

TEACHER STRATEGIES FOR CULTIVATING BASIC SCIENCE PROCESS SKILLS IN STATIC FLUID LEARNING: A NATURALISTIC QUALITATIVE INQUIRY

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Abstract

This study aimed to explore teacher strategies for cultivating students' Basic Science Process Skills during static fluid learning in a natural classroom setting. A naturalistic qualitative approach was employed at Senior High School 10 Kota Jambi, involving one physics teacher and students selected through purposive sampling. Data were collected through classroom observations, semi-structured interviews, and document analysis, and analyzed using the interactive model of Miles, Huberman, and Saldaña supported by NVivo 14 software. The findings revealed that the teacher systematically cultivated students' Basic Science Process Skills through demonstrations, structured observations, laboratory experiments, collaborative discussions, and laboratory worksheets. These strategies effectively developed students' abilities in observing, classifying, measuring, communicating, predicting, and drawing conclusions throughout the learning process. The originality of this study lies in providing comprehensive qualitative evidence of teacher strategies that cultivate all six Basic Science Process Skills through authentic physics classroom practices supported by NVivo-assisted analysis. The findings contribute to physics education by offering practical guidance for designing inquiry-oriented learning that systematically strengthens students' science process skills.

Keywords: Basic Science Process Skills, Physics Learning, Qualitative Inquiry, Teacher Strategies



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INTRODUCTION

Physics education is expected to cultivate students' scientific reasoning by engaging them in meaningful learning experiences that promote inquiry and evidence-based thinking. Within this context, Basic Science Process Skills, including observing, classifying, measuring, communicating, predicting, and drawing conclusions, constitute fundamental competencies that support scientific literacy and conceptual understanding (Gyllenpalm, Rundgren, and Lederman 2022; Kersting et al. 2023). These skills enable students to construct knowledge through direct interaction with scientific phenomena rather than relying solely on memorization. Static fluid learning provides meaningful opportunities for students to develop these competencies because many of its concepts can be explored through observation and experimentation (Pike et al. 2024; Marsh and Deacon 2025). Consequently, cultivating Basic Science

Process Skills has become an essential objective of physics learning in contemporary secondary education.

Despite their importance, the development of Basic Science Process Skills remains challenging in many physics classrooms. Practical activities are frequently implemented as procedural exercises in which students merely follow predetermined instructions without sufficient opportunities to investigate, interpret evidence, or communicate scientific findings (Peplow and Peplow 2024; Drephal and Drephal 2024). Such learning conditions reduce students' active participation and limit the development of scientific reasoning during laboratory work. Static fluid topics, including hydrostatic pressure, Pascal's principle, and Archimedes' principle, often require students to connect theoretical concepts with observable phenomena, yet this potential is not always fully utilized during instruction (Durowse and Durowse 2024; (Neill and Neill 2023). These challenges indicate that the way teachers design and implement instructional strategies plays a crucial role in cultivating students' Basic Science Process Skills.

Previous studies have consistently demonstrated that instructional strategies significantly influence the development of students' science process skills. Inquiry-based learning, guided laboratory activities, collaborative learning, and process-oriented worksheets have been reported to improve students' engagement in scientific investigations and conceptual understanding (Love and Randall 2024; (Strong and Strong 2024). Other studies have emphasized that teacher guidance during experimentation contributes to students' ability to observe phenomena, organize information, communicate findings, and construct scientific explanations. Research has also shown that meaningful laboratory experiences strengthen students' participation in scientific inquiry when teachers provide appropriate scaffolding throughout the learning process (Miragall et al. 2021; Piper et al. 2025). These findings confirm the important contribution of teacher instructional practices to science process skill development in physics education.

However, most existing studies primarily evaluate the effectiveness of particular learning models, instructional media, or experimental interventions using quantitative approaches. Comparatively limited attention has been given to understanding how teachers naturally cultivate Basic Science Process Skills during authentic classroom instruction and laboratory activities (Hillman, Burrows, Jessen, et al. 2025; Ortega-jiménez et al. 2025). Furthermore, previous research generally examines science process skills as a comprehensive construct without specifically focusing on the six fundamental Basic Science Process Skills. Studies investigating teacher strategies within the context of static fluid learning using a naturalistic qualitative perspective remain relatively scarce (Tan et al. 2024; Moreira and Moreira 2025). This gap suggests the need for research that explores teachers' instructional practices as they naturally occur in real educational settings.

Understanding teacher strategies is particularly important because teachers determine how learning experiences are designed, facilitated, and adapted to students' learning needs. In the implementation of Indonesia's Merdeka Curriculum, physics instruction is expected to encourage students to investigate scientific phenomena, develop critical thinking, and construct knowledge through authentic learning experiences. These expectations cannot be achieved solely by providing laboratory activities but require instructional strategies that intentionally cultivate Basic Science Process Skills throughout the learning process (Hillman, Burrows, and Hauser 2025; (Thies and Thies 2025). A comprehensive understanding of teachers' classroom practices therefore provides valuable insights for improving physics instruction and strengthening students' scientific competencies (Zejdlik and Vozenilek 2025), (Wan 2023). Such evidence may also support teachers in designing more contextual and inquiry-oriented learning environments.

This study contributes to the existing literature by examining teacher strategies for cultivating Basic Science Process Skills during static fluid learning through a naturalistic qualitative inquiry. Rather than measuring instructional effectiveness, this study explores how teachers plan, implement, and adapt instructional strategies that foster students' abilities to observe, classify, measure, communicate, predict, and draw conclusions in authentic classroom and laboratory contexts (Esteban and Savirón-cornudella 2025; Salazar and Matous 2025). The investigation captures instructional practices as they naturally occur without manipulating the learning environment. This perspective provides a richer understanding of the pedagogical processes that support the development of Basic Science Process Skills in secondary physics education (Niebergall-roth et al. 2024). The findings are expected to enrich the theoretical discussion of science process skill development while offering practical implications for improving physics teaching in real classroom settings.

RESEARCH METHOD

This study employed a naturalistic qualitative inquiry to explore how physics teachers cultivated students' Basic Science Process Skills during static fluid learning in authentic classroom and laboratory settings. This approach was selected because it allows an in-depth understanding of instructional practices as they naturally occur without manipulating the teaching and learning process (Leggat et al. 2023), (Gorman, Farsides, and Bonner 2024). The researcher acted as the primary research instrument by observing classroom interactions, conducting interviews, and interpreting multiple sources of qualitative evidence. The investigation focused on teacher strategies that supported students' abilities to observe, classify, measure, communicate, predict, and draw conclusions during learning activities. Therefore, the naturalistic qualitative inquiry provided comprehensive insights into how teacher strategies facilitated the development of Basic Science Process Skills in real educational contexts.

The research was conducted at Senior High School Negeri 10 Kota Jambi, Indonesia, during physics instruction on the topic of static fluids. The participants consisted of one experienced physics teacher and students from Class XI F8 who actively participated in both classroom learning and laboratory activities. Participants were selected using purposive sampling because they were directly involved in instructional practices relevant to the objectives of this study. The selected teacher had consistently implemented practical learning activities designed to encourage students' engagement in scientific investigations (Ahmadi et al. 2020; Broderick and Roscigno 2025). This research setting enabled the exploration of authentic teacher strategies for cultivating Basic Science Process Skills throughout the learning process.

Data were collected through classroom observations, semi-structured interviews, and document analysis to obtain a comprehensive understanding of teacher strategies for cultivating Basic Science Process Skills. Classroom observations focused on instructional activities related to the six indicators of Basic Science Process Skills, namely observing, classifying, measuring, communicating, predicting, and drawing conclusions. Semi-structured interviews with the physics teacher explored instructional planning, classroom implementation, and evaluation practices supporting the development of these skills. Document analysis included lesson plans, students' worksheets (LKPD), teaching materials, and assessment documents to verify and enrich the observational and interview findings (Halama, Záhorcová, and Škrobáková 2021; Eseonu and Okoye 2024). The integration of these three data collection techniques enhanced the depth and credibility of the research data through methodological triangulation.

Table 1. Data Collection Techniques

Data Collection Technique	Data Source	Research Focus
Classroom Observation	Physics teacher and students	Teacher strategies for cultivating the six Basic Science Process Skills during classroom and laboratory learning
Semi-structured Interview	Physics teacher	Planning, implementation, and evaluation of instructional strategies
Document Analysis	Lesson plans, LKPD, teaching materials, assessment documents	Supporting evidence for instructional planning and learning implementation

The collected data were analyzed using the interactive model of Miles, Huberman, and Saldaña, which consists of data condensation, data display, and conclusion drawing and verification. Observation notes, interview transcripts, and supporting documents were first organized and coded according to the six indicators of Basic Science Process Skills (MacLure 2024a; Lin and Huang 2026). Similar codes were then grouped into broader categories representing teacher strategies implemented during lesson planning, classroom instruction, laboratory activities, and learning evaluation. The categorized data were interpreted to explain how instructional strategies contributed to cultivating students' Basic Science Process Skills during static fluid learning. Continuous comparison across different data sources ensured that the findings accurately represented instructional practices observed in authentic learning environments.



Figure 1. Research Procedure of the Naturalistic Qualitative Inquiry

The trustworthiness of the findings was established through credibility, dependability, confirmability, and transferability procedures. Credibility was strengthened through methodological triangulation by comparing data obtained from classroom observations, interviews, and document analysis, as well as source triangulation across different participants and documents. Member checking was conducted by confirming the interview interpretations with the participating teacher to ensure the accuracy of the findings. Dependability and confirmability were enhanced through regular discussions with academic supervisors and by maintaining detailed documentation of the research process. These procedures ensured that the findings accurately reflected teacher strategies for cultivating Basic Science Process Skills in authentic classroom and laboratory settings.

RESULTS AND DISCUSSION

The qualitative data collected through classroom observations, semi-structured interviews, and document analysis were analyzed using the interactive model of Miles, Huberman, and Saldaña, consisting of data condensation, data display, and conclusion drawing and verification. Through this analytical process, six major themes were identified, representing teacher strategies for cultivating students' Basic Science Process Skills during static fluid learning. The findings are presented according to the six indicators of Basic Science Process Skills, namely observing, classifying, measuring, communicating, predicting, and drawing conclusions. Each finding is supported by the hierarchical distribution of coded themes generated using NVivo to visualize the dominant instructional strategies identified throughout the analysis.

Teacher Strategies for Cultivating Observing Skills

The findings indicate that observing skills were cultivated through structured observation activities integrated into classroom instruction and laboratory practice. Analysis of classroom observations, interviews, and supporting documents revealed that the teacher consistently encouraged students to observe physical phenomena systematically before conducting experiments. Students were guided to record observational data, use laboratory equipment appropriately, and verify the accuracy of their observations through structured activities provided in the students' worksheets. Recording observation results and the use of laboratory equipment emerged as the most dominant coded themes, indicating that observing skills were primarily developed through systematic documentation of experimental evidence and direct engagement with laboratory activities. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 2.

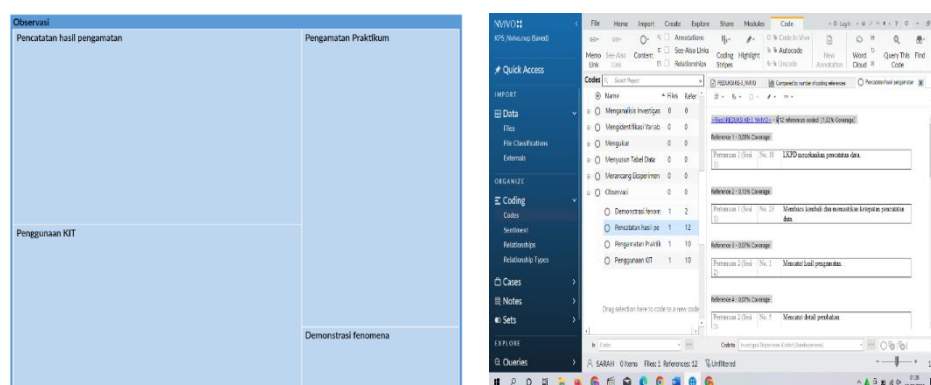


Figure 2. Hierarchical Distribution of Coded Themes for Observing Skills Generated Using Nvivo

Teacher Strategies for Cultivating Classifying Skills

The findings demonstrate that the teacher cultivated students' classifying skills by engaging them in activities requiring the organization and categorization of experimental data throughout the static fluid learning process. Students classified objects according to observable characteristics, organized variables systematically, and distinguished similarities and differences identified during laboratory investigations. Classroom observations, interview findings, and instructional documents consistently showed that classification activities were integrated into every stage of learning through structured laboratory worksheets and collaborative learning. Data classification and the identification of similarities and differences emerged as the dominant coded themes, indicating that students continuously developed the ability to organize scientific information logically and systematically. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 3.

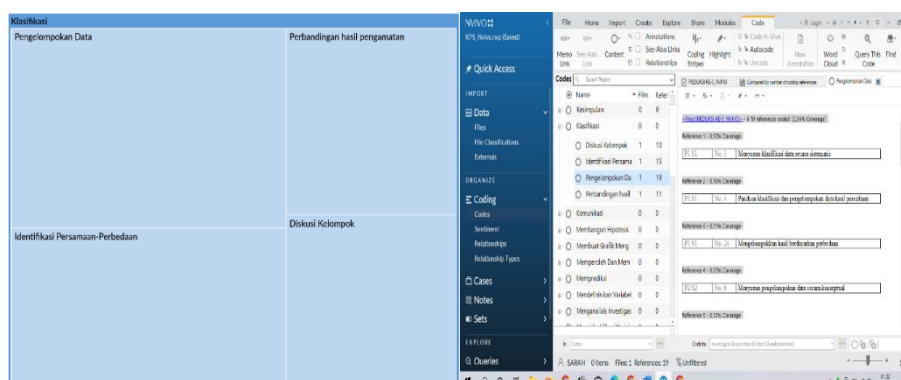


Figure 3. Hierarchical Distribution of Coded Themes for Classifying Skills Generated Using NVivo

Teacher Strategies for Cultivating Measuring Skills

The findings reveal that measuring skills were primarily cultivated through direct laboratory practice involving the appropriate use of scientific measuring instruments during static fluid experiments. Students repeatedly used measuring cylinders, digital balances, and other laboratory equipment while following standardized measurement procedures provided by the teacher through the laboratory worksheets. Observation, interview, and document analysis consistently indicated that the teacher emphasized measurement accuracy, correct instrument usage, and careful recording of measurement results throughout practical activities. The use of measuring instruments emerged as the dominant coded theme, demonstrating that hands-on measurement activities became the principal strategy for strengthening students' measuring skills. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 4.

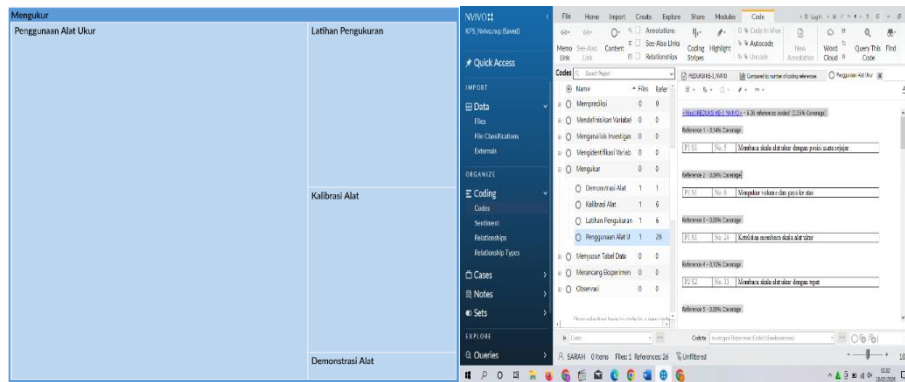


Figure 4. Hierarchical Distribution of Coded Themes for Measuring Skills Generated Using NVivo

Teacher Strategies for Cultivating Communicating Skills

The findings show that communicating skills were developed through scientific discussions, classroom interactions, presentations, and collaborative learning activities conducted throughout the static fluid lessons. The teacher actively encouraged students to explain experimental findings, exchange ideas, answer questions, and communicate scientific arguments supported by observational evidence. Classroom observations, interview data, and instructional documents consistently demonstrated that scientific discussion represented the primary instructional strategy for strengthening students' communication skills. Scientific discussion emerged as the dominant coded theme, indicating that communication skills were mainly cultivated through analytical dialogue and collaborative interpretation of experimental findings. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 5.

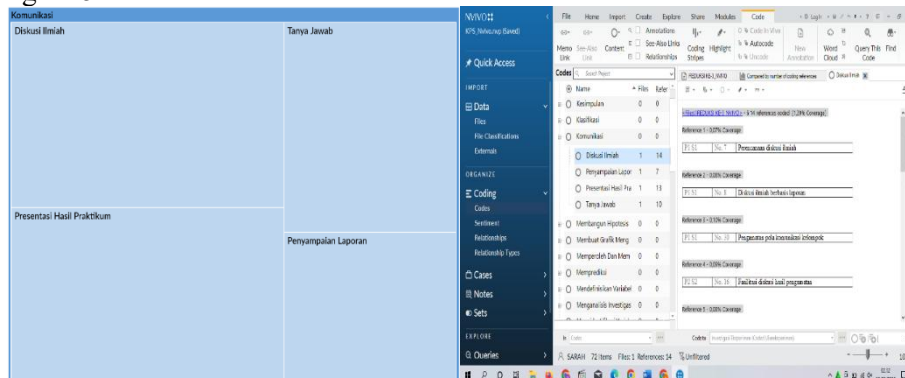


Figure 5. Hierarchical Distribution of Coded Themes for Communicating Skills Generated Using NVivo

Teacher Strategies for Cultivating Predicting Skills

The findings indicate that predicting skills were cultivated by encouraging students to formulate initial predictions before experiments and evaluate these predictions after analyzing empirical evidence. During classroom discussions and laboratory investigations, the teacher facilitated prediction-based learning activities by connecting students' prior knowledge with scientific reasoning and experimental observations. Observation notes, interview findings, and supporting documents consistently demonstrated that prediction discussions became an integral component of the instructional process. Prediction discussion emerged as the dominant coded theme, suggesting that reflective comparison between initial predictions and experimental findings played a central role in developing students' predicting skills. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 6.

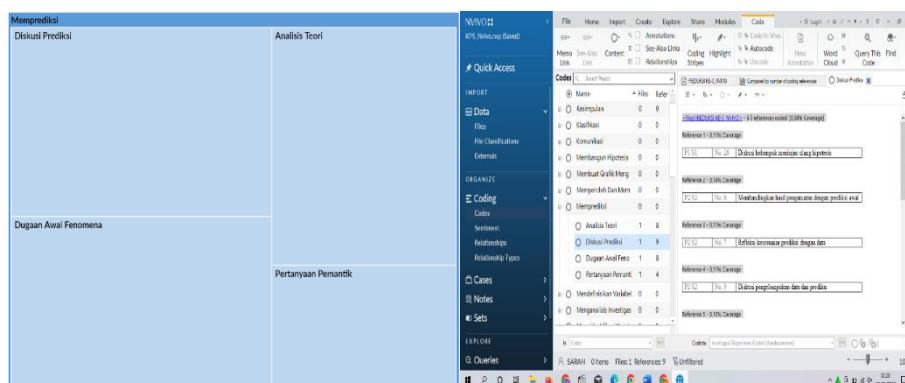


Figure 6. Hierarchical Distribution of Coded Themes for Predicting Skills Generated Using NVivo

Teacher Strategies for Cultivating Drawing Conclusions Skills

The findings demonstrate that drawing conclusions skills were developed through activities requiring students to interpret experimental findings, compare empirical evidence with scientific concepts, and formulate evidence-based conclusions collaboratively. The teacher consistently guided students to synthesize observational findings, analyze experimental data, and justify conclusions using scientific explanations during classroom discussions and laboratory reflection sessions. Observation data, interview findings, and instructional documents consistently indicated that drawing conclusions represented the culminating stage of students' scientific investigations. Drawing conclusions emerged as the dominant coded theme, reflecting the teacher's emphasis on logical reasoning, scientific interpretation, and evidence-based reflection throughout static fluid learning. The hierarchical distribution of coded themes generated using NVivo is presented in Figure 7.

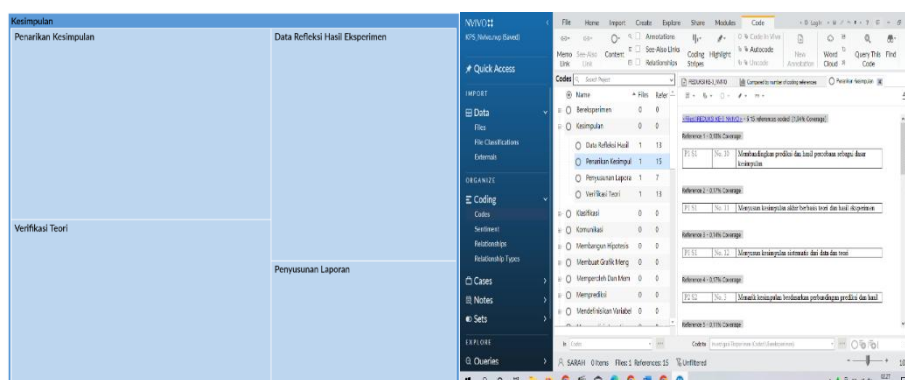


Figure 7. Hierarchical Distribution of Coded Themes for Drawing Conclusions Skills Generated Using NVivo

Findings of this study demonstrate that the teacher cultivated students' Basic Science Process Skills through a combination of structured instructional strategies implemented during classroom instruction and laboratory activities. Integration of demonstrations, guided observations, collaborative discussions, laboratory experiments, and structured laboratory worksheets (LKPD) enabled students to develop observing, classifying, measuring, communicating, predicting, and drawing conclusions in a systematic manner. Teacher guidance consistently encouraged students to participate actively in scientific investigations by providing opportunities to observe phenomena, collect evidence, organize information, and communicate scientific ideas throughout the learning process. These instructional practices created meaningful learning experiences in which students gradually developed fundamental scientific inquiry skills rather than merely receiving conceptual explanations. Consequently, teacher strategies played a central role in cultivating students' Basic Science Process Skills during static fluid learning.

Development of Basic Science Process Skills occurred through continuous interactions between teacher guidance, laboratory practice, and collaborative learning. Rather than teaching each skill separately, the teacher integrated multiple science process skills within a sequence of interconnected learning activities beginning with observation and ending with evidence-based conclusions. Demonstrations conducted before experiments, systematic observations through LKPD, collaborative

discussions, and reflective evaluation enabled students to strengthen scientific reasoning while conducting investigations. This instructional sequence encouraged students to construct scientific understanding through direct experience instead of relying solely on theoretical explanations. Results therefore suggest that cultivating Basic Science Process Skills should be viewed as a continuous instructional process supported by appropriate teacher strategies throughout science learning.

Previous studies have consistently reported that inquiry-oriented instructional strategies, practical laboratory activities, and collaborative discussions contribute positively to the development of students' Science Process Skills. Active student engagement in scientific investigations provides opportunities to strengthen observation, measurement, communication, and scientific reasoning through authentic learning experiences (Lavonen et al. 2021; Daniel et al. 2023). Likewise, structured teacher guidance during laboratory activities has been recognized as an important factor influencing students' scientific inquiry competencies (Ghassan 2022; MacLure 2024b). Findings of the present study support these earlier investigations by demonstrating that systematic instructional planning combined with continuous teacher facilitation contributes to the development of Basic Science Process Skills during static fluid learning (Levin et al. 2024;). Evidence generated from this research further extends previous knowledge by providing a comprehensive qualitative description of how these instructional strategies are implemented in authentic classroom and laboratory settings.

Novelty of this study lies in its comprehensive exploration of teacher strategies for cultivating all six indicators of Basic Science Process Skills within a naturalistic qualitative inquiry. Unlike many previous studies that primarily evaluated students' achievement or examined the effectiveness of particular instructional models using quantitative approaches, this research focused on authentic instructional practices implemented during physics learning (Jha et al. 2021; Vázquez-parra, Tariq, and Castillo-martínez 2025). Integration of classroom observations, semi-structured interviews, document analysis, and NVivo-assisted qualitative analysis provided a comprehensive representation of teacher strategies in natural classroom settings, (Bashir et al. 2023; Shambare and Jita 2024). Visualization of coded themes through NVivo hierarchy charts also strengthened the transparency and credibility of qualitative data analysis, (Areljung, Bäckström, and Grenemark 2023; Sáiz-manzanares et al. 2024). These contributions provide new empirical evidence regarding how teacher strategies facilitate the cultivation of Basic Science Process Skills during static fluid learning.

Practical implications of this study extend to physics teaching, curriculum implementation, and teacher professional development. Physics teachers may integrate demonstrations, structured observations, laboratory investigations, collaborative discussions, and reflective learning activities into a coherent instructional sequence to strengthen students' Basic Science Process Skills (Maratkyzy et al. 2025; Shambare and Jita 2025). Structured laboratory worksheets can further assist students in documenting observations, organizing experimental findings, and developing evidence-based scientific conclusions ((Pečiuliauskienė 2023; Lotriet and Gouws 2026). School administrators and curriculum developers may also utilize these findings when designing professional development programs that enhance teachers' competence in inquiry-oriented science instruction (Solomon et al. 2022; Laumann et al. 2025). Adoption of these instructional strategies has the potential to improve both students' scientific inquiry competencies and meaningful learning experiences in secondary physics education.

Several limitations should be acknowledged when interpreting the findings of this study. Data were collected from a single senior high school involving one physics teacher and one class of students, which may limit the transferability of the findings to different educational contexts (Hunegnaw and Melesse 2023; Melesse et al. 2025). Research also focused exclusively on static fluid learning and the six indicators of Basic Science Process Skills without examining integrated science process skills or other science topics. Although data triangulation and NVivo-assisted qualitative analysis enhanced the credibility of the findings, future investigations involving multiple schools, diverse instructional settings, and broader science topics are recommended. Such studies would provide a more comprehensive understanding of teacher strategies for cultivating students' Science Process Skills across different educational environments (Beggan 2023).

CONCLUSION

This study concludes that teacher strategies implemented during static fluid learning effectively cultivated students' Basic Science Process Skills through integrated classroom instruction and laboratory activities. Demonstrations, structured observations, laboratory experiments, collaborative discussions, and laboratory worksheets played important roles in developing students' observing, classifying,

measuring, communicating, predicting, and drawing conclusions skills. These findings indicate that consistent teacher guidance and authentic learning experiences support the development of scientific inquiry skills in physics learning. Practical implications suggest that similar instructional strategies can be adopted to strengthen students' Basic Science Process Skills in secondary science education. Nevertheless, this study was limited to one school and one physics topic, which may restrict the transferability of the findings. Future studies are recommended to involve broader educational settings and different science topics to further validate and extend these findings.

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AUTHOR CONTRIBUTIONS

Conceptualization, S.P., Y., and D.A.K.; Methodology, S.P.; Software, S.P.; Validation, Y. and D.A.K.; Formal Analysis, S.P.; Investigation, S.P.; Resources, S.P.; Data Curation, S.P.; Writing – Original Draft Preparation, S.P.; Writing – Review & Editing, Y., D.A.K., and S.P.; Visualization, S.P.; Supervision, Y. and D.A.K.; Project Administration, S.P.; Funding Acquisition, None.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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