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Limited-Scale Implementation of a Guided Inquiry Worksheet for Identifying Buffer Properties in Mouthwash

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Abstract: *Buffer solutions are an abstract topic in high school chemistry, while practicum is often constrained by limited facilities and tends to be procedural rather than inquiry-based. Guided inquiry worksheets have been developed for buffer practicums using eye drops and packaged foods, but how students carry them out in a mouthwash context has not been examined. This study aimed to analyze the implementation of a guided inquiry-based practicum on identifying buffer properties in mouthwash, using a student worksheet in a limited-scale trial. A descriptive quantitative design was applied to 12 eleventh-grade students from one class at SMA Pasundan 8 Bandung, divided into four heterogeneous groups. Data were collected using two validated instruments, an observation sheet and a scoring rubric for students' written worksheet answers, and analyzed as percentages using established criteria. Implementation based on observation ranged from 75% to 100%, while the quality of worksheet answers ranged from 81.25% to 100%, both in the good to very good categories. Hypothesis formulation and variable identification scored lowest in observation. Because the sample was limited to 12 students from a single class and learning gains were not measured, the findings are preliminary and cannot be generalized.*

Keywords: *Guided inquiry; student worksheet; buffer solution; mouthwash; practicum implementation*

INTRODUCTION

The rapid growth of scientific knowledge, globalization, and information technology advancements present major difficulties for education institutions in the twenty-first century. Students are therefore required to acquire learning and creative skills in addition to mastering knowledge (Arnyana, 2019). One teaching strategy that actively involves students in the development of applied skills, teamwork, and technology adaptation is the use of practical activities (Nuai & Nurkamiden, 2022). Students learn how to develop hypotheses, evaluate information, and reach conclusions supported by evidence through these exercises (Mulia & Murni, 2022). Supporting instructional materials, including Student Worksheets(LKPD), are necessary for the execution of practical tasks. These materials are intended to help and assist students during the practical learning process (Lusiana et al., 2021).

Despite the widespread development and usage of student worksheets by educators, a number of studies have found a number of problems with their application in classroom environments. Current student worksheets are

frequently too short, which hinders students' comprehension of the practical exercises and leads to passive participation (Yase et al., 2020). Furthermore, a lot of the student worksheets that are currently available are thought to be inadequately contextualized and are mostly modified from pre-existing worksheet templates (Luh et al., 2022). In order to encourage meaningful learning and develop scientific thinking abilities, they must be revised (Rohmatika et al., 2025). Additionally, it has been noted that teachers underutilize student worksheets, which restricts students' chances to practice critical thinking and teamwork (Ningtiaz & Suswanto, 2025). These results suggest that the problem is not just the availability of student worksheets but also how well they can be used as intended.

Given the issues with student worksheets that have not promoted active student participation, it is essential to employ student worksheets that directly involves students in problem formulation, planning investigations, and data analysis and discussion in order to find solutions, with educators serving as facilitators (Aryani & Nana, 2020). Guided inquiry, which involves students conducting investigations based on problems, tools, and materials provided by educators, is thought to be able to address this issue. The investigation design is created by students themselves (Masruhah et al., 2022), allowing students to develop their own understanding through experience and reflection (Pramana et al., 2024).

Through the creation of student worksheets for buffering property identification using commonplace items like eye drops (Rizky, 2017) and packaged foods (Inayati et al., 2023), guided inquiry has been applied to a variety of chemistry topics, including buffer solutions, and both have received positive feedback. With a score of 90%, the student worksheet created in the context of packaged goods in particular showed a high degree of practicum application (Inayati et al., 2023). These results suggest that guided inquiry-based student worksheets for the subtopic of buffering property identification can be implemented successfully across various material contexts and yield workable instructional materials. Sutiani & Maisyarah (2021) developed a guided inquiry-based module on reaction rates that was declared feasible, which supports the potential of guided inquiry-based materials in chemistry teaching.

However, there is still a disconnect between the ideal circumstances outlined in earlier research and the actualities of classroom instruction. Despite the fact that most chemistry teachers thought the subtopic of buffering property identification was important or very important for laboratory education, preliminary needs analysis showed that two out of five had never carried out practical activities on it in their learning. This disparity between the subtopic's perceived significance and its restricted application is in line with the nature of buffer solutions, which are both extremely applicable and important to daily life and theoretically abstract and difficult. Thus, it is crucial to enhance students' conceptual knowledge through hands-on experiences (Sariati et al., 2020). Instead of developing a thorough grasp of the underlying concepts, pupils are more likely to rely on rote recollection in the absence of such reinforcement (Sariati et al., 2020).

Another gap lies in the context of the materials used. Prior research has concentrated on things that are frequently studied, like eye drops and packaged foods, but it is preferable to have a more varied and real-world setting that is directly connected to students' daily experiences. Mouthwash may provide buffering qualities in a setting that has not been investigated in earlier research. A weak acid and its conjugate base produce a weak acid buffer system when benzoic acid and sodium benzoate are combined in some mouthwash preparations. Additionally, mouthwash was seen by every respondent who took part in the needs analysis as a pertinent and suitable resource for hands-on exercises meant to improve the contextualization of buffer solution ideas.

They also agreed that a guided inquiry-based student worksheet for this subtopic is needed. Moreover, previous studies on buffering property identification have mainly reported the development of such worksheets and their overall level of implementation or practicality. Beyond an overall implementation score, this study examines implementation stage by stage and compares the participation observed in each group with the quality of students' written worksheet responses, in order to identify which guided inquiry stages can be carried out readily and which require additional teacher guidance. To the best of our knowledge, such an analysis has not been reported for a mouthwash context.

Based on these considerations, a guided inquiry-based student worksheet for the practical activity on buffering property identification in mouthwash was developed to address these needs. However, the availability of such a student worksheet alone is not sufficient, it must also be successfully implemented as planned. This is in line with research demonstrating that students frequently rely only on laboratory instructions during chemistry practical exercises, following each step by step without fully comprehending the practicum's underlying concepts. As a result, the existence of a student worksheet does not guarantee that guided inquiry objectives will be met until its learning phases are completed in a meaningful way (Rahayu & Sari, 2023).

Therefore, the implementation of the guided inquiry stages in this practical activity needs to be specifically evaluated through classroom observations during the limited-scale trial and through the assessment of students' responses to the tasks included in the student worksheet. The level of implementation reflects the extent to which the developed student worksheet can be effectively carried out by students in the classroom, rather than merely being validated theoretically. This evaluation also determines whether the designed practical activity successfully avoids becoming a purely procedural exercise without conceptual understanding, as described previously. Accordingly, analyzing the implementation of the practical activity represents an essential step before recommending the student worksheet for broader use. Based on this rationale, this study aims to analyze the implementation of the Buffering Property Identification in Mouthwash practical activity using a guided inquiry-based student worksheet through a limited-scale trial involving 12 students from a single class at SMA Pasundan 8 Bandung.

Specifically, this study addresses one research question: How is the implementation of the practical work, based on observation and students' answers, using the developed guided-inquiry-based worksheet for the practicum on identifying buffer properties in mouthwash? To address this question, a limited-scale trial of the developed worksheet was conducted with students from one class. Observation scores describe the proportion of group members involved in each component, so a lower score means a lower level of implementation, whereas worksheet-answer scores describe the quality of the groups' answers, that is, their ability to complete each task. This trial aimed to obtain an initial overview of the implementation of practical activities and students' answers to the tasks presented in the worksheet. Drawing on Inayati et al. (2023), who reported a very high level of implementation of a similar guided-inquiry-based worksheet, this study expected the developed worksheet to be implemented at a good to very good level during the limited-scale trial.

LITERATURE REVIEW

Practical Work

Any teaching and learning activity that ultimately requires students to observe or handle actual things and materials is considered practical work, according to Millar (2004). Based on its learning objectives, practical work can be divided into three categories and serves a variety of purposes in science education:

1. Type A: To assist students in gaining a more comprehensive comprehension of the natural world and the ways in which science clarifies important ideas, hypotheses, and models.
2. Type B: To instruct students on how to operate scientific apparatus and/or carry out standard scientific processes.
3. Type C: To teach students how to use scientific procedures to explore topics, such as organizing investigations, gathering and analyzing data, interpreting evidence to make findings, and determining the validity of those results.

Practical work is an integral part of the learning process and cannot be separated from chemistry education. Making practical work more effective than traditional teaching approaches is the challenge. Clearly establishing learning objectives, carefully assessing instructional needs, and creating and implementing activities that motivate students to reflect on the information they get and the actions they take during practical work are all necessary to achieve this (Millar & Abrahams, 2009).

Guided Inquiry Model

The guided inquiry learning model enables students to engage in identifying problems, formulating research questions, developing hypotheses, collecting data, verifying findings, and drawing conclusions, while receiving guidance from the teacher (Matthew & Igharo, 2013, as cited in Almira et al., 2023). Unlike free inquiry, in which the entire inquiry process is carried out independently by students, guided inquiry positions the teacher as a facilitator who provides the problem, equipment, and materials, whereas the investigation design and the process of discovering solutions are undertaken by the students themselves (Masruhah et al., 2022).

Six sequential steps make up the guided inquiry learning model, according to Sanjaya (2008, as cited in Indawati et al., 2021). In order to develop students' problem-solving thinking abilities, the teacher puts them at the center of the learning process at the first stage, orientation. In the second phase, known as problem formulation, students create research questions based on their past conceptual understanding and the phenomena the teacher has presented. After then, these research questions are provisionally answered in the hypothesis formation step, where students create hypotheses based on what they already know about the pertinent ideas.

To test the proposed hypotheses, students conduct experiments during the data collection stage. The experimental results are then examined in the data analysis stage to verify the hypotheses that have been formulated. In the final stage, drawing conclusions, students explain their findings based on the experimental data and hypothesis testing. These conclusions are subsequently refined and validated through a review of relevant scientific literature. In this study, these six stages are broken down into 14 observed aspects (Table 2) and 11 worksheet tasks (Table 3), so that each stage can be followed in both data sources.

Student Worksheet

A Student Worksheet is an instructional resource developed by teachers to support students in conducting investigations or solving problems (Romadhon et al., 2024). It also serves as an important bridge between the theoretical concepts taught in the classroom and the practical experiences gained by students. Beyond functioning as a technical guide, a student worksheet is an instructional tool that promotes meaningful, contextualized, and student-centered learning (Nurjihan & Bunawan, 2025). The development of student worksheets requires careful planning, taking into account several important factors. These include the learning context, the quality and complexity of the subject matter, the diversity of students' learning needs, and the alignment of the worksheet with the selected instructional approach or learning model (Nurjihan & Bunawan, 2025).

Buffer Solutions

Brown et al. (2012) define buffer solutions as solutions containing a conjugate acid–base pair that resists significant pH changes upon the addition of small amounts of strong acid or base. Buffer solutions are classified as acidic, consisting of a weak acid and its conjugate base, or basic, consisting of a weak base and its conjugate acid. Their buffering mechanism involves the conjugate base reacting with added acid and the weak acid reacting with added base, thereby reducing pH variations (Silberberg, 2007, as cited in Dewi et al., 2021; Whitten et al., 2014)

Despite these established principles, buffer solutions remain challenging for students because understanding them requires integrating macroscopic, submicroscopic, and symbolic representations (Ulva et al., 2016), as well as mathematical skills and conceptual knowledge of chemical equilibrium and acid-base chemistry (Istiana et al., 2015; Panggabean et al., 2022; J. Purba & Siregar, 2020). These difficulties are reflected in the prevalence of misconceptions: 47% of students held misconceptions, 37% understood the concepts correctly, and 16% lacked conceptual understanding (Nurhidayatulah & Prodjosantoso, 2018).. Misconceptions concerning buffer definitions, components, mechanisms, and pH calculations have also been reported among senior high school students (Dewi et al., 2021), with contributing factors including teaching strategies, textbook quality, learning interest, and reasoning skills. Furthermore, chemistry learning outcomes on buffer solutions are strongly associated with mathematical aptitude and prior knowledge (Silitonga et al., 2022). These findings highlight the need for contextual learning experiences, such as guided practical activities, that connect chemical representations and strengthen students' conceptual understanding.

Mouthwash as a Context for Buffer Solutions

Mouthwash is an aqueous solution used to maintain oral hygiene and help prevent or manage conditions such as dental caries, tooth erosion, halitosis, gingivitis, and periodontitis (Radzki et al., 2022). It complements rather than replaces toothbrushing and flossing (Singh et al., 2022) and can be classified as therapeutic or preventive according to its intended use (Radzki et al., 2022). Its formulations contain various ingredients, including active agents, solvents, preservatives, flavoring agents, and pH regulators or buffers (Radzki et al., 2022; Yazicioglu et al., 2023) Common active ingredients include fluoride compounds, essential oils, cetylpyridinium chloride, and chlorhexidine digluconate (Radzki et al., 2022; Yazicioglu et al., 2023).

Mouthwash provides a relevant context for studying buffer solutions because some formulations contain benzoic acid and sodium benzoate. Sodium benzoate is commonly used as a preservative (Amin & Arman, 2025; Diana Hayati, 2025) and is the sodium salt of benzoic acid, a weak aromatic carboxylic acid (Mendrofa, 2019; Yuniantari & Susilowati, 2025). When both substances are present, they can form a conjugate acid-base pair capable of resisting pH changes. Mouthwash formulations may also contain other buffering agents, such as citric acid, potassium phosphate, sodium bicarbonate, phosphate and citrate buffer systems, and sodium lactate (Radzki et al., 2022; Yazicioglu et al., 2023).

Buffer systems in mouthwash can help maintain pH and support the stability and efficacy of active ingredients. Maintaining an appropriate oral pH is important because acidic conditions can promote enamel demineralization, while fluorapatite is more resistant to acid than hydroxyapatite (Yazicioglu et al., 2023). Therefore, mouthwash offers a meaningful real-world context for guided practical activities in which students identify buffer properties and

connect the composition of everyday products with the concepts of acid–base equilibria.

METHODS

Research Design

This study employed a descriptive quantitative research design to describe the implementation of the Buffering Property Identification in Mouthwash practical activity using a guided inquiry-based student worksheet through a limited-scale trial. The student worksheet used in this study had undergone expert validation prior to the trial. The limited-scale trial was conducted to examine the extent to which students were able to carry out the guided inquiry stages incorporated in the student worksheet

Research Participants

The participants in this study were 12 eleventh-grade students from SMA Pasundan 8 Bandung, who were randomly selected from a single class. According to Arikunto (2013), a small-group trial consists of 4 to 14 participants; therefore, the number of participants in this study met the recommended criterion for a limited-scale trial. The 12 students were divided into four groups, each consisting of three members. Group assignment was conducted by the chemistry teacher using a heterogeneous grouping strategy based on students' learning abilities, ensuring that students with higher learning abilities were distributed evenly across all groups. Students' responses to the tasks in the student worksheet were assessed at the group level, whereas the implementation of the practical activity was observed by two observers, each of whom was responsible for observing two student groups. The observers were peers of the researcher and were briefed prior to the practicum on the groups that each of them would observe and on the use of the scoring rubric.

Research Instruments

Data on the implementation of the practical activity were collected using two instruments: an observation sheet for the implementation of the guided inquiry stages and an assessment sheet for answers to assignments in the student worksheet. The observation sheet was used to evaluate the extent to which each stage of the guided inquiry process was carried out during the practical activity. Scores ranged from 1 to 3 according to the proportion of group members (three per group) involved in carrying out each component: a score of 3 was given when all three members were involved, 2 when two members were involved, and 1 when only one member was involved. Therefore, a lower observation percentage means that fewer group members were involved in carrying out that component, that is, a lower level of implementation. Meanwhile, the assessment sheet for the answers to the tasks in the student worksheet uses an assessment rubric for each stage of the investigation to assess the quality of the students' answers. The maximum score of each task differed according to its rubric, with a total maximum score of 90 per group. These scores describe the quality of each group's answers, that is, the ability of the group to complete each task. Both instruments were validated by three chemistry education lecturers at Universitas Pendidikan Indonesia prior to their use in the limited-scale trial. The observation sheet consisted of 14 aspects derived from the guided inquiry stages, whereas the answer assessment rubric consisted of 11 aspects corresponding to the tasks in the student worksheet, which were also derived from the inquiry stages. Each validator indicated agreement or disagreement with each aspect, and all validators agreed with all aspects. Reliability testing of the instruments was not conducted. Inter-observer agreement was also not calculated; consistency between the two observers relied only on the briefing described above.

Data Collection Procedure

The practical activity used mouthwash as the buffer solution, and 0.01 M CH_3COOH, 0.01 M NH_4OH, and 0.09% NaCl as non-buffer solutions. Each solution was tested by adding 10 drops of 0.1 M HCl or 0.1 M NaOH to 20 mL of the sample, and the pH was measured using a pH meter.

Data were collected through two methods during the Buffering Property Identification in Mouthwash practical activity using the guided inquiry-based student worksheet. First, the observers monitored and recorded the level of participation of each student group at every stage of the guided inquiry process using a structured observation sheet. Scores were assigned according to a validated practicum implementation observation rubric, beginning with students' engagement in the orientation section of the student worksheet and ending with the formulation of their conclusions. Second, after the practical activity was completed, the completed student worksheets from each group were collected. The answers to each task in the worksheet were then evaluated using a predefined scoring rubric for student worksheet answers.

Data Analysis

The implementation data obtained from the classroom observations and the assessment of student worksheet responses were analyzed using descriptive quantitative methods with Microsoft Excel. Although both datasets underwent the same analytical procedure, they were reported separately and subsequently interpreted together. First, each group was assigned a score for every observed or assessed component based on the validated scoring rubric. The scores obtained by all groups for each component were then summed, and the maximum possible score for each component was determined by multiplying the highest score specified in the rubric by the total number of observed groups, as shown in Equation (1):

$$Maximum\ score = highest\ score \times number\ of\ groups \quad (1)$$

Next, the percentage score for each component or task was calculated by comparing the total score obtained with the maximum score, using Equation (2):

$$Percentage\ (\%) = \frac{total\ score}{maximum\ score} \times 100 \quad (2)$$

For data on the results of assessing answers to tasks in the student worksheet, the average percentage for each stage was obtained by averaging the percentage of all tasks in one stage, using Equation (3):

$$Average\ percentage(\%) = \frac{total\ percentage\ of\ each\ task}{number\ of\ tasks\ in\ the\ stage} \quad (3)$$

The percentages obtained were then interpreted based on the category criteria according to Riduwan (2014) in Table 1.

Table 1. Interpretation Criteria for Implementation Scores (Riduwan, 2014)

Score range(%)	Category
0-20	Very less
21-40	Less
41-60	Enough
61-80	Good
81-100	Very good

The interpreted results were used to describe the extent to which students were able to carry out each stage of guided inquiry in the student worksheet during the limited-scale trial. They also served as the basis for identifying aspects of the student worksheet requiring further improvement.

RESULT AND DISCUSSION

Practicum Implementation Results

A limited-scale trial with 12 eleventh-grade students who were split into four groups examined the use of the Buffering Property Identification in Mouthwash practical exercise using the guided inquiry-based student worksheet. Two data sources were used to assess the level of implementation: (1) classroom observations of students' activities during the practical session and (2) an evaluation of students' answers to the tasks in the student worksheet.

Table 2. Implementation of Guided Inquiry Stages by Students During the Practicum (Observation)

No	Observed Implementation Aspect	%	Category
1	Reading the phenomenon	100	Very good
2	Make a question	100	Very good
3	Focusing questions	83.33	Very good
4	Make a hypothesis	75	Good

5	Creating experimental objectives	83.33	Very good
6	Determining materials	83.33	Very good
7	Determining tools	91.67	Very good
8	Determining variables	75	Good
9	Designing procedures	83.33	Very good
10	Conducting experiments	100	Very good
11	Writing down observation results	100	Very good
12	Analyzing data	83.33	Very good
13	Testing hypotheses	100	Very good
14	Drawing conclusions	100	Very good
	Mean	89.88	Very good

Based on Table 2, the implementation scores ranged from 75% to 100%, with a mean of 89.88%, corresponding to the good and very good categories according to the criteria proposed by Riduwan (2014). Twelve of the fourteen assessed components were classified as very good, whereas the two components with the lowest percentages, hypothesis formulation and identification of experimental variables, each achieved a score of 75%, which falls into the good category. Because the observation scores reflect the proportion of group members involved, the 75% obtained for hypothesis formulation and variable identification means that not all members were involved in these two components in every group.

Table 3. Scores of Students' Worksheet Responses to the Guided Inquiry Tasks

No	Assignments in Student Worksheets	%	Category
1	Formulate the problem	100	Very good
2	Formulate a hypothesis	87.50	Very good
3	Creating experimental objectives	87.50	Very good
4	Determining materials	81.25	Very good
5	Determining tools	97.92	Very good
6	Determining variables	100	Very good
7	Designing procedures	95.14	Very good
8	Writing down observation results	100	Very good
9	Analyzing data	89.29	Very good
10	Testing hypotheses	100	Very good
11	Drawing conclusions	100	Very good
	Mean	94.42	Very good

Based on Table 3, the quality of students' responses to all tasks in the student worksheet ranged from 81.25% to 100%, with a mean of 94.42%, with all components classified as very good according to the criteria proposed by Riduwan (2014). The component with the lowest percentage was determining materials (81.25%), whereas five components, formulating the problem, determining variables, recording observations, hypothesis testing, and drawing conclusions, achieved the maximum score of 100%. The means of 89.88% and 94.42% are the averages of the component percentages in Table 2 and Table 3, respectively. These scores describe the groups' ability to complete each task, as shown in their written answers.

Discussion

Overall, the results of observations and assessments of students' answers to the tasks in the student worksheets (Table 2 and Table 3) show that the practicum on identifying buffer properties in mouthwash using the developed guided inquiry-based student worksheets was carried out in the very good category on a limited scale, with implementation scores ranging from 75-100% (observation, mean 89.88%) and 81.25-100% (worksheet answers, mean 94.42%). This result is consistent with the expectation stated in the Introduction that the worksheet would be implemented at a good to very good level. In the observation data, reading the phenomenon, making questions, conducting experiments, writing down observation results, testing hypotheses, and drawing conclusions were carried out by all group members (100%), whereas the lowest involvement was found in making hypotheses and determining variables (75%). In the worksheet answers, the lowest scores were found in determining materials (81.25%), formulating hypotheses and experimental objectives (87.50%), and analyzing data (89.29%).

One possible explanation for this trend is variations in the cognitive demands of each

guided inquiry level. The guiding questions in the student worksheet may directly assist the fundamental science process abilities included in stages including observing events, carrying out experiments, documenting findings, testing hypotheses, and drawing conclusions. This may explain why students could accomplish these steps accurately and actively with considerable ease.

On the other hand, the lower involvement in making hypotheses and determining variables (75%) shows that these two components were not carried out by all group members in every group. A possible reason is that formulating hypotheses and identifying variables are classified as integrated science process skills, whereas observing and measuring are basic skills, as described by Darmaji et al. (2018). Integrated skills may require more complex reasoning, but cognitive demand and individual ability were not measured in this study, so this explanation remains tentative. The teacher's role may also matter: in guided inquiry, the teacher keeps directing students when they are unsure about the direction of the investigation, as reported by Purba et al. (2024). This suggests that the stages with lower involvement may need stronger teacher guidance.

Comparing the two data sources at these two stages revealed another intriguing finding: while developing hypotheses and identifying variables had the lowest implementation (75%) in the observation results, both stages achieved the very good category (87.50% and 100%) in the written responses to the Student Worksheet. The two data sources measure different things: observation scores show how many group members were involved in a component, whereas worksheet scores show how well the group answered the task, which reflects the group's ability. The result therefore indicates that, although not all members were involved in these two components, the groups were still able to answer the tasks well. This may be because the guiding questions in the student worksheet were structured enough to lead the group to correct answers, but this was not examined directly. In addition, because the worksheet was answered as a group, its scores cannot show the ability of each individual student.

In the worksheet answers, scores below the maximum were also found in determining tools and designing experimental procedures (97.92% and 95.14%), which did not reach the maximum score, possibly because of students' technical errors in converting multiple guiding questions into a comprehensive technical response, and in the components of data analysis and material selection (89.29% and 81.25%), which may call for the capacity to choose pertinent information and combine quantitative data with the qualitative idea of buffer solutions.

The results of this study are in line with those of Inayati et al., (2023), who created a guided inquiry-based practicum worksheet for the subtopic of buffering property identification using packaged foods. With a score of 90%, their study also revealed a very high degree of practical implementation. The comparable implementation scores (89.88% for observation and 94.42% for worksheet answers in the current study versus 90% in the previous study), the similar learning topic (buffering property identification), and the assessment tools (a combination of observation sheets and student worksheet response assessments) further imply that guided inquiry-based student worksheets for buffering property identification can generally be implemented well, in both contexts, mouthwash or packaged foods. Silaban et al. (2019) reported that, in a limited trial on buffer solutions, students taught with scientific literacy-based teaching materials had higher learning outcomes and interest than students in a comparison class, which suggests that well-structured materials may also benefit learning. However, learning outcomes were not measured in the current study, so whether good implementation leads to better learning still needs to be tested.

However, high level of implementation in this study is not necessarily found in all other studies. In the creation of a guided inquiry-based student worksheet for acid-base content at a senior high school in Banda Aceh, Zulyani (2021) reported a lower average score of 72.5% for students' answers to the worksheet, although the worksheet was still considered usable. Because this score reflects the quality of worksheet answers, it is comparable to the worksheet-answer scores in this study (Table 3) rather than to the observation scores, although the aspects assessed in the two studies differ. Numerous contextual factors across studies, such as students' familiarity with inquiry-based learning, the intricacy of the concepts under investigation, the nature of the guiding questions in the student worksheet, and the quantity and makeup of groups participating in the trial, may have an impact on this variation in achievement. These variations suggest that the application of guided inquiry-based practical tasks may depend on the quality of the student worksheet design and the students' readiness to participate in inquiry-based learning, rather than being generalizable across various subjects and educational settings.

Overall, these findings indicate that the implementation of the practicum on identifying buffer properties in mouthwash using student worksheets based on guided inquiry was carried out at a good to very good level in a limited-scale trial, in terms of both the involvement of group members and the quality of their written answers. These results are consistent with previous studies on similar topics, although they are not entirely consistent with all guided inquiry-based student worksheet studies in other chemistry topics. The differences in achievement among studies highlight the importance of the quality of guiding questions and the suitability of the worksheet context with students' characteristics. These stages with lower scores can be improved through stronger teacher guidance and refinement of the guiding questions in the student worksheet before conducting trials on a larger scale. Because the study involved only 12 students from one class and measured implementation rather than learning gains, these findings should be interpreted cautiously.

CONCLUSION

The practicum on identifying buffer properties in mouthwash using the guided inquiry-based student worksheet was implemented at a good to very good level in a limited-scale trial. Observation scores, which reflect the proportion of group members involved, ranged from 75% to 100% (mean 89.88%), with the lowest involvement in making hypotheses and determining variables. Worksheet-answer scores, which reflect the groups' ability, ranged from 81.25% to 100% (mean 94.42%), with the lowest score in determining materials. These findings contribute to the development of contextual chemistry teaching materials by showing that mouthwash can serve as an alternative context for buffer practicums, beyond eye drops and packaged foods, and they point to the stages that may need stronger teacher guidance or refined guiding questions. The findings are preliminary: they come from 12 students in one class, observation was carried out by two observers without calculating inter-observer agreement, instrument reliability was not tested, and learning gains were not measured. They therefore cannot be generalized or taken as evidence of learning effectiveness. Further research with more students and in different school contexts is needed before the worksheet is recommended for wider use.

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REFERENCES

Almira, A., Rachmawati, A., Jelita, I. N., & Nurlaili, Y. (2023). *Evaluasi penerapan model pembelajaran inkuiri terbimbing dalam pembelajaran kimia : Suatu tinjauan sistematis literatur*. http://arxiv.org/abs/2312.10090

Amin, S., & Arman, S. A. (2025). Formulasi Dan Evaluasi Mouthwash Mengandung Ekstrak Bunga Honje Laka (Etlingera Hemisphaerica) Dan Minyak Atsiri Daun Kemangi (Ocimum Basilicum): Studi Tentang Aktivitas Antimikroba Terhadap Streptococcus Mutans. *Journal of Public Health Science*, *2*(1), 59–65. https://doi.org/10.70248/jophs.v2i1.2109

Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik*. Rineka Cipta.

Arnyana, I. B. P. (2019). Pembelajaran untuk meningkatkan kompetensi 4c (communication, collaboration, critical thinking dancreative thinking) untukmenyongsong era abad 21. *Prosiding : Konferensi Nasional Matematika Dan IPA Universitas PGRI Banyuwangi*, *1*(1), i–xiii.

Aryani, S. D., & Nana, N. (2020). Aplikasi Model Inkuiri Terbimbing Berbantuan Lkpd Untuk Meningkatkan Keterampilan Proses Sains Pada Materi Kalor. *Relativitas: Jurnal Riset Inovasi Pembelajaran Fisika*, *3*(1), 37. https://doi.org/10.29103/relativitas.v3i1.2489

Brown, T. L., H. Eugene LeMay, J., Bursten, B. E., Murphy, C. J., & Woodward, P. M. (2012). *Chemistry: The Central Science* (12th ed.). Pearson Prentice Hall.

Darmaji, Kurniawan, D. A., Parasdila, H., & Irdianti. (2018). Deskripsi Keterampilan Proses Sains Mahasiswa pada Materi Termodinamika. *Berkala Ilmiah Pendidikan Fisika*, *6*(3), 345. https://doi.org/10.20527/bipf.v6i3.5290

Dewi, Y. F., Nahadi, & Siawaningsih, W. (2021). Misconceptions Profile of High School Students in Sumedang on Buffer Solution Material. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *9*(1), 59–70. https://ejournal.upi.edu/index.php/JRPPK/index%0AProfil

Diana Hayati. (2025). Formulasi Mouthwash Ekstrak Herba Putri Malu (Mimosa Pudica) Sebagai Antibakteri Terhadap Bakteri Streptococcus Mutan. *Jurnal Keperawatan Dan Kebidanan*, *11*(15 mm), 74–87.

Inayati, N., Wahyu, W., Supriyanti, F. M. T., Suhanda, H., & Suryatna, A. (2023). Pengembangan Lembar Kerja Peserta Didik (LKPD) Praktikum Berbasis Inkuiri Terbimbing pada Subtopik Identifikasi Sifat-Sifat Larutan Penyangga dalam Makanan Kemasan. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *11*(1), 28–41. https://doi.org/10.17509/jrppk.v11i1.57943

Indawati, H., Sarwanto, S., & Sukarmin, S. (2021). Studi Literatur Pembelajaran Inkuiri Terbimbing Terhadap Kemampuan Berpikir Kritis Ipa Smp. *INKUIRI: Jurnal Pendidikan IPA*, *10*(2), 98. https://doi.org/10.20961/inkuiri.v10i2.57269

Istiana, G. A., Saputro, C., Nugroho, A., & Sukardjo, J. S. (2015). Penerapan Model Pembelajaran Discovery Learning untuk Meningkatkan Aktivitas dan Prestasi belajar pokok bahasan larutan penyangga pada siswa kelas xi ipa …. *Jurnal Pendidikan Kimia*, *4*(2), 65–73.

Luh, N., Karang, G., Ayu, D., Manu, M., &

Priantini, O. (2022). Lembar Kerja Peserta Didik Berbasis Kontekstual pada Muatan Pelajaran IPA. *Jurnal Ilmiah Pendidikan Profesi Guru*, *5*(1), 147–160. https://doi.org/http://dx.doi.org/10.23887/jippg.v5i1

Lusiana, L., Enawaty, E., & Rasmawan, R. (2021). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Inkuiri Terbimbing Pada Materi Laju Reaksi Di SMA Indonesia Muda. *Jurnal Eksakta Pendidikan (Jep)*, *5*(1), 51–58. https://doi.org/10.24036/jep/vol5-iss1/569

Masruhah, G. D., Rusdianto, R., & Wahyuni, S. (2022). Pengembangan E-LKPD Berbasis Inkuiri Terbimbing untuk Meningkatkan Keterampilan Proses Sains Siswa SMP. *SAP (Susunan Artikel Pendidikan)*, *7*(1). https://doi.org/10.30998/sap.v7i1.12935

Mendrofa, N. (2019). *Analisis Kadar Natrium Benzoat Pada Tauco yang Dipasarkan di Pajak Kota Medan dengan Metode S Spektrofotometri Ultra Violet Tahun 2019*. Institut Kesehatan Helvetia.

Millar, R. (2004). *The role of practical work in the teaching and learning of science*.

Millar, R., & Abrahams, I. (2009). Practical work : making it more effective. *School Science Review*, *91*(September), 59–64.

Mulia, S., & Murni, S. (2022). Implikasi Pembelajaran Praktikum Ilmu Pengetahuan Alam Dalam Kemajuan Kognitif Siswa. *SEARCH: Science Education Research Journal*, *1*(1), 1–1. https://e-jurnal.iainsorong.ac.id/index.php/jaser

Ningtiaz, P. G., & Suswanto, H. (2025). Penerapan LKPD untuk meningkatkan Keterampilan Critical Thinking dan Collaboration. *Didaktika: Jurnal Kependidikan*, *14*(3), 5731–5742.

Nuai, A., & Nurkamiden, S. (2022). Urgensi Kegiatan Praktikum Dalam Pembelajaran Ilmu Pengetahuan Alam di Sekolah Menengah Pertama. *Science Education Research (Search) Journal*, 48–63.

Nurhidayatulah, N., & Prodjosantoso, A. K. (2018). Miskonsepsi materi larutan penyangga. *Jurnal Inovasi Pendidikan IPA*, *4*(1), 41–51. https://doi.org/10.21831/jipi.v4i1.10029

Nurjihan, D. S., & Bunawan, W. (2025). Peningkatan Hasil Belajar Peserta Didik melalui Penerapan LKPD Berbasis Discovery learning. *Jurnal Pendidikan MIPA*, *15*(3), 1120–1127.

Panggabean, F. T. M., Silitonga, P. M., Syahputra, R. A., Sinaga, M., & Simatupang, L. (2022). Hubungan Motivasi, Kepercayaan Diri dan Kemampuan Awal dengan Kemampuan HOTS Siswa pada Materi Kesetimbangan Kimia. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*, *4*(2), 139–146.

Pramana, P. M. A., Suarni, N. K., & Margunayasa, I. G. (2024). Relevansi Teori Belajar Konstruktivisme dengan Model Inkuiri Terbimbing terhadap Hasil Belajar Siswa. *Ideguru: Jurnal Karya Ilmiah Guru*, *9*(2), 487–493. https://doi.org/10.51169/ideguru.v9i2.875

Purba, J., & Siregar, N. (2020). Pengembangan Bahan Ajar Berbasis Proyek Di SMA Negeri 2 Lintongnihuta pada materi Asam dan Basa. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*, *2*(2), 110. https://doi.org/10.24114/jipk.v2i2.19619

Purba, M. I., Syahputra, R. A., Purba, J., Sutiani, A., & Silitonga, P. M. (2024).

Analysis of Students' Learning Outcomes and Scientific Literacy Activities Using Guided Inquiry and Discovery Learning Models. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*, *5*(2), 102. https://doi.org/10.24114/jipk.v5i2.55908

Radzki, D., Wilhelm-w, M., Pruska, K., Kusiak, A., & Ordyniec-kwa, I. (2022). A Fresh Look at Mouthwashes—What Is Inside and What Is It For ? *International Journal of Environmental Research Public Health*. https://doi.org/https://doi.org/10.3390/ijerph19073926

Rahayu, A., & Sari, R. S. (2023). Guided Inquiry-Based Basic Chemistry Practicum Guidelines and Its Impact on Students' Science Process Skills and Critical Thinking Skills. *Jurnal Pendidikan Kimia Indonesia*, *7*(1), 1–9. https://doi.org/10.23887/jpki.v7i1.46212

Riduwan. (2014). *Dasar-Dasar Statistika*. Alfabeta.

Rizky, F. (2017). *Pengembangan Lembar Kerja Siswa (LKS) Praktikum Berbasis Inkuiri Terbimbing pada Sifat-Sifat Penyangga Obat Tetes Mata*. Universitas Pendidikan Indonesia.

Rohmatika, V., Biologi, P., & Indonesia, U. P. (2025). Inovasi Desain Kegiatan Laboratorium : Analisis dan Rekonstruksi Percobaan Ingenhousz untuk Pembelajaran Fotosintesis yang Bermakna di SMA Inovasi Desain Kegiatan Laboratorium : Analisis dan Rekonstruksi Percobaan Ingenhousz untuk Pembelajaran Fotosintesi. *Jurnal Riset Dan Inovasi Pembelajaran*, *5*(2), 614–627.

Romadhon, M. S., Dianita, E., & Susilawati, S. (2024). Studi Komparatif: Hakikat Bahan Ajar Modul dan LKPD pada Mata Pelajaran IPS dan PPKN di Sekolah Dasar. *Jurnal Ilmiah Madrasah*, *1*(2), 2024.

Sariati, Kadek, N., Suardana, Nyoman, I., Wiratini, & Made, N. (2020). Analisis Kesulitan Belajar Kimia Siswa Kelas Xi Pada Materi Larutan Penyangga. *Jurnal Imiah Pendidikan Dan Pembelajaran P-ISSN : 1858-4543 e-ISSN : 2615-6091*, *4*(1), 86–97. https://doi.org/10.23887/jipp.v4i1.15469.

Silaban, R., Panggabean, F. T. M., Sitompul, S. M., Simarmata, P. R. S., & Silaban, I. Y. (2019). Pengembangan Pembelajaran Kimia Larutan Berdasarkan Ilmu Pengetahuan dan Pengaruhnya Terhadap Hasil Belajar dan Minat Siswa di Kelas XI SMA. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*, *1*(2), 100. https://doi.org/10.24114/jipk.v1i2.15528

Silitonga, P. M., Panggabean, F. T. M., Susanti, N., Sinaga, M., & Situmorang, L. (2022). Hubungan Kemampuan Matematika dan Kemampuan Awal dengan Hasil Belajar Kimia Siswa pada Materi Larutan Penyangga. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*, *4*(2). https://jurnal.unimed.ac.id/2012/index.php/jipk

Singh, G., Devi, M. H., & Mukopadayay, D. S. (2022). A brief review article on "herbal mouthwash." *International Journal of Health Sciences*, *6*(4), 7178–7186. https://doi.org/https://doi.org/10.53730/ijhs.v6nS4.10157

Sutiani, A., & Maisyarah, D. (2021). Pengembangan Modul Berbasis Guided Inquiry Pada Pokok Bahasan Laju Reaksi. *Jurnal Inovasi Pembelajaran Kimia (Journal of Innovation in Chemistry Education)*,

3(1), 96. https://doi.org/10.24114/jipk.v3i1.24100

Ulva, Y. I., Santosa, & Parlan. (2016). Identifikasi Tingkat Pemahaman Konsep Larutan Penyangga. *Jurnal Pembelajaran Kimia (J-PEK) Vol. 01, No. 2, Desember 2016*, *1*(2), 69–75. http://arxiv.org/abs/2312.10090

Whitten, K. W., Davis, R. E., Peck, M. L., & Stanley, G. G. (2014). *Chemistry* (10th ed.). Brooks/Cole, Cengage Learning.

Yase, I. M. D., Basuki, B., & Savitri, S. (2020). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Inkuiri Pada Materi Sistem Sirkulasi di SMA Negeri 5 Palangka Raya. *BiosciED: Journal of Biological Science and Education*, *1*(1), 10–15.

Yazicioglu, O., Kazim, M., & Guven, K. (2023). Ingredients in Commercially Available Mouthwashes. *International Dental Journal*, *74*(2), 223–241. https://doi.org/10.1016/j.identj.2023.08.004

Yuniantari, N. L. P., & Susilowati, E. (2025). Literatur Review: Pengaruh Jenis dan Posisi Substituen terhadap Keasaman Asam Benzoat dan Turunannya. *INSOLOGI: Jurnal Sains Dan Teknologi*, *4*(1), 24–32. https://doi.org/10.55123/insologi.v4i1.4720

Zulyani, R. (2021). Pengembangan LKPD Berbasis Inkuiri Terbimbing pada Materi Asam Basa di Sekolah Menengah atas Negeri 5 Darussalam Banda Aceh. *Internasional Conference on Islamic Civilization*, (October), 29–41.