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The Implementation of Project-Based Worksheets for Making Taro Tape with Dragon Fruit Peel to Develop Students' Psychomotor Skills

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Abstract

Developing students' psychomotor skills is insufficient through theoretical learning in the classroom alone. Still, it must be supported by contextual, practical activities, such as fermenting taro tape with dragon fruit peel, through the application of project-based worksheets. This study aims to analyze students' ability to complete project-based worksheets and the development of students' psychomotor skills through testing the characteristics of taro tape. The method employed was a pre-experimental design with a one-shot case study involving tenth-grade students at a senior high school in Bandung City as the research subjects. The assessment instruments included a six-stage project-based worksheet, psychomotor tests covering three characteristics, and product and presentation assessments with eight and six aspects, respectively. Project-based worksheets were implemented in several stages: identifying problems, designing projects, conducting experiments, developing prototypes, evaluating products, and finalizing. The study's results showed that students' ability to complete project-based worksheets achieved an average score of 92, categorized as very good. The ability to complete project-based worksheets in the product evaluation stage received the highest score of 100, while the experimentation and prototype development stages received the lowest score of 88. Additionally, the development of students' psychomotor skills, as measured by the Taro Tape Characteristic Test, showed an average score of 95, categorized as very good. Psychomotor skills in organoleptic tests received the highest score of 100, while the TAT test received the lowest score of 85. Implementing project-based worksheets proved effective in developing students' psychomotor skills through the stages of project-based learning. These findings underscore the importance of using project-based worksheets as a contextual learning approach that supports chemistry education and fosters active student engagement in developing psychomotor skills.

Keywords: Dragon fruit peel, project-based worksheet, psychomotor, taro tape

Introduction

Practical work is essential in chemistry teaching and learning (Islam & Ratman, 2021). This activity is considered capable of overcoming students' difficulties in understanding complex and abstract material, which can be supported by applying project-based learning models (Drastisianti et al., 2022; Kunusa et al., 2023). A project-based learning model with worksheets can enhance student engagement and learning outcomes through activities that support understanding (Lestari et al., 2024). Laboratory worksheets typically only contain direct instructions without guiding students to understand the rationale behind each step (Wirda et al., 2018). This results in an unfocused practical process, leaving no challenges for students to improve their thinking, communication, collaboration, and scientific attitudes (Supratania et al., 2021). Students' understanding and learning outcomes can be improved through the use of project-based worksheets, as they guide students to design experiments and produce a final product at the end of the practicum, with an emphasis on active and independent engagement (Khoirunnisa et al., 2025; Pujaningsih et al., 2022).

Project-based worksheets guide student learning activities because they include important aspects such as observation, problem formulation, hypothesis development, experiment planning, experiment implementation, data interpretation, and communication (Harso & Fernandez, 2019). Based on these steps, it is necessary to identify students' psychomotor skills that support practical skills, accuracy in performing procedures, and the ability to use tools and materials effectively. This psychomotor domain is related to the skills or abilities to perform actions after gaining specific learning experiences (Mudhakiyah et al., 2022).

Psychomotor aspects involve understanding, designing, implementing, and presenting learning outcomes (Oktaviani et al., 2019). Chemistry learning in developing psychomotor skills is carried out through practical activities, such as

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fermentation, because students gain conceptual understanding and skills through direct practice and group work (Anggarkasih & Fatimah, 2022; Safitri et al., 2022). Psychomotor skills are developed while testing fermentation product characteristics, focusing on developing process skills, motor skills, and scientific attitudes (Fadhel et al., 2024). Fermentation is a conventional process using organisms to convert raw materials into valuable products, one example of which is tape (Sari et al., 2023).

Tape is a traditional Indonesian food made through the fermentation of carbohydrate-rich foods, such as tubers. Indonesia is rich in various tubers, such as potatoes, sweet potatoes, and cassava, which must be utilized to produce nutritious products (Oktavia & Azara, 2020). Taro serves as an alternative tuber that can be used as a raw material for tape production and cassava (Ambu et al., 2021). Indonesia is the native region of taro with 297 varieties, but this plant is still considered a minor commodity in terms of economic potential and genetic resources. Diversifying the diversity of taro plants into a product should solve this problem (Widajati et al., 2023).

Taro tape contains higher levels of protein and amino acids than steamed taro (Darmayanti et al., 2017). The fermentation process of taro into tape requires the help of yeast, which acts as a microorganism. These microorganisms convert carbohydrates in taro into sugar and alcohol (Oktavia & Azara, 2020). The texture of the tape from the taro is relatively complex, and the appearance is less attractive (Suanda & Sunarya, 2019). Adding dragon fruit peel is considered to improve the characteristics of taro tape to make it look more attractive (Yusmarini et al., 2020).

So far, the flesh of dragon fruit is the most consumed part, while the peel, which weighs about 30%-35% of the total weight of the fruit, has not been fully utilized and is only considered waste (Ni'matusyukriyah & Swasono, 2020). Dragon fruit skin contains flavonoids, dietary fiber, phenolic compounds, and anthocyanin pigments. Anthocyanin pigments in dragon fruit skin give a red or blue color whose presence is spread over plant parts (Marlina et al., 2023). This makes the dragon fruit peel utilized in making taro tape as a natural colorant. According to Masyhura et al. (2018), dragon fruit peel contains antioxidant activity derived from betacyanin and anthocyanin compounds, which are capable of inhibiting free radicals and are even effective in scavenging DPPH, thus having potential as a natural antioxidant source and enhancing the functional value of fermented products. In addition, dragon fruit skin also functions as a source of nutrients, especially carbohydrates, which support microbial growth in the fermentation process (Yusmarini et al., 2020).

Dragon fruit peel-assisted taro tape contains ethanol and organic acids, which are produced from the conversion of carbohydrates through starch hydrolysis and alcohol fermentation, so it is necessary to analyze its content through various characteristic tests to develop psychomotor (Tanamal et al., 2021). The tests include an organoleptic, pH, and total titratable acid (TAT) test. This analysis evaluates the acidity and fermentation quality during the tape-making process. The psychomotor ability in the organoleptic test includes observations on the color, taste, smell, and texture aspects of the taro tape produced (Syarumsyah et al., 2021).

Students' psychomotor skills in the pH test were evaluated based on their pH meter accuracy. Measure results are observed to accurately determine the sample's acidity (Pratiwi & Setiorini, 2023). The TAT test is also conducted to measure the material's overall content of organic acids (Sijabat et al., 2024). TAT analysis on taro tape uses the acid-base titration method to measure the acidity levels formed during fermentation. Students' skills in titration include assembling the tool, adding NaOH solution to the burette, sampling using an Erlenmeyer flask, performing the titration, and observing the final results (Enawaty, 2020).

The fermentation of taro into tape is an example of an everyday chemical reaction that is easy for students to understand and can serve as a suitable topic for project-based learning. Through hands-on experimentation, students grasp the theoretical aspects of chemical reactions and develop their psychomotor skills. This approach serves as an effective strategy for fostering contextual and in-depth understanding of chemistry (Anugrah & Awalliyah, 2022).

Previous studies have widely implemented project-based learning models to enhance cognitive and collaborative skills (Kunusa et al., 2023; Safaruddin et al., 2024). However, few studies have focused on developing psychomotor skills through contextual practicum activities in chemistry education. Moreover, no studies have specifically applied project-based worksheets that integrate local food fermentation contexts, such as taro tape production, with the addition of dragon fruit peel to train students' psychomotor skills through product characteristic testing. Based on these considerations, this study aims to analyze the implementation of project-based worksheets in the context of a fermentation practicum and organic waste utilization, supporting the development of students' psychomotor skills through meaningful and applicable chemistry learning.

Methods

This research uses a pre-experimental method with a Shot Case Study design. This method is a pre-experimental design because it has not yet been fully developed into a formal experiment. Additional variables may influence the experimental results, indicating that the independent variable does not solely determine them. This is because there are no control variables, and the sample selection is not random (Hardani et al., 2020).

This research was applied to grade X students in one of the Madrasah Aliyah in Bandung City for three meetings from April 22 to May 6, 2025. A total of 35 students, 19 males and 16 females, participated as research subjects in a project-based learning activity involving the production of taro tape assisted by using dragon fruit peel waste. The research procedure includes three main stages: preparation, implementation, and data analysis. The first stage in this procedure is the preparation stage, which involves analyzing the achievement of learning materials in chemistry subjects, the results of relevant research, the application of project-based learning, and the material concepts. The trial of making taro tape with the addition of dragon fruit peel waste extract was carried out first. The next step was to develop research instruments, including a project-based worksheet comprising six learning stages, a psychomotor assessment sheet comprising three characteristic tests, a product assessment sheet covering eight aspects, and a presentation assessment sheet comprising six aspects. The research instruments were validated by a subject-matter expert and an education expert and were declared suitable for use in the learning process.

The second step consists of executing the implementation process. At this point, the students are arranged into six groups and given a project-based worksheet on making taro tape with dragon fruit peel waste, with six learning stages. These stages are identifying problems, designing projects, conducting experiments, preparing product drafts/prototypes, assessing and improving products, and finalizing and publishing (Harso & Fernandez, 2019). Psychomotor assessment is carried out when testing the characteristics of taro tape products that have been made. The characteristic tests include organoleptic tests, pH tests, and TAT tests. The data obtained were processed, analyzed, and concluded in the analysis stage. This research focuses on student learning activities and outcomes, and the development of psychomotor skills obtained through implementing project-based learning in producing taro tape with dragon fruit peel waste.

Data was collected by completing project-based worksheets, psychomotor observation during the characteristic test, product quality assessment, and group presentations. The data were analyzed quantitatively by calculating the percentage scores from the worksheets' rubric, psychomotor, product, and presentation assessments using a standard formula for category interpretation (Enawaty, 2020; Indriajati & Ngazizah, 2018).

$$Score = \frac{\sum Obtained\ Score}{\sum Total\ Score} \times 100$$

The resulting scores are interpreted based on several categories: very good (80–100), good (66–79), fair (56–65), low (50–55), and very low (0–49). The analysis results are summarized as an assessment of the effectiveness of project-based learning applied in this study.

Results and Discussion

The application of project-based worksheets for making taro tape with the help of dragon fruit peel was conducted on class X students at one of the Madrasah Aliyah in Bandung City. This study aimed to analyze students' ability to work on project-based worksheets and their psychomotor development by testing the characteristics of taro tape. The implementation took place over three sessions. The first meeting introduced making taro tape by completing project-based papers and experiments. The second meeting focused on observing students' psychomotor skills through testing taro tape, while the third meeting presented student work. Student activities during learning are shown in **Figure 1**.

Figure 1. Student activities at the problem identification stage

Students' Ability to Work on Project-based Worksheets

The results of students' ability to work on project-based worksheets, such as making taro tape with dragon fruit peel, focus on several project stages (Harso & Fernandez, 2019), as listed in **Table 1**.

Table 1. Project-based worksheets skills score

No	Project-Based Learning Stages	Average Score	Category
1	Identifying the Problem	97	Very good
2	Designing the Project	91	Very good
3	Conducting an Experiment	88	Very good
4	Develop a Prototype	88	Very good
5	Evaluating the Product	100	Very good
6	Product Finalization	90	Very good
	Overall Score	**92**	**Very good**

Referring to the table above, students' ability to work on project-based worksheets appears very good. In the problem identification stage, students are trained to recognize a problem through discourse related to innovation in making taro tape with the help of dragon fruit peel waste. Triggering questions are then given to encourage students to formulate the issues and write hypotheses. Students obtained an average score of 97, showing they could understand and develop the problem well. This result is supported by Purnami & Widiadnya (2024), who stated that project-based learning can enhance students' ability to deal with problems.

During the project planning phase, students designed the taro tape-making experiment by determining the objectives, tools, and materials needed and compiling the experimental procedure in a flowchart format. The average score of students at this stage is 91, which is a very good category. This shows that students demonstrated practical skills in planning experiments. A systematic planning process is a key factor in ensuring the smooth implementation and effectiveness of project-based learning (Tarigan, 2021).

Furthermore, at the stage of conducting experiments, students make taro tape and characteristic tests according to the procedures that have been prepared, then collect observation data collaboratively. Characteristic testing is carried out to assess psychomotor development based on the organoleptic, pH, and total titratable acid tests. Students achieved an average score of 88 at this stage, which falls into the very good category. Practicum is a core component of project-based learning, enabling students to observe and verify phenomena through experimentation. Its implementation has proven effective in developing students' skills in understanding and carrying out experimental procedures properly (Juwita, 2022).

When developing a prototype product, students analyze experimental data in paragraphs based on organoleptic changes, pH, and total titratable acid content. This analysis is used to assess students' ability to apply the theory of fermentation that has been learned into direct practice, and an average score of 88 is obtained, which is included in the very good category. Students compared products between groups at the product evaluation stage and assessed their quality based on previous studies. The highest mean score was recorded at this stage, reaching 100 and categorized as very good. Project-based learning encourages students to compare results and critically evaluate solutions as they address problems encountered during the experimental process (Nihayati et al., 2024). The assessment outcomes of the students' tape products are shown in **Table 2**. The average score on the product assessment is 88, which is a good category for taste, aroma, texture, and acidity. At the same time, creativity and packaging aesthetics are still classified as sufficient.

Evaluation in project-based learning assesses the final product and includes planning, teamwork, and adjustments to obstacles that arise during the project. The low creativity and packaging aesthetics scores indicate that students prioritised product quality over external appearance. The packaging was still limited to a single type, without considering protective function or aesthetic value. Limitations in design skills and a lack of understanding of packaging innovation resulted in products that tended to be simple.

Table 2. Product assessment results

No	Aspects Measured	Average Score	Category
1	Taste	83	Very good
2	Color	89	Very good
3	Aroma	94	Very good
4	Texture	100	Very good
5	pH	89	Very good
6	Total titratable acid	100	Very good
7	Cleanliness and neatness of presentation	83	Very good
8	Creativity and aesthetics of packaging	66	Good
	Overall Score	**88**	**Very good**

Finally, at the product finalization stage, students discussed the taro tape manufacturing and characteristics test project results. They concluded and presented them in groups, with an assessment of 90, which was included in the excellent category. Additionally, the students engaged in discussions by responding to questions from other groups. Project-based learning has enhanced students' ability to formulate and present conclusions clearly and systematically during class discussions (Candra et al., 2019).

Specifically, the presentation assessment results showed an average score of 90, categorised as very good, demonstrating the students' well-developed scientific communication skills. This indicates that project-based worksheets not only direct students in completing the project technically but also form an understanding of concepts that can be expressed again during the presentation. Students' scientific abilities are reflected in their participation in the project implementation process and their explanations when presenting the project results (Khotimah, 2020). Student presentation scores are summarized in **Table 3**.

The presentation evaluation yielded an average score of 90, placing it in the very good category. This proves the students' well-developed scientific communication skills.

Table 3. Presentation assessment results

No	Aspects Measured	Average Score	Category
1	Introduction	100	Very good
2	Main points	83	Very good
3	Closing	89	Very good
4	Systematics	83	Very good
5	Use of language	94	Very good
6	Effectiveness of delivery	89	Very good
	Overall Score	**90**	**Very good**

This indicates that project-based worksheets not only direct students in completing the project technically but also form an understanding of concepts that can be expressed again during the presentation. Students' scientific abilities are reflected in their participation in the project implementation process and their explanations when presenting the project results (Khotimah, 2020).

Overall, students' ability to work on project-based worksheets was generally categorized as very good, as indicated by an average score of 92. The students' success in understanding, designing, implementing, analyzing, evaluating, and finalizing the project collaboratively suggests that implementing project-based worksheets can effectively support the development of project-based learning stages in meaningful chemistry learning. This aligns with the study by Kariadinata & Kurniati (2024), which states that project-based worksheets are practical for use in learning activities, providing students with meaningful and contextual learning experiences. Project-based learning has significantly enhanced student learning outcomes and positively contributed to academic achievement (Zhang & Ma, 2023).

Analysis of Student Psychomotor Development

Psychomotor aspects in chemistry learning are assessed through laboratory practicum (Fadhel et al., 2024). This activity serves to hone student skills effectively, increase expertise, and help develop skills more optimally (Meishanti & Fariyanti, 2020). Students' psychomotor skills in applying project-based worksheets and making taro tape with dragon fruit peel were assessed during the test of the product's characteristics. The characteristic tests include organoleptic, pH, and total titratable acid. The psychomotor results of the students during the organoleptic test are listed in **Table 4**.

Table 4. Psychomotor score of the organoleptic test

No	Observed Psychomotor	Average Score	Category
1	Observing the color of taro tape to assess uniformity and changes due to fermentation	100	Very good
2	Tasting taro tape to determine the level and balance of flavor	100	Very good
3	Touching and chewing the taro tape to evaluate the softness and uniformity of the texture	100	Very good
4	Inhaling the aroma of taro tape to detect the characteristic odor of fermentation	100	Very good
Overall Score		**100**	**Very good**

Based on Table 4, students' psychomotor skills in the organoleptic test showed an average score of 100, categorized as very good. This reflects their accuracy and sensitivity in carefully and precisely observing and evaluating the characteristics of the resulting taro tape. These psychomotor skills were assessed based on the students' ability to observe the taro tape's organoleptic aspects, including colour, taste, aroma, and texture (Syarumsyah et al., 2021).

Students' psychomotor skills in the pH test were assessed based on their accuracy in using the pH meter to determine the acidity level of the taro tape. The results of students' psychomotor skills during the pH test are listed in **Table 5**.

Table 5. Psychomotor score of pH test

No	Observed Psychomotor	Average Score	Category
1	The pH meter was calibrated by dipping it in buffer 7 solution and then drying it.	67	Good
2	Rinse with distilled water and then dry again	100	Very good
3	Dissolve the sample using distilled water	83	Very good
4	Immerse the pH meter in the sample and observe the pH scale until it shows a precise reading	100	Very good
Overall Score		**88**	**Very good**

Based on the data, students' skills in pH testing were classified as very good, with an average score of 88. The lowest score was found when calibrating the pH meter using buffer solution 7, which was 67, and was categorised as good. This relatively low score indicates that some students still faced difficulties distinguishing between the calibration stage and the actual use of the instrument, particularly among those performing the practice for the first time, as their psychomotor skills had not yet been fully developed. Calibration is a fundamental skill that requires both conceptual understanding and precision of movement, thus demanding habituation and repeated practice. Overall, students demonstrated good psychomotor performance in pH testing and improved their basic laboratory skills and understanding of the importance of accuracy and reliability of results.

Another test is the total titratable acid test, which determines the total amount of organic acids in taro tape (Sijabat et al., 2024). Total acid analysis is performed through acid-base titration. The psychomotor results of students during the TAT test are listed in **Table 6**.

Table 6. Psychomotor score of the TAT test

No	Observed Psychomotor	Average Score	Category
1	Preparation of the sample solution	86	Very good
2	Assembling the titration apparatus	86	Very good
3	Pouring NaOH solution into the burette	72	Good
4	Take the sample solution to be analyzed	83	Very good
5	Adding bromothymol blue (BTB) indicator	98	Very good
6	Doing titration	72	Good
7	Reading the scale on the burette	67	Good
8	Determining the titration endpoint	100	Very good
9	Determining the total titratable acidity	100	Very good
Overall Score		**85**	**Very good**

The data in **Table 6** clearly show that students effectively dissolved and diluted the samples during the sample solution preparation stage, with an average score of 86. However, some variation was noted among groups. The skill of assembling the titration apparatus also yielded an average score of 86; however, some students still need to improve their psychomotor accuracy in positioning the equipment and correctly distinguishing the assembly stages. This finding aligns with a study by Holly et al. (2018), which revealed that some students still lack precision when assembling titration equipment, particularly in small yet significant aspects that impact the accuracy of endpoint readings, such as failing to use a contrasting background to observe indicator colour changes better.

In the next stage, the skill of pouring the NaOH solution into the burette received a lower score of 72, indicating a need for improvement in fine motor skills, particularly hand stability and concentration, to prevent the formation of air bubbles and ensure that the solution volume does not exceed the required level. Meanwhile, the skills of drawing the sample solution (score of 83) and adding the BTB indicator (score of 98) were categorized as very good, indicating careful mastery of the practical procedures involved in the experimental steps. This finding is consistent with the results of Sakur & Masriani (2016), who noted that many students still struggle with precision when filling the burette with NaOH solution, particularly in ensuring the absence of air bubbles that can affect the accuracy of titration results. Nevertheless, students also demonstrated attentiveness during the sample-taking and indicator-adding stages, both of which are crucial for the success of the titration.

During the titration process, students obtained a score of 72, which was categorised as good, indicating that although they understood the basic steps of titration, further practice is required to improve hand stability and control of the titrant drop rate. In addition, students were able to observe the colour change with sufficient accuracy; however, the score for reading the burette scale varied, with an average of 67, suggesting that psychomotor accuracy in reading small scales remains a challenge for some students, particularly for those performing titration for the first time. These results are consistent with the findings of Budi & Masriani (2024), who reported that only 69% of students could correctly observe the volume of titrant, suggesting that accuracy in volume reading remains an area for improvement in titration practice.

The determination of the titration endpoint and the calculation of total titratable acidity were performed excellently, each receiving a perfect score of 100. This indicates the students' ability to accurately perform calculations and apply formulas correctly. Overall, students showed good psychomotor skills in conducting the TAT test using acid-base titration, with an average score of 85.

This finding aligns with the study conducted by Enawaty (2020), which reported that students' psychomotor performance in acid-base titration experiments achieved an average score of 82.16, categorized as very good. Student activities during the TAT test are shown in **Figure 2**.

Based on the data obtained, the overall results of students' psychomotor skills in the characteristic test showed excellent skills in the various tests. Students' psychomotor scores reached an average of 91, indicating high mastery of practicum skills. These findings suggest that using project-based worksheets supports students in progressing through each stage of project-based learning and effectively enhances their psychomotor abilities.

This statement is further supported by Nurkanti et al. (2019), who emphasised that project-based worksheets can optimally develop students' psychomotor skills by emphasizing authentic scientific processes and performance-based assessment. Project-based librarianship has effectively provided students with a more meaningful and contextualized learning experience.

This study contributes to science education by presenting an innovative approach to integrating local food processing and the utilization of organic waste into project-based chemistry learning aimed at developing students' psychomotor skills. The project empowers students to understand the chemical processes and reactions that occur during fermentation in everyday life. In addition, this study provides tangible benefits to the school community by implementing project-based worksheets that teachers can use to create more meaningful learning experiences, while promoting active student engagement in hands-on practice.

Figure 2. Student activities in the TAT Test

This study faced limitations due to the limited number of laboratory tools, some of which were not in optimal condition. This situation required students to take turns during practical sessions, thereby reducing the efficiency of the implementation time. Additionally, malfunctioning equipment may have impacted the accuracy of observations, particularly in pH testing and titration. The number of subjects involved also limited the study. Therefore, future research should involve a larger number of participants and be conducted in laboratories with better facilities, so that the results are more accurate and the understanding of the studied topic can be more comprehensive.

Conclusions

Based on the analysis of students' ability to work on project-based learning, the average score was 92, indicating a very good category. The ability to work on project-based worksheets for evaluating the product received the highest score of 100. In contrast, the stage of conducting experiments and compiling prototypes received the lowest score of 88. Meanwhile, the analysis of students' psychomotor development through the Taro Tape Characteristics Test showed an average score of 91, indicating a very good category. The psychomotor component in the organoleptic test received the highest score of 100, while the TAT test received the lowest score of 85. The application of project-based worksheets proved effective in developing the stages of project-based learning and student psychomotor skills through the dragon fruit peel-assisted taro tape characteristics test. This result demonstrates that project-based learning offers students a practical and in-depth learning experience through direct experimentation.

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