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Reflective Analysis of PGSD Students' Science Process Skills in the Perspective of 21st Century Skills

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Abstract: The rapid shift toward 21st-century learning requires prospective primary teachers to master science process skills (SPS) that support critical thinking, problem-solving, and innovation. This study aims to analyse PGSD students' SPS and 21st-century skills through a reflective approach. A descriptive qualitative design supported by quantitative data was employed. Data were collected from 22 first-year PGSD students enrolled in an elementary science education course using a Likert-scale questionnaire and written reflective journals. Questionnaire data were analysed descriptively using mean scores and categorical achievement levels, while journal data were examined through thematic analysis. The results show that students' SPS are at a very high level (M = 4.21), particularly in observing, conducting experiments, drawing conclusions, and applying scientific concepts. Their 21st-century skills are at a high level (M = 4.19), with collaboration and critical thinking higher than creativity and communication. Reflective journals confirm that practice-based and project-based science activities help students recognise their strengths and weaknesses and plan improvements. It can be concluded that reflective, experiment-oriented science learning effectively develops SPS and 21st-century skills in prospective primary teachers, although communication and creativity still need systematic reinforcement.

Keywords: Basic Education; PGSD Students; Reflection; Science Process Skills; 21st Century Skills

Introduction

The demands of 21st-century learning focus on fundamental changes in the learning paradigm. Specifically, these changes relate to the optimization of skills relevant to the current digital era and the 4.0 industrial revolution (Erwinsyah et al., 2025; Fitriani et al., 2024; Putriani, Jesika Dwi., 2021). Prospective teachers must master a variety of skills related to professional teaching competencies. One of the fundamental competencies for prospective teachers is mastery of Science Process Skills (SPS). SPS includes a series of scientific activities, including observing a phenomenon, systematically collecting information (data), developing hypotheses, conducting experiments, and drawing conclusions (Buaga., 2025; Murdani, 2020; Wulandari et al., 2025). In addition to the skills mentioned above, several other skills included in KPS are asking questions, interpreting and communicating, grouping/classifying, predicting, initiating questions, utilizing experimental resources (tools & materials), and being able to effectively relate theory to practice (Fitriani & Putri, 2020). In addition to being fundamental to science learning, KPS also contributes to strengthening critical thinking, creativity, communication, and collaboration skills, which are priority competencies in 21st-century skills. KPS is recommended to be taught to students from elementary, middle, to higher education levels (Rozhana, 2022).

Various studies on KPS in the context of education have been conducted, but some still focus on cognitive aspects, such as those conducted by Farida and Laila (2024) & Widodi et al (2023). Research focusing on the development of KPS instruments has also been

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conducted, including by Geraldine & Simmie (2025); Sa et al., (2024); Sinuraya et al., (2024) has integrated various learning models to improve KPS. So far, there has not been much KPS research that explores reflective approaches in measuring the understanding and application of these skills. The novelty of this study lies in reflective analysis through the use of reflective journals that allow students to reflect on their learning experiences in developing KPS and relate them to the challenges and needs of the 21st century. Pramitasari et al., (2024) have found the positive benefits of using reflective journals in developing the professionalism of elementary school teachers. Through a reflective approach, student professionalism can be developed (Oktaria et al., 2022). The reflection process contributes to improving the quality of learning, especially through writing and reflecting on learning experiences (Yanti & Novitasari, 2021). Reflection is the process of carefully forming information through careful consideration in logical decision-making in an educational context, followed by a review (reflection) of the results of the decisions made (Armelia, 2021). The reflective approach is believed to increase students' metacognitive awareness of their own thinking processes, enabling them to identify strengths and weaknesses in developing scientific skills.

On the other hand, this study also fills a gap in the study of KPS integration with 21st-century skills in the elementary school teacher education environment. PGSD students, as future educators, play an important role in developing scientific skills in students from the early stages of education. 21st-century learning requires the application of KPS as a means to build students' abilities in finding solutions and developing contextual learning strategies rooted in real life) (Harjono & Firdaus, 2024). Therefore, mapping and analyzing these skills is crucial in preparing them to be adaptive and innovative educators. This statement reflects the spirit of education in the 21st-century digital era, which demands the ability to adapt to the dynamics and changes of the times (Jannah, 2024). Likewise, teachers, as the frontline, are required to be adaptive to change and quick to absorb the latest information in order to deliver relevant and up-to-date material (Lasmawan & Suharta, 2024).

Based on the discussion in the background section, the focus of this study's findings is to: (1) conduct a reflective analysis of PGSD students' science process skills and 21st century skills; and (2) identify the challenges and potential of PGSD students in developing KPS. The findings of this study are projected to provide tangible benefits and serve as a foundation for the design of engaging, creative, innovative, and visionary science learning strategies.

Method

This study adopts a qualitative descriptive approach to present a detailed description of concrete findings regarding science process skills in 22 first-year PGSD students from the perspective of 21st-century skills. The research was conducted in the Primary School Teacher Education (PGSD) Program at Universitas Widya Dharma, and data were collected over a six-month period, from September 2024 to February 2025. The population consisted of first-year PGSD students enrolled in the elementary science education course, while the sample comprised 22 students selected using a total sampling technique, as all participants took part in the complete series of learning and reflective activities.

The research focuses on students' reflections on their experiences of experiment-based and project-based learning. They participated in a series of science learning activities based on practical work and projects, which served as relevant sources of data. Data were collected using various techniques, namely: (1) a closed reflective questionnaire consisting of 19 statements with a 1-5 Likert scale (Sugiyono, 2021), developed based on science process skill indicators (Q1–Q11) and 21st-century competencies (Q12–Q15); (2) an open-ended reflective questionnaire requiring students to write about their experiences during the learning process, including their responses to challenges or successes in scientific practice; (3) student reflective journals completed after four main activities making ice cream, analyzing the nutritional content of food products, grouping the characteristics of living things, and compiling a pocket book on elementary science learning models. The journals covered six reflective aspects: (a) understanding SPS; (b) critical thinking; (c) creativity; (d) collaboration; (e) communication; and (f) conclusions and improvement plans, each accompanied by two reflective questions requiring narrative and in-depth responses; and (4) observation and documentation. The following section presents an overview of the SPS and 21st-century skills indicators examined in this study.

Table 1 describes the statements representing each indicator in the KPS and students' 21st-century skills. KPS indicators are represented by Q1-Q11, while 21st-century skills indicators are represented by the last four indicators, which are divided into eight items, Q12-Q15. Data analysis is divided into two types: quantitative and qualitative. (1) Quantitative data from the Likert questionnaire is analyzed descriptively by calculating the average score per indicator, then categorized into the following 5 levels. The Very Low (VL) achievement level ranges from a score of 1.00 to 1.79, followed by the Low (L) achievement level, which ranges from a score of 1.80 to 2.59. Meanwhile, the Medium (M) achievement level has a score range of 2.60 to 3.39, the High (H)

achievement level ranges from 3.40 to 4.19, and the Very High (VH) achievement level is in the score range of 4.20 to 5.00.

Table 1. Indicators and Statements of Science Process Skills for PGSD Students

Code	Indicator	Statement
Q1	Observing	I am skilled at making observations using all my senses.
Q2	Classifying	I am able to group/classify objects based on specific categories.
Q3	Interpreting	I am able to interpret experimental data logically.
Q4	Predicting	I am able to make predictions based on observed patterns or data.
Q5	Formulating questions	I am able to formulate critical questions about a topic/theme.
Q6	Formulating hypotheses	I am able to formulate clear and logical hypotheses.
Q7	Designing Experiments	I am able to design experiments or research systematically.
Q8	Conducting Experiments	I am able to carry out experiments according to the correct procedures.
Q9	Drawing Conclusions	I am able to draw conclusions based on evidence and data analysis.
Q10	Applying Scientific Concepts	I am able to use conceptual understanding in real-world contexts.
Q11	Communicating	I am able to communicate learning outcomes and experiments confidently, both orally and in writing.
Q12	Critical Thinking	a. I am able to identify problems in experiments and find solutions. b. I am accustomed to questioning results and seeking further explanations.
Q13	Creativity	a. I try to find new ways to complete experiments. b. I often propose innovative ideas for completing experiments.
Q14	Collaboration	a. I feel comfortable working in groups when conducting experiments. b. I actively contribute to group discussions.
Q15	Communication	a. I can clearly explain the results of experiments to friends or lecturers. b. I can write scientific reports well and systematically.

The data collected from open-ended questions and reflective journals were analyzed using a thematic analysis approach, namely: (a) data reduction, (b) theme development based on six aspects of reflection, and (c) interpretation: drawing meaning from the emerging themes to reveal how students build scientific skills and 21st-century skills from their learning experiences. The results of this analysis were used to reflect on the success of practice-based science learning and to assess the potential and challenges of PGSD students in developing the skills needed in the 21st century.

Result and Discussion

The research findings were classified into two main categories, namely: (1) quantitative data from closed-ended Likert scale questionnaires and (2) qualitative data from reflective journals and open-ended questionnaires.

Quantitative Science Process Skills and 21st Century Skills

Science Process Skills are divided into 11 indicators, while 21st Century Skills are viewed from 4 indicators. The achievements of KPS and 21st Century Skills from 22 respondents were calculated by finding the average score for each indicator. The following are the results of the achievements.

Table 2. Achievement of Science Process Skills and 21st Century Skills of PGSD Students

Variable	Indicator	Average Score	Achievement Level
Science Process Skills (SPS)	Observe	4,45	Very High
	Classify	4,27	Very High
	Interpret	3,95	High
	Predict	4,27	Very High
	Formulate questions	3,90	High
	Formulate hypotheses	4,00	High
	Design experiments	4,10	High
	Conduct experiments	4,70	Very High
	Draw conclusions	4,20	Very High
	Apply scientific concepts	4,30	Very High
	Communicate	4,10	High
	Average	4,21	Very High
21st Century Skills	Critical Thinking	4,20	Very High
	Creativity	4,10	High
	Collaboration	4,60	Very High
	Communication	3,90	High
	Average	4,19	High

In general, the average KPS achievement of students is in the very high category (4.21), indicating that most students have demonstrated initial mastery of

several scientific skill indicators in a very optimal manner. Several indicators with the highest scores come from the aspects of conducting experiments and observing. Experiments and direct experiences are the activities that dominate science lectures. The experimental method is considered effective in enabling students to seek and find answers to the problems they are facing (Berciano & Uskola, 2024). Meanwhile, the average achievement of students' 21st-century skills is in the high category (4.19). The highest aspect comes from collaboration skills, while the lowest score is in the communication aspect. Through collaboration, it is believed that various characteristics in students can be improved. Collaboration and communication skills can be improved through various approaches, but the most effective way is through direct interaction with other individuals (Reyes, 2023).

Qualitative Reflection on Learning Experiences

All student learning experiences are recorded in reflective journals, which can reinforce quantitative results in greater depth regarding the development of KPS achievements. Writing reflective journals allows students to process various information from their experiences with the help of guiding questions, thereby forming meaningful concepts (Aidoo, 2024). The practice of writing reflective journals is considered effective in strengthening students' cognitive thinking skills while improving their ability to regulate and manage themselves (Woon et al., 2025). These learning journals are compiled by integrating students' 21st-century skills. The reflective journal study was analyzed from five aspects of skills, including: (a) understanding of KPS; (b) critical thinking; (c) creativity; (d) collaboration; (e) communication; and (f) conclusions and improvement plans. These five aspects were examined from four main activities in learning, namely making ice cream, analyzing food nutrition content, grouping living things, and compiling a science learning pocket book.

The first activity was making ice cream: students conducted experiments making ice cream with ingredients and flavors agreed upon by the group. The tool used was an old biscuit tin that was turned by hand. The second activity was learning how to do a gallery walk in class. Students took turns visiting each stand displaying a collection of labeled food products. Together with their groups, students analyze nutritional values and identify additives and addictive substances in food ingredients. The third activity involves each student group being given an impraboard and an envelope containing dozens of picture cards. Students are tasked with classifying the characteristics of living things based on the cards and presenting them on the impraboard in an interesting and creative way. The fourth activity involved students creating a book containing popular innovative learning models in science education. The concept was designed to be visually appealing using the Canva application. This activity aimed to introduce the integration of technology in learning as a first step in exploring the TPACK concept. The following is a summary of the students' learning experience reflections.

a) Making Ice Cream

In the activity of making ice cream, students learn to understand the change in the form of objects from liquid to solid through direct experimentation. They prepare tools and materials, measure the composition, and carry out the procedure carefully. This process requires precision in determining the temperature, freezing time, and stirring technique. Creativity emerges through variations in flavors, toppings, and ideas for using tools to make the process more practical. Collaboration is built by sharing tasks, taking turns turning the can, and recording observations. Communication is reflected in the ability to explain procedures and compile reports. The final reflection shows the importance of patience, responsibility, and the courage to conduct new experiments in elementary school.

b) Nutritional Analysis of Food Content

This activity trains students to read nutrition labels carefully, compare similar products, and identify additives. They learn to relate nutritional content to health and calculate consumption limits based on daily nutritional references. The use of technology such as Google Lens and the creation of comparison tables added creativity to the analysis. Group work was carried out by taking turns recording, observing, and searching for additional information. The results of communication were demonstrated by the ability to recommend healthy products and explain the negative effects of additives. The reflection gained was an awareness to be more selective in choosing food and wise in maintaining consumption patterns.

c) Classification of Living Things

In this activity, students further recognize the characteristics of living things through observing picture cards. Challenges arise when finding similarities between creatures, so they need to think critically to find specific characteristics with the help of additional sources. Creativity is evident in the use of applications and the creation of classification tables. Collaboration is built through the division of roles, from identification to presentation. Communication is carried out by presenting the classification results visually and structurally. Reflection shows the importance of team

cohesiveness, the use of various sources of information, and future plans to create more interesting learning media, such as quizzes or games.

d) Compiling a Pocket Book on Learning Models

Students collect information from journals, compile it systematically, and then package it in the form of a pocket book using the Canva application. Critical thinking skills are demonstrated in selecting relevant sources, simplifying information, and ensuring accuracy. Creativity is demonstrated through attractive visual designs, color selection, images, and the addition of interactive elements. Collaboration is carried out through discussions, joint material preparation, and taking turns reviewing manuscripts. Communication is established when students explain the concept of innovative learning models to their peers while practicing the use of the application. Reflection on this activity emphasizes the importance of compiling learning materials that are neat, informative, and creative, as well as a commitment to continue deepening digital literacy through the use of Google Scholar.

The description of the majority of students' statements on the first aspect related to understanding KPS states that through direct experimental activities that take place in the classroom environment and activities outside the classroom, they gain a better understanding of the scientific concept of changes in the form of objects, specifically in the example of changes in the form of freezing through the experimental activity of making ice cream. The ease of understanding concepts through real experiences was also experienced in the other three activities. The following is documentation of students conducting experiments to make ice cream.

Figure 1. Students Conducting an Experiment to Make Ice Cream

Students feel that activities such as observing, measuring, weighing, classifying, drawing conclusions, and writing reports make the learning process more concrete. This type of course design guides students to discover concepts independently, resulting in more meaningful learning and increased student concentration (Farida, Laila., 2024). From the results of the reflection, students became more aware of the importance of science process skills in understanding the material in a more applicable and integrated way in the context of everyday life through science activities. Through science activities, it is assumed that these activities are able to provide positive stimulation to KPS (Ivan et al., 2025).

In terms of critical thinking, students realized that during the learning process in class, they often encountered obstacles such as limited prior knowledge, limited tools when making ice cream, which resulted in pain in their hands when they had to turn the can containing the milk solution, difficulties in using the concepts of additives and addictive substances, and a lack of information for making books. However, most of them were able to find solutions through discussions with their group mates and lecturers. KPS is believed to not only play a role in helping students discover scientific concepts, but also contribute to fostering and honing critical thinking skills (Lovia et al., 2024). Activities that allow students to have concrete experiences will be able to encourage students' critical thinking abilities (Iqbal et al., 2025). Students will use all their knowledge to solve the problems they face, and the final result of this thinking process will show the intellectual level of the students (Setiadi, 2025).

Creativity emerged when students were engaged in learning activities, including the desire to try combining several other ingredients to produce different flavors and textures of ice cream. The challenge of hand muscle pain when turning the can led students to think of adding a drill to the top of the can so that it could rotate automatically. Student creativity is also evident when choosing aesthetic designs in the Canva application to create more attractive book products, as well as optimizing various learning resources to obtain more complete information (e.g., Gemini, Google Scholar, Google Lens). Here are some of the students' creative results in the lecture.

Figure 2. Students' Creativity Results during Science Lectures

Creativity is an individual's capacity to develop new innovative ideas and strategies to solve problems, provide answers, and convey meaning in an original way (Ujud et al., 2023). Creativity is also evident in divergent, productive, and imaginative thinking processes (Wahyuni et al., 2024). Creativity is an indication of fluency and flexibility in thinking and expressing thoughts, as well as the ability to modify and elaborate to the point of being able to create original new works. During the learning process, students are guided to enhance their creativity through discussion-triggering questions.

Reflection on collaboration shows that group work opens up space for complementing each other and learning from peers. Students mention that fair task distribution, smooth communication, and sensitivity to friends' difficulties are the keys to group success.

Figure 3. Students Collaborating to Group Picture Cards

In addition to critical thinking, communication, and creativity skills, collaboration has become an important framework in facing educational developments in the 21st century. Collaboration skills are students' ability to solve problems through group work to achieve common goals (Ananta et al., 2023). In general, collaboration is defined as a form of teamwork that emphasizes the principles of flexibility, effectiveness, and fairness in achieving collective goals (Taher, 2023). Students feel that their collaboration skills are very high, which has an impact on their success in completing each learning activity well.

In reflecting on communication aspects, students feel capable of explaining their work to lecturers and classmates verbally, although sometimes they still lack confidence. In writing, students stated that they were more skilled at presenting important information with a more aesthetic and visually appealing design through the Canva application, but their accuracy and creativity still needed to be honed. The use of reflection journals is believed to be able to improve communication skills (Azizah et al., 2024). Communication skills must be practiced continuously during the learning process, both in terms of learning material and other matters between teachers and students or among students (Rahmayani, 2024). Group-based learning can develop students' communication skills as well as other social skills such as teamwork and problem solving.

Finally, in terms of conclusions and follow-up plans, students are increasingly aware that concepts will remain in their memory longer if they are given hands-on experience, not just theory. Especially considering the rapid pace of technological innovation in today's digital age, lecturers must be able to design innovative learning so that students not only understand biological and physical concepts theoretically, but are also able to apply them in real-world contexts (Suryanda, 2024). However, the theoretical knowledge gained by students during lectures will be more meaningful if it can be applied in real life (Wisudojati et al., 2024). Students are also trained to formulate follow-up plans. Follow-up is an important part of efforts to improve the learning process in order to achieve more optimal results (Gea, 2024). As one of the follow-up plans, students stated that they were able to recommend food products that are safe for consumption based on the learning experiences they had gained through analyzing nutrition labels and food product compositions. In terms of character, students will further improve their accuracy, patience, responsibility, concern, teamwork, willingness to ask questions, creativity in developing learning media, and self-development by improving literacy skills and optimizing technology to support learning. Through the learning dynamics that have been undergone, it is hoped that the four indicators of 21st-century skills can be realized in harmony. An individual who already possesses communication skills, critical thinking, and continues to demonstrate their existence through creative ideas needs to move to the next level, which is to maintain and develop these abilities through collaboration and synergy with other colleagues.

Conclusion

The findings of this study confirm that first-year PGSD students at Widya Dharma University possess very high science process skills and high levels of 21st-century competencies, particularly in observing, conducting experiments, collaboration, and critical thinking. These results demonstrate that practice-based and reflective science learning can effectively strengthen the foundational scientific abilities required of future primary teachers. The reflective activities further reveal that students have begun to develop metacognitive

awareness of their strengths and areas requiring improvement, especially in communication and creativity.

This study highlights an important implication: integrating reflective journals into science learning can serve as a systematic mechanism for developing scientific literacy and professional growth among prospective teachers. However, the study is limited by its small sample size, single-institution context, and reliance on self-reported reflections, which may influence the objectivity of the data. Future research may expand the participant pool, compare multiple teacher-education institutions, employ performance-based assessments, or explore longitudinal changes in SPS and 21st-century skills throughout students' academic progression. Strengthening these aspects will provide a more comprehensive understanding of how reflective, experiment-oriented learning contributes to teacher professionalism in the 21st century..

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MMIS contributed to the conceptualization, methodology, data analysis, investigation, and writing of this research, and was fully responsible for completing the study from start to finish. All authors have read and agreed to the published version of the manuscript.

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References

Aidoo, B. (2024). A reflective study on adopting inquiry-based science teaching methods. *Disciplinary and Interdisciplinary Science Education Research*, *3*, 2–18. https://doi.org/https://doi.org/10.1186/s43031-024-00119-3

Ananta, A. S., Azis, Z., & Amri, Z. (2023). Pengaruh Free Discovery Learning dan Collaborative Inquiry pada Berpikir Kritis dan Kolaborasi Siswa. *Jurnal Gammath*, *8*(1), 64–73. https://doi.org/https://doi.org/10.32528/gammath.v8i1.333

Armelia, M. N. (2021). Pengaruh Self-Regulated Learning terhadap Kemampuan Berpikir Reflektif Matematis Siswa. *Jurnal Pendidikan Matematika*, *05*(02), 1757–1768. https://doi.org/https://doi.org/10.31004/cendekia.v5i2.687

Azizah, W., Sinaga, B., Rahman, A. A., & Simanullang, L. (2024). *Penerapan Model Pembelajaran Berbasis Projek (PjBL) Terintegrasi Berdiferensiasi Untuk Meningkatkan Motivasi Belajar Siswa Kelas 12 IPS SMA Negeri 10 Medan*. *07*(01), 4409–4417. https://doi.org/https://doi.org/10.31004/joe.v7i1.6640

Berciano, A., & Uskola, A. (2024). Evaluation of Mathematical and Scientific Competences in Primary Education STEAM Projects in Spain : A Systematic Review. *Education Sciences*, *14*(2), 1–20. https://doi.org/https://doi.org/10.3390/educsci14121349

Buaga, Garib firman., S. (2025). Development of Multiple Intelligence-Based Indonesian Learning E-Modules for Grade V Elementary School. *KEMBARA: Jurnal Keilmuan Bahasa, Sastra, Dan Pengajarannya*, *11*(1), 14–28. https://doi.org/https://doi.org/10.22219/kembara.v11i1.36579

Erwinsyah, A., Hiola, Z., Mohamad, S. N., Napu, D. D., Nadjamuddin, A., & Datunsolang, R. (2025). The Impact of Project-Based Flex Blended Learning Model on Critical Thinking Skills of Students in Science Courses. *Jurnal Penelitian Pendidikan IPA*, *11*(6), 783–792. https://doi.org/10.29303/jppipa.v11i6.11250

Farida, Laila., F. (2024). Inkuiri Terbimbing Dan Peningkatan Keterampilan Proses Sains Siswa Sma Pada Materi Asam Basa. *Indonesian Journal of Science Education and Applied Science (IJSEAS)*, *4*((1)), 32–48. https://doi.org/https://doi.org/10.20527/i.v4i1.13311

Fitriani, Eka., Saipul Annur., A. (2024). Revolusi Industri 4.0: Inovasi dan Tantangan dalam. *Journal of Education and Culture*, *4*(1), 28–35. https://doi.org/https://doi.org/10.58707/jec.v4i1.860

Fitriani, M. A., & Putri, A. A. (2020). *Analisis pengembangan bahan ajar*. *2*, 170–187.

Gea, J. (2024). Potential and Challenges in Implementing the Merdeka Belajar Curriculum at schools in Nias Utara. *Sintaksis : Publikasi Para Ahli Bahasa Dan Sastra Inggris*, *2*(1), 231–235. https://doi.org/10.61132/sintaksis.v2i1.374

Geraldine, D. V. V., & Simmie, M. (2025). Assessing Scientific Inquiry : A Systematic Literature Review of Tasks , Tools and Techniques. In *International Journal of Science and Mathematics Education* (Vol. 23, Issue 4). Springer Nature Singapore. https://doi.org/10.1007/s10763-024-10498-8

Harjono, A., & Firdaus, F. (2024). Improving Students ' Science Process Skills Through Project Based Learning Models : A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 711–720. https://doi.org/10.29303/jppipa.v10i10.9381

Iqbal, M., Istiyono, E., Nurjanah, S., Sutrimo, M S., Fauzan, M. I. (2025). Research Trends In Science Process Skills In Education: Bibliometric Analysis Of Scopus Publications 2019-2024. *Jurnal Pendidikan Fisika*, *10*(1), 181–195. https://doi.org/10.59052/edufisika.v10i1.43514

Ivan, F., Pinar, L., Panergayo, A. A. E., Sagcal, R. R., Acut, D. P., Roleda, L. S., & Prudente, M. S. (2025). Fostering scientific creativity in science education through scientific problem-solving approaches and STEM contexts : a meta- analysis. *Disciplinary and Interdisciplinary Science Education Research*, *9*(18), 2–17. https://doi.org/https://doi.org/10.1186/s43031-025-00137-9

Jannah, M. (2024). Analysis of Students ' Science Process Skills Profile : Case Study in Pekanbaru. *JSER: Journal of Science Education Research*, *8*(2), 162–170. https://doi.org/https://orcid.org/0000-0002-9197-3822

Lasmawan, I. W., & Suharta, I. G. P. (2024). Improving Students ' Science Process Skills Through Implementing An Integrated Learning Model With Local Wisdom. *International Journal of Applied Science and Sustainable Development(IJASSD)*, *6*(2), 129–134. https://doi.org/https://doi.org/10.36733/ijassd.v6i2.9510

Lovia, S., Kwame, O., Penu, A., Boateng, R., Budu, J., Serbe, J., & Asamoah, P. (2024). Heliyon Educational technologies and elementary level education – A bibliometric review of scopus indexed journal articles. *Heliyon*, *10*(7), e28101. https://doi.org/10.1016/j.heliyon.2024.e28101

Murdani, E. (2020). Hakikat Fisika dan Keterampilan Proses Sains. *Jurnal Filsafat Indonesia*, *3*(3), 72–80. https://doi.org/https://doi.org/10.23887/jfi.v3i3.22195

Oktaria, D., Sari, D. P., Soemantri, D., & Greviana, N. (2022). Memfasilitasi Kemampuan Refleksi Diri Mahasiswa Kedokteran: Apa Dan Bagaimana? *Jurnal Pendidikan Kedokteran Indonesia*, *11*(3), 340–348. https://doi.org/10.22146/jpki.65660

Pramitasari, N., Hastuti, P. W., Tyas, R. A., & Anjarsari, P. (2024). The Influence of Inquiry Learning Models Containing STEAM to Improve the Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 11109–11120. https://doi.org/10.29303/jppipa.v10i12.8985

Putriani, Jesika Dwi., H. (2021). EDUKATIF : JURNAL ILMU PENDIDIKAN Penerapan Pendidikan Indonesia di Era Revolusi Industri 4 . 0. *Jurnal Ilmu Pendidikan*, *3*(3), 831–838. https://doi.org/https://doi.org/10.31004/edukatif.v3i3.407

Rahmayani, M. (2024). Integrated Renewable Energy E-Module PBL Model with Smartphone to Improve Students ' Creative Thinking and Communication Skills. *Jurnal Pendidikan Indonesia*, *13*(1), 93–104. https://doi.org/https://doi.org/10.23887/jpiundiksha.v13i1.65177

Reyes, R. R. C. (2023). Project-Based Learning in Science: Effects on Students' Science Process and 21st - Century Skills. *Psychology And Education: A Multidisciplinary Journal*, *10*((3)), 1010–1019. https://doi.org/10.5281/zenodo.8166219

Rozhana, K. M. (2022). Development of Interactive Teaching Materials Based on Multiple Intelligences and Character. *Pedagogia : Jurnal Pendidikan*, *11*(2), 113–121. https://doi.org/10.21070/pedagogia.v11i2.1510

Sa, S., Andini, F. S., & Yusup, I. R. (2024). Improving Students ' Science Process Skills through Level of Inquiry Learning Assisted by Liveworksheet on The Concept of Environment Change. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 3983–3991. https://doi.org/10.29303/jppipa.v10i7.8120

Setiadi, M. I. (2025). Problem-Based E-Module for Enhancing Fifth-Grade Critical Thinking in Integrated Science and Social Studies. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *34*(01), 129–144. https://doi.org/https://doi.org/10.17977/um009v34i12025p129-144

Sinuraya, J., Mihardi, S., & S, A. H. (2024). Implementation of Inquiry Learning Based on Creativity and Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 3650–3655. https://doi.org/10.29303/jppipa.v10i7.8008

Sugiyono. (2021). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Suryanda, A. (2024). Eksplorasi Strategi Inovatif Pembelajaran Biologi di Abad 21. *DIAJAR: Jurnal Pendidikan Dan Pembelajaran*, *3*(1), 102–107. https://doi.org/10.54259/diajar.v3i1.2270

Taher, T. (2023). Analisis Keterampilan Komunikasi dan Kolaborasi Siswa Introvert dengan Pendekatan Culturally Responsive Teaching. *Jambura Journal of Educational Chemistry*, *5*(1), 21–27. https://doi.org/https://doi.org/10.34312/jjec.v5i1.17463

Ujud, S., Nur, T. D., Yusuf, Y., Saibi, N., & Ramli, M. R. (2023). Penerapan Model Pembelajaran Discovery Learning Untuk Meningkatkan Hasil Belajar Siswa Sma Negeri 10 Kota Ternate Kelas X Pada Materi Pencemaran Lingkungan. *Jurnal Bioedukasi*, *6*(2),

337–347. https://doi.org/10.33387/bioedu.v6i2.7305

Wahyuni, S., Arsyad, M., & Khaeruddin, K. (2024). Development of Physics Teaching Materials Based on I-SETS (Islamic, Science, Environment, Technology, Society) to Improve Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3433–3442. https://doi.org/10.29303/jppipa.v10i6.7395

Widodi, B., Darmaji., A. (2023). Identifikasi Keterampilan Proses Sains Dan Kemampuan Berpikir Kreatif Siswa. *Jurnal Inovasi Dan Pembelajaran Fisika*, *13*(1), 1–8. https://doi.org/https://doi.org/10.23887/jppii.v13i1.57131

Wisudojati, B., Iswadi, M. K., Aminullah, A. M., & Laelatunnufus, A. (2024). Peningkatan Keterampilan Literasi Berpikir Kritis Pada Pada Siswa Sekolah Menengah Melalui Integrasi Tekhnologi Pendidikan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(3), 1815–1821. https://doi.org/10.29303/jipp.v9i3.2629

Woon, C., Teng, C., Boon, R., & Lim, T. (2025). A qualitative analysis of student reflections on public health internships. *Education + Training*, *66*(10), 58–74. https://doi.org/10.1108/ET-07-2023-0302

Wulandari, I. S., Nugroho, I. A., & Buaga, G. F. (2025). Development of Eco-Friendly Big Book Media to Increase Interest and Science Literacy of 1st Grade Students. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 187–194. https://doi.org/10.29303/jppipa.v11i3.10500

Yanti, A. W., & Novitasari, N. A. (2021). Penggunaan Jurnal Reflektif pada Pembelajaran Matematika untuk Melatih Kemampuan Komunikasi Matematis Siswa. *Jurnal Pendidikan Matematika*, *10*(2), 321–332. https://doi.org/http://dx.doi.org/10.31980/mosharafa.v10i2.891