ORBITAL: JURNAL PENDIDIKAN KIMIA
Website : jurnal.radenfatah.ac.id/index.php/orbital
ISSN 2580-1856 (print) ISSN 2598-0858 (online)

Guided Inquiry-Based Worksheet for Science Process Skills Assessment: Pineapple Peel Vinegar Content Analysis

Amara S Handiyanti[1], Risa R Sunarya[2*)], Saepudin Rahmatullah[3], Iis Dahriah[4], Riri Aisyah[5], and Nissa N Insani[6]

[1,2,3,4,5]Universitas Islam Negeri Sunan Gunung Djati, Bandung, Indonesia
[6]SMA Al-Ihsan Cimencrang, Bandung, Indonesia

[*)]E-mail: risarahmawatis@uinsgd.ac.id

ARTICLE INFO

Article History:
Received 29 May 2026
Revised 21 June 2026
Accepted 24 June 2026
Published 30 June 2026

Keywords:
Guided inquiry-based worksheet;
Science process skills;
Vinegar.

ABSTRACT

This study aimed to develop a guided inquiry-based worksheet on acid–base titration to improve students' science process skills through analysis of vinegar derived from pineapple peel waste. This research used an R&D approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The participants were 15 eleventh-grade students who had previously studied acid–base titration and were willing to complete the entire experimental process. The guided inquiry-based worksheet had undergone an expert validation stage, and the collected data were analyzed using percentage analysis to determine the feasibility of the worksheet, while students' science process skills and worksheet scores were converted into percentage scores and interpreted based on predetermined criteria. The validation results showed that the worksheet had a very high level of feasibility with an average score of 88.09%. The implementation results showed that students' science process skills were very good, with the highest aspect in observation reaching 93. The average guided inquiry worksheet score was 80. The worksheet developed in this study was declared valid and showed positive results in supporting students' science process skills.

INTRODUCTION

The low level of students' Science Process Skills (SPS) remains a problem in science education in Indonesia. Students' abilities to understand scientific concepts, apply scientific knowledge in everyday life contexts, explain scientific phenomena, design and evaluate investigations, and interpret data and evidence scientifically, which reflect the indicators of SPS, are still not optimal. This condition is reinforced by the results of the 2022 Programme for International Student Assessment (PISA), which showed that Indonesian students' science scores were still below the OECD average, with a score of 393 compared to the global average of 489 points (Purnomo et al., 2023). The limited emphasis on scientific thinking processes also hinders the development of SPS. This is influenced by practicum activities that focus more on the final results of experiments rather than on a deeper understanding of the scientific process (Adhwa et al., 2025; Hosbein & Walker, 2022).

An approach proven effective in overcoming the problem of low students' SPS is guided inquiry (Rahmawati, 2025). In science learning, guided inquiry includes several stages, namely orientation, problem formulation, hypothesis formulation, experimental design, data collection, data analysis, and conclusion drawing. (Suherman, 2023). Guided inquiry stages are highly relevant to SPS because both emphasize scientific thinking activities that include observing, classifying, interpreting data, formulating hypotheses, designing experiments, drawing conclusions and communicating (Dahlan et al., 2025). In its implementation, guided inquiry requires worksheets designed to guide students in designing experiments, observing, analyzing data, and drawing conclusions. This type of worksheet contributes significantly to SPS and has a strong correlation with student learning outcomes (Saidaturrahmi et al., 2020).

Learning will be more optimal when it is related to real phenomena close to students' daily lives (Adhwa et al., 2025; Delima et al., 2025; Li et al., 2023). One local potential that can be utilized in chemistry learning is pineapple peel waste. Based on data from BPS (2023), national pineapple production reaches approximately 2.9 million tons per year, which results in pineapple peel waste accounting for around 30–40% of the total fruit parts. Pineapple peel contains carbohydrates and glucose needed for alcohol fermentation reactions and is then fermented into acetic acid (Zidane et al., 2023). The acetic acid produced from fermentation is then analyzed using the acid–base titration method with sodium hydroxide (NaOH) as the titrant (Yao et al., 2022). The titration process is relevant to the development of SPS because it involves activities such as formulating hypotheses, conducting precise measurements, analyzing quantitative data, and drawing conclusions based on empirical evidence (Adiningsih et al.,2020)

Previous research has shown that the guided inquiry learning model is able to improve students' science process skills at various educational levels with a score of 1.98, which is included in the very high category (Tauhidah et al., 2022). In addition, the use of guided inquiry-based worksheets also resulted in the development of SPS with a score of 0.849, which is included in the very high category (Saidaturrahmi et al., 2020). The utilization of local materials in chemistry learning can be carried out through the use of pineapple peel waste as raw material for vinegar production by Saccharomyces cerevisiae and Acetobacter aceti with acetic acid content meeting the SNI standard, namely 4–4.5% (Hidayah et al., 2022)

Guided inquiry provides a framework for students to systematically carry out the stages of the scientific method, while local potential presents real phenomena that can be directly observed and investigated. In the topic of acid–base titration, the utilization of pineapple peel waste as a raw material for vinegar production provides an authentic learning context, as students can study the formation process of acetic acid and determine its concentration through titration analysis. This helps students connect abstract concepts with phenomena in their surrounding environment. Through a series of scientific activities carried out in learning, students are able to develop their SPS more optimally.

Based on these research results, there has been no study integrating guided inquiry-based worksheets with the context of analyzing vinegar content from pineapple peel in chemistry learning. Therefore, this study develops guided inquiry-based worksheets to help students understand acid–base titration concepts while simultaneously developing SPS through contextual and applicable laboratory activities. This study aims to develop a guided inquiry-based worksheet on acid–base titration using pineapple peel vinegar, as well as to assess its validity and examine its use in developing students' science process skills.

METHODS

Research Design

This study is a Research and Development (R&D) type of research, which is a method involving the process of developing or improving educational products (Nurfadhilah et.al, 2025) Development research is used to produce a specific product and test the effectiveness of that product(Sugiyono, 2010). The research design uses the ADDIE model consisting of five stages: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation

(Zuriyatina et al., 2021). The concept map of the ADDIE model is shown in Figure 1.

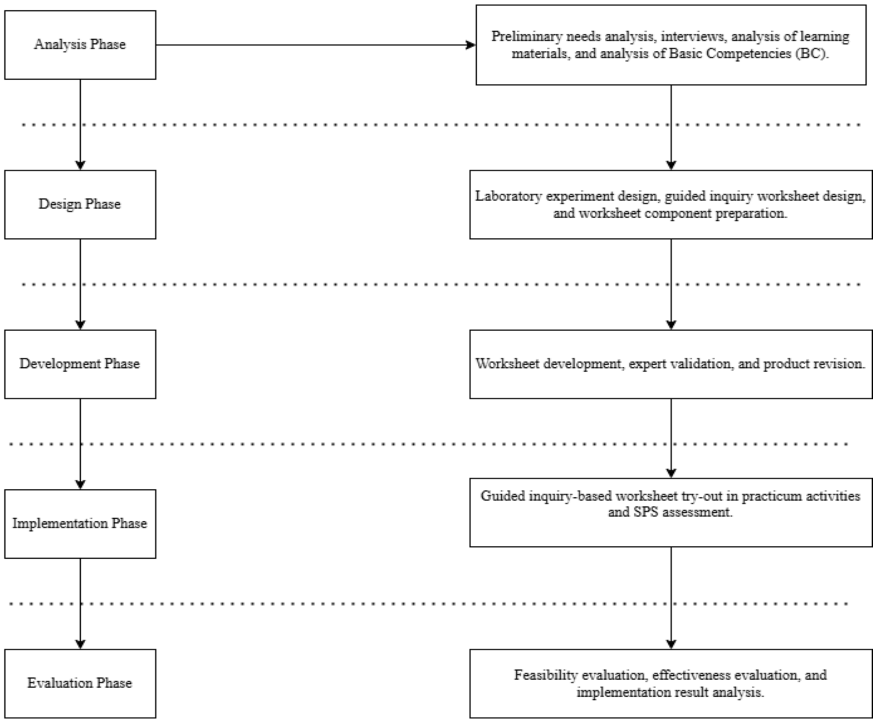

Figure 1. ADDIE Concept Map

The development carried out is guided inquiry-based worksheets to develop students' SPS on acid–base titration material in the analysis of vinegar content from pineapple peel. The research results include worksheet validation data, students' SPS assessment data, worksheet assessment data, and data from the analysis of pineapple peel vinegar content.

Research Target

The subjects of this study were 15 eleventh-grade students at SMA Al-Ihsan Cimencrang Bandung who had previously studied acid–base titration material. The subjects were selected using a purposive sampling technique, namely by choosing students who met the criteria. And were willing to participate in the entire product trial process. The sample size of 15 students was selected because this study employed a R&D approach that focuses on product evaluation and improvement. This is in line with previous studies that used between 9 and 10 participants during the small-group trial stage (Sari et al., 2019); (Indriani & Pratiwi, 2023). Therefore, the use of 15 students in this study remains within the range commonly employed in product trial studies.

Research Data

Data collection techniques in this study were carried out through expert validation, observation, worksheet assessment, and analysis of practical work results. Validation data were obtained from the assessment of two expert lecturers and one chemistry teacher on the developed guided inquiry-based worksheet. SPS data were obtained through observation sheets completed by three observers. Each observer was responsible for observing and assessing one group of students directly during laboratory practical activities. Worksheet assessment data were obtained from assessment sheets and student responses to the use of worksheets in learning. Meanwhile, data from the analysis of pineapple peel vinegar content were obtained through acid–base titration laboratory activities to determine the acetic acid content produced.

Research Instruments

The research instruments used in this study included expert validation sheets consisting of 14 assessment items covering four aspects, namely content construction, presentation technique, completeness of presentation, and language. The guided inquiry-based worksheet on the analysis of pineapple peel vinegar content contained eight stages of guided inquiry with a total of 15 items. The SPS assessment sheet consisted of 10 items and was used to measure students' SPS during laboratory activities. In addition, there were procedures for producing and analyzing pineapple peel vinegar content used as guidelines in implementing laboratory work and analyzing acetic acid content.

Data Analysis

Validation data from expert validators were analyzed quantitatively by calculating the percentage of feasibility of the guided inquiry-based worksheet and comparing it with the criteria in Table 1.

Table 1. Validation Criteria for Expert Validation Sheet

Percentage (%)	Category
85-100	Very Valid
70-<85	Valid
50-<70	Less Valid
0-<50	Not Valid

The analysis of observation scores for each SPS indicator was converted into achievement percentages and categorized according to the guidelines presented in Table 2.

Table 2. Interpretation Criteria for Science Process Skills Assessment

Interval	Category
80–100	Very Good
66–79	Good
56–65	Fairly Good
40–55	Poor
0–39	Very Poor

(Sugiyono, 2022)

The results of the guided inquiry-based worksheet were analyzed to determine students' ability to complete the inquiry stages and referred to the guidelines in Table 3.

Table 3. Interpretation Criteria for Guided Inquiry-Based Worksheet Assessment

Interval	Category
80–100	Very Good
66–79	Good
56–65	Fairly Good
40–55	Poor
0–39	Very Poor

(Sugiyono, 2022)

RESULTS AND DISCUSSION

The product developed in this study is a guided inquiry-based worksheet on acid–base titration material for the analysis of vinegar content from pineapple peel, aimed at developing students' SPS. It includes the production of vinegar from pineapple peel, which is then tested for quality by students, and was trialed with Grade 11 students of SMA Al-Ihsan. The results of this study are as follows:

a) Analysis Stage

This analysis stage was conducted to identify the gap between the expected learning process and the actual learning practices in the classroom(Kuswandi et al., 2023). A preliminary needs analysis was carried out through interviews with chemistry teachers regarding the use of learning tools and the implementation of laboratory activities at school (Oladejo et al., 2023). An interview was conducted with a chemistry teacher, as there was only one chemistry teacher at the school. The interview results revealed several problems, including teacher-centered instruction in acid–base titration, limited laboratory activities, and the use of worksheets that had not facilitated the development of students' SPS. In addition, the teacher also expressed the need for worksheets that provide clear laboratory procedures and guide students through the stages of inquiry. Furthermore, an analysis of learning outcomes was conducted to ensure the alignment between learning materials, indicators, and laboratory activities with the expected competencies, and a literature review and concept mapping were also carried out to identify the potential implementation of the guided inquiry approach in chemistry learning. Interview data were analyzed descriptively by identifying and summarizing key information related to learning and students' SPS. Previous studies have reported that inquiry-based learning is still rarely implemented in experimental activities, resulting in limited opportunities for students to develop scientific skills through direct experience (Nurfadilah et al., 2025). The findings from these analyses served as the basis for developing a guided inquiry-based worksheet for the analysis of vinegar content from pineapple peel.

b) Design Stage

The design stage in the ADDIE model aims to develop a systematic learning tool in accordance with previously analyzed learning needs and objectives (Arofah & Cahyadi, 2019). The experimental design was carried out at the Chemistry Education Laboratory of UIN Sunan Gunung Djati Bandung by systematically designing the laboratory procedure, starting from sample preparation, production of vinegar from pineapple peel, dilution, solution standardization, titration process, to quality testing and acetic acid content analysis. Before being used by students, the laboratory procedure and the developed worksheet were validated by a subject matter expert to ensure their alignment with the acid–base titration concept, learning objectives, and the feasibility of implementing the laboratory activities. This validation served as the basis for determining that the developed procedure was appropriate for classroom implementation.

Furthermore, the guided inquiry-based worksheet was designed using the Canva application. At this stage, the selection of templates, fonts, colors, layout, supporting images, and worksheet formatting was carried out to make it more attractive and easier for students to understand. Visually attractive instructional materials can increase learning motivation and help students understand information more effectively (Fitriati et al., 2023). In addition, the worksheet components were arranged, including practical identity, learning objectives, practical instructions, problem orientation, problem formulation, hypothesis, tools and materials, experimental procedures, observation tables, data analysis, inquiry-based questions, and conclusions. The systematic preparation of the worksheet aims to help students follow the learning stages and develop SPS through laboratory activities, which is in line with previous research showing that inquiry-based worksheets can improve learning activities and students' SPS (Boimau et al., 2022). The initial design of the guided inquiry-based worksheet on the analysis of vinegar content from pineapple peel that has been developed is presented in Figure 2.

Figure 2. Initial Display Design of the Guided Inquiry-Based Worksheet on the Analysis of Vinegar Content from Pineapple Peels

c) Development Stage

The development stage is the process of realizing the design into a tangible product. This stage focuses on the process of product creation, validation, and refinement until it meets feasibility criteria (Hanifah & Irwansyah, 2021). The initial product produced was a guided inquiry-based worksheet, which was then validated by three experts, namely a content expert, a media expert, and a chemistry teacher from *Al-Ihsan*. Validation was conducted to assess the suitability of the content with chemistry concepts, language clarity, and the attractiveness of the presentation. Feedback from the validators was used to improve the worksheet so that it would be easier for students to understand and apply. The validation results are presented in Table 4 below.

Table 4.Validation Results of the Worksheet by Expert Validators

Assessment	Validator	Obtained Score	Maximum Score	Percentage (%)	Description
Material Validation Expert	1	54	70	77.14%	Valid
Media Validation Expert	2	67	70	95.71%	Very Valid
Teacher Validation	3	64	70	91.43%	Very Valid
Average				88.09%	Very Valid

The material expert validation obtained a score of 77.14%, which falls into the valid category. The lower score compared to the media and teacher validations indicates that several aspects of the content and presentation still required improvement. The validator suggested adding the underlying principles of the experiment to strengthen students' conceptual understanding, incorporating organoleptic testing into the worksheet to provide more comprehensive data, and revising the formula used to ensure its suitability for acetic acid content analysis. These revisions improved the completeness of information, conceptual accuracy, and usability of the worksheet in supporting guided inquiry-based laboratory activities.

The validation instrument was developed based on four aspects, namely content construction, presentation techniques, presentation completeness, and language. Content construction includes the alignment of material with learning objectives and inquiry stages. Presentation techniques include the use of images and font selection. Presentation completeness includes title, instructions, objectives, tools and materials, and procedures. The language aspect includes sentence clarity and the use of communicative language. A good learning material must meet content validity and readability to be considered appropriate for instructional use (Manurung, 2023). Media validation obtained a percentage of 95.71% in the "very valid" category. This indicates that the design of the worksheet meets visual and readability aspects, thereby reducing cognitive load and supporting students' information processing.

Teacher validation obtained a percentage of 91.43% in the "very valid" category. The results show that the worksheet is appropriate as learning material for students and is easy to implement in the learning process. Teachers' evaluation of the learning material reflects that the developed worksheet is aligned with learning needs and can be effectively used in students' practical activities (Putri et al., 2025). Overall, the average score obtained was 88.09% in the "very valid" category. Based on the interpretation criteria, this score falls within the range of 81–100%, thus categorized as very feasible. Revisions included simplifying instructions in the hypothesis formulation section and improving the layout of the observation table.

d) Implementation Stage

The implementation stage was conducted with eleventh-grade students of SMA Al-Ihsan Cimencrang Bandung who had previously studied acid–base titration material. A total of 15 students participated in the study and were divided into three practicum groups, each consisting of five students. During this stage, students used guided inquiry based worksheets, which were completed collaboratively within each group throughout the laboratory activities. Before the practicum began, students were asked to complete the initial section of the worksheet, which included formulating research problems, developing hypotheses, and designing experiments. Activities involving problem formulation and hypothesis development in the inquiry model can train students' scientific thinking and problem-solving skills (Rahmawati & Partana, 2019). During the practicum, students also completed the worksheets to record observations and collect experimental data. Guided inquiry-based worksheets help students organize observational data and guide the investigation process systematically. After the practicum was completed, students continued working on the worksheets to analyze the experimental data, draw conclusions, and finally present the results of their group discussions in the form of posters at the following meeting. Data analysis activities and the presentation of discussion results are part of scientific communication skills that are important in 21st-century science learning.

The assessment of students' SPS was conducted through observation sheets covering nine aspects, namely observing, asking questions, predicting, planning experiments, using tools and materials, applying concepts, classifying, interpreting data, and communicating results (Dahlan et al., 2025). The SPS assessment results are presented in Table 5.

Table 5. Average Score of SPS Assessment

No	SPS Aspect	SPS Average Score	Standard Deviation (SD)	Description
1	Observation	93	9.43	Very Good
2	Asking Questions	73	9.43	Good
3	Predicting	73	9.43	Good
4	Planning Experiments	80	0.00	Very Good
5	Using Equipments and Materials	87	9.43	Very Good
6	Applying Concepts	80	0.00	Very Good
7	Classifying	87	9.43	Very Good
8	Interpreting	87	9.43	Very Good
9	Communicating	87	9.43	Very Good
	Average	**83**	**-**	**Very Good**

The observation aspect obtained the highest score, namely 93, in the very good category. The high score in this aspect indicates that students were able to observe and read the presented discourse carefully and understand the important information contained in it (Khalda et al., 2025). Nevertheless, there were still groups whose members sometimes chatted or were less focused while observing the discourse, so the information obtained was not fully optimal. However, this did not significantly affect the overall results because most students still demonstrated very good observation skills compared to other SPS aspects.

The asking questions aspect obtained a score of 73, which falls into the good category. Students were generally able to formulate questions based on the observed discourse; however, some of the questions were still insufficiently specific or not fully aligned with the main problem being investigated. This finding is also consistent with the results of the needs analysis interviews, which revealed that students were rarely involved in learning activities that required them to formulate research problems and develop corresponding hypotheses. This indicates that students still need practice in developing critical thinking skills to formulate research problems more accurately (Azis & Supardi, 2019). Likewise, the predicting aspect obtained a score of 73, which falls into the good category. Because the problem formulations developed by the students were still not sufficiently precise, the hypotheses they generated were also less aligned with the answer key, although they remained consistent with the problem formulations they had constructed. This finding is also consistent with the results of the needs analysis interviews, which revealed that students were rarely involved in learning activities requiring them to formulate hypotheses. The lack of experience in developing hypotheses may have contributed to the difficulties some students experienced in generating predictions that were appropriate to the given problems.

The planning experiments aspect obtained a score of 80 in the very good category. These results indicate that students were sufficiently able to determine the objectives of the experiment, arrange work procedures, and determine the tools and materials used in the research. Most students were able to design experimental procedures systematically so that the practicum could run well. The ability to plan experiments indicates that students have understood the basic stages of the scientific method in practicum activities (Candra, 2020).

The using equipments and materials aspect obtained a score of 87 in the very good category. These results indicate that students were able to carry out the research according to the tools, materials, and experimental design that had been prepared beforehand. During the dilution stage, students were able to use tools such as beakers, filter paper, measuring pipettes, and volumetric flasks appropriately according to the procedures. Students were also able to homogenize the sample before it was used in the next stage. In the acid-base titration stage, students were able to use Erlenmeyer flasks, NaOH solution, oxalic acid, phenolphthalein indicator, and burettes for standardization and titration of pineapple peel vinegar samples according to the planned procedures. Most students were able to perform titration until a pale pink color change occurred and lasted for 30 seconds, as well as record the solution volume properly. In addition, students were also able to calculate normality and acetic acid content based on the titration data obtained. This indicates that students were sufficiently skilled in using laboratory tools and materials during experiment activities. The activities carried out during the experiment can be seen in Figure 3. Permission was obtained from the students to use their photographs in this study.

Figure 3. Students’ Activities While Conducting the Experiment of Titration

The applying concepts aspect obtained a score of 80 in the very good category. In this aspect, students were able to record the experimental results; however, there were still some students who were less accurate in recording the experimental results according to the given instructions. Furthermore, students calculated the vinegar content produced from pineapple peels. The ability to apply concepts indicates that students are able to connect theory with practicum activities contextually (Pradana et al., 2020).

The classifying aspect obtained a score of 87 in the very good category. These results indicate that students were able to analyze the experimental results and compare the vinegar content produced with the Indonesian National Standard (SNI) for fermented vinegar. Students were able to classify the research data properly, making it easier to draw conclusions from the conducted experiment. Based on the analysis results, acetic acid contents of 5.06%, 6.05%, and 8.08% were obtained. The acetic acid content met the Indonesian National Standard (SNI 01-4371-1996) for acetic acid content in fermented vinegar (Said et al., 2021). These results indicate that students were able to analyze the data properly and obtain appropriate data.

The interpreting aspect obtained a score of 87 in the very good category. In this aspect, students were able to analyze the experimental data and discuss the research results based on the learned concepts. Data analysis was carried out by answering five questions related to the practicum results and connecting them briefly with theoretical concepts. In addition, students were also able to prepare research result posters properly and systematically. This indicates that students were sufficiently able to understand the meaning of the data obtained during the practicum. Example of students’ worksheet answers at the data analysis stage can be seen in Figure 4.

The communicating aspect obtained a score of 87 in the very good category. These results indicate that students were able to present the experimental results through the posters they had created. Most students were able to explain the research results quite clearly and confidently. Scientific communication skills are important to train students to convey ideas and research findings systematically (Dwi et al., 2025). Overall, students’ SPS obtained an average score of 83 in the very good category.

Based on the data distribution analysis, the Planning Experiment and Applying Concept aspects showed a standard deviation value of 0.00. This value indicates that there was no variation in scores among the groups for these two aspects, meaning that all groups obtained the same scores. Meanwhile, the observation, questioning, predicting, planning experiments, using equipment and materials, applying concepts, classifying, interpreting, and communicating aspects obtained a standard deviation value of 9.43, which falls into the low category. This indicates that students’ abilities in all these aspects were relatively evenly distributed among groups (Saputro, 2018). A small standard deviation indicates that the data have a low level of dispersion, so the obtained results tend to be homogeneous.

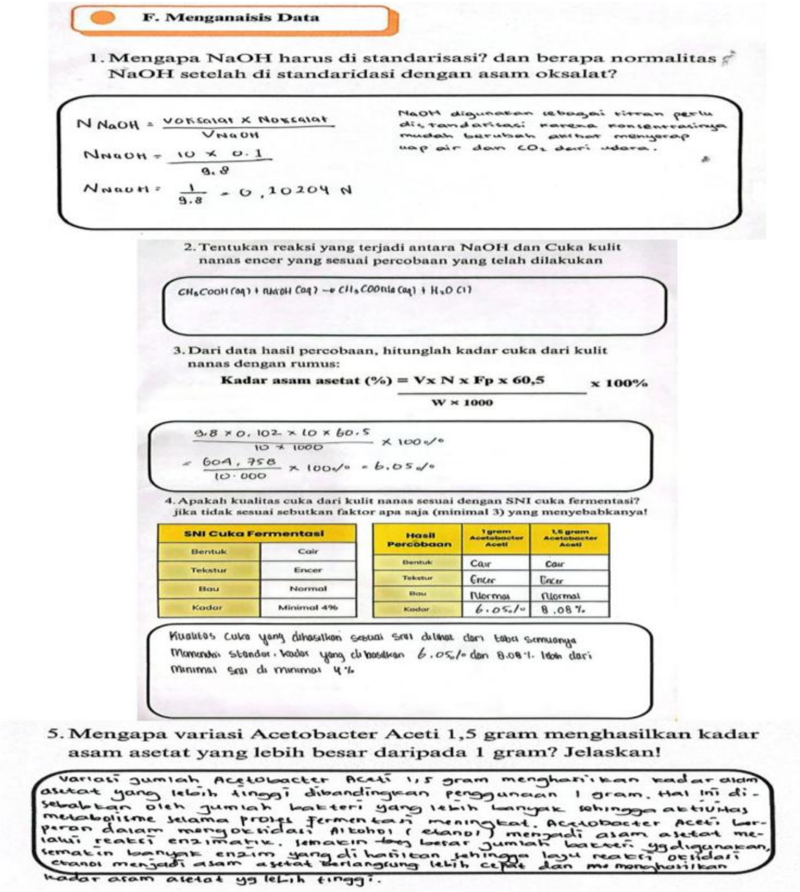

Figure 4. Students' Worksheet Answers at the Data Analysis Stage.

In the guided inquiry-based worksheet, there are nine inquiry stages that must be carried out by students during the learning activities. These stages include several stages, namely orientation, problem formulation, hypothesis formulation, experimental design, data collection, data analysis, and conclusion drawing (Suherman, 2023). After being converted into percentages, the worksheet assessment results are presented in Table 6.

Table 6. Results of the Guided Inquiry-Based Worksheet Score on the Analysis of Vinegar from Pineapple Peels

No	Guided Inquiry-Based Worksheet Stage	Average Worksheet Score	Standard Deviation (SD)	Description
1	Orientation	93	4.71	Very Good
2	Formulating Problems	70	8.16	Good
3	Formulating Hypotheses	70	8.16	Good
4	Planning Experiments	80	0.00	Very Good
5	Collecting Data	78	4.71	Good
6	Analyzing Data	8	2.36	Very Good
7	Conclusion Drawing	83	4.71	Very Good
	Overall Average	**80**		**Very Good**

The worksheet score was calculated based on the ratio of the obtained score to the maximum score, multiplied by 100 to obtain a percentage, and then compared with the percentage criteria of the guided inquiry-based worksheet assessment guidelines. The assessment was conducted in groups, where each group produced a single score based on collective performance during the laboratory activities. The results of the implementation of guided inquiry-based worksheets showed that each stage of inquiry achieved different levels of attainment. The orientation stage obtained the highest score of 93 and was categorized as very good, indicating that students were able to clearly understand the initial context and learning objectives. The problem formulation stage obtained a score of 70 with a good category, indicating that students were fairly capable of identifying and formulating research problems, although they still required guidance in constructing scientific questions. The hypothesis formulation stage also obtained a score of 70 with a good category, indicating that students were able to formulate temporary assumptions based on the observed phenomena; however, their scientific reasoning skills still need improvement. This is in line with a study stating that the lowest score was found in the aspect of formulating hypotheses because students were not yet accustomed to proposing hypotheses during the learning process (Astuti et al., 2019).

The experimental design stage obtained a score of 80 with a very good category, reflecting those students were generally able to arrange experimental procedures and determine appropriate tools and materials for investigation activities. The data collection stage obtained a score of 78 with a good category, indicating that most students were able to correctly and systematically record observation results and collect experimental data during practicum activities. However, there were still several students who had not fully understood how to properly place observation results and experimental data into the data collection column in the worksheet.

The data analysis stage obtained a score of 83 and was categorized as very good, indicating that students were able to process and interpret experimental data. The ability to analyze and interpret data is an important skill in science learning because it helps students build understanding based on scientific evidence obtained during the experimental process (OECD, 2019). Lastly, the conclusion drawing stage obtained a score of 83 with a very good category, indicating that students were able to summarize the experimental results and relate them to the objectives of the experiment in a structured manner.

The standard deviation results of the guided inquiry-based worksheet showed relatively low data distribution, indicating that students' abilities at each guided inquiry stage tended to be homogeneous and evenly distributed among groups. The Planning Experiments stage obtained a standard deviation of 0.00, indicating that there were no differences in ability among groups in designing experiments. Meanwhile, the Orientation and Collecting Data stages obtained a standard deviation of 4.71, while the Analyzing Data stage showed the lowest variation after that, with a standard deviation of 2.36. The Formulating Problems and Formulating Hypotheses stages obtained the highest standard deviation of 8.16, indicating that there were still slight differences in students' abilities in formulating problems and developing hypotheses, although the data distribution was still relatively low and homogeneous. Overall, the average result of the implementation of the guided inquiry-based worksheet was 80, which falls into the very good category. This indicates that the use of systematic worksheets can help students become more active, independent, and focused during the learning process. (Farhah et al., 2025).

e) Evaluation Stage

This evaluation summarizes the validation and implementation results of the developed worksheet. Expert validation resulted in an average score of 88.09% with a very feasible category, indicating that the content and learning media were appropriate. The implementation involving 15 students showed an average worksheet score of 80 and students' SPS score of 83. These results indicate a relationship between each inquiry stage in the worksheet and the SPS trained during the practicum activities. Each stage in inquiry-based learning is related to the development of because students are directly involved in scientific activities such as observation, asking questions, predicting, planning experiments, using tools and materials, applying concepts, classifying, interpreting, and communicating. This relationship can be seen in Figure 4.

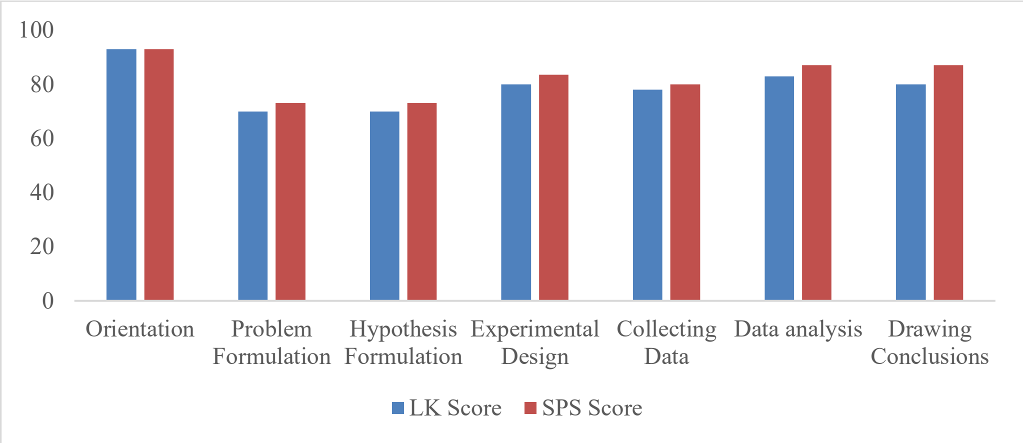

Figure 4. Worksheet Score and SPS Score in Each Stage of Guided-Inquiry Learning

The highest skill was found in the observation aspect, reaching 93, which was supported by the orientation stage, indicating that students were able to understand the initial learning phenomena very well. This finding is in line with previous studies indicating that the orientation stage is closely related to the ability to observe phenomena, as this stage helps in better understanding the initial learning context (Fahmi et al., 2023). The problem formulation and hypothesis formulation stages were related to the skills of asking questions and predicting, while the data analysis and conclusion drawing stages supported students' abilities to interpret and communicate experimental results. The lowest skill was found in the aspect of questioning and predicting, with a score of 73. This study is in line with previous research which shows that the average ability in hypothesis-forming aspects is lower than in observation aspects, with a difference of 27.08 points (Adikalan & Wicaksono, 2022). These findings indicate the need for additional scaffolding or guidance. Scaffolding in inquiry-based learning is needed to help students develop the ability to ask questions and make scientific predictions during the investigation process. Laboratory analysis confirmed that the vinegar produced met the Indonesian National Standard (SNI) with an acetic acid content ranging from 5.06–8.08 This finding strengthens the evidence that guided inquiry-based learning supported by the utilization of local potential not only facilitates the understanding of chemistry concepts but also contributes positively to the development of students' SPS. This is evidenced by the guided inquiry worksheet score, which was in the very good category, namely 80. The stages in the worksheet are interconnected with the aspects of students' SPS, resulting in an SPS score of 83, also in the very good category. However, the limitations of this study include the small sample size and implementation in only one school. This is because the study used the ADDIE development model, which is generally conducted in small-scale trials; therefore, the use of a sample of 15 students is still considered appropriate in development research (Sari et al., 2019); (Indriani & Pratiwi, 2023). In addition, since the focus of this study is on the development of students' SPS, this study does not emphasize measuring the improvement of SPS through comparison before and after the treatment. Overall, the developed worksheet is valid and suitable for use in developing SPS, although further experimental studies are still needed.

CONCLUSION AND RECOMMENDATIONS

The guided inquiry-based worksheet developed in acid–base titration learning through the analysis of pineapple peel waste vinegar has been shown to be highly valid and to contribute positively to supporting chemistry learning as well as developing students'SPS. The worksheet obtained an average validation result of 88.09% in the very valid category, indicating that the aspects of content, design, and learning structure are appropriate for use in learning activities.

The implementation results showed that students were able to carry out the guided inquiry stages well, with an average implementation of 80 Students' SPS were in the very good category, with the highest achievement in the observation aspect at 93.

Theoretically, these findings strengthen the idea that guided inquiry-based learning can develop SPS through contextual and experiment-based learning activities. The integration of real-life contexts, such as the utilization of pineapple peel waste, helps students connect chemistry concepts with everyday phenomena, making learning more meaningful. Practically, this worksheet can be used as an alternative teaching material for chemistry teachers in implementing more active, student-centered, and inquiry-based laboratory learning.

However, this study has limitations, namely the limited sample size and the restricted scope of the material, specifically acid–base titration and the assessment focused on developing SPS. Therefore, future research is recommended to involve larger and more diverse samples, expand application to other chemistry topics, and examine other learning outcomes such as critical thinking, creativity, and scientific literacy. Further implementation may also consider integrating digital or interactive media to enhance student engagement and support independent learning in laboratory activities.

REFERENCES

Adhwa, J. B., Sunarya, R. R., Sari, S., Farida, I., & Izzulhaq, B. D. (2025). The Use of Problem Based Interactive Video Quizzes to Improve Students' Chemical Literacy on the Topic of Water Pollution. *Jurnal IPA & Pembelajaran IPA*, *9*(2), 650–665. https://doi.org/10.24815/jipi.v9i2.46249

Adikalan, T. H., & Wicaksono, I. (2022). *Kemampuan Inkuiri Siswa SMP dalam Pembelajaran IPA Memanfaatkan Media E-LKPD*. *Pedagogi: Jurnal Ilmu Pendidikan*, *22*(1), 39-45. https://doi.org/10.24036/pedagogi.v22i1.1271

Adiningsih, M. D., Karyasa, I. W., & Muderawan, I. W. (2020). Profile of students' science process skills in acid-base titration practicum at class XI MIPA 3 SMA Negeri 1 Singaraja Bali. *Journal of Physics: Conference Series, 1503*(1), 012037. https://doi.org/10.1088/1742-6596/1503/1/012037

Arofah, R., & Cahyadi, H. (2019). Pengembangan Bahan Ajar Berbasis Addie Model: Addie Model-Based Teaching Material Development. *Halaqa: Islamic Education Journal, 3*(1), 35–42. https://doi.org/10.21070/halaqa.v3i1.2124

Astuti, E. A., Wardani, S., Kadarwati, S., & Kasmui, K. (2019). The effectiveness of practicum-based worksheet based on salt hydrolysis material viewed from the aspect of laboratory skills and interpersonal intelligence learners. *Journal of Education and Learning (EduLearn)*, *13*(4), 502–509. https://doi.org/10.11591/edulearn.v13i4.12397

Azis, R. F. Al, & Supardi, Z. A. I. (2019). Penerapan model pembelajaran inkuiri terbimbing untuk meningkatkan keterampilan proses sains siswa pada materi getaran. *Inovasi Pendidikan Fisika, 2*(3), 203–208.

Boimau, S. K., Tukan, M. B., Lawung, Y. D., & Boelan, E. G. (2022). Pengembangan LKPD dengan memanfaatkan indikator alami berbasis inkuiri terbimbing pada materi titrasi asam basa. *Educativo: Jurnal Pendidikan, 1*(2), 374–380. https://doi.org/10.56248/educativo.v1i2.45

Dahlan, A., Agustini, S., Yani, A., & Manarfah, L. (2025). Longitudinal Descriptive Study of Science Process Skill Growth in Basic Physics Practicum. *ARRUS Journal of Social Sciences and Humanities*, *5*(5), 1201–1208. https://doi.org/10.35877/soshum4417

Delima, D., Windayani, N., Aisyah, R., Sunarya, R. R., & Sukmawardani, Y. (2025). Application of project-based worksheet to develop students' scientific performance through making hand cream from black rice kefir. *Jurnal Pendidikan MIPA, 15*(2). https://doi.org/10.37630/jpm.v15i2.2803

Tauhidah, D., Rofi'ah, N. L., & Adi, W. C. (2022). Meninjau Efek Pembelajaran Inkuiri Terbimbing pada Keterampilan Proses Sains Peserta Didik dalam Pembelajaran Sains: Sebuah Meta-Analisis. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *6*(2), 167-174 https://doi.org/10.20961/jdc.v6i2.61210

Dwi, P., Putra, A., Wahyuni, S., Sulaeman, N. F., & Dina, R. (2025). Enhancing scientific communication skills in junior high school pupils : A mixed methods investigation of engineering design process tools. *Journal of Turkish Science Education*, *22*(3), 436–450. https://doi.org/10.36681/tused.2025.022

Ekaresta Prihardjati Saputro, S. A. (2018). *Keefektifan Manajemen Program Pembelajaran Bipa (Bahasa Indonesia Bagi Penutur Asing) Di Kota Yogyakarta*. *6*(1), 123–138. https://doi.org/10.21831/amp.v6i1.8066

Fahmi, J., Nahadi, & Hernani. (2023). Pengembangan Asesmen Formatif Berbasis Problem Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis: Need Assessment Study. *Orbital : Jurnal Pendidikan Kimia*, *7*, 237–249. https://doi.org/10.19109/ojpk.v7i2.19922

Farhah, A., Subarkah, C. Z., Deliana, C., & Sundari, D. (2025). *Development Of Science Literacy-Oriented Interactive Learning Multimedia On Nanotechnology Applications : Nanoquest*. *10*(2), 267–279. https://doi.org/10.36709/jpkim.v10i2.198

Fitriati, A., Hartikasari, A. I., Pandansari, T., Pramurinda, R., & Nuryana, I. (2023). *Development of innovative audiobooks to optimize e-learning*. *Jurnal Dinamika Ilmiah Pendidikan Dasar*, *15*(2), 83-90. https://doi.org/10.30595/dinamika.v15i2.18717

Hanifah, S., & Septi Irwansyah, F. (2021). Pembuatan Aplikasi Inventaris Alat Dan Bahan Laboratorium Kimia Berbasis Web Making of Web-Based Chemical Laboratory Equipment and Materials Inventory Application. *Gunung Djati Conference Series*, *2* https://doi.org/10.51903/dn7ejk03

Hidayah, F. F., Imaduddin, M., Yuliyanto, E., Gunawan, G., Djunaidi, M. C., & Tantayanon, S. (2022). "Counting Drops and Observing Color": Teachers' and Students' First Experiences in Small-Scale Chemistry Practicum of Acid-Base Solutions. *Journal of Technology and Science Education*, *12*(1), 244–258. https://doi.org/10.3926/JOTSE.1388

Hosbein, K., & Walker, J. (2022). Assessment of Scientific Practice Proficiency and Content Understanding Following an Inquiry-Based Laboratory Course. *Journal of Chemical Education*, *99*(12), 3833–3841. https://doi.org/10.1021/acs.jchemed.2c00578

Khalda, N., Sunarya, R. R., Aisyah, R., & Dahriah, I. (2025). *Project-Based Learning in Creating Edible Straws from Red Dragon Fruit Peel to Develop Science Process Skills*. *7*(1), 1–14. https://doi.org/10.21580/jec.2025.7.1.26563

Kuswandi, D., Zulnaidi, H., Kurniawan, C., Aulia, F., Thaariq, Z. Z. A., Wijanarko, D. A., Nafi'a, M. Z. I., & Maknuunah, L. (2023). Digital Learning Literacy Training and Mentoring using ADDIE Model. *Proceedings of the International Conference on Information Technology and Education (ICITE 2021)*, *609*(Icite), 98–103. https://doi.org/10.2991/assehr.k.211210.016

Li, J., Goei, S. L., & Van Joolingen, W. R. (2023). A case study of teacher learning in enacting maker pedagogy through lesson study. *International Journal for Lesson & Learning Studies*, *12*(3), 240-256. https://doi.org/10.1108/IJLLS-04-2023-0042

Nurfadilah, L., Sunarya, R.R., Nurhayati, Irwansyah, F.S., (2025). *JKPI : Jurnal Kajian Pendidikan IPA*. *5*(2), 105–116. https://doi.org/10.52434/jkpi.v5i2.42652

Manurung, S. L. (2023). development of digital teaching materials based on higher order thinking skills (hots) to improve students ' creative thinking. *The 10th Annual International Seminar on Trends in Science and Science Education (AISTSSE).* Sciendo, 2024, pp. 530-538. https://doi.org/10.2478/9788367405782.

OECD. (2019). *OECD Learning Compass 2030: A series of concept notes.* OECD Publishing.

Oladejo, A.I., Ademola, I.A., Ayanwale, M.A., & Tobih, D. (2023). Concept difficulty in secondary school chemistry – An intra-play of gender, school location and school type. *Journal of Technology and Science Education,* 13(1), 255-275. https://doi.org/10.3926/jotse.1902

Pradana, D. A., Hermawan, C., & Susanti, H. D. (2020). Nasionalism : Character Education Orientation in Learning Development. *Budapest International Research and Critics Institute-Journal, 3*(4), 4026–4034. https://doi.org/10.33258/birci.v3i4.1501

Purnomo, S., Rahayu, Y. S., & Agustini, R. (2023). Effectiveness of ADI-STEM to Improve Student's Science Literacy Skill. *IJORER : International Journal of Recent Educational Research*, *4*(5), 632–647. https://doi.org/10.46245/ijorer.v4i5.382

Putri, H. K., Rusilowati, A., Supriyadi, S., & Widiyatmoko, A. (2025). *Unnes Science Education Journal Accredited Sinta 2 The Implementation of Local Wisdom-Based Teaching Material to Increase Students' Literacy and Numeracy*. *14*(2), 268–279. https://doi.org/10.15294/usej.v14i2.24474

Rahmawati. (2025). Implementasi inkuiri terbimbing berbantuan live worksheet untuk meningkatkan keterampilan proses sains siswa smp pada materi getaran dan gelombang. *Jurnal Inovasi Pendidikan Matematika Dan IPA, 5(2), 837–845.* https://doi.org/10.51878/science.v5i2.5713

Rahmawati, T., & Partana, C. F. (2019). Pengaruh Media Pembelajaran Asam Basa Berbasis Android Terhadap Efikasi Diri Peserta Didik. *JTK (Jurnal Tadris Kimiya)*, *4*(2), 147–156. https://doi.org/10.15575/jtk.v4i2.5022

Said, F., Darma, G. C. E., & Kodir, R. A. (2021). Formulasi Sediaan Cuka Buah Kopi Menggunakan Ragi (Saccharomyces cerevisiae) dan Bakteri (Acetobacter aceti). *Jurnal Riset Farmasi*, *1*(1), 38–45. https://doi.org/10.29313/jrf.v1i1.46

Saidaturrahmi, S., Gani, A., & Hasan, M. (2020). Penerapan Lembar Kerja Peserta Didik Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Peserta Didik. *Jurnal Pendidikan Sains Indonesia*, *7*(1), 1–8. https://doi.org/10.24815/jpsi.v7i1.13554

Sugiyono. (2010). *Metode penelitian kuantitatif dan R&D.* Alfabeta.

Sugiyono. (2022). *Metode Penelitian Kuantitatif*. Alfabeta.

Suherman, S. (2023). Improving Students' Basic Chemistry Competences Through Implementation of Class-Based Assessments in Inquiry-Based Chemistry Learning. *Hydrogen: Jurnal Kependidikan Kimia*, *11*(2), 129. https://doi.org/10.33394/hjkk.v11i2.7448

Yao, P., Gong, H., Wu, Z., Fu, H., Li, B., Zhu, B., Ji, J., Wang, X., Xu, N., Tang, C., Zhang, H., & Zhu, J. (2022) Greener and higher conversion of esterification via interfacial photothermal catalysis. *Nature Sustainability*, 5, 348–356. https://doi.org/10.1038/s41893-021-00841-0

Zidane, A., Zam Zami, R., Putra Mahardika, M., & Barlian, A. A. (2023). Formulasi dan uji sifat fisik permen jelly dari ekstrak kulit nanas madu (Ananas comosus (L.) Merr.) menggunakan basis karagenan dan gum arab. *Inovasi Teknik Kimia*, 8(2), 139–148.

Zuriyatina, R., W., K. A., & Sari, D. K. (2021). Validitas dan efektivitas modul pembelajaran kimia terintegrasi STEM-PBL topik pakan jeroan ikan untuk ikan lele dan topik lain pada mata kuliah kewirausahaan. *Jambura Journal of Educational Chemistry*, 3(2), 48–55. https://doi.org/10.34312/jjec.v3i2.4045