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Research Trend of Science Process Skills in Prospective Physics Teachers: An Analytical Review

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Abstract

It is imperative to research the science process skills of prospective physics teachers in higher education to improve the quality of physics education, support curriculum development, and enhance student understanding. This study examines the research trends regarding the science process skills of prospective physics teachers in physics education at higher education institutions. The review of journal publications from 2019 to 2023 was conducted using content analysis, a qualitative method. A total of 24 journal articles focusing on the science process skills of prospective physics teachers in higher education were identified through Publish or Perish, using the Google Scholar and Scopus databases between 2019 and 2023. The analysis steps included framing review questions, identifying relevant research, assessing study quality, summarizing evidence, and conducting data analysis. The results showed that research on the science process skills of prospective physics teachers has been prevalent since 2019, with quantitative research dominating the field. Basic physics practicum courses are the primary focus for exploring students' science process skills, with tests being the most commonly used instruments. Several interventions, such as Project-Based Learning (PjBL), STEAM, Discovery, and Inquiry, have been implemented to enhance the science process skills of physics teacher candidates. Communication skills, a component of the 21st-century 4C skills, are particularly pertinent to the future challenges that educators will encounter, as evidenced by the science process skills examined in previous research. These skills are critical in fostering collaboration, problem-solving, and effective teaching. In conclusion, this study emphasizes the importance of developing physics teacher candidates' science process skills, particularly communication skills, in higher education. Future research is expected to deepen the understanding and develop more effective learning strategies to improve these essential skills in physics teacher candidates.

Keywords: physics learning; physics teachers; science process skills

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INTRODUCTION

Physics, as a branch of science, employs the analysis of everyday phenomena as the foundation for technological advancements and scientific applications, emphasizing the importance of scientific processes in producing valuable outcomes (Klein et al., 2019; Musyarrof et al., 2018). However, numerous studies from various countries indicate that students frequently regard physics as a challenging subject (Ady, 2022; Çermik, 2020; Janah et al., 2020; Ngo, 2022; Redish et al., 2006). These challenges are primarily the result of an imbalance in physics education, which prioritizes the product aspect over the process aspect and emphasizes theory without sufficient practice (Zainuddin et al., 2021) and theory without practice (Iskandar et al., 2021), Another contributing factor is the low proficiency in science process skills (SPS) among students, which hinders their deeper understanding of physics concepts (Wibowo et al., 2019).

Science process skills are crucial for prospective physics teachers, especially in the globalized era, where the development of scientific competencies is vital (Arsyad & Sartika, 2021; Darmaji et al., 2018). As a natural science discipline, physics is dependent on investigative processes to cultivate an understanding of fundamental concepts, principles, theories, and laws (Darmaji et al., 2019). Students are anticipated to participate in processes such as experimentation, analysis, and observation to uncover scientific concepts and products, as science process skills are in accordance with scientific activities (Harahap et al., 2019). Moreover, science process skills represent the full spectrum of purposeful scientific abilities (Mulyeni et al., 2019) that can be used to discover new concepts or develop existing ones (2009). The close relationship between students' scientific process skills and cognitive development was further underscored by Özgelen (2012)

research.

The two categories are basic and integrated science process skills (Can et al., 2017). Students actively utilize basic science process skills to explore nature, including observation, classification, communication, measurement, prediction, and inference. Students actively employ fundamental scientific process skills to investigate the natural world, encompassing observation, classification, communication, measurement, prediction, and inference. These skills serve as the foundation for integrated process skills. Furthermore, integrated process skills encompass activities such as the identification of variables, the formulation of hypotheses, the analysis of research results, the arrangement of data in tables, the creation of diagrams based on data, the explanation of data, and the exploration and design of experiments (Rezba et al., 2007). Scientific process skills, both basic and integrated, are essential for physics education students who will become teachers in the future (Maison et al., 2020). Educators, including lecturers who are accountable for the course, must make an effort to provide teaching materials in the form of pertinent practicum guidelines or guides to facilitate the implementation of practicums (Harlis & Budiarti, 2017).

Physics education programs aim to provide graduates with diverse competencies, with particular emphasis on developing skills (Yumusak, 2016). In order to be effective in real-world teaching contexts, prospective teachers must have a strong SPS as a component of their pedagogical competence (Maison et al., 2019). Nevertheless, research has demonstrated that many students, including prospective physics teachers in Indonesia, continue to lack sufficient development in these skills, which presents a significant challenge for educational practices (Yuliskurniawati et al., 2019). Many studies have shown that the ability of students and prospective physics teachers in terms of process skills in Indonesia, especially in physics subjects, has not yet reached adequate development (Anam et al., 2020; Mahmudah et al., 2019; Syazali et al., 2021).

Although there has been extensive research on SPS, especially for prospective physics teachers in higher education, much of it has focused on identifying the level of SPS (Agustina, 2020; Arsyad & Sartika, 2021; Dari & Nasih, 2020; Lumbantoruan et al., 2019;

Murniati et al., 2021; Nurwahidah, 2023; Rohman, 2019; Sambiri et al., 2023; Yolanda, 2019, 2022), the impact of specific educational designs on SPS (Esomar et al., 2020; Harlis & Budiarti, 2017; Rukmi & Perdana, 2023), and the relationship between SPS and other educational variables (Purwanti & Heldalia, 2022; Sakdiah et al., 2022; Septaria et al., 2019; Wahyudi & Lestari, 2019). However, no comprehensive review has been conducted to synthesize and analyze research findings specifically focused on SPS in higher education. This exposes a clear gap in the literature.

Therefore, this study aims to address the gap by conducting a comprehensive review of research on the science process skills (SPS) of prospective physics teachers in higher education. By analyzing trends and findings from various studies, this research provides an overview of the current state of SPS research. In addition to presenting trends, this review offers recommendations for a framework of SPS that can be applied in teaching various physics topics, such as measurement, mechanics, thermodynamics, and electricity. These recommendations aim to help educators create more effective and focused learning experiences that promote the development of SPS in physics education. Additionally, this review promotes the further investigation of effective teaching strategies to enhance these critical skills, thereby contributing to future improvements in educational practices.

METHOD

This study employed a qualitative method with content analysis to investigate and analyze the research trends of prospective physics teachers' science process skills in learning Physics in higher education. The steps used in this content analysis stage refer to the method developed by Khan et al. (2003) and are presented in Figure 1.

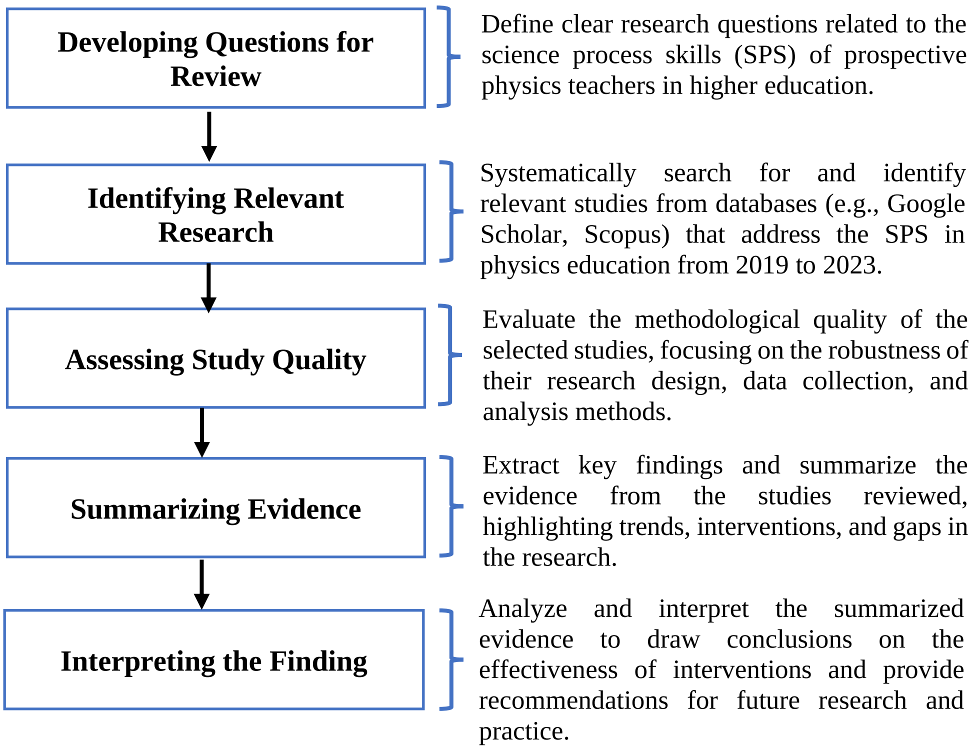

Figure 1 The steps in a systematic review

Developing Questions for Review

Developing well-structured questions

when formulating the content analysis review is a crucial stage. The questions should be precise, clear and relevant to the research objectives. The question revealed in this study is: How is the research trend of science process skills in physics learning in higher education? Which includes (1) the Number of publications per year, (2) the Type of research, (3) Physics topics selected for research, (4) Treatment, (5) Data collection instruments, and (6) Data analysis methods.

Identifying Relevant Research

This study employed various scientific journals relevant to the science process skills of prospective physics teachers in the context of higher education physics learning. Relevant research is chosen based on its relevance to the current research topic. The literature search was conducted on the Scopus and Google Scholar websites using the Publish or Perish (PoP) database search. There were 24 journals obtained to be used for review as a result of the PoP search conducted on the Scopus website during the 2019-2024 period using the keywords "science process skills," "students," and "physics."

Assessing Study Quality

This procedure aims to confirm the validity, reliability, and intensity of the evidence produced by the studies included in the review. The inclusion and exclusion criteria were implemented to ascertain the pertinent and appropriate literature for inclusion in the study, guaranteeing the research's quality. The parameters that are employed to select studies for inclusion in the literature review are referred to as inclusion criteria. The following criteria were employed to select the literature for this study: 1) Research articles published from 2019-2024; 2) Research articles that discuss the science process skills of prospective physics teachers in the form of journals; 3) Research in formal education in higher education in physics lessons. The exclusion criteria used to exclude research from the literature review are: 1) Research articles published before 2019; 2) Research in the form of books or other forms other than journals; 3) Research does not discuss the science process skills of prospective physics teachers in education in physics learning.

Adhering to these criteria during the literature selection process enabled the literature review to concentrate on studies pertinent to the research question, confirm the quality and reliability of the included studies, and restrict the review's scope to achieve more focused and reliable results.

Summarizing Evidence

Summarizing the evidence in the research results is an important step in preparing an informative and structured content analysis review. This stage involves preparing a clear and comprehensive summary of the main findings of each study identified based on Sinta/Scopus-indexed journals, taking into account the research questions and inclusion requirements.

Interpreting Findings

The discovery process in content analysis involves identifying, analyzing, and synthesizing significant discoveries that have been derived from prior research and scholarly publications. This research's synthesis of findings is a critical phase involving integrating and combining results from various literature. This process organizes a coherent and structured conceptual framework by organizing a variety of views and approaches related to the science process skills of physics teacher candidates. The proposed recommendations to enhance the quality of physics learning are based on this conceptual framework.

RESULTS AND DISCUSSION

Number of Publications

The research on the science process skills of prospective physics teachers has been the primary focus since 2019, as demonstrated in Figure 2, as indicated by the analysis of the number of journal publications in the 2019-2023 period. The number of publications reached its highest point in 2019, with seven articles, surpassing the number in subsequent years. The quality of education in Indonesia, particularly in the field of physics learning, has the potential to be significantly enhanced by the science process abilities of physics teacher candidates. However, it is important to emphasize that research is not just an intellectual exploration but also a tool to formulate and improve learning practices and effective strategies (Flor et al., 2021; Hake, 1998).

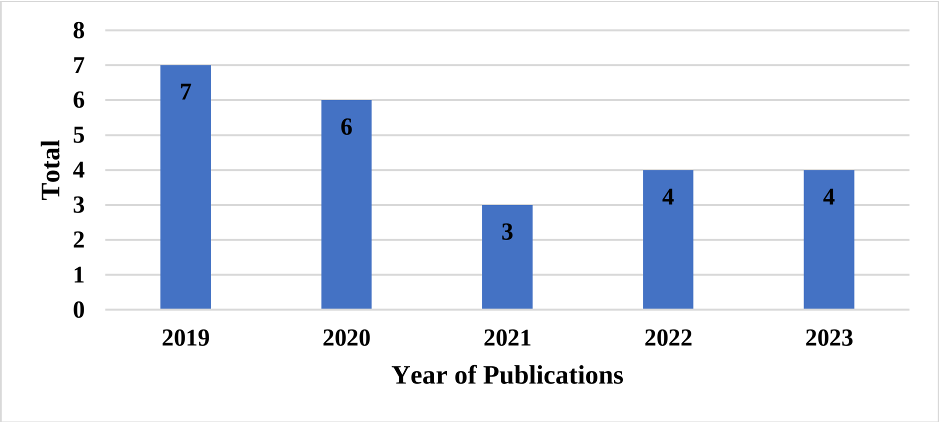

Figure 2 Distribution of research with science process skills of physics teacher candidates as the main concern based on the number of studies

Consequently, it is crucial to conduct research evaluating the science process skills of potential physics teachers in higher education physics education. Future researchers are anticipated to conduct more comprehensive research, with a particular emphasis on these skills. This step is crucial in the ongoing endeavour to enhance the quality of education, as physics education plays a critical role in advancing science and technology (Darmaji et al., 2019).

Type of Research

The significance of research type and design in determining the focus of a study is undeniable. Science Process Skills are the primary focus of the research distribution in Figure 3, which is based on the research category. Quantitative research is the most frequently employed design for evaluating the SPS of potential physics teachers. Given that the quantitative approach can generate measurable data that can be statistically analyzed, this is not unexpected, as it is in accordance with the requirements of such studies. Nevertheless, observation-based instruments are frequently used when assessing specific scientific process skills, including data interpretation, experimental result explanation, and conclusion drawing. Basic physics courses frequently employ direct observation of students demonstrating their abilities in real time to evaluate these skills. Observation sheets are frequently employed to assess vital SPS components, as they offer a more precise representation of students' abilities, which are frequently difficult to ascertain through alternative methods. This is consistent with prior research findings, which suggest a preference for observation-based instruments in SPS research, particularly in practical and hands-on learning environments (Johnston, 2014; Lincoln et al., 2004).

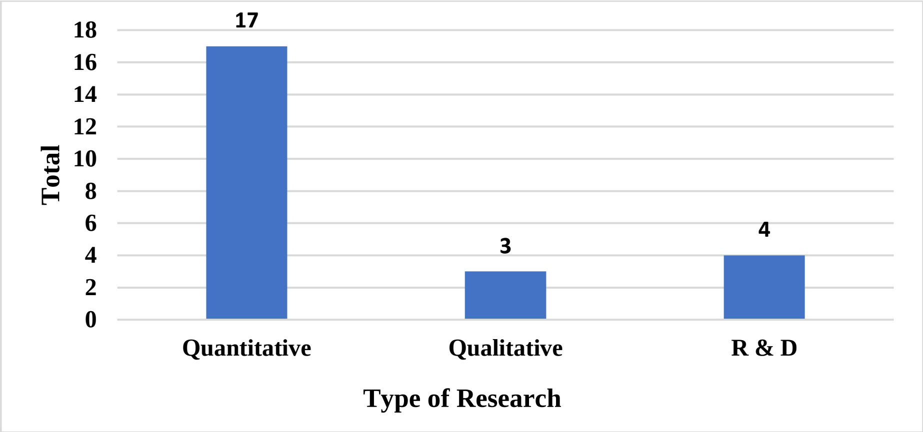

Figure 3 Distribution of research with science process skills of prospective physics teachers is the main concern based on the type of research

Meanwhile, R&D research has also begun to receive attention as an effort to produce educational products based on research findings, such as learning materials and teaching aids (Esomar et al., 2020; Rukmi & Perdana, 2023). Meanwhile, qualitative research continues to be pertinent in its ability to provide a comprehensive and detailed account of phenomena (Nurwahidah, 2023; Yolanda, 2019, 2022). However, it is important to acknowledge that current research in R&D and qualitative methodologies is insufficient in the context of science process skills among prospective physics teachers in higher education. This provides a chance for future researchers to investigate these aspects further.

Physics Topics

The courses that researchers most frequently employed in examining the science process skills of prospective physics teachers were fundamental physics practicum, as revealed by the analysis of various journals (Figure 4). This course is a progression in enhancing skill competencies closely associated with practicum activities (Dari & Nasih, 2020). Science process skills, including formulating hypotheses, identifying and defining variables, analyzing data, and drawing conclusions, are essential for practical activities in fundamental physics practicum courses (Arsyad & Sartika, 2021).

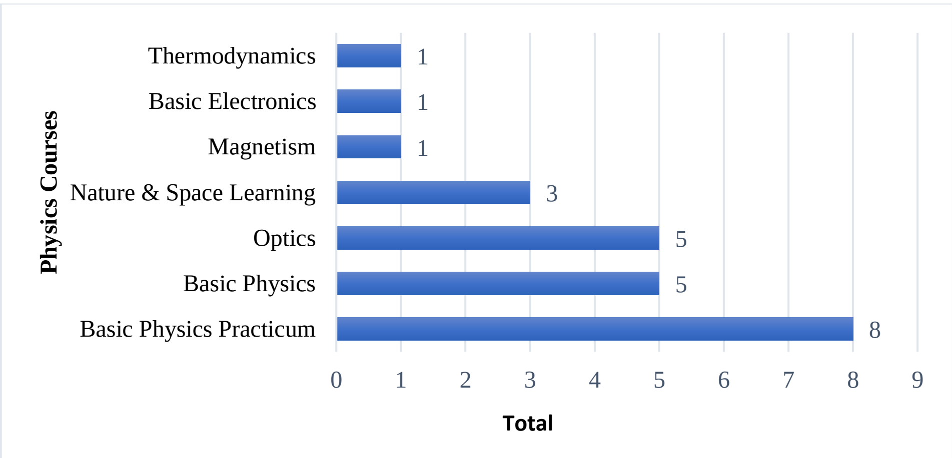

Figure 4 Distribution of research with science process skills of prospective physics Teachers as the main concern based on physics topics

These findings are in accordance with previous research (Sakdiah et al., 2022), which demonstrated that basic physics practicum courses are frequently locations where students can cultivate science process skills, including inference, data analysis, measurement, and observation, and investigate the extent to which basic physics practicum can assist students in refining their science process skills. The material in thermodynamics, fundamental electronics, and magnetic electricity courses presents a chance for future researchers to enhance the comprehension and development of science process skills in prospective physics teachers. Additionally, additional research in this field is anticipated to offer more specific recommendations and deeper insights into the development of curricula and the practice of learning physics.

Instrument Type

Based on the graph in Figure 5, observation sheets, questionnaires and interviews are the types of instruments used by researchers to assess students' science process skills. Among the various instruments, tests are the most commonly used by researchers. This test instrument offers a competitive edge in evaluating students' scientific process skills in the application of fundamental physics concepts, including the capacity to interpret data, elucidate experimental results, and draw conclusions. Furthermore, test instruments offer a comprehensive assessment of the degree to which students comprehend fundamental physics concepts and are capable of utilizing science process skills in practicum (Arsyad & Sartika, 2021; Sakdiah et al., 2022).

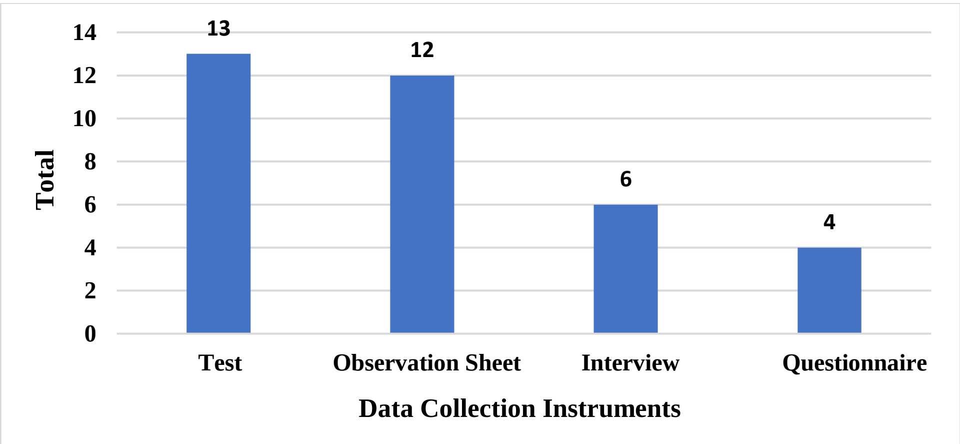

Figure 5 Distribution of research with science process skills of prospective physics teachers as the main concern based on test instruments

Nevertheless, future researchers must conduct a more thorough examination of the use of alternative instruments, including questionnaires, interviews, and observation diaries. This research has the potential to offer supplementary insights into a variety of aspects of students' scientific process skills that may not be quantifiable solely through test instruments. Furthermore, researchers can create instruments that are more comprehensive and suitable for the physics learning context being studied.

Intervention

The provision of intervention aims to test the researcher's hypothesis or identify the significance of a particular condition to any parameter under investigation. Based on the Table 1, PjBL, STEAM, Discovery and Inquiry. PjBL immerses students in genuine problems akin to real-world tasks, fostering the cultivation of soft skills, including teamwork, collaboration, communication, scientific inquiry, and creativity. Involving students directly through practicum activities or involvement in projects is one strategy that can be applied to develop students' science process skills (Putri et al., 2022).

Table 1 Distribution of research with science process skills of prospective physics teachers as the main concern based on intervention

Intervention	
PjBL	(Rukmi & Perdana, 2023)
STEAM	(Sakdiah et al., 2022)
Discovery	(Esomar et al., 2020)
Inquiry	(Wahyudi & Lestari, 2019)

Integrating STEAM learning approaches into Physics laboratory courses can enhance students' scientific process skills and attitudes toward science, thereby establishing a comprehensive and innovative learning environment (Sakdiah et al., 2022). Discovery learning is a learning model in which students are afforded the opportunity to make discoveries. This is achieved by independently analyzing, managing, and resolving problems (Esomar et al., 2020). Furthermore, the scientific inquiry approach improves students' capacity to think, work, and conduct scientifically while also honing their communication skills, which are essential for success in life. Inquiry-based learning also significantly enhances critical SPS, including inference, interpretation, and observation. For instance, implementing an inquiry-based optics practicum module has been shown to benefit students' scientific attitudes and SPS. Similarly, STEAM and PjBL methodologies offer opportunities to enhance observation, communication, and inference abilities by facilitating collaborative, hands-on learning experiences that closely resemble real-world scientific processes (Wahyudi & Lestari, 2019).

Data Analysis Method

Figure 6 presents research on science process skills as the main focus of prospective physics teachers based on data analysis methods.

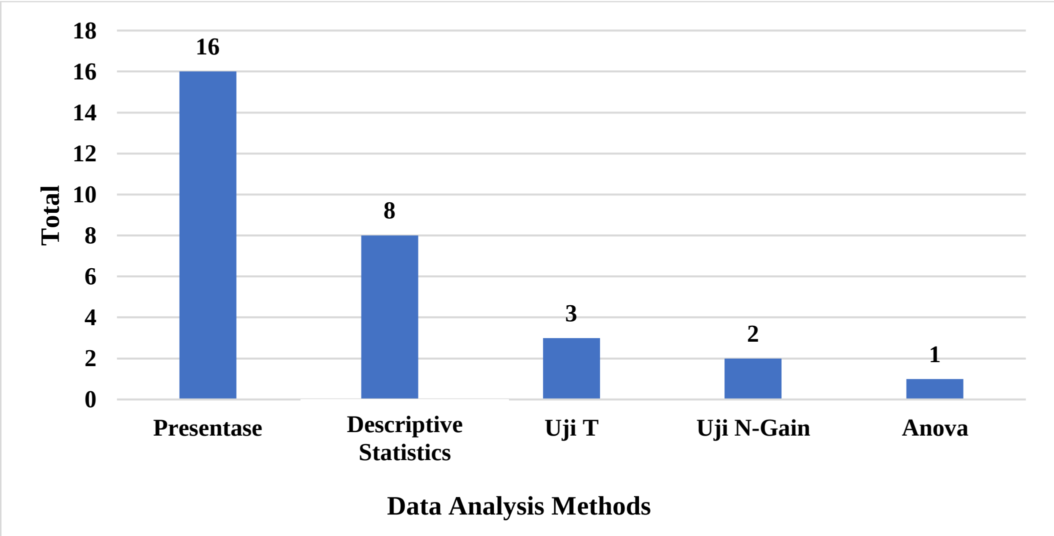

Figure 6 Distribution of research with science process skills of prospective physics teachers as the main concern based on data analysis method

The study's validity is determined by the precision with which data analysis methods are selected. The percentage test is the most frequently employed data analysis method in studying the scientific process skills of prospective physics teachers in higher education, as indicated by the graph in Figure 6. In the interim, the ANOVA test is employed infrequently. Therefore, the utilization of Anova is advised for future research that aims to investigate the science process skills of physics teacher candidates.

CONCLUSION

This study has reviewed scholarly articles on developing science process skills (SPS) in prospective physics teachers, focusing on research published between 2019 and 2023. The results suggest that the number of publications on this subject is inconsistent, indicating that the emphasis on SPS in physics teacher education has increased but remains stagnant. The most prevalent context for examining the development of SPS was the fundamental physics practicum, while quantitative research methods dominated the studies, indicating a preference for measurable data. Tests and presentations were the primary data collection and analysis tools, with various pedagogical interventions—such as PjBL, STEAM, Discovery, and Inquiry—being employed to enhance these skills.

The most successfully developed SPS, including observation, communication, measurement, interpretation, and inference, was attained through learning approaches that prioritized collaborative problem-solving, active student engagement, and hands-on activities. These attributes encourage a more profound engagement with the material, facilitating a more thorough comprehension of scientific concepts. Although these results offer valuable insights, there is a clear need for additional investigation, particularly in enhancing the representation of qualitative data and diversifying research methodologies. Prospective physics teachers should be better prepared for the challenges of contemporary education by developing more comprehensive learning strategies and interventions that strengthen their SPS. Future research should pursue this objective. Furthermore, the advancement of this field of research and the enhancement of physics education practices could be substantially facilitated by implementing more comprehensive interventions and more robust data analysis methods.

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