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# Project-Based Learning in Creating Edible Straws from Red Dragon Fruit Peel to Develop Science Process Skills

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**Abstract**

This study aimed to analyze the implementation of project-based worksheets utilizing red dragon fruit peel waste (Hylocereus polyrhizus) to develop students' science process skills (SPS). The research employed a pre-experimental method with a one-shot case study design, conducted at a vocational high school in Cimahi City, involving 31 senior high school students from Class XI Industrial Chemistry-C. The research instruments consisted of student activity observation sheets, project-based worksheets, and SPS performance sheets. The results showed an average student activity score of 95%, a cognitive SPS score of 90%, and a psychomotor SPS score of 96%, all categorized as "excellent." Hence, the project-based worksheet on producing edible straws from red dragon fruit peel waste was proven to be highly feasible and effective in developing students' SPS.

Keywords: edible straw; project-based worksheet; red dragon fruit peel; science process skills

**Abstrak**

Penelitian ini bertujuan menganalisis penerapan lembar kerja (LK) berbasis proyek dengan memanfaatkan limbah kulit buah naga merah (Hyolocereus polyrhizus) untuk mengembangkan keterampilan proses sains (KPS) peserta didik. Metode yang digunakan adalah pre-eksperimental dengan desain one-shot case study, dilaksanakan di salah satu SMK di Kota Cimahi dengan 31 peserta didik kelas XI Kimia Industri-C. Instrumen penelitian meliputi lembar observasi aktivitas peserta didik, LK berbasis proyek, dan lembar kinerja KPS. Hasil menunjukkan rata-rata aktivitas peserta didik sebesar 95%, nilai kognitif KPS 90%, dan psikomotorik KPS 96%, yang termasuk kategori sangat baik. LK berbasis proyek dalam pembuatan edible straw dari limbah buah naga merah terbukti sangat layak dan efektif untuk mengembangkan KPS peserta didik.

Keywords: edible straw; keterampilan proses sains; kulit buah naga merah; lembar kerja berbasis proyek

## Introduction

Science education plays a crucial role in preparing the younger generation to meet the increasingly complex challenges of a continuously evolving modern society. It is grounded in practice and interpretation and is designed to engage students in scientific inquiry (Behera, 2023). Within this context, chemistry, as one of the core branches of science, relies on observation and the analysis of substances and their transformations (Raymond, 2022). In science classes, particularly in chemistry, students are expected to develop science process skills (SPS) to acquire knowledge and skills scientifically (Beichumila et al., 2022). Thus, chemistry is a discipline firmly anchored in up-to-date research. However, science learning is not solely about memorizing facts and concepts; it also involves cultivating the skills necessary to understand and explore the scientific world (Sunarya et al., 2022). Among the essential elements of science learning is the development of SPS.

These skills guide students through learning processes that enhance their conceptual understanding while fostering the ability to identify, evaluate, and apply facts and values relevant to everyday life (Widdina et al., 2018). SPS encompasses cognitive abilities (e.g., information processing, critical thinking, and problem-solving) and group-oriented psychomotor skills (e.g., interpersonal communication, teamwork, and management) (Sunarya et al., 2023). They represent core learning objectives, as such competencies are not only essential for scientific inquiry but are also highly valued in the workplace and within the broader scientific community (Reynders et al., 2019).

In practice, students often exhibit low levels of SPS, primarily due to a limited understanding of scientific concepts (Af'idayani et al., 2018). This shortfall is frequently linked to instructional approaches that overemphasize cognitive aspects at the expense of other domains; for instance, assigning excessive homework and relying on one-way, content-centered teaching methods (Subarkah et al., 2016). In secondary schools, lecture-based methods often dominate chemistry instruction, leading to low creativity in problem-solving, minimal participation, inefficient learning activities, and suboptimal academic outcomes (Nnoli, 2024). Prior research has shown that instruction incorporating SPS results in significantly higher learning achievement than the conventional lecture method for reduction and oxidation topics. In one study, the experimental group's posttest average score was 15.0 (SD = 3.09), compared to only 9.09 (SD = 2.31) in the control group, with a statistically significant difference ($p = 0.00$, $p < 0.05$) based on a paired t-test (Majeed et al., 2023).

These challenges are compounded by the abstract nature of chemistry content and the tendency of educators to adopt a predominantly one-way instructional approach, which limits student engagement during the learning process. Consequently, it is essential to employ instructional models that foster active participation, critical thinking, and problem-solving through direct engagement in scientific processes. Student-centered learning activities can promote critical thinking, investigation, communication, and collaboration during experimentation (Farida et al., 2017).

Given these circumstances, there is a clear need for instructional approaches that enhance student engagement and scientific skills development. One such approach is the Project-Based Learning (PjBL) model. It allows students to participate in concrete learning experiences, develop solutions, and practice real-world decision-making (Lou et al., 2017). It is designed to equip students with conceptual understanding and problem-solving abilities (Budner & Simpson, 2018).

The syntax of PjBL can effectively guide students toward solving real-world problems (Almulla, 2020). Problem-solving skills are a critical competency to be developed throughout the educational journey, with particular significance in the context of chemistry education (Sunarya et al., 2024). In this regard, student worksheets are essential in facilitating PjBL by embedding SPS indicators directly into project tasks. This integration enables students to observe, classify, experiment, and interpret throughout the learning process. Consequently, PjBL, when supported by well-structured worksheets, serves as an effective means of developing SPS.

SPS encompasses cognitive and psychomotor domains, fostering the expansion of prior knowledge and the generation of new ideas, principles, and innovations (Winandika, 2020). Ten indicators can be developed within SPS: identifying problems, posing questions, formulating hypotheses, designing experiments, making observations, interpreting results, applying concepts, classifying, communicating, and drawing conclusions (McLaughlin et al., 2024).

The implementation of PjBL to develop SPS can be enhanced through project-based worksheets, which assist students in planning and designing projects during learning activities (Ruder & Stanford, 2020). Research indicates that such worksheets could significantly enhance students' SPS, aligning with findings that PjBL could increase student engagement and effectively foster these skills' development (Fatnah et al., 2021).

The PjBL model can also address pressing real-world issues, such as plastic waste, particularly single-use plastic straws (Baran et al., 2018). According to data from the Ministry of Environment and Forestry, Indonesia generates approximately 64 million tons of waste annually, of which 14% is plastic waste. Among these, plastic straws constitute a significant portion, with an estimated 93.2 million units discarded daily (Purwaningrum, 2016). Recycling conventional plastic straws is particularly challenging due to the difficulty of separation and processing, as well as their widespread disposal after single use (Guo et al., 2023).

One promising solution is the production of edible straws made from a mixture of polysaccharides, lipids, and proteins (Liu et al., 2024). They are considered an environmentally friendly choice because they are food-grade and produce zero waste (Petchimuthu, 2021). The peel of red dragon fruit (Hylocereus polyrhizus) has potential as a raw material for edible straw production, as it constitutes 30–35% of the fruit's weight and contains approximately 19.39% pectin, a natural binding agent (Riyamol et al., 2023). This innovation aligns with Sustainable Development Goal (SDG) 12: Responsible Consumption and Production, which emphasizes reducing food loss and waste across production and consumption chains. Utilizing agricultural by-products such as dragon fruit peel contributes to a circular economy by converting waste into value-added products, thereby minimizing environmental impact and promoting sustainable resource use (United Nations, 2015).

Based on the background described above, this study aimed to analyze the implementation of project-based worksheets utilizing red dragon fruit peel waste to develop students' SPS. While the theme of edible straw production has been previously explored within green chemistry topics, the present research introduced an innovative approach by integrating waste valorization of red dragon fruit peel into PjBL. This strategy could simultaneously enhance students' practical scientific skills and environmental awareness. Furthermore, it addressed a gap in the literature by combining hands-on scientific inquiry with sustainable waste management practices in chemistry education.

## Method

This study focused on student activities and PjBL to develop students' science process skills (SPS). A pre-experimental method with a one-shot case study design was employed. This research design was chosen because it does not involve a control group; instead, the treatment is applied to a single group, followed by observation of the outcomes (Sugiyono, 2021).

This study aimed to develop a product in the form of a worksheet, referred to as a student worksheet. The worksheet developed in this research was based on

PjBL and was oriented toward the application and processing of organic waste, incorporating green chemistry concepts.

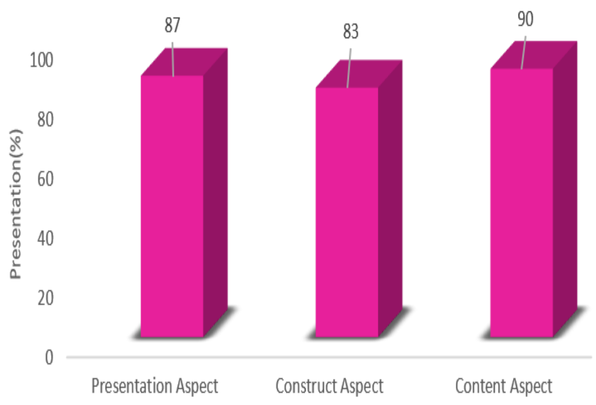
The subjects of this study were Grade XI Industrial Chemistry-C students at a vocational high school in Cimahi City during the 2024/2025 academic year. The focus was on the application and processing of organic waste. The students were divided into five groups, each consisting of 6–7 members, and were given a treatment involving the implementation of project-based worksheets. Observations were then conducted to assess their SPS, which served as the main focus for analysis and data collection in evaluating the impact of the applied method or treatment during the study.

Data collection techniques included: (1) observation sheets to monitor student activities during project-based learning; (2) student worksheets as evidence of project implementation and outcomes; and (3) performance assessment sheets (assessment rubrics) to evaluate the SPS demonstrated by students throughout the learning process. The data were analyzed using a descriptive quantitative approach, which involved calculating the average scores and percentages from the observation sheets and SPS performance rubrics.

Instrument validation was conducted before data collection to ensure the reliability and feasibility of the observation sheets, performance rubrics, and project-based worksheets. The validation process is described in the Preparation Phase subsection. The research was carried out in three phases: (1) the Preparation Phase, which involved instrument development and validation; (2) the Implementation Phase, where PjBL activities were carried out and data were collected; and (3) the Conclusion Phase, where data were analyzed and findings were interpreted.

The preparation phase included key activities to ensure instrument validity and the effective implementation of the PjBL model. It began with designing observation sheets, student worksheets containing SPS indicators, and performance assessment rubrics to evaluate SPS during the project. Three expert validators conducted validation prior to the research. The validation assessed three aspects: presentation, construct, and content. The results are presented in Figure 1.

**Figure 1**.
Graph of Expert Validation Scores for the Worksheet




The average score shown in Figure 1 was 88, which can be interpreted as a high feasibility rating (Puspitasari & Febrinita, 2021). The instrument used in this study was therefore deemed valid.

The implementation phase began with an explanation to students regarding the description and objectives of using project-based worksheets to create edible straws from dragon fruit peel waste. Students were divided into small groups and conducted experiments, which were assessed by observers. They were guided to complete the worksheets, reflect on the experimental results in relation to the theories previously studied, and discuss any challenges encountered during the process.

The final phase involved analyzing the collected data to evaluate student performance and practicum outcomes. The analysis results were presented and described to provide an overview of the research findings. Conclusions were drawn based on the data analysis to respond to the research questions identified.

## Result and Discussion

This section presents the implementation results of project-based worksheets to enhance students' science process skills (SPS) in green chemistry. Student activity data during the learning process were collected through observations by three observers. The overall average activity score was 95, indicating an “excellent” level of student engagement.The highest score, 100, was observed in the indicators of problem identification, conducting experiments, and closing activities. The lowest score, 87, was found in the product rating activity, which still falls under the “excellent” category. These results suggest that students actively participated across all stages of PjBL. A detailed breakdown of scores for each activity is presented in Table 1.

**Table 1**.
Average Scores of Student Activities at Each Stage of PjBL

| No. | Student Activities | Average | Interpretation |
|---|---|---|---|
| 1 | Introduction | 89 | Excellent |
| 2 | Identifying the problem | 100 | Excellent |
| 3 | Designing the project | 94 | Excellent |
| 4 | Conducting the experiment | 100 | Excellent |
| 5 | Drafting/prototyping the product | 98 | Excellent |
| 6 | Rating the product | 87 | Excellent |
| 7 | Finalizing and publishing the product | 92 | Excellent |
| 8 | Closing | 100 | Excellent |

The observation sheet was used solely to assess student activity during the learning process. Therefore, in addition to measuring student activity, this study also examined the development of students’ science process skills through project-based worksheets, supported by performance sheets. The performance sheet was specifically designed to assess students’ performance during experimental activities. These supporting instruments, the worksheet and performance sheet, were used to observe the cognitive and psychomotor aspects of SPS. The project-based worksheet functioned as a learning medium that embedded indicators of SPS, aiming to stimulate students to think critically as well as to design and solve scientific problems.

In the problem identification stage, there were two indicators. The first indicator of SPS was "observing." The researchers divided the students into five groups, each consisting of six to seven members, to facilitate discussion. The students were then given a reading passage to help them identify a problem they needed to discuss and resolve collaboratively. In terms of the observation aspect, students were able to answer the questions provided after reading the passage. This outcome was supported by the group seating arrangement, which allowed them to engage in discussions and collaborate effectively during the learning process (Candia et al., 2022; Jais et al., 2021).

The next stage was project design, which included the SPS indicator of "designing an experiment." This stage involved formulating the experiment's objectives, identifying the underlying principles, selecting tools and materials, and outlining the experimental procedures in the form of a flowchart. In this indicator, students analyzed information based on a given context and a series of experimental images provided in the worksheet. The average score obtained by the students was 81, which falls into the “excellent” category.

The subsequent stage, "conducting the experiment," included the SPS indicator of "making observations." Students carried out the experiment and recorded the process and observations regarding treatments applied and outcomes observed using the worksheet and the SPS performance sheet. At this stage, students achieved an average score of 100, categorized as “excellent.” The resulting edible straw products made from red dragon fruit peel are shown in Figure 2.

**Figure 2**.
Edible Straw Products from Red Dragon Fruit Peel: (a) Dried Using a Dehydrator, (b) Dried Using an Oven


Figure 2(a) shows the edible straw dried using a dehydrator at 60°C, while Figure 2(b) shows the edible straw dried using an oven at the same temperature. However, the drying methods produced differences in the color of the edible straws. This variation is attributed to the stability of anthocyanin pigments, which is affected by factors such as pH, light, and temperature (Nassour et al., 2020).

Anthocyanin degradation occurred more rapidly in the oven due to higher heat intensity and oxidation, which caused the pigments to break down, resulting in a faded, brownish, or dull color. In contrast, the dehydrator maintained a more stable and controlled temperature, with hot air circulating effectively. The drying process was slower and more uniform, preserving the structure and color of the anthocyanin pigments. The slow-moving dry air can reduce oxidation and overcooking, thereby maintaining the reddish-purple color of the peel (Mattioli et al., 2020).

The next stage, drafting/prototyping the product, included the indicator of "interpreting observation results" by applying theoretical concepts to the observed outcomes. In this stage, students were required to organize their observation data into coherent paragraphs and relate their findings to relevant theoretical concepts. However, they encountered difficulties finding suitable theoretical references from academic journals, as they were not accustomed to examining such sources (Aziz et al., 2024). Hence, the average score achieved by the students for this indicator was 74, which falls into the "good" category.

In the product evaluation stage, the SPS indicator involved was "classifying." Students compared and assessed the characteristics of the edible straw products they had created with those produced by other groups. The evaluation was based on the results of organoleptic tests (color, aroma, taste), swelling tests (absorption capacity), and solubility tests. These tests were conducted by the students, as shown in Figure 3.

**Figure 2**.
Students' Activities During Product Testing

Good characterization was determined based on the organoleptic test results, where the product exhibited no taste, no strong odor, and displayed a reddish-purple color, the natural color of dragon fruit peel. This condition is important to ensure that the edible straw made from red dragon fruit peel does not alter the taste of beverages consumed. Furthermore, in the absorption test, swelling did not exceed 150%, and the solubility test showed complete dissolution, indicating that the edible straw easily decomposes when immersed in water (Deswinta et al., 2024). At this stage, students produced products with varying characteristics; however, they were able to compare the differences, analyze the distinguishing factors, and classify which product was the best. The highest-quality product was the edible straw made with 35 g and 40 g of red dragon fruit peel. Students achieved an average score of 100, which is interpreted as "excellent."

The final stage was finalization and publication, which included the indicators of "drawing conclusions" and "communicating research results." Students prepared experimental reports in the form of scientific posters, which were then presented. The session concluded with a question-and-answer discussion and the reading of conclusions. In this stage, the researchers assessed the students' presentations and scientific posters, as detailed in Table 2 and Table 3.

The average score obtained for the indicators of drawing conclusions and communicating research results was 85, which falls into the "excellent" category. This was supported by the high scores achieved by students in their presentations and scientific posters, which were also classified as "excellent." Based on the analysis of each SPS aspect in the worksheet, it was evident that all students demonstrated SPS at an "excellent" level. The overall average score across all aspects of the worksheet was 90, also categorized as "excellent." These outcomes reflect the significant positive impact of using the PjBL model in learning.

**Table 2**.
Average Score of Presentation Assessment

| No. | Observed Aspects | Average | Interpretation |
|---|---|---|---|
| 1 | Title | 100 | Excellent |
| 2 | Purpose of the experiment | 100 | Excellent |
| 3 | Theoretical framework | 87 | Excellent |
| 4 | Results and discussion | 93 | Excellent |
| 5 | Conclusion | 87 | Excellent |
| 6 | References | 80 | Excellent |

**Table 3**.
Average Poster Rating Score

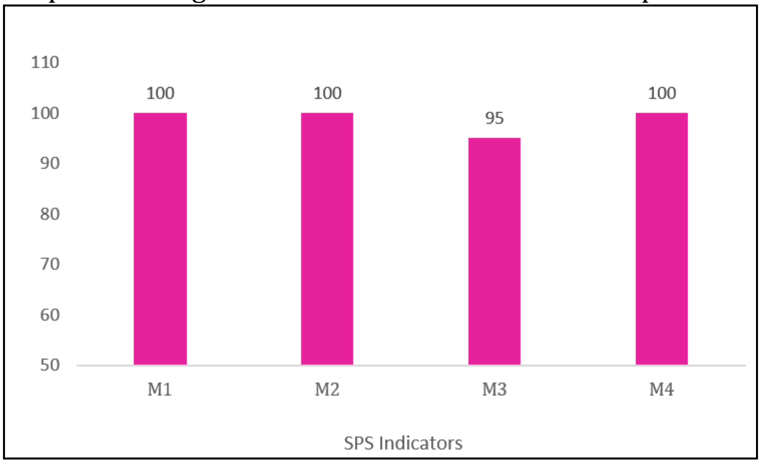
| No. | Observed Aspects | Average | Interpretation |
|---|---|---|---|
| 1 | Introduction | 95 | Excellent |
| 2 | Main discussion | 100 | Excellent |
| 3 | Closing | 95 | Excellent |
| 4 | Systematics of presentation | 100 | Excellent |
| 5 | Use of language | 80 | Excellent |
| 6 | Effectiveness of material delivery | 95 | Excellent |

The average score obtained for the indicators of drawing conclusions and communicating research results was 85, which falls into the "excellent" category. This was supported by the high scores achieved by students in their presentations and scientific posters, which were also classified as "excellent." Based on the analysis of each SPS aspect in the worksheet, it was evident that all students demonstrated SPS at an "excellent" level. The overall average score across all aspects of the worksheet was 90, also categorized as "excellent." These outcomes reflect the significant positive impact of using the PjBL model in learning.

The SPS performance sheet was also used to assess students' psychomotor abilities when applying SPS. This performance sheet focused on two stages of the PjBL model: the project design stage, which was aligned with the SPS indicator of designing experiments, and the experiment implementation stage, which was aligned with the indicator of making observations. During the experiment design phase, students demonstrated a high level of caution and accuracy in selecting the prepared tools and materials, and they reported any items found to be in poor condition. Students' sense of responsibility was evident in how they handled laboratory equipment carefully.

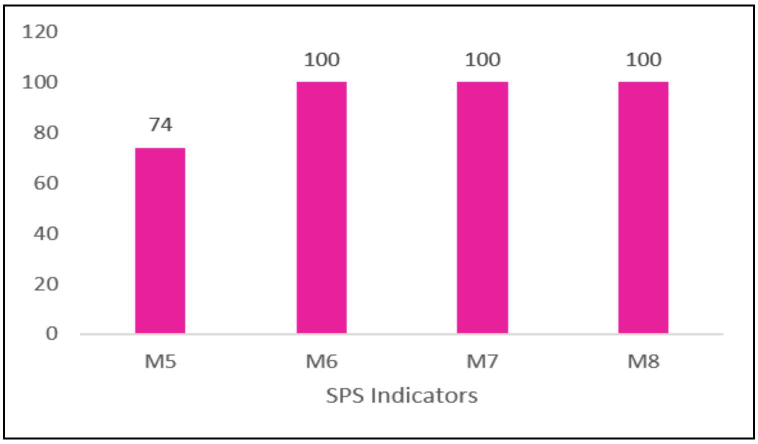
In the implementation stage of the experiment, under the SPS indicator of making observations, three aspects were assessed: sample weighing, solution measurement, and the overall product-making process. During the sample weighing process, some students tended to overlook decimal values, indicating a lack of precision in measurement. However, when measuring solutions such as glycerol and distilled water, which are both colorless, students were able to measure accurately by ensuring the reading was taken at the bottom of the meniscus. In the overall product-making process, students followed the series of procedural diagrams provided in the worksheet, which helped develop their analytical thinking skills. The achievement of students' SPS, as assessed through the performance sheet, is illustrated in greater detail in Figure 4 and Figure 5.

**Figure 3**.
Graph of Average Value of Science Process Skills Aspects




M1: Observing
M2: Asking questions
M3: Planning experiments
M4: Making observations

**Figure 4**.
Graph of Average Value of Science Process Skills Aspects (M5–M8)




M5: Interpreting observation results by applying theoretical concepts
M6: Classifying products
M7: Drawing conclusions
M8: Communicating findings

Based on the analysis of the performance assessment sheets and the student worksheets containing SPS indicators, the findings demonstrate a consistently high level of student competence in science process skills. The average performance score reached 96%, also categorized as "excellent." This result indicates that the implementation of PjBL not only engaged students actively in the learning process but also strengthened and refined their previously acquired SPS. Qualitative observations further support these quantitative outcomes. Students demonstrated the ability to observe, formulate hypotheses, conduct experiments, and interpret data with minimal guidance from the instructor. These behaviors indicate increased independence and confidence in applying scientific thinking, reinforcing the PjBL approach's positive impact on SPS development (Fatnah et al., 2021).

## Conclusion

The findings of this study highlight the effectiveness of the project-based learning (PjBL) model in enhancing students' science process skills (SPS) through environmentally oriented projects. Learning activities proceeded smoothly, as indicated by an average student engagement score of 95. Students also demonstrated strong SPS development, achieving an average score of 90 on the project-based worksheets. In terms of performance, they reached an outstanding score of 96. These results underscore the success of integrating PjBL with project-based worksheets to address real-world issues, specifically plastic straw waste, through the innovative use of red dragon fruit peel (Hylocereus polyrhizus) to create edible straws. This approach not only supports green chemistry education but also proves to be a practical and impactful instructional strategy for high school students.

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## References


Af'idayani, N., Setiadi, I., & Fahmi. (2018). The Effect Of Inquiry Model On Science Process Skills And Learning Outcomes. *European Journal Of Education Studies*, *4*(12), 177–182. Https://Doi.Org/10.5281/Zenodo.1344846

Almulla, M. A. (2020). The Effectiveness Of The Project-Based Learning (PBL) Approach As A Way To Engage Students In Learning. *SAGE Open*, *10*(3). Https://Doi.Org/10.1177/2158244020938702

Aziz, A., Sarifah, T., Syed, A., Awang, S., Aziz, R. A., Nurshafezan, S., Afifah, N., Azlan, B., Bahasa, A. P., & Mara, U. T. (2024). Student Insights : Challenges In Acquiring Critical Academic Reading Skills. *International Journal Of Research And Innovation In Social Science (IJRISS)*, *VIII*(2454), 938–950. Https://Doi.Org/10.47772/IJRISS

Baran, M., Maskan, A., & Yasar, S. (2018). Learning Physics Through Project-Based Learning Game Techniques. *International Journal Of Instruction*, *11*(2), 221–234. Https://Doi.Org/10.12973/Iji.2018.11215a

Beichumila, F., Bahati, B., & Kafanabo, E. (2022). Students' Acquisition Of Science Process Skills In Chemistry Through Computer Simulations And Animations In Secondary Schools In Tanzania. *International Journal Of Learning, Teaching And Educational Research*, *21*(3), 166–195. Https://Doi.Org/10.26803/Ijlter.21.3.10

Biswal Biswajit Behera, S. (2023). Enhancing Science Process Skills Through Inquiry - Based Learning: A Comprehensive Literature Review And Analysis. *International Journal Of Science And Research (IJSR)*, *12*(8), 1583–1589. Https://Doi.Org/10.21275/Sr23817121415

Budner, D., & Simpson, B. (2018). Project-Based Integrated Lecture And Laboratory Quantitative Analysis Course. *Journal Of Chemical Education*, *95*(9), 1533–1540. Https://Doi.Org/10.1021/Acs.Jchemed.8b00146

Candia, C., Maldonado-Trapp, A., Lobos, K., Bruna, C., Condes, L., & States, U. (2022). Disadvantaged Students Increase Their Academic Performance Through Collective Intelligence Exposure In Emergency Remote Learning Due To. *Arxiv Physics Education*.

Https://Doi.Org/Https://Doi.Org/10.48550/Arxiv.2203.05621

Deswinta, T., Dalem, A. A. G. D. P. K. P., Agung, A., & Alit, K. (2024). Organoleptic Test Of Fruit Leather Made From Dragon Fruit Peel Uji Organoleptik Fruit Leather Berbahan Dasar Kulit Buah Naga. *Indonesian Journal Of Applied And Industrial Sciences (ESA)*, *3*(6), 825–836. Https://Doi.Org/Https://Doi.Org/10.55927/Esa.V3i6.11308

Farida, I., Hadiansah, Mahmud, & Munandar, A. (2017). Project-Based Teaching And Learning Design For Internalization Of Environmental Literacy With Islamic Values. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 277–284. Https://Doi.Org/10.15294/Jpii.V6i2.9452

Fatnah, N., Azizah, D., & Cahyani, M. D. (2021). Penerapan Model Pembelajaran Berbasis Proyek Melalui Kegiatan Fun Chemistry Untuk Meningkatkan Keterampilan Proses Sains Di Smk. *Jurnal Zarah*, *9*(1), 15–21.

Guo, X., Zhao, Y., Zhao, H., Lv, Y., & Huo, L. (2023). Multidimensional Evaluation For Environment Impacts Of Plastic Straws And Alternatives Based On Life Cycle Assessment. *Journal Of Cleaner Production*, *404*(October 2022), 136716. Https://Doi.Org/10.1016/J.Jclepro.2023.136716

Jais, A., Yahaya, N., & Hasniza, N. (2021). Sustainable Development For Teachers ' Questioning Techniques For High Order Thinking Skill ( HOTS ) Sustainable Development For Teachers ' Questioning Techniques For High Order Thinking Skill ( HOTS ). *International Journal Of Academic Research In Business & Social Sciences*, *1*(1), 114–125. Https://Doi.Org/10.6007/IJARBSS/V11-I1/8163

Liu, Y., Li, N., Zhang, X., Wei, T., Ma, M., Sun, Q., & Li, M. (2024). Trends In Food Science & Technology Eco-Friendly Drinking Straws : Navigating Challenges And Innovations. *Trends In Food Science & Technology*, *148*(April), 266109. Https://Doi.Org/Https://Doi.Org/10.1016/J.Tifs.2024.104511

Lou, S. J., Chou, Y. C., Shih, R. C., & Chung, C. C. (2017). A Study Of Creativity In Cac 2 Steamship-Derived STEM Project-Based Learning. *Eurasia Journal Of Mathematics, Science And Technology Education*, *13*(6), 2387–2404. Https://Doi.Org/10.12973/EURASIA.2017.01231A

Majeed, S., Farhana, Y., & Ahmad, R. (2023). Inquiry-Based Instruction And Students' Science Process Skills: An Experimental Study. *Pakistan Journal Of Social Sciences (PJSS)*, *43*(1), 155–166. Https://Makhillpublications.Co/Journal-Detail/1683-8831

Mattioli, R., Francioso, A., Mosca, L., & Silva, P. (2020). Anthocyanins: A Comprehensive Review Of Their Chemical Properties And Health Effects On Cardiovascular And Neurodegenerative Diseases. *Molecules*, *25*(17). Https://Doi.Org/10.3390/Molecules25173809

Mclaughlin, S., Amir, H., Garrido, N., Turnbull, C., Rouncefield-Swales, A., Swadźba-Kwaśny, M., & Morgan, K. (2024). Evaluating The Impact Of Project-Based Learning In Supporting Students With The A-Level Chemistry Curriculum In Northern Ireland. *Journal Of Chemical Education*, *101*(2), 537–546. Https://Doi.Org/10.1021/Acs.Jchemed.3c01184

Nassour, R., Ayash, A., & Al-Tameemi, K. (2020). Anthocyanin Pigments: Structure And Biological Importance. *Article In Journal Of Chemical And*

*Pharmaceutical Sciences*, *11*(4), 677. Www.Jchps.Com

Nations, U. (2015). *Ensure Sustainable Consumption And Production Patterns*. Department Of Economic And Social Affairs Sustainable Development. Https://Sdgs.Un.Org/Topics/Sustainable-Consumption-And-Production

Nnoli, J. N. (2024). Enhancing Senior Secondary School Students' Academic Performance In Chemistry Through The Implementation Of Think-Pair-Share Strategy. *Social Education Research*, 370–379. Https://Doi.Org/10.37256/Ser.5220244727

Petchimuthu, P. (2021). Production Of Cost-Effective Biodegradable Straw. *International Journal For Research In Applied Science And Engineering Technology*, *9*(VII), 3710–3713. Https://Doi.Org/10.22214/Ijraset.2021.37096

Purwaningrum, P. (2016). Upaya Mengurangi Timbulan Sampah Plastik. *Jurnal Teknik Lingkungan*, *8*(2), 141–147.

Puspitasari, W. D., & Febrinita, F. (2021). Pengujian Validasi Isi (Content Validity) Angket Persepsi Mahasiswa Terhadap Pembelajaran Daring Matakuliah Matematika Komputasi. *Journal Focus Action Of Research Mathematic (Factor M)*, *4*(1), 77–90. Https://Doi.Org/10.30762/Factor_M.V4i1.3254

Raymond, C. (2022). *Chemistry 14th Edition*. Mcgraw Hill LLC.

Reynders, G., Suh, E., Cole, R. S., & Sansom, R. L. (2019). Developing Student Process Skills In A General Chemistry Laboratory. *Journal Of Chemical Education*, *96*(10), 2109–2119. Https://Doi.Org/10.1021/Acs.Jchemed.9b00441

Riyamol, Gada Chengaiyan, J., Rana, S. S., Ahmad, F., Haque, S., & Capanoglu, E. (2023). Recent Advances In The Extraction Of Pectin From Various Sources And Industrial Applications. *ACS Omega*, *8*(49), 46309–46324. Https://Doi.Org/10.1021/Acsomega.3c04010

Ruder, S. M., & Stanford, C. (2020). Training Undergraduate Teaching Assistants To Facilitate And Assess Process Skills In Large Enrollment Courses. *Journal Of Chemical Education*, *97*(10), 3521–3529. Https://Doi.Org/10.1021/Acs.Jchemed.9b00912

Subarkah, C. Z., Rahmawati Sg, R., & Dalli, A. (2016). Internalizing Islamic Values In Electrochemistry Learning. *Jurnal Pendidikan Islam*, *2*(2), 270. Https://Doi.Org/10.15575/Jpi.V2i2.790

Sugiyono. (2021). Metode Penelitian Kuantitatif, Kualitatif Dan R&D. In *Alvabeta. CV*. Https://Www.Academia.Edu/118903676/Metode_Penelitian_Kuantitatif_Kualitatif_Dan_R_And_D_Prof_Sugiono

Sunarya, R. R., Gustini, N., Subarkah, C. Z., & Halimah, D. (2022). Argument Driven Inquiry (ADI) in Chemistry Learning: Enhancing Student's Argument Skills and Attitudes toward Chemistry. *AIP Conference Proceedings*, *2468*. https://doi.org/10.1063/5.0102783

Sunarya, R. R., Listiawati, A., & Subarkah, C. Z. (2023). Voltaic cell test: Android-based assessment instrument on multiple representation oriented. *AIP Conference Proceedings*, *2572*. https://doi.org/10.1063/5.0118627

Sunarya, R. R., Hijriansyah, R., & Aisyah, R. (2024). Implementation Of Problem Solving-Based Electron Configuration E-Modules To Improve Student Learning Outcomes. *Jurnal Pendidikan Kimia Indonesia*, *8*(1), 11–20. Https://Doi.Org/10.23887/Jpki.V8i1.70029

Widdina, S., Rochintaniawati, D., & Rusyati, L. (2018). The Profile Of Students' Science Process Skill In Learning Human Muscle Tissue Experiment At Secondary School. *Journal Of Science Learning*, *1*(2), 53. Https://Doi.Org/10.17509/Jsl.V1i2.10146

Winandika, G. (2020). Keefektifan Model Pembelajaran Keterampilan Proses Sains Bervisi Salingtemas (Sains, Lingkungan, Teknologi Dan Masyarakat) Di SD Negeri Tinggarjaya. *PANCAR (Pendidik Anak Cerdas Dan Pintar)*, *04*(1), 305–322. Https://Doi.Org/Https://Ejournal.Unugha.Ac.Id/Index.Php/Pancar/Article/View/312

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