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Evaluation of Basic Chemistry Practicum Programs 1 and 2 in Developing Students' Science Process Skills Using the CIPP Model

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Abstract

The Basic Chemistry Practicum I and II are integral components of the chemistry education curriculum, designed to develop students' Science Process Skills (SPS). However, the effectiveness of these programs is often constrained by misalignment between course objectives and practicum modules, insufficient laboratory facilities, and a lack of structured assessment tools. This study aims to evaluate the implementation of these practicum programs using the CIPP (Context, Input, Process, Product) evaluation model. A mixed-methods approach involved document analysis, questionnaires, and checklists. The evaluation was conducted within the Chemistry Education Study Program at a university in East Nusa Tenggara, Indonesia, with participants including 17 third-semester students, one lecturer, and one laboratory assistant. The findings reveal that while the practicum programs contribute to the achievement of learning outcomes, several issues remain. There are inconsistencies between the Semester Learning Plan (RPS) and practicum modules, particularly regarding the sequencing of materials and skill development targets. Students demonstrated moderate mastery of basic and integrated SPS but still required significant support in hypothesis formulation, data interpretation, and understanding of experimental variables. The study also found that instructional strategies and evaluation tools were not fully optimized to foster independent scientific inquiry. To enhance the program's effectiveness, the study recommends revising practicum modules to align more closely with course objectives, integrating interactive media such as virtual simulations, and developing formal assessment instruments to measure SPS development comprehensively. These improvements will better prepare students for complex laboratory work and strengthen their scientific reasoning as future educators.

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INTRODUCTION

Science Process Skills (SPS) are widely recognized as foundational in science education, particularly chemistry. These skills encompass a range of cognitive and procedural abilities, including observing phenomena, classifying data, making predictions, drawing evidence-based conclusions, and effectively communicating experimental findings (Inayah et al., 2020). SPS is integral for fostering scientific literacy and cultivating critical thinking and inquiry-based learning, essential competencies in the 21st century. In chemistry education, where students often encounter abstract and complex concepts such as thermodynamics, organic reaction mechanisms, and chemical kinetics, strong SPS enables learners to approach problems systematically and interpret results meaningfully. Moreover, mastering these skills is a scaffold for developing scientific attitudes, enhancing students' readiness for research-based tasks, and supporting their long-term professional growth in science-related careers (Yuanita et al., 2020). Despite their pedagogical importance, efforts to systematically develop SPS among students often face several practical and institutional challenges. One common issue is the limited availability of laboratory resources, which constrains students' opportunities for hands-on experimentation. Additionally, many educators lack familiarity with instructional strategies designed to nurture SPS, such as inquiry-based learning or problem-solving frameworks. Another critical gap lies in the assessment domain—existing evaluation tools often focus more on conceptual knowledge than process-oriented skills, leaving students' actual scientific thinking underexplored (Lubis et al., 2022).

A structured evaluation framework is required to comprehensively analyze science practicum programs' design, resources, implementation, and outcomes. The Context, Input, Process, and Product (CIPP) model is one such tool, providing a holistic and iterative framework suitable for both formative and summative evaluation in educational settings (Irene, 2023). Applying the CIPP model in chemistry education allows educators and program evaluators to systematically examine the alignment between instructional goals and actual teaching practices. At the Context level, the model helps identify the learning objectives and stakeholder needs. The Input aspect evaluates teaching materials, infrastructure, and human resources adequacy. The Process stage assesses the fidelity of instructional delivery, while the Product component evaluates both short-term outcomes and long-term impacts on students' competencies (Zhao et al., 2024).). Empirical studies have demonstrated that this model is particularly effective in evaluating science practicum programs, as it facilitates the identification of gaps between theoretical instruction and laboratory experiences (Irvani et al., 2020).). Moreover, teachers' limited understanding of SPS has been identified as a significant barrier to practical implementation. When educators are not fully equipped to integrate these skills into instruction, students are less likely to internalize them meaningfully (Samitra & Kristiawan, 2021). Thus, teacher training and professional development, along with investment in laboratory infrastructure, are necessary components of an effective SPS-oriented curriculum (Sanchez, 2019). In the CIPP model, the Input dimension is critical for determining the resources and strategies necessary to support the achievement of learning objectives. One practical pedagogical approach is Problem-Based Learning (PBL), which encourages students to engage in real-world problem-solving and reflection. When combined with authentic assessment, PBL not only enhances conceptual understanding but also provides meaningful contexts for students to practice SPS (Duda et al., 2019). Evaluation tools should be designed to assess not only the correctness of outcomes but also the process of reasoning, collaboration, and inquiry to measure students' skills reliably. Incorporating collaborative projects into science instruction has proven to be a powerful method for cultivating analytical thinking and SPS (Irwanto, 2022). Consequently, integrating high-quality instructional methods and targeted assessment instruments into chemistry practicum programs is essential to ensure that students develop a well-rounded scientific skill set (Robbia & Fuadi, 2020).

In chemistry teaching, practical activities in the laboratory are an important means of developing KPS (Pathoni et al., 2020). Laboratory-based practical activities are among the most effective instructional strategies for developing SPS in chemistry education. These activities allow students to test hypotheses, observe chemical phenomena firsthand, manipulate variables, and interpret results based on empirical evidence. This experiential learning bridges the gap between theory and practice and fosters deeper conceptual understanding and scientific reasoning (Zabala & Dayaganon, 2023). However, the effectiveness of these experiences can be limited by factors such as inadequate instructional guidance, poorly aligned practicum modules, and a lack of structured reflection. Research has shown that students with well-developed SPS demonstrate a greater capacity to analyze experimental data, identify trends, and connect their findings to broader scientific concepts (Zainuddin et al., 2020). Therefore, it is imperative that laboratory activities are thoughtfully designed to go beyond rote procedures and instead encourage students to engage in critical and analytical thinking throughout the experimental process.

Basic Chemistry Practicum is one of the learning activities designed to develop KPS. KPS is a supporter and an important element that strengthens the foundation of students' understanding of complex and abstract chemical concepts (Matsna et al., 2023). Students' conceptual understanding of chemistry often involves attempts to relate various elements of theory to practical phenomena that can be observed or replicated in the laboratory (Puteri et al., 2022). Laboratory facilities are also a crucial factor in supporting the development of KPS. Laboratories equipped with modern equipment and adequate chemicals allow students to conduct experiments more effectively and safely (Taş et al., 2022). However, in many educational institutions, budget constraints are often a significant obstacle in providing adequate laboratory facilities. Therefore, using technologies such as virtual laboratories and computer simulations can be an effective alternative (Nassar & Tekian, 2020). Virtual laboratories provide a learning experience similar to real experiments and allow students to repeat experiments without the risk of equipment damage or chemical hazards (Taber, 2020). Virtual labs can use interactive and simulation methods, namely utilizing technology as a practical learning alternative (Brown et al., 2021; Lee et al., 2023; Penn & Ramnarain, 2019). Virtual laboratories provide a learning experience similar to real experiments and allow students to repeat experiments without the risk of equipment damage or chemical hazards (Fombona-Pascual et al., 2022). The use of these media serves to help train skills, such as virtual laboratories or e-learning modules, proven to be effective in improving students' KPS (Romadona et al., 2021). Another way, for example, is by using a learning approach that emphasizes inquiry (investigation), which can encourage students to be more active in the learning process, increasing KPS (Liu et al., 2021; Roberts, 2023). Finally, the product of the learning process, namely the KPS obtained by students, can be evaluated through various assessment methods. Research shows that students' KPS is often still low, even though students show a high interest in learning (Mirian, 2023). Therefore, evaluation of the implementation of this practicum is critical to ensure the effectiveness of learning and development of basic KPS and integrated KPS for students.

The CIPP model was used in this study to conduct a comprehensive evaluation. The CIPP model allows the evaluation of four main aspects that influence students' KPS based on the educational context and the input used, the learning process, and the final product of learning (Henukh et al., 2024). The reason for using the CIPP model is that it provides a systematic framework for assessing learning programs, both in terms of implementation and results achieved, so that it can provide constructive input for improving programs in the future. Based on these considerations, this evaluation aims to assess the implementation of basic chemistry one and basic chemistry two practicums in developing students' KPS, identify supporting and inhibiting factors, and provide recommendations for improving the quality of the practicum program. This evaluation is expected to obtain a comprehensive picture of the effectiveness of the practicum program in developing basic KPS and integrated KPS for students so that it can help provide recommendations in order to improve the quality of the implementation of practicum activities and prepare students to become competent educators. Therefore, the title of this study is Evaluation of Basic Chemistry 1 and 2 Practicum Programs in Developing Students' Science Process Skills Using the CIPP Model.

METHODS

This study employed a mixed-methods approach to evaluate the implementation of the basic chemistry practicum program, utilizing the Context, Input, Process, and Product (CIPP) evaluation model as its analytical framework (Fitzpatrick et al., 2021). The mixed-methods design was chosen to capture both quantitative perceptions and qualitative insights into the program's effectiveness. The Context component involved assessing the alignment between the practicum program and the intended learning outcomes, including Graduate Learning Outcomes (CPL) and Course Learning Objectives (CPMK) as outlined in the Semester Learning Plan (RPS). The Input component focused on evaluating the initial capabilities of students, as well as the qualifications and readiness of lecturers and laboratory assistants. The Process evaluation aimed to examine the instructional practices and facilitation strategies used during the laboratory sessions, as perceived by both instructors and assistants. Finally, the Product evaluation assessed the extent to which students developed both Basic Science Process Skills (KPSD) and Integrated Science Process Skills (KPST) through their participation in the practicum sessions. This study was conducted within the chemistry education program at a university in East Nusa Tenggara Province, involving 17 third-semester chemistry education students, one lecturer teaching Basic Chemistry I, and one laboratory assistant.

Data Collection Tools

Data collection tools in this study include:

a. Questionnaire: Used to measure students' and lecturers' perceptions of implementing basic chemistry practicums.
b. Checklist Sheet: Record the conformity between the practical module and the learning plan.
c. Document Analysis: This includes analyzing the RPS and practical modules to assess the suitability of the stated objectives for implementation in the field.

Data Collection Procedures and Data Processing Techniques

The data collection procedure is carried out in several stages, namely:

a. Questionnaires were distributed to students and lecturers involved in basic chemistry practicums to measure their perceptions of various aspects of practicum implementation.
b. Analysis of documents in the form of RPS and practical modules to evaluate the suitability between the objectives stated in the document

The data collected was then processed descriptively and qualitatively to identify gaps between the practicum program's objectives and its implementation (Creswell, 2015). The results of this analysis are used to provide recommendations for improving future practicum programs. The CIPP model design used to evaluate the basic chemistry practicum program can be seen in Figure 1.

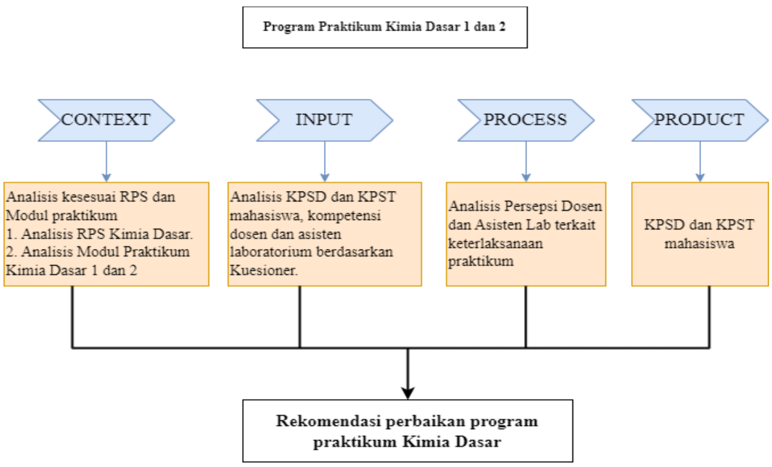

Figure 1. Basic chemistry practical program evaluation model design source (Fitzpatrick et al., 2021)

RESULTS AND DISCUSSION

The evaluation of the basic chemistry practicum program using the CIPP model revealed several important findings in each aspect. These findings provide a comprehensive picture of the implementation of Basic Chemistry Practicum 1 and Basic Chemistry 2 and their effectiveness in developing students' KPS. Based on the results of the questionnaire and analysis of the Basic Chemistry 1 and 2 RPS documents and the basic chemistry practicum module documents 1 and 2, the following results were obtained.

Evaluation Reviewed From Context Aspect

The evaluation results on the context aspect indicate that the objectives of the basic chemistry practicum program have been prepared to support CPL and CPMK. However, there are several gaps between the RPS and the practicum modules used. Several KPSD and KPST have not been fully accommodated in the existing practicum activities. This indicates the need for improvements in the preparation of the RPS and practicum modules to match the competencies to be achieved, especially in terms of developing student KPS. The following data on the suitability between the content of basic chemistry material and the RPS and practicum modules used can be seen in Table 1.

Table 1. Table of content compliance with basic chemistry 1 rps and basic chemistry 1 practical module

No	Experiment Title (Module)	Learning Materials (RPS)	Supported CPL	CPMK Achieved	Compliance with RPS	Information
1	Introduction to Laboratory Equipment and Its Use	Scientific method, properties of matter, problem-solving methods in chemistry	CPL-1, CPL-2, CPL-4	Sub-CPMK-1: Explaining the concepts of chemistry and scientific methods, properties of matter	In accordance	The module supports mastery of laboratory equipment in accordance with the introduction to basic chemistry in RPS.
2	Introduction to Chemical Reactions and Solution Dilution	Stoichiometry, basic laws of chemistry, chemical calculations	CPL-2	Sub-CPMK-2: Applying basic chemical laws and completing chemical calculations	In accordance	This practicum supports learning the basic concepts of chemical reactions and dilution in accordance with the material in the RPS.
3	Acid-Base Titration	Available in RPS Basic Chemistry 2	CPL-1, CPL-2, CPL-3 CPL-4	Sub-CPMK-5: Able to understand concepts, basic principles, and calculations and experimentally prove titration of acid-base solutions.	It is not in accordance with	This practicum supports the learning of the basic concept of titration of acid-base solutions in accordance with the Basic Chemistry 2 RPS.
4	Separation of Mixtures	Available in RPS Basic Chemistry 2	CPL-2, CPL-4	Sub-CPMK-2: Understand the concepts, basic principles, and how to apply the	It is not in accordance with	Practical work on separating mixtures in accordance with Basic Chemistry 2 RPS

No	Experiment Title (Module)	Learning Materials (RPS)	Supported CPL	CPMK Achieved	Compliance with RPS	Information
				concepts of solution chemistry.		
5	Precipitation Reaction	Periodic Table of Elements, basic laws of chemistry	CPL-2, CPL-4	Sub-CPMK-4: Explaining the periodic table of elements and chemical calculations	In accordance	Precipitation labs provide an understanding of chemical reactions related to the periodic table of elements.
6	Determination of Pb2+ and Cu2+ Levels Using Gravimetry	Stoichiometry, basic laws of chemistry, thermochemistry and energetics	CPL-1, CPL-2	Sub-CPMK-2 and Sub-CPMK-6: Explain the basic laws and concepts of chemical energy.	In accordance	Covers an understanding of stoichiometry and gravimetric analysis that supports learning thermodynamics.
7	Electrical Conductivity	Chemical bonds, chemical kinetics	CPL-2, CPL-4	Sub-CPMK-7: Explaining reaction kinetics and factors that influence reaction rates.	In accordance	This practicum discusses the measurement of electrical conductivity related to the chemical kinetics in RPS.
8	Freezing Point Depression of Solution	Thermochemistry and Energetics, Hess's law, laws of thermodynamics	CPL-2, CPL-4	Sub-CPMK-6: Calculating enthalpy and bond energy of compounds	In accordance	Supports understanding of thermodynamics taught in class
9	Standardization of NaOH and Determination of Acetic Acid Content	Stoichiometry, the basic laws of chemistry	CPL-1, CPL-2	Sub-CPMK-2: Solving chemical calculations through basic laws	In accordance	This activity follows the stoichiometric calculations in the basic material of chemical laws.
10	Colorimetric Analysis	Chemical Kinetics	CPL-2, CPL-4	Sub-CPMK-7: Explaining reaction rates, reaction mechanisms, and reaction rate constants	In accordance	This practicum supports visual analysis of reaction rates using colorimetric methods.

Source: Basic chemistry practical module one of the chemistry education study programs in NTT (2024)

This discussion is based on an analysis of the suitability of the practicum content in the Basic Chemistry 1 module and the RPS applicable to the course. This evaluation is important to ensure that practicum activities support the achievement of the planned CPL and CPMK.

Based on the evaluation of the content in the Basic Chemistry 1 table, two experiments were identified as not by the established CPMK and RPS. The practicum on Acid-Base Titration and Separation of Mixtures is listed in the Basic Chemistry 1 module. However, it is only relevant to the learning outcomes of Basic Chemistry 2, especially in the sub-CPMK, which includes the concept and application of titration of acid-base solutions and theoretical concepts of the structure, dynamics, and energy of chemicals, as well as the basic principles of separation, analysis, synthesis, and characterization. This inconsistency indicates that the material is more appropriately placed in the Basic Chemistry 2 practicum module to support progressive and structured learning continuity.

In order to align all materials with the objectives of the RPS, it is suggested that the Acid-Base Titration material be transferred to the Basic Chemistry 2 module so that the practicum in the Basic Chemistry 1 module can focus more on the introduction of basic chemistry concepts and initial KPS. This revision is expected to improve the connection between practicum activities and learning outcomes and support students in achieving the expected competencies at each course level optimally. Furthermore, a study of the RPS for Basic Chemistry 2 and the Basic Chemistry 2 module can be presented in Table 2.

Table 2. Table of content compliance with basic chemistry 2 RPS and basic chemistry 2 practical module

No	Experiment Title (Module)	Learning Materials (RPS)	Supported CPL	CPMK Achieved	Compliance with RPS	Information
1	Solution and Concentration	Solution Chemistry and Concentration	CPL2 (P1), CPL3 (KU1)	CPMK-2: Understanding the concept of solution chemistry	In accordance	The experiment involves preparing and calculating the concentration of a solution.
2	Acid-Base Titration	Acid-Base and Titration	CPL2 (P1), CPL3 (KU1)	CPMK-3: Applying acid-base concepts and titration	In accordance	This practicum covers quantitative analysis skills.
3	Electrolysis	Redox Reactions and Electrochemistry	CPL2 (P1), CPL4 (KK3)	CPMK-6: Understanding redox reactions and electrolysis	In accordance	Electrolysis practicum complements the learning of electrochemical concepts.
4	Properties of Fat	Not mentioned	Not related	Not related	It is not in accordance with	The topic of fat is not included in the Basic Chemistry 2 RPS material.
5	Carbohydrate Identification	Not mentioned	Not related	Not related	It is not in accordance with	Identification of carbohydrates is more relevant to biochemistry courses.
6	Protein Identification	Not mentioned	Not related	Not related	It is not in accordance with	The protein topic does not correspond to the CPMK in the Basic Chemistry 2 RPS.

Source: Basic chemistry practical module one of the chemistry education study programs in NTT (2024)

The results of the study of the Basic Chemistry 2 RPS and the Basic Chemistry 2 Practical Module, there are more diverse findings in terms of the suitability of the practical module content with the applicable RPS. Of the six experiments studied, three experiments were appropriate, while the other three experiments were not relevant to the RPS material.

Experiments such as Solution and Concentration, Acid-Base Titration, and Electrolysis are directly related to the learning materials in the Basic Chemistry 2 RPS. Solution and Concentration and Acid-Base Titration are relevant to the concepts of solution chemistry and quantitative analysis that require a deep understanding of acids-bases and concentration. This practicum supports CPMK-2 and CPMK-3 so that students can understand and apply the concepts of solution chemistry and titration. Electrolysis is also in accordance with the redox and electrochemical reaction materials listed in the RPS. This practicum supports CPMK-6, which aims to understand redox reactions and electrochemical mechanisms.

However, there are experiments that do not match the material listed in the RPS: Properties of Fat, Identification of Carbohydrates, and Identification of Proteins do not support learning in the Basic Chemistry 2 RPS. These topics are more relevant to the field of biochemistry and are not mentioned in the RPS, which focuses on basic chemistry concepts. This material is not directly related to the expected learning outcomes. For example, the identification of carbohydrates and proteins is more relevant in the context of biochemistry or other courses that focus on macromolecules. In terms of implementation, this inconsistency can cause students to study topics that are not needed to achieve the CPL and CPMK that have been determined in the RPS.

Evaluation is Reviewed from The Input Aspect

Evaluation of input is seen from the aspects of KPSD and KPST of students, lecturer competency and laboratory assistants. The results of the study indicate that students have varying KPSD and KPST. Based on the contents of the Basic Chemistry RPS 1 and 2 documents and the Basic Chemistry Practical Modules 1 and 2 that have been reviewed, there is no specific instrument explicitly mentioned to assess students' KPS during the practical activities. The assessment is based only on the practical results report.

The results of the questionnaire showed that most students had a good understanding of KPSD and KPST. Students were also guided by the lab assistant to be able to ask questions or even communicate the results. In addition, students were quite good at describing the relationship between variables and collecting data. However, there are some skills that still need to be improved, especially in formulating hypotheses before the experiment begins, as well as defining the variables involved, so strengthening these aspects can be a concern for further curriculum development. The following is a visualization of students' KPSD and KPST through a questionnaire.

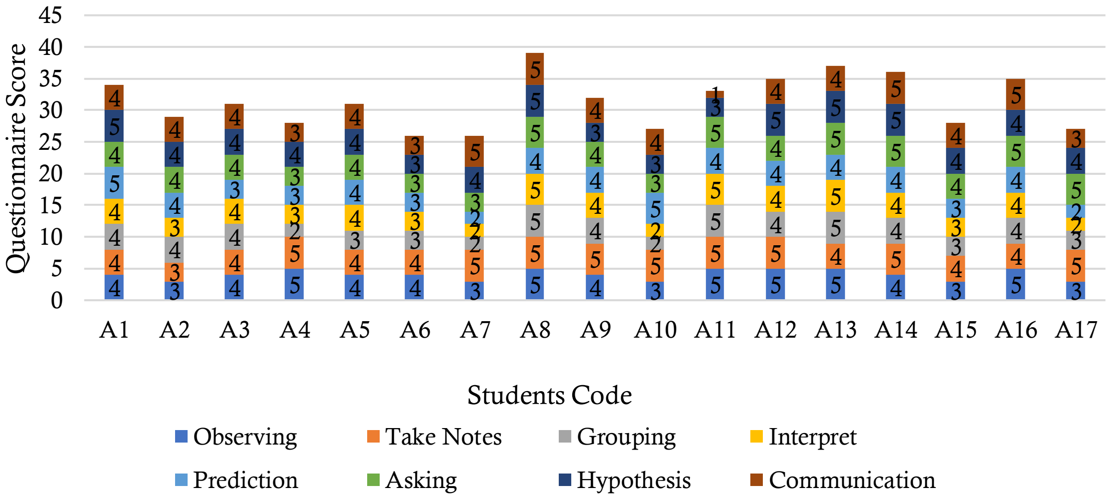

Figure 1. Basic Science Process Skills Graph
Source: Chemistry Education Students (2024)

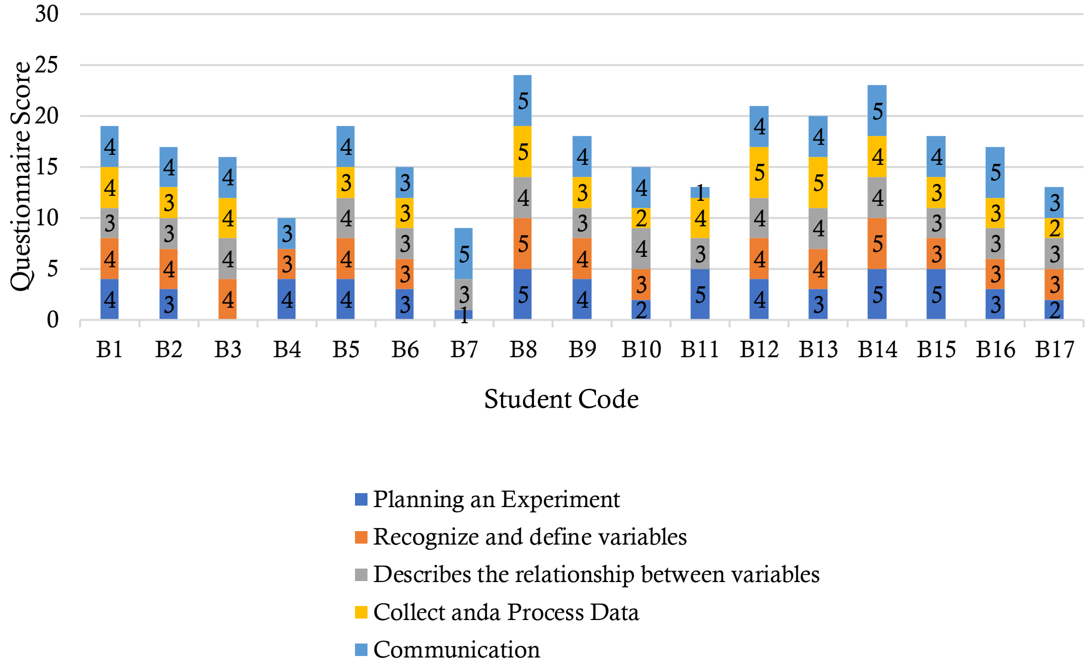

Figure 2. Integrated Science Process Skills Graph
Source: Chemistry Education Students (2024)

The results of the visualization of KPSD and KPST show several important things related to the development of KPS that students obtain. Most students stated that they felt sufficiently directed to observe changes in the experiment. Students also understand the basic principles of grouping experimental results according to specific categories, such as acidic or basic properties. However, there are some students who feel that the guidance in this classification is still not specific enough, so they do not fully understand the classification in more complex experiments. This indicates a need for more detailed guidance to help students group experimental results more precisely.

Data interpretation and understanding of theoretical concepts are also challenges for students. Several students expressed that they did not always receive in-depth explanations regarding the relationship between experimental variables and the results obtained. This difficulty in interpretation indicates that students tend to accept experimental data raw without conducting critical analysis that can link the results to the underlying theoretical concepts (Roche Allred & Bretz, 2019). The inability to interpret data well indicates that students' understanding is still focused on the data they observe without connecting it to scientific concepts that are relevant to the data obtained during the practicum (Pakaya et al., 2023).

Furthermore, students' ability to make predictions and formulate hypotheses before starting an experiment is also still limited. Students are generally rarely asked to make initial predictions or formulate hypotheses as the basis for experiments, which may reduce their active involvement in the learning process. This lack of attention to predictions and hypotheses can also weaken theoretical understanding, because without formulating hypotheses, students are less motivated to critically explore the results of the experiment (Orosz et al., 2022).

In terms of planning and understanding variables, some students showed basic skills in designing experiments but still needed further guidance to recognize the role of independent, dependent, and control variables in the practicum. This shows a lack of experience in conducting independent experiments that require systematic planning and a deep understanding of the role of each variable in the experiment.

Overall, third semester students have mastered the basics of KPSD and KPST. However, in order for them to achieve a more comprehensive understanding, reinforcement is still needed in the aspect of independent analysis, especially in data interpretation, hypothesis formulation, and overall management of experimental variables.

Evaluation is Reviewed from The Process Aspect.

In the process aspect, data were obtained from questionnaires to examine the perceptions of lecturers and lab assistants related to the implementation of learning in class and activities in the laboratory. The evaluation results showed that the implementation of basic chemistry practicums was mostly in accordance with the RPS that had been prepared. Practical activities were designed to encourage KPSD and KPST. However, the use of pre-practicum learning media has not been optimally utilized to teach students to recognize basic process skills.

Based on the questionnaire responses, lecturers use various methods to support observation skills learning, such as illustrations, videos, and case-based methods. These methods allow students to relate the material to real problems that are relevant to everyday life. However, there are indications that the implementation of this learning media is not yet fully optimal because it is still limited to visual aids without direct integration into laboratory-based practical learning. Strengthening more interactive media and interactive virtual simulations could increase student involvement and understanding of abstract chemical practical concepts (Chan et al., 2021; Liaw et al., 2022; Nabuasa et al., 2020).

Meanwhile, the questionnaire data by the lab assistant revealed that in the practicum activities, several learning approaches had been implemented to develop students' KPS. The approach used focuses on student-centered learning with a guided inquiry model. Through this model, the assistant can direct students in observing changes that occur during the experiment, such as changes in color and volume that appear in the acid-base titration experiment (Nzomo et al., 2023; Orosz et al., 2022). However, although this approach encourages active participation, the lab assistant still has to provide quite intensive guidance in each stage of observation, which shows that students' independence in observing and understanding laboratory phenomena still needs to be guided.

One of the main challenges reported is in the interpretation of laboratory data, where students often only record results without reflection, linking the data to theoretical concepts. Lecturers provide basic instructions on the classification of substances and experimental variables, but variable learning is still limited to the laboratory context, so understanding independent, dependent, and control variables requires additional guidance. The implementation of project-based learning (PjBL) can help students to understand better the relationship between the concept of variables and experimental results and prepare them to face more complex laboratory scenarios (Ilyas et al., 2019; Mite et al., 2021; Widyaningsih & Yusuf, 2020).

Furthermore, the questionnaire showed that the approach to prediction and hypothesis formulation was still not prioritized. Lecturers did not always invite students to make predictions or formulate hypotheses before the experiment began, so students' analytical thinking skills and ability to connect theory with experimental expectations still needed to be trained. In addition, the understanding of variables also needed to be strengthened. Although lecturers and lab assistants had provided sufficient instructions on the importance of identifying variables in experiments, it also needed to be introduced in the context of classroom learning. So that students understand the relationship between independent variables, dependent variables, and overall experimental results, it is advisable to emphasize strengthening these skills, for example, through pre-practical assignments that ask students to make hypotheses or predictions based on chemical theory before the experiment begins.

The questionnaire data showed that lecturers strongly agreed with the development of interactive virtual learning media. This step is considered important to help students in pre-practical activities where students can see practical simulations that make it easier for them to understand abstract concepts in chemistry, such as reaction kinetics or molecular interactions (Martin & Ariza, 2024). The development of this media needs to be integrated as a skills-based assessment tool so that lecturers can assess the understanding of the science process in a more structured and comprehensive manner. Overall, lecturers and lab assistants have played a good role in guiding students to achieve KPS, but there are still aspects that need to be strengthened, such as honing prediction skills, hypotheses, and variable identification.

Evaluation is Reviewed from The Product Aspect.

Product evaluation in the implementation of basic chemistry practicums has so far focused on the final results in the form of practicum reports without involving a comprehensive assessment of the process of developing skills and understanding concepts during practicum activities. To improve the quality of student learning outcomes, here are some recommendations for improvement:

1. The implementation of the practicum and its conformity with the RPS developed so that theoretical learning in class and practicum in the lab support each other in CPMK.
2. The aspects of KPS that need to be strengthened are formulating hypotheses before the experiment begins and defining the variables involved, so that strengthening these aspects can be a concern for further curriculum development.
3. Development of more formal and measurable evaluation instruments in order to assess students' KPSD and KPST. So that the assessment is not only on the practicum report but also on students' skills during the practicum activities, the evaluation results show that there is still a need for a more comprehensive and standardized assessment to ensure that science process skills can continue to be improved according to student needs.
4. Practical-based concept mastery measures students' conceptual understanding more comprehensively than just based on written practical reports.
5. Development of interactive virtual learning media. This media is designed to support pre-practical activities, where students can access practical simulations before conducting actual experiments in the laboratory. Through this interactive media, students will have a clearer picture of the practical steps and can understand the variables that play a role in the experiment. Thus, they are expected to be more prepared and confident when carrying out practical work in the laboratory and more skilled in linking observation results with relevant chemical theory concepts.

These suggestions for improvement can help maximize the potential of practicums in supporting more focused learning, in accordance with the RPS, and ensure that all aspects of students' skills, concepts, and attitudes can be measured effectively.

CONCLUSION

This study shows that the basic chemistry practicum programs 1 and 2 are effective in developing students' KPS, although they still need some adjustments. The use of the CIPP model identified that the objectives of the practicum have supported learning outcomes, but the mismatch between the RPS and the practicum module indicates the need for adjustments. In addition, students' skills have developed, but the lack of comprehensive assessment instruments limits optimal learning outcomes. In terms of the process, inquiry-based methods have been applied, but students still need intensive guidance in data interpretation and understanding between variables. The use of interactive media, such as virtual simulations, can improve their readiness to understand abstract concepts. In terms of the product, assessments that focus too much on the final report do not accommodate the assessment of the overall skills process. With the development of virtual media for pre-practicum, students can be better prepared to face complex practicums. Overall, this program is effective, but adjustments to the module, increased guidance, and innovation of learning media are needed to achieve optimal results.

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