & Muslim, B. 2023. Analisis Keterampilan Proses Sains Mahasiswa Kimia UIN Syarif Hidayatullah Jakarta Pada Praktikum Kimia Anorganik Dari Rumah. *Dalton: Jurnal Pendidikan Kimia Dan Ilmu Kimia*, *6*(2), 127–136.

Daryanto, D. 2013. Menyusun modul bahan ajar untuk persiapan guru dalam mengajar. *Yogyakarta: Gava Media*.

Depdiknas. 2008. Panduan Pengembangan Bahan Ajar. *Jakarta: Direktorat Jendral Pendidikan Dasar Dan Menengah*.

Haatainen, O., & Aksela, M. 2021. Project-Based Learning in Integrated Science Education: Active Teachers' Perceptions and Practices. *LUMAT: International Journal on Math, Science and Technology Education*, *9*(1), 149–173.

Haryanto, R, A., Asrial, & Harizon. 2018. The Development Of The Conceptual Learning Design Model Based On Generic Skills. *The Online Journal of New Horizons in Education-January*, *8*(1).

Hidayatullah, Z., Wilujeng, I., Nurhasanah, N., Gusemanto, T. G., & Makhrus, M. 2021. Synthesis of the 21st Century Skills (4C) Based Physics Education Research In Indonesia. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(1), 88–97.

Jovero, M. B., & Picardal, J. P. 2022. Green Chemistry Education In The Emerging Economies In Asia. *Jurnal Pendidikan IPA Indonesia*, *11*(4).

Juwita, R. 2022. Best Practice Membangun Keterampilan Proses Sains Melalui Model Project Based Learning Pendekatan Steam Materi Asam Basa Kelas Xi Ipa Sman 1 Bontang. *Learning: Jurnal Inovasi Penelitian Pendidikan Dan Pembelajaran*, *2*(3), 268–277.

Khoiri, N., Ristanto, S., & Kurniawan, A. F. 2023. Project-Based Learning Via Traditional Game in Physics Learning: Its Impact on Critical Thinking, Creative Thinking, and Collaborative Skills. *Jurnal Pendidikan IPA Indonesia*, *12*(2).

Mandler, D., Mamlok-Naaman, R., Blonder, R., Yayon, M., & Hofstein, A. 2012. High-school chemistry teaching through environmentally oriented curricula. *Chemistry Education Research and Practice*, *13*(2), 80–92.

Minarni. 2022. *Kimia Lingkungan*. Sarnu Untung.

Mitarlis, M., Azizah, U., & Yonatha, B. 2018. Pemanfaatan Indikator Alam dalam Mewujudkan Pembelajaran Kimia Berwawasan Green Chemistry. *Jurnal Penelitian Pendidikan IPA*, *3*(1), 1–7.

Prabawati, S. Y., & Wijayanto, A. 2015. Penerapan Green Chemistry Dalam Praktikum Kimia Organik: Materi Reaksi Nitrasi Pada Benzena. *Integrated Laboratory*, *3*(1), 1–8.

Ramadani, Y., Pujiriyanto, P., Suwartia, S., & Minarni, M. 2023. Developing Students' Worksheets based on the Inquiry-Flipped Classroom Learning Model to Improve Argumentation Skills. *AL-ISHLAH: Jurnal Pendidikan*, *15*(1).

Rini, T. A., & Cholifah, P. S. 2020. Electronic module with project based learning: Innovation of digital learning product on 4.0 era. *Teknologi Pendidikan*, *5*(2), 155–161.

Setyowati, R., Parmin, P., & Widiyatmoko, A. 2013. Pengembangan modul IPA berkarakter peduli lingkungan tema polusi sebagai bahan ajar siswa SMK N 11 Semarang. *Unnes Science Education Journal*, *2*(2).

Sudarmin, S., Pujiastuti, R. S. E., Asyhar, R., Prasetya, A. T., Diliarosta, S., & Ariyatun, A. (2023). Chemistry project-based learning for secondary metabolite course with ethno-STEM approach to improve students' conservation and entrepreneurial character in the 21st century. *JOTSE*, *13*(1), 393–409.

Sugiyono. 2018. *Metode Penelitian Kuantitatif*. Alfabeta.

Supriyanto, S., Nurhidayanti, N., & Pratama, H. F. 2021. Dampak Cemaran Residu Klorpirifos Terhadap Penurunan Kualitas Lingkungan pada Lahan Pertanian. *Jurnal Tekno Insentif*, *15*(1), 30–40.

Suradika, A., Dewi, H. I., & Nasution, M. I. 2023. Experimental of Project Based Learning and Problem Based Learning Models in Students' Critical and Creative Categories in Coloid Chemistry Subject. *Jurnal Pendidikan IPA Indonesia*, *12*(1).

Tauhidah, D., & Farikha, Y. 2022. Analisis keterampilan proses sains mahasiswa selama praktikum daring. *Jurnal Education and Development*, *10*(2), 6–9.

Widiastiningsih, R., Asrial, A., & Effendi-Hasibuan, M. H. 2022. Pengembangan E-Modul berbasis Pola Argumentasi Toulmin untuk Meningkatkan Argumentasi Siswa pada Materi Asam Basa. *PENDIPA Journal of Science Education*, *6*(2), 410–414.