



## Analysis of students' science process skills in low plant botany online learning through telegram



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### Article Info

#### Article History:

Received 11 July 2025

Revised 10 September 2025

Accepted 13 October 2025

Published 30 November 2025

#### Keywords:

Low plant botany

Online learning

Science process skills

Telegram



### ABSTRACT

Research that discusses and examines the role of Telegram in developing science process skills (SPS) in low plant botany (LPB) learning in depth is still minimal. Therefore, the research aims to determine the level of SPS of students in LPB online learning through Telegram. The research method used a quantitative descriptive study of students' SPS levels after LPB learning through Telegram. The research was conducted with 60 students, using a questionnaire as the research instrument, followed by quantitative analysis. Results showed that students had a deep understanding and an adequate level of SPS in LPB online learning through Telegram, as evidenced by the average SPS score of 72.91% in the high category. Thus, Telegram has been proven to help develop students' SPS in LPB online learning. The study provides implications for educators by utilizing Telegram as a platform for online learning methods to develop students' SPS skills.

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**Citation:** Yudhistian, & Wulandari, T.S.H. (2025). Analysis of students' science process skills in low plant botany online learning through telegram. *JPBIO (Jurnal Pendidikan Biologi)*, 10(2), 318-327. DOI: <https://doi.org/10.31932/jpbio.v10i2.5156>

### INTRODUCTION

Science Process Skills (SPS) are cognitive abilities that are important to develop from an early age for prospective science educators, especially in biology, in knowledge creation, problem identification, and formulation of results (Arslan et al., 2023; García-Carmona et al., 2024; Sailaubay et al., 2024). SPS includes further scientific inquiry skills, such as asking questions, planning and conducting experiments, using appropriate tools and techniques to collect data, thinking critically and logically about the relationship between evidence and explanations, constructing and analyzing explanations, and communicating scientific arguments (Arslan et al., 2023). SPS is vital for college and high school students as it helps them quickly seek new information, solve problems in different situations, and gain knowledge from practice (Elfeky et al., 2024; Hiğde & Aktamış, 2022). SPS is integral to the STEM (Science, Technology, Engineering,



and Mathematics) learning model (Khamhaengpol et al., 2021). SPS helps students understand complex concepts but also fosters students' activeness to utilize science knowledge, skills, and attitudes through challenges in real-life situations (Khamhaengpol et al., 2024).

Nowadays, mastery of SPS is one of the essential skills that are important to have and master in 21st-century learning, especially for biology education students (Darmaji, Astalini, Kurniawan, Chen, et al., 2022; Tunga & Jumadi, 2022). Mastery of SPS in biology education students is in line with the demands of the world of work, which increasingly prioritizes 4C skills (Critical thinking, Creativity, Communication, and Collaboration skills) (N. F. Ahmad & Iksan, 2021; Wulandari et al., 2021). SPS is much needed in biology learning, one of which is learning Low Plant Botany (LPB). LPB is one of the biology education courses conducted in a hybrid manner, namely through face-to-face, practicum, and online discussion activities, which require a lot of SPS through observation questionnaires, research experiments, analysis of observation results, and problem-solving. One of the platforms commonly used to conduct LPB online is Telegram. Telegram is an instant messaging application that has interactive features that can support collaborative learning, provide real-time feedback, and access digital learning resources flexibly (Azzahra et al., 2024; Khomsah & Ariffin, 2024; Lorenz & König, 2023). Using Telegram, students can participate in group discussions, receive instant feedback from lecturers, and access learning materials anytime and anywhere to increase student engagement and learning motivation. However, many lecturers and educators do not realize the potential of Telegram as an online LPB learning platform.

So far, the utilization of Telegram as a learning platform still needs to be improved, and there are many obstacles in higher education. The obstacles that arise are the need for more readiness of lecturers and students in adapting to new ICT, so that many are not skilled and reluctant to use Telegram as a practical learning tool, and the need for in-depth and detailed studies on using Telegram features in learning. These obstacles have led to many lecturers needing ICT integration in digital-era learning. Additionally, many lecturers and students need comprehensive training and familiarity with optimizing Telegram features in LPB to assess students' SPS levels. Therefore, there needs to be more in-depth research that discusses and examines Telegram in developing students' SPS in LPB learning, even though the utilization of Telegram in LPB learning has significant potential benefits to develop students' SPS and open new insights as an adaptive learning method over the times.

Several studies have been conducted to investigate SPS developed positively and significantly in online learning, such as through the utilization of mobile scientific inquiry in online learning (Ekici & Erdem, 2020); utilization of hybrid Android interface practicum mode (Adiyanto et al., 2024); utilization of flipped classroom (Elfeky et al., 2020); use of mobile AR applications (Setiawaty et al., 2024); application of visual learning media (Maizaliani et al., 2024); development of Edmodo-Based Science Module (N. F. Ahmad & Iksan, 2021); use of the Process Oriented Guided Inquiry Learning (POGIL) learning model (Glebova et al., 2024); through guided exploratory experiments using Smartphones (Pacala, 2024); application of the Cybergogy approach using PhET as V-Lab media (Hidayat & Subekti, 2022); through practicum activities (Rini & Aldila, 2023); application of practicum e-modules (Maulidinah & Ekasari, 2023). In addition, the results of the literature review research by Mardiah et al. (2024) showed that the predicted observed explanation, Project Based Learning (PjBL), and Inquiry learning models were proven to improve SPS.

Based on the urgency of the research that has been explained and some previous studies that have been mentioned, online learning through the Telegram platform needs to be revised and found. Therefore, the novelty of the research is the utilization of the Telegram application in supporting LPB online learning to determine the level of student SPS. The research is expected not

only to expand the study of 21st-century learning through the use of the Telegram platform but also to provide practical solutions to improve and determine the level of student SPS needed in facing the challenges of digital-era learning. The research question formulated is: how is the level of students' SPS in LPB online learning through Telegram? The research aims to determine the level of students' SPS in LPB online learning through Telegram.

## RESEARCH METHODS

### Research Design

The research method used a quantitative descriptive study that describes the level of student SPS after conducting LPB online learning through Telegram. The quantitative descriptive method was chosen because it is more structured and specific through the collection and analysis of numerical data to answer the research questions, thereby achieving objective, systematic, and thorough results (Slater & Hasson, 2025).

### Population and Samples

The research population consisted of education students at Universitas PGRI Ronggolawe. The research samples were biology education students of Universitas PGRI Ronggolawe, with all classes totaling 60 students. Samples were selected directly using a purposive sampling technique based on student participation in LPB online learning via Telegram.

### Instruments

The research instrument used is a questionnaire sheet through Google Forms, divided into six indicators that refer to Wesnawati (2021) and Putri et al. (2022), which have been developed and modified, namely observer (OBS), hypothesize (HYP), predict (PRD), investigate (INV), interpret and summarize findings (ISF), and communicate (CMC). The rating scale used in the questionnaire sheet is a five-point Likert scale, with the highest score being 5 (very good) and the lowest being 1 (very poor). Expert biology education lecturers have validated the instrument, making it feasible for data collection.

### Procedures

The research procedure is adapted from Darmaji et al. (2022), presented in Figure 1. The data collection technique was done by recapitulating the questionnaire sheet data distributed to all subjects after LPB online learning via Telegram and collected on Google Forms into Microsoft Excel format to facilitate data analysis.

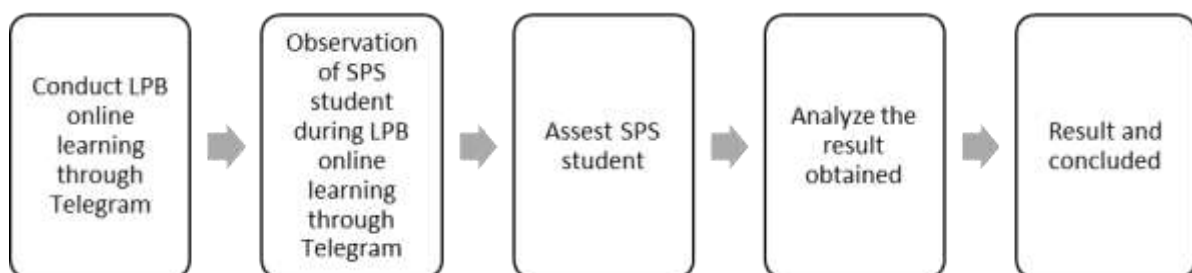


Figure 1. Research procedure

### Data Analysis

The data analysis technique was carried out quantitatively by calculating the percentage value of each SPS component that had been recapitulated using Equation 1.

$$\text{Percentage of Science Process Skills (SPS)} = \frac{\text{Score obtained}}{\text{Maximum score}} \quad \text{Equation I}$$

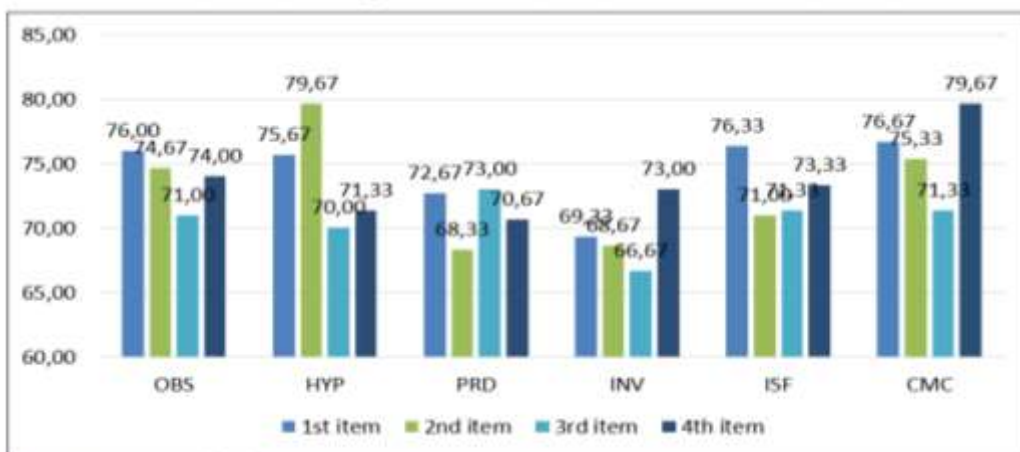
The data from the analysis are then interpreted in Table I, which refers to the modified Darmaji et al. (2022) and Kurniawan et al. (2023).

**Table I.** Interval and category of SPS level

| Interval (%)  | Category      |
|---------------|---------------|
| 24.99 – 43.72 | Not very good |
| 43.74 – 62.48 | Not good      |
| 62.50 – 81.24 | Good          |
| 81.26 – 100   | Very good     |

## RESULTS

The results of the student SPS questionnaire for each four items of each six indicators in LPB online learning via Telegram are presented in Figure 2. Figure 2 shows that the highest value of SPS in LBP online learning through Telegram is in the indicator of communication skills (CMC), which is 79.67% (4<sup>th</sup> item), and hypothesize skills (HYP), which is 79.67% (2<sup>nd</sup> item).



**Figure 2.** Results of student SPS in LPB online learning via Telegram

Table 2 shows the overall percentage of students' SPS for each indicator in LPB online learning through Telegram. Overall, Table 2 shows that students have a deep understanding and an adequate level of SPS in LPB online learning through Telegram, as evidenced by the average SPS score of 72.91% in the good category.

**Table 2.** Percentage results of SPS for each indicator overall

| SPS Indicator                          | NP (%) | Category |
|--|--------|----------|
| Observe (OBS)                          | 73.92  | Good     |
| Hypothesize (HYP)                      | 74.17  | Good     |
| Predict (PRD)                          | 71.17  | Good     |
| Investigate (INV)                      | 69.42  | Good     |
| Interpret and Summarize Findings (ISF) | 73.00  | Good     |
| Communicate (CMC)                      | 75.75  | Good     |
| $\bar{X}$ Percentage                   | 72.91  | Good     |

## DISCUSSION

Overall, the findings indicate that online learning for the Low Plant Botany (LPB) course through Telegram is effective in developing students' Science Process Skills (SPS). The platform proves to be superior in facilitating collaboration and communication, yet it also highlights challenges in adapting investigation activities that are ideally hands-on.

The highest score was achieved in communication (CMC) at 75.75%, which falls into the good category (Table 2). This suggests that students were significantly aided by Telegram's features, such as discussion groups, document sharing, and voice or video messages, to practice and enhance their communication skills. Through intensive communication, students became more active, enabling them to formulate hypotheses accurately. This finding is consistent with Citrawati et al. (2021) and Alharbi (2024), who stated that Telegram can improve students' communication, reading, writing, and listening skills. The main elements of Telegram can be utilized for conversational communication and sending files without size restrictions in its groups and channels foster communication that supports collaborative learning (Fitriyana et al., 2023; Zhao et al., 2022). These features provide real-time and continuous feedback, which is crucial for developing scientific communication skills (Owusu-Mensah et al., 2020).

Conversely, the investigative skill (INV) was the indicator with the lowest score at 69.42% (Table 2), although still in the good category. Figure 2 further shows one item related to this skill scoring even lower at 66.67%. This result is understandable within the context of a Low Plant Botany course, where the essence of investigation often requires direct, hands-on experiments and practicum. While Telegram can be used for collaboration, coordination, and organizing the investigation process through groups, it requires additional features to fully support the experimental phase where students test their hypotheses (Kuang et al., 2024). To address this, educators could utilize interactive features like a Telegram chatbot to guide students through investigation steps, providing hints and clues to develop their skills, as explained by (Merelo et al., 2024). Despite the limitations, students were still able to use the platform to share notes, pictures, and videos in real-time to record and share practicum results. This aligns with Faramarzi et al. (2019), who state that Telegram supports sending all file formats.

Other Science Process Skills also demonstrated promising results. Hypothesizing ability (HYP) scored 74.17% (Table 2), as students used features like polling and voting in groups to gather different perspectives and engage in brainstorming sessions to select the best hypothesis. This aligns with Ali et al. (2024), who noted that flexible peer-to-peer interactions support collaborative and adaptive learning. The importance of this skill is fundamental for designing experiments and interpreting data (Kalinowski & Pelakh, 2024; Karunarathna et al., 2024). Furthermore, observation skills (OBS) achieved a score of 73.92%, indicating that students effectively collected data by sharing and discussing images and videos from their real-time experiences. This is essential in science learning and requires direct observation, which can be shared digitally (Kraus, 2024; Roa & Fajardo, 2022). Students found this learning experience to be engaging and accessible (E. A. Ahmad, 2024). The skills of interpreting and summarizing findings (ISF) recorded a score of 73.00%, as students participated in data analysis discussions and shared reports, which is crucial for developing the ability to conclude and summarize data (Adiyanto et al., 2024; Alharbi, 2024). Lastly, prediction ability (PRD) was at 71.17%; students sharpened this skill using group voting features to collect predictions, although further simulation sessions or case studies would be needed for enhancement, a practice that Telegram's platform can flexibly support (Adiyanto et al., 2024; Andrayani et al., 2024).

Telegram proves to be more than just a communication tool; it functions as a flexible and interactive learning platform for the LPB online course. SPS are student-centered skills aimed at building the ability to apply ideas in daily life. Telegram's various features, including groups,



channels, polling, media sharing, and chatbots, facilitate this by providing an immersive experience to facilitate collaborative learning (Chetti & Hashim, 2023; Hartati et al., 2024; Rezai et al., 2024; Syaiful, 2023; Yasir & Khoiriyah, 2024). The platform's flexibility, breadth, and personalization make it a suitable application for learning (Abu-Ayfah, 2020). Active student participation in discussions strengthens the development of all SPS indicators, from observing to communicating. The chatbot feature, in particular, offers learning flexibility that facilitates collaborative learning and skill development (Hartati et al., 2024; Rezai et al., 2024). Thus, Telegram is a proven and valuable pedagogical tool for developing SPS. However, it may require supplementary methods to fully address the limitations of hands-on practical work in an online setting.

## CONCLUSION

Based on the results of the research that has been conducted, students show good science process skills, with the acquisition of an overall average indicator of 72.91%. The score shows that Telegram is proven to help develop students' SPS in LPB online learning through group and channel features, polling and voting features, and media sharing. The study provides implications for educators by utilizing Telegram as a platform for online learning methods to develop students' SPS skills.

## ACKNOWLEDGMENT

The author would like to thank the Biology Education Study Program at Universitas PGRI Ronggolawe and all the study's samples.

## REFERENCES

- Abu-Ayfah, Z. A. (2020). Telegram App in Learning English: EFL Students' Perceptions. *English Language Teaching*, 13(1), 51–62. <https://doi.org/10.5539/elt.v13n1p51>
- Adiyanto, D., Riandi, R., & Solihat, R. (2024). Hybrid Android Interface Practicum Mode to Develop Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, 10(2), 431–440. <https://doi.org/10.29303/jppipa.v10i2.3904>
- Ahmad, E. A. (2024). Revolutionizing learning: leveraging social media platforms for empowering open educational resources. *International Journal of E-Learning and Higher Education (IJELHE)*, 19(1), 83–106. <https://ir.uitm.edu.my/id/eprint/91995>
- Ahmad, N. F., & Iksan, Z. H. (2021). Edmodo-Based Science Module Development on Students' Mastery of Science Process Skills: Need Analysis. *Creative Education*, 12(11), 2609–2623. <https://doi.org/10.4236/ce.2021.1211195>
- Alharbi, A. (2024). Jeddah University Students' Attitude toward Using Telegram to Support Their EFL Learning. *Open Access Library Journal*, 11(7), 1–20. <https://doi.org/10.4236/oalib.1111700>
- Ali, I., Mikhail, K., Jawad, I. A., Abdullaev, D., & Khalikov, A. A. (2024). To See from the Eyes of Other Peers: Exploring the Impact of Interactional Feedback on EFL Students' Writings via Telegram and its Possible Effects on Coping Strategies, Self-esteem, as well as Progress in Writing Skill. *Computer Assisted Language Learning Electronic Journal (CALL-EJ)*, 25(4), 234–257. <https://callej.org/index.php/journal/article/view/490>
- Andrayani, L. W., Rusmini, R., & Hariawan, H. (2024). Telegram as a tool for nursing laboratory practice for undergraduates: Peyton's 4-step approach. *Healthcare in Low-Resource Settings*, 12, 477–481. <https://doi.org/10.4081/hls.2024.12075>
- Arslan, H. O., Genc, M., & Durak, B. (2023). Exploring the effect of argument-driven inquiry on pre-service science teachers' achievement, science process, and argumentation skills and their views on the ADI model. *Teaching and Teacher Education*, 121, 103905.



- <https://doi.org/10.1016/j.tate.2022.103905>
- Azzahra, S. I., Elmumtaza, S., Saniyyah, Z., Azizi, M. M., Jasmine, A. S., Fatimatu, J., Aras, M. I. A., Ariyana, R., Khasanah, N., Inggri, P. B., Ilmu, F., Universitas, K., & Negeri, I. (2024). Digital Learning Innovation : Language Collaboration In Tanjungmojo Village. *Jurnal Pengabdian Sosial*, 1(11), 1897–1911. <https://doi.org/10.59837/7a3yy142>
- Chetti, M. S., & Hashim, H. (2023). Mobile Instant Messaging (MIM) as a Tool in Teaching English Among ESL Learners: A Systematic Review (2019–2023). *International Journal of Academic Research in Business and Social Sciences*, 13(12), 141–166. <https://doi.org/10.6007/IJARBSS/v13-i12/19728>
- Citrawati, N. kadek, Suwastini, N. K. A., Jayantini, I. G. A. S. R., Artini, N. N. A., & Dantes, G. R. (2021). Telegram as Social Networking Service (SNS) For Enhancing Students' English: A Systematic Review. *Journal of English Language Teaching and Linguistics*. <https://doi.org/10.21462/JELTL.V6I2.531>
- Darmaji, D., Astalini, A., Kurniawan, D. A., Chen, D., Wirayuda, R. P., & Winda, F. R. (2022). Investigation gender difference towards science process skills (SPS) using problem based learning. *Cypriot Journal of Educational Sciences*, 17(10), 3849–3862. <https://www.cceol.com/search/article-detail?id=I076305>
- Darmaji, D., Astalini, A., Kurniawan, D. A., & Putri, W. A. (2022). Science Process Skills and Critical Thinking Ability Assessed from Students' Gender. *Jurnal Pendidikan Fisika Indonesia*, 18(1), 83–95. <https://doi.org/10.15294/jpfi.v18i1.30534>
- Ekici, M., & Erdem, M. (2020). Developing Science Process Skills through Mobile Scientific Inquiry. *Thinking Skills and Creativity*, 36, 100658. <https://doi.org/10.1016/j.tsc.2020.100658>
- Elfeky, A. I. M., Masadeh, T. S. Y., & Elbyaly, M. Y. H. (2020). Advance organizers in flipped classroom via e-learning management system and the promotion of integrated science process skills. *Thinking Skills and Creativity*, 35, 100622. <https://doi.org/10.1016/j.tsc.2019.100622>
- Elfeky, A. I. M., Najmi, A. H., & Elbyaly, M. Y. H. (2024). The impact of advance organizers in virtual classrooms on the development of integrated science process skills. *PeerJ Computer Science*, 10, 1–15. <https://doi.org/10.7717/peerj-cs.1989>
- Famarzi, S., Tabrizi, H. H., & Chalak, A. (2019). Telegram: An Instant Messaging Application To Assist Distance Language Learning (App Review). *Teaching English with Technology*, 19(1), 132–147.
- Fitriyana, I., Anjaniputra, A. G., & Semarang, U. N. (2023). The Teaching of Writing Skills in An EFL Online Classroom at A Secondary School: Between Bandwith and Immediacy. *Journal of English Pedagogy and Applied Linguistics*, 3(2), 65–76. <https://doi.org/10.32627/jepal.v3i2.682>
- García-Carmona, A., Muñoz-Franco, G., Criado, A. M., & Cruz-Guzmán, M. (2024). Validation of an instrument for assessing basic science process skills in initial elementary teacher education. *International Journal of Science Education*, 46(4), 362–381. <https://doi.org/10.1080/09500693.2023.2232936>
- Glebova, O., Al-Faris, A., & Vielleux, N. (2024). Guiding Students to Discover CS Concepts and Develop Process Skills Using POGIL --- Conference Workshop. *Journal of Computing Sciences in Colleges*, 39(8), 184–185. <https://doi.org/10.5555/3665609.3665623>
- Hartati, R., Meisuri, M., Ginting, S. A., & Ariatna, A. (2024). Enhancing Students'creativity: Implementing Digital Literacy Through A Telegram Chatbot For Creative Projects At Yayasan Pendidikan Bina Bersaudara. *Jurnal Pengabdian Mandiri*, 3(6), 563–570. <https://www.bajangjournal.com/index.php/JPM/article/view/8002>

- Hidayat, M. I. M., & Subekti, H. (2022). Promoting science process skills and learning outcomes through cybergogy approaches with PhET media for Junior High School Students. *Jurnal Pijar Mipa*, 17(4), 499–506. <https://doi.org/10.29303/jpm.v17i4.3623>
- Hiğde, E., & Aktamış, H. (2022). The effects of STEM activities on students' STEM career interests, motivation, science process skills, science achievement and views. *Thinking Skills and Creativity*, 43, 101000. <https://doi.org/10.1016/j.tsc.2022.101000>
- Kalinowski, S. T., & Pelakh, A. (2024). A hypothetico-deductive theory of science and learning. *Journal of Research in Science Teaching*, 61(6), 1362–1388. <https://doi.org/10.1002/tea.21892>
- Karunarathna, I., Gunasena, P., Hapuarachchi, T., & Gunathilake, S. (2024). *The role of scientific hypotheses in shaping modern research and innovation*. ResearchGate. <https://www.researchgate.net/publication/383205323>
- Khamhaengpol, A., Nokaew, T., & Chuamchaitrakool, P. (2024). Development of STEAM activity “Eco-Friendly Straw” based science learning kit to examine students' basic science process skills. *Thinking Skills and Creativity*, 53, 101618. <https://doi.org/10.1016/j.tsc.2024.101618>
- Khamhaengpol, A., Sriprom, M., & Chuamchaitrakool, P. (2021). Development of STEAM activity on nanotechnology to determine basic science process skills and engineering design process for high school students. *Thinking Skills and Creativity*, 39, 100796. <https://doi.org/10.1016/j.tsc.2021.100796>
- Khomsah, S. N. F. S. M., & Ariffin, K. (2024). On the Efficacy of Instant Messaging Apps: ESL Students' Learning Experience in Hybrid Classrooms. *Gading Journal for Social Sciences*, 27(October 2024), 34–42. <https://gadingssuitm.com/index.php/gadingss/article/view/473>
- Kraus, S. F. (2024). The method of observation in science education: Characteristic dimensions from an educational perspective. *Science & Education*, 33(4), 1033–1068. <https://doi.org/10.1007/s11191-023-00422-x>
- Kuang, X., Eysink, T. H. S., & de Jong, T. (2024). Presenting domain information or self-exploration to foster hypothesis generation in simulation-based inquiry learning. *Journal of Research in Science Teaching*, 61(1), 70–102. <https://doi.org/10.1002/tea.21865>
- Kurniawan, D. A., Darmaji, D., Astalini, A., & Muslimatul Husna, S. (2023). Study of Critical Thinking Skills, Science Process Skills and Digital Literacy: Reviewed Based on the Gender. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1741–1752. <https://doi.org/10.29303/jppipa.v9i4.1644>
- Lorenz, P., & König, L. (2023). Engaging students through messaging applications in foreign language learning. *Journal of Applied Learning & Teaching*, 6(2), 241–251. <https://doi.org/10.37074/jalt.2023.6.2.30>
- Maizaliani, C. R., Muhibbuddin, M., Syukri, M., Saminan, S., Nurmaliah, C., Evendi, E., & Herliana, F. (2024). Utilizing Visual Teaching Materials to Assist Students in Science Subjects Improves Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, 10(4), 2162–2169. <https://doi.org/10.29303/jppipa.v10i4.6815>
- Mardiah, A. A., Sukarno, & Supianto. (2024). Literature Review: Analysis of Learning Models to Improve Students' Science Process Skills. *Mini International Conference of Educational Research and Innovation (MICERI)*, 7(Miceri 2023), 1–23. <https://doi.org/10.20961/shes.v7i1.84268>
- Maulidinah, M., & Ekasari, A. (2023). Application of E-Module to Identify Students' Science Process Skills in the Practicum of Refraction on Prisms. *Schrödinger: Journal of Physics Education*, 4(2), 30–35. <https://doi.org/10.37251/sjpe.v4i2.502>



- Merelo, J. J., Castillo, P. A., Mora, A. M., Barranco, F., Abbas, N., Guillén, A., & Tsivitanidou, O. (2024). Chatbots and messaging platforms in the classroom: An analysis from the teacher's perspective. In *Education and Information Technologies* (Vol. 29, Issue 2). <https://doi.org/10.1007/s10639-023-11703-x>
- Owusu-Mensah, F., Pufaa, H. A. K., & Sakyi, D. K. (2020). Delivery of learning modules through the telegram social media application: Views of post graduate diploma in education distance students of university of education, Winneba. *2nd International Conference on New Trends in Teaching and Education*, 29–31.
- Pacala, F. A. (2024). *Improving Students' Conceptual Understanding of Magnetic Fields and Science Process Skills Through Guided Exploratory Experiments Using a Smartphone BT - Information Technology for Education, Science, and Technics* (E. Faure, Y. Tryus, T. Vartiainen, O. Danchenko, M. Bondarenko, C. Bazilo, & G. Zaspas (eds.); pp. 283–296). Springer Nature Switzerland. [https://doi.org/10.1007/978-3-031-71804-5\\_19](https://doi.org/10.1007/978-3-031-71804-5_19)
- Putri, R. Y., Sudarti, S., & Prihandono, T. (2022). Analisis Keterampilan Proses Sains Siswa dalam Pembelajaran Rangkaian Seri Paralel Menggunakan Metode Praktikum. *Edumaspul: Jurnal Pendidikan*, 6(1), 497–502. <https://doi.org/10.33487/edumaspul.v6i1.3145>
- Rezai, A., Kumar, T., & Robso Wodajo, M. (2024). Disclosing the Effects of Online Collaborative Writing on Writing Skills and Self-Perception of Technology: A Study on Ethiopian EFL Learners. *Applied Research on English Language*, 13(2), 81–104. [https://are.ui.ac.ir/article\\_28088.html](https://are.ui.ac.ir/article_28088.html)
- Rini, E. F. S., & Aldila, F. T. (2023). Practicum Activity: Analysis of Science Process Skills and Students' Critical Thinking Skills. *Integrated Science Education Journal*, 4(2), 54–61. <https://doi.org/10.37251/isej.v4i2.322>
- Roa, G. R., & Fajardo, M. T. M. (2022). Science Process Skills Survey as Input to Instructional Materials Development. *American Journal of Educational Research*, 10(12), 697–701. <https://doi.org/10.12691/education-10-12-6>
- Sailaubay, A., Myrzakhmetova, N., Tunçel, M., & Kishibayev, K. (2024). Analysis of the Relationships Between University Students' Laboratory Self-Efficacy Beliefs, Science Process Skills and Achievement in Chemistry Courses. *Journal of Curriculum Studies Research*, 6(2), 36–51. <https://doi.org/10.46303/jcsr.2024.1>
- Setiawaty, S., Lukman, I. R., Imanda, R., Sudirman, S., & Rauzatuzzikrina, R. (2024). Integrating Mobile Augmented Reality Applications Through Inquiry Learning To Improve Students' Science Process Skills and Concept Mastery. *Jurnal Pendidikan IPA Indonesia*, 13(1), 90–102. <https://doi.org/10.15294/jpii.v13i1.48891>
- Slater, P., & Hasson, F. (2025). Quantitative Research Designs, Hierarchy of Evidence and Validity. *Journal of Psychiatric and Mental Health Nursing*, 32(3), 656–660. <https://doi.org/10.1111/jpm.13135>
- Syaiful, J. M. (2023). The Implementation of Telegram in Reading Class to Improve Students' Skimming and Scanning Skills. *Elsya: Journal of English Language Studies*, 5(2), 173–184. <https://doi.org/10.31849/elsya.v5i2.13535>
- Tunga, M. F., & Jumadi, J. (2022). Content Analysis of Physics Textbooks for Senior High School on The Principle of Direct Current Circuits. *Jurnal Penelitian Pendidikan IPA*, 8(1), 414–422. <https://doi.org/10.29303/jppipa.v8i1.1294>
- Wesnawati, A. C. D. (2021). *Pengembangan Sumber Belajar IPA Berorientasi Nature Of Science Dalam Bentuk Website Untuk Meningkatkan Keterampilan Proses Sains Siswa* [Universitas Pendidikan Ganesha]. <https://repo.undiksha.ac.id/id/eprint/8865>
- Wulandari, B. C., Rusilowati, A., & Saptono, S. (2021). The Development of Performance Assessment Instrument Integrated 4C for Measuring Science Process Skills in the Science

- Experiments of Elementary School Students Article Info. *Journal of Primary Education*, 10(2), 233–224I. <https://doi.org/10.15294/jpe.v10i2.34456>
- Yasir, M., & Khoiriyah, K. (2024). Analysis of Junior High School Students' Science Process Skills in Environmental Pollution Based on Ethnoscience and Local Wisdom. *Science Education and Application Journal*, 6(1), 34–46. <https://doi.org/10.30736/seaj.v6i1.910>
- Zhao, Z., Wang, X., & Ismail, S. M. (2022). Social media and academic success: Impacts of using telegram on foreign language motivation, foreign language anxiety, and attitude toward learning among EFL learners. *Front. Psychol.*, September, 1–12. <https://doi.org/10.3389/fpsyg.2022.996577>

