Journal of Innovative Physics Teaching
Volume 4, Issue 1 June 2026, 63 – 74
ISSN: 3021-8551 (Online)
Doi: https://doi.org/10.24036/jipt/vol4-iss1/127
https://jipt.ppj.unp.ac.id/index.php/jipt

Need Analysis of Interactive Electronic Student Worksheets on Dynamic Fluids Based on Dual Space Inquiry to Stimulate Students' Science Process Skills

Winda Rudespika[1*], Fuja Novitra[2], Akmam[3], Selma Riyasni[4]
[1,2,3,4] Department of Physics, Padang State University, Padang, Indonesia.

Article Info

Article history:

Received April 21, 2026
Revised June 10, 2026
Accepted June 15, 2026

Keywords:

Electronic Student Worksheet
Dynamic Fluids
Dual Space Inquiry
Science Process Skills
Need Analysis

ABSTRACT

This research is motivated by the urgency of the Science–A Process Approach (SAPA), which emphasizes the importance of science process skills in physics learning. However, classroom practices still show low student engagement in scientific activities and are dominated by conventional teaching materials. This research aims to analyze the need for developing interactive Electronic Student Worksheets based on the Dual Space Inquiry approach to stimulate students' science process skills on dynamic fluid topics. The research uses an Educational Design Research approach with the Plomp model, focusing on the preliminary research phase through needs analysis. Data were collected through observations, interviews, and questionnaires involving students and teachers and analyzed descriptively. The results indicate that students' science process skills are generally low, especially in classifying, inferring, predicting, and communicating. In addition, teaching materials have not optimally integrated science process skills and show minimal use of digital technology, while students have a high demand for interactive digital learning materials. These findings reveal a gap between SAPA-based learning expectations and classroom practices. Therefore, the development of interactive Electronic Student Worksheets based on Dual Space Inquiry is recommended to support inquiry-based learning and improve students' science process skills.

***Correspondence:**
Winda Rudespika, Department of Physics, Padang State University, Padang, Indonesia.
· email : windarudespika@gmail.com

INTRODUCTION

The development of information and communication technology in the 21st century has brought about a significant transformation in the educational world, particularly in the study of science that requires an integration between concept mastery and scientific skills. Physical learning is no longer simply oriented towards material delivery, but needs to be directed towards processes capable of building meaningful insights through an active and contextual learning experience (Selwyn, 2022). In the Independent Curriculum, learning is expected to develop scientific processing skills that allow students to construct knowledge through scientific activities such as observing, classifying, interpreting, and communicating results (Carmila, 2022; Aulia & Usman, 2023). In this context, scientific processing skills form an important cornerstone in shaping critical and analytical thinking abilities relevant to the demands of the 21st century.

Physical learning has characteristics that emphasize the union of abstract concepts and real phenomena, requiring an approach capable of effectively bridging both. Scientific processing skills serve as a means of linking theory to reality through systematic scientific inquiry activities (Ignacio & Yabut, 2025). Students who are actively involved in the process tend to have a deeper understanding because they not only receive information, but also experience the process of discovering concepts independently (Kartika et al., 2024). Therefore, effective physical learning needs to be designed by considering students' active involvement in each learning stage, so that the learning process becomes more meaningful and competency-oriented.

Various findings suggest that the implementation of physics learning in the field still faces a number of obstacles, especially in terms of the low skills of the student's science process. Science processing skills are a fundamental component of science learning that plays an important role in shaping students' scientific thinking (Evains et al., 2024). This concept is seen not only as a set of technical skills, but also as a means of developing critical, logical, and systematic thinking in understanding natural phenomena (Kurniahtunnisa et al., 2024). According to Science - A Process Approach (SAPA), scientific processing skills are transferable capabilities that reflect scientists ' behavior in conducting scientific investigations (Ignacio & Yabut, 2025). This view asserts that these skills are universal and can be applied in various disciplines, so that they have strategic value in providing students with the challenges of developing science and technology.

Learning that is still dominated by the exposure approach causes students to tend to be passive and less involved in scientific activities. One factor that contributes to the skills of the science process is the limitations of the teaching materials used in learning (Adilah & Martini, 2022). The available worksheets are not yet in accordance with the purpose of learning and have not integrated the technology and learning approaches that encourage inquiring activities (Syafrudin et al., 2025; Aisyah & Fajrina, 2025). In addition, teacher time limitations in developing innovative teaching materials are a separate obstacle in presenting quality learning (Yuliastutik & Mahbubah, 2024). This suggests that the development of technology-based teaching materials designed systematically and according to students' needs is a must in an effort to improve the quality of physics learning.

In recent years, the use of digital technology in learning has grown rapidly and provides great opportunities to increase the effectiveness of learning. The Electronic Student Worksheet as a form of digital teaching material offers various advantages, such as access flexibility, interactivity, and the ability to provide direct feedback (Mahombar & Mihardi, 2025). The use of the Student Worksheet allows students to actively engage in the learning process through structurally designed activities, thus increasing learning motivation and participation (Asrizal et al., 2023). Thus, the integration of technology in the form of the Student Worksheet is one of the relevant alternative solutions in addressing the physics learning problem in an effective and efficient manner.

Nevertheless, the use of technology in learning needs to be balanced with the right pedagogical approach to not only serve as a medium for information delivery, but also be able to stimulate the skills of science processes. The Dual Space Inquiry learning model comes as an approach that integrates physical and digital learning spaces in a balanced manner, allowing students to explore concepts through direct and virtual activities (Novitra et al., 2025). This model emphasizes the importance of students' active involvement in the structured inquiring process, so that learning focuses not only on results but also on the process of knowledge formation.

Basically, developing a study is inseparable from previous studies. First, research by (Zulfa et al., 2025) shows that inquiry-based learning is effective in increasing student activity in formulating problems, hypothesizing, and conducting investigations, but is still limited to conventional learning without digital technology support. Second, research by (Sambiri et al., 2024)it was found that science process skills contributed significantly to students' critical thinking abilities, but have not yet been supported by structured learning tools. Third, research by (Syafrudin et al., 2025) revealed that the use of the Student Worksheet could increase learning interest and provide immediate feedback, although its activities have not been fully designed to develop comprehensive science process skills. Fourth, research by (Aisyah & Fajrina, 2025) emphasized that interactive learning media can increase student participation, but it has not been specifically directed at strengthening scientific skills. Fifth, research by (Novitra et al., 2025) developed a Dual Space Inquiry model that integrates physical and digital space to create a more flexible and constructive learning experience, but is still conceptual and has not been widely implemented in concrete teaching materials and classroom learning practice settings.

The novelty of this research lies in the development of the Dual Space Inquiry-based Interactive Student Worksheet that systematically integrates the skills of science processes in each learning stage. In contrast to previous studies that tended to separate the use of technology and the inquiring approach, this study combined the two in one complete learning framework. This innovation is expected to provide a more in-depth learning experience, increase student involvement, and strengthen scientific skills in a sustainable manner. In addition, the use of interactive features in the Student Worksheet allows learning to be more interesting and adaptive to student needs.

The problem formulation in this study was directed at how the characteristics, validity, and practicality of the Dual Space Inquiry-based Student Worksheet stimulated students' science process skills. The purpose of this study was to describe the characteristics of the developed product, analyze its validity level, and evaluate its practicality in the study of physics. Expected benefits include contribution to the development of innovative teaching materials, improvement of the quality of physics learning, and provision of references to subsequent research in the field of physics education.

The urgency of this study is based on the need for learning innovation that can address the challenges of 21st century education, especially in optimally developing students' science process skills. An alternative solution offered through the development of the Dual Space Inquiry-based Student Worksheet was chosen because it has the potential to integrate scientific technologies and approaches in a balanced manner. Thus, this research is expected to make a real contribution to improving the quality of physics learning and supporting the creation of a more effective, interactive, and meaningful learning process.

METHODS

This study used an approach to research and development using a three-phase Plomp model (preliminary research, development or prototyping phase and assessment phase). This approach was chosen because it was able to integrate the product development process with empirical studies in the field systematically and repeatedly (Sugiyono, 2023). The development model used refers to the Plomp model that emphasizes iterative processes through preliminary research stages, prototype development, and assessment (Plomp & Nieveen, 2013). The choice of this model is based on its suitability in producing learning tools that are not only theoretically feasible, but also applicable in the context of real learning and effective educational implementation practices.

The research was conducted in the even semester of the academic year at one of the State High School 1 Merangin which has the characteristics of physics learning based on an independent curriculum. The selection of research sites is based on the consideration of the suitability of needs to the development of science process skills based on the results of the needs analysis (Sambiri et al., 2024; Ignacio & Yabut, 2025). The research time was designed to gradually follow the development model's path, ranging from utility analysis to product practicality tests (Farhana et al., 2025). Scheduling activities are systematically organized to ensure that each stage of the study can be carried out optimally and produce accurate data. The subjects of this study were class XI phase F students and physics teachers who were directly involved in the learning process. The determination of the subject is made using purposive sampling techniques taking into account the characteristics of students in class and readiness in the application of technology-based learning (Fitriana, 2025). In addition, validators consisting of material experts, media experts, and educational practitioners are also involved to assess the quality of the developed products. This involvement of various parties aims to obtain comprehensive data from various perspectives.

The research procedures follow the Plomp model stage starting from the preliminary research phase. This stage provides needed analysis through observation, interviews, and documentation studies to identify physics learning problems, particularly concerning the skills of science processes and the use of teaching materials (Evains et al., 2024; Rezba et al., 2007). The analysis also includes curriculum studies, student characteristics, and dynamic fluid material analysis (Aulia & Usman, 2023). The results of this stage form the basis for designing products that fit the needs of learning in the field. The next phase is the development or development of prototypes (development or prototyping phases), which are carried out in stages through product design, evaluation, and revision (Yuliaristiawan & Praherdhiono, 2024). The interactive Student Worksheet was developed by integrating the Dual Space Inquiry syntax and indicators of science process skills in each learning activity (Novitra et al., 2026). The resulting prototype was then validated by experts to assess the feasibility of the content, learning design, visual appearance, and conformity to the learning model used. This process is performed iteratively until a product that meets the valid criteria is obtained and deemed suitable for practical use.

Furthermore, the assessment phase is carried out to test the practicality of the developed products by involving students and teachers as direct users. At this stage, it was observed how ease of use, clarity of appearance, and the use of the Student Worksheet in supporting learning (Yuliaristiawan & Praherdhiono, 2024). The data obtained from this stage are used to make final improvements to the product before it is declared fit for use in the study of physics.The types of data collected in this study consisted of qualitative and quantitative data. Qualitative data were obtained from interview results, validator comments, and teacher and student responses to the use of the Student Worksheet (Ariani, 2022). Meanwhile, quantitative data is obtained from the results of validity and practice figures analyzed using the Likert scale (Sugiyono, 2023). The combination of these two types of data allows researchers to obtain a more comprehensive picture of the quality of the developed products in various relevant educational contexts.

Data collection techniques are performed through several methods, namely observation, interviewing, and distribution of questionnaires. Observations are made to view the learning conditions directly, while interviews are used to extract in-depth information from teachers and students. Instruments are used to obtain quantitative data regarding the assessment of developed products (Ginanto et al., 2024). All data collection techniques were conducted systematically to ensure that the data obtained was relevant to the purpose of the study. Data analysis techniques are performed using descriptive analysis. The results of this analysis are then associated with the purpose of the study to assess the extent to which the Dual Space Inquiry-based Interactive Student Worksheet is able to stimulate students' science process skills and contribute to improving the quality of physical learning.

To measure students' science process skills, this done by calculating the value obtaining using the following formula.

$$NP = \frac{R}{SM} \times 100\%$$

Description:
NP = Percentage value sought or expected
R = Raw score obtained by the student
SM = Ideal maximum score
100 = Fixed number
The interpretation categories of the result of the analysis of science process skills can be seen in Table 1 below.

Table 1. Criteria for Science Process Skills

Interval	Category
86-100	Very High
75-85	High
60-75	Enough
55-69	Low
≤ 54	Very Low

(Purwanto, 2013)

RESULTS AND DISCUSSION

Results

Analysis of Science Process Skills Needs

Scientific processing skills are basic skills that students must have in understanding, studying, and applying physical concepts through a systematic scientific process. These capabilities include various indicators such as observing, communicating, classifying, measuring, inference and predicting (Rezba et al., 2007). Through these skills, students are expected to be able to relate theoretical concepts to the reality of everyday life more meaningfully. Thus, the need for scientific process skills analysis is a crucial first step in designing teaching materials that can optimally stimulate students' scientific activity (Evains et al., 2024). This analysis is done by observing the skills of students in Class XII of the Merangin 1 State Senior High School. The following table presents the results of an analysis of students' science process skills based on predefined indicators.

Table 2. Result of Student Science Process Skills Analysis

Science Process Skills Indicators (Rezba et al., 2007)	Score	Category	Percentage (%)
Observing	50	Very Low	50 %
Communicating	42	Very Low	42 %
Classifying	22	Very Low	22 %
Measuring Metrically	50	Very Low	50 %
Inferring	33	Very Low	33 %
Predicting	33	Very Low	33 %

This condition suggests that students have not been able to optimize basic scientific abilities in physics learning. Indicators categorize and ask questions into aspects with the lowest achievement of 22.2%, indicating that students still have difficulty classifying data characteristics and formulating relevant scientific questions. This low ability indicates that the learning process has not fully encouraged students to think critically and actively in exploring phenomena. In addition, inferring and predicting indicators at 33.3% show that students are not used to processing observation information or connecting physical concepts with real situations. The ongoing learning still tends to be centered on teachers and has not provided sufficient space for students to conduct the scientific investigation process independently (Sulistiyono & Arini, 2025). Indicators communicating that only reached 42% also indicate that students have not been able to deliver systematic and scientific thought or findings. Furthermore, the low ability to observe and measure students' practical experience is still limited. In fact, this skill is an important part in building strong conceptual understanding through direct experience.

These findings suggest an urgent need to present learning innovations capable of systematic and sustainable integration of science process skills. One relevant alternative is the development of the Dual Space Inquiry-based Interactive Student Worksheet, which combines inquiry activities in physical and digital spaces. This learning model allows students to be directly involved in the exploration, experimentation, and reflection processes through the use of interactive technology. Thus, learning focuses not only on mastery of concepts, but also on the development of scientific skills as a whole. The implementation of this approach is expected to improve the quality of physics learning, especially in stimulating students' science process skills to be more active, critical, and able to relate concepts to real phenomena more deeply.

Analysis of Teaching Materials Problems

In addition to analyzing students' science process skills, this study also examined the actual conditions for the use of teaching materials in physical learning based on the results of document analysis and field observation. The data show that the teaching materials used are still dominated by worksheets that do not match the achievements of the learning objectives and available textbooks are still dominated by abstract concepts, while the use of digital-based teaching materials (Fauziah & Rusilowati, 2025). This condition indicates that learning is still oriented towards one-way delivery of material and has not fully provided room for students to be actively involved in the inquiring process (Noprianda et al., 2023). This limitation affects students' low chance of developing science process skills through exploratory and hands-on experience-based activities. This analysis is done by assessing the components of the student spreadsheet used by the school. The following table 3 provides the results of the analysis of student teaching materials based on the assigned indicators.

Table 3. Teaching Materials Analysis

Teaching Materials Analysis Aspects	Score	Category	Percentage (%)
Alignment of Student Worksheets with the Curriculum	80	High	80 %
Alignment of Student Worksheets with Scientific Steps	47	Very Low	47 %
Alignment of Student Worksheets with Science Process Skills	46	Very Low	46 %
Alignment of Student Worksheets with Technology Application	20	Very Low	20 %

Document analysis shows that the Electronic Student Worksheets currently used do not systematically integrate science process skill indicators and do not effectively encourage scientific activities such as formulating hypotheses, conducting experiments, and communicating findings. The materials also tend to lack the use of technology as a learning medium, resulting in limited interactivity and variation in learning experiences. This condition reflects a broader issue in which learning materials remain conventional and less responsive to the demands of modern education. Limited technology integration is often associated with constraints in teacher preparedness and time for developing innovative resources. As a result, students are not sufficiently engaged in meaningful and active learning processes. Overall, these findings indicate that existing teaching materials have not fully supported the development of science process skills and interactive learning experiences in meaningful educational contexts.

From a technology perspective, the use of Electronic Student Worksheets as interactive digital teaching materials has not yet been widely implemented in classroom practices. In fact, digital materials have strong potential to enhance engagement through features such as videos, simulations, and instant feedback. This gap between technological advancement and classroom implementation shows that learning has not fully aligned with 21st-century demands, including digital literacy and scientific thinking. The development of Dual Space Inquiry-based teaching materials offers a relevant solution by integrating physical and digital learning environments. This approach enables students to experience a combination of hands-on investigation and technology-supported exploration. Therefore, it can be seen that developing interactive Electronic Student Worksheets is a strategic effort to create more engaging, contextual, and effective learning that improves both processes and outcomes.

Analysis of Problems in the Learning Models

In addition to analyzing students' science process skills and the actual conditions of teaching material use, this study also analyzed problems in the learning model used. Based on data from the instrument, it was revealed that the majority of students had a higher preference for learning strategies involving direct experimental activities, collaboration through dialogue, and in-depth investigation activities, because these approaches were perceived as more entertaining and had a significant impact on enriching theoretical insights (Yuliastutik & Mahbubah, 2024). However, in field practice, they still tended to use an expository model that focused on the transmission of knowledge from the teacher (Kamlasi et al., 2025). Detecting these conditions is highly relevant to uncovering inhibiting factors in achieving learning objectives that can support science process skills and deepen the meaning of concepts. Table 4 contains an assessment of the scientific learning steps that were observed during the learning process.

Table 4. Analysis of Problems in the Learning Models

Problems in the Learning Models	Score	Category	Percentage (%)
Observing	33	Very low	33 %
Asking	33	Very low	33 %
Trying	50	Very low	50 %
Reasoning	22	Very low	22 %
Communicating	33	Very low	33 %

The data in Table 4 indicate that learning is still dominated by one-way information delivery, which leads to very low student engagement and limited active participation, even though effective learning requires empirical exploration, systematic observation, logical data processing, and evidence-based conclusions (Noprianda et al., 2023). The limited integration of experimental activities further exacerbates this issue, as students have minimal opportunities to conduct direct observations, test hypotheses, or perform scientific simulations, making it difficult to relate empirical data to theoretical concepts. The development of Dual Space Inquiry-based teaching materials offers a promising solution by integrating conceptual understanding with hands-on experience through structured investigative activities, enabling students to connect concepts with real-world phenomena while simultaneously strengthening evidence-based analytical skills (Fauzi et al., 2021). Thus, it can be seen that a shift toward inquiry-oriented learning is essential to enhance both science process skills and deeper conceptual understanding.

Another equally important issue relates to the lack of connection between learning materials and contextual phenomena and the low level of student participation caused by limited interactivity in the learning process. Learning materials are often presented in abstract form without being connected to real-life realities, making it difficult for them to develop meaningful understanding. The integration of interactive digital learning materials with inquiry strategies can provide a richer learning experience through simulations, discussions, and experimental activities that encourage active engagement. Thus, an experimental and investigation-based learning approach not only aligns with student preferences but has also proven effective in developing science process skills and higher-order analytical thinking skills. The shift toward learning that emphasizes scientific activities is a strategic step in improving the overall quality of the learning process.

Analysis of Student Needs

In addition to analyzing students' science process skills, the actual use of teaching materials, and analyzing learning models, this study also analyzed student needs. Detecting these conditions is highly relevant for uncovering factors that hinder the achievement of learning objectives and deepening the meaning of learning. Figure 1 displays the results of the analysis of students observed during the learning process.

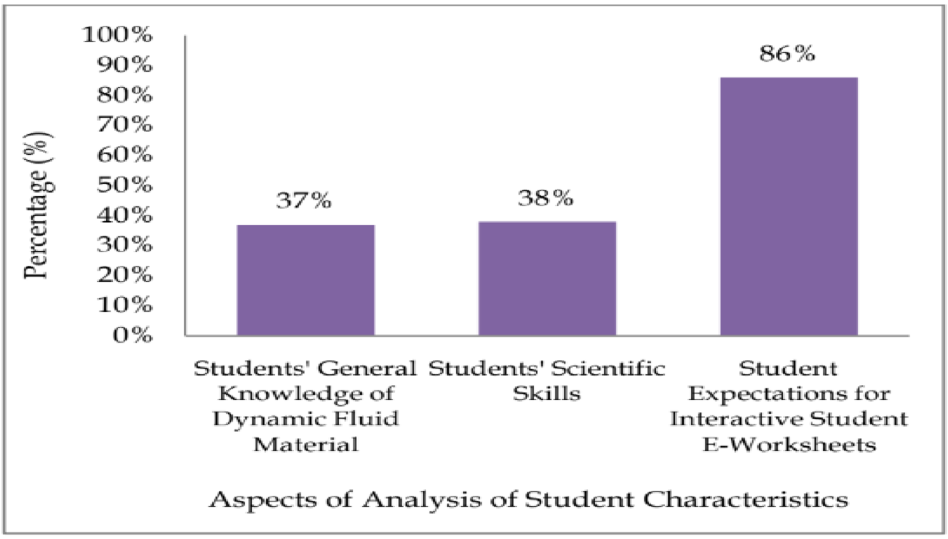

Figure 1. Student Need Analysis

The results of the student needs analysis indicate that students' initial mastery of fundamental concepts related to the learning topic remains low. Most students demonstrate limited understanding of essential principles, indicating that the conceptual foundation required to support higher-order thinking and meaningful learning has not yet been fully established. This condition is particularly problematic in science learning, where students are expected to connect abstract theoretical concepts with observable phenomena encountered in everyday life. Weak conceptual understanding restricts students' ability to interpret scientific phenomena accurately and construct new knowledge through inquiry and reflection. Furthermore, previous instructional practices have not sufficiently facilitated meaningful conceptual change or encouraged active cognitive engagement during learning activities. As a result, students tend to rely on memorization rather than deep understanding, which affects their ability to apply concepts in different contexts.

In addition, students' science process skills remain at a relatively low level, as reflected in the limited development of abilities such as observing systematically, formulating problems, designing investigations, analyzing data, and drawing evidence-based conclusions. These skills are fundamental components of science learning because they enable students to engage actively in scientific inquiry rather than functioning merely as passive recipients of information. The analysis also demonstrates that students possess very high expectations toward interactive and digital-based learning materials, reflecting a strong desire for more innovative and technology-integrated learning experiences. Students expect learning resources that incorporate interactive simulations, exploratory activities, visual representations, multimedia integration, and immediate feedback to support independent learning and conceptual clarification. Such expectations indicate an increasing awareness of the importance of technology-enhanced learning environments that can improve motivation, curiosity, and active participation. Therefore, the findings emphasize the importance of improving learning resources to better align with students' needs and expectations.

The disparity between students' low conceptual mastery and science process skills, and their high expectations for interactive digital learning, emphasizes the necessity of developing innovative and student-centered learning materials. Interactive Student E-Worksheets based on the Dual Space Inquiry model offer a relevant solution because they integrate conceptual learning with inquiry-based activities that encourage active exploration and critical thinking. Through this approach, students are guided not only to understand scientific concepts theoretically but also to investigate phenomena and construct knowledge independently through scientific inquiry processes. The integration of interactive digital features can increase learning engagement, facilitate visualization of abstract concepts, and provide opportunities for immediate feedback. These advantages support continuous learning improvement while strengthening both conceptual understanding and science process skills. Therefore, the development of Interactive Student E-Worksheets based on Dual Space Inquiry is highly essential for improving the quality of science learning.

Discussion

The results of the needs analysis indicate that students' science process skills remain in the low-to-low categories across all indicators, particularly in classifying, inferring, and predicting. Substantively, these findings suggest that physics learning has not yet facilitated students in engaging in a complete scientific process. This condition reflects a learning orientation that is still dominated by knowledge transmission rather than knowledge construction through scientific experience. However, this study reveals a more comprehensive deficiency, as nearly all science process skill indicators fall into the low category, indicating a more critical gap between curriculum demands and actual classroom practices in contemporary educational learning environments.

Demonstrating that inquiry-based learning can enhance student activity in formulating problems and conducting investigations, the present study shows a contrasting condition. In this context, inquiry activities have not been optimally implemented, mainly due to the lack of structured instructional materials supporting such processes. This difference highlights that the effectiveness of inquiry-based learning strongly depends on the availability of well-designed and systematic learning tools. From the perspective of teaching materials, the analysis shows that the existing worksheets have not optimally integrated science process skills and demonstrate low utilization of technology. Identified limited innovative teaching materials as a key factor in low learning quality. Nevertheless, this study extends previous findings by revealing that the issue lies not only in the availability of teaching materials but also in their misalignment with science process skill indicators. In other words, the problem is not merely quantitative (availability) but also qualitative (design and structure).

On the other hand, the student needs analysis reveals an interesting paradox low conceptual understanding and science process skills coexist with a very high demand for interactive digital learning materials. Reported that Electronic Student Worksheets have been effectively used to increase student interest. In contrast, this study shows that such digital learning tools are still rarely implemented, resulting in unmet student expectations for technology-integrated learning. This discrepancy indicates a significant gap between the potential of educational technology and its actual implementation in classrooms.

Furthermore, the analysis of learning models shows that instructional practices are still dominated by one-way communication, with low achievement in observing, questioning, and reasoning indicators. Emphasized that science process skills significantly contribute to students' critical thinking abilities. In this study, however, the low level of science process skills indicates that such potential cannot develop optimally due to the lack of appropriate instructional strategies. In addition, the Dual Space Inquiry model has primarily remained conceptual and has not been widely implemented in concrete teaching materials. This study contributes novel insights by linking real classroom needs with the practical implementation of this model through interactive Electronic Student Worksheets. Therefore, this research not only identifies existing problems but also proposes a structured solution that integrates inquiry-based approaches with digital technology.

Overall, the findings suggest that the challenges in physics learning are interconnected, involving low science process skills, limited teaching materials, and inappropriate instructional models. Unlike previous studies that tend to examine these aspects separately, this research provides a more integrative perspective by positioning them within a unified needs analysis framework. Thus, the main contribution of this study lies in strengthening the argument that the development of interactive Electronic Student Worksheets based on Dual Space Inquiry is not merely a technological innovation but also a pedagogical solution. This approach has the potential to bridge the gap between theory and practice by integrating physical and digital learning environments, while simultaneously stimulating students' science process skills more comprehensively than previous approaches.

CONCLUSION

Based on the results of the analysis, students' science process skills in physics learning are generally still low, especially in classifying, inferring, predicting, and communicating scientific findings. This condition indicates that students have not yet been able to actively engage in scientific processes or connect concepts with real-life phenomena. Learning practices are still dominated by teacher-centered approaches and conventional teaching materials that do not fully support inquiry activities or meaningful understanding. In addition, the limited use of interactive digital materials reduces opportunities for students to explore concepts actively, even though students show a strong need for more engaging and technology-based learning experiences. Therefore, the development of interactive Electronic Student Worksheets based on the Dual Space Inquiry approach becomes a relevant and promising solution. This approach integrates physical and digital learning experiences, allowing students to participate in structured inquiry activities while linking theory with real-world contexts. As a result, it can support the improvement of science process skills and create more meaningful, interactive, and student-centered physics learning, contributing to the advancement of innovative teaching practices and fostering deeper conceptual understanding through active scientific exploration.

REFERENCES

Adilah, J., & Martini. (2022). Keterampilan Proses Sains dalam Pembelajaran Tatap Muka. *Pensa E-Jurnal: Pendidikan Sains*, 10(3), 443–448.

Aisyah, & Fajrina, S. (2025). Pengelolaan Teknologi Pendidikan sebagai Strategi Peningkatan Mutu Pembelajaran di Era Abad ke-21: Literature Review. *Jurnal Pendidikan Tambusai*, *9*(3), 32360–32369.

Ariani, W. (2022). Praktikalitas Lembar Kerja Peserta Didik Berbasis Penemuan Terbimbing pada Materi Teorema Pythagoras. *Jurnal Pendidikan Tambusai*, 6(1), 1073–1077.

Asrizal, Dier, M., Mardian, V., & Festiyed, F. (2023). STEM Integrated Electronic Student Worksheet To Promote Conceptual Understanding And Literacy Skills of Students STEM Integrated Electronic Student Worksheet To Promote Conceptual Understanding And Literacy Skills Of Students. *Journal of Physics: Conference Series*, 2582, 012052

Dwi U, A., & Usman, H. (2023). Analisis Kebutuhan Guru dan Siswa Terhadap Pengembangan Bahan Ajar Lembar Kerja Peserta Didik Elektronik (E-LKPD) IPA Berbasis Liveworksheet Dengan Model Problem Based Learning. *Jurnal Pendidikan dan Kebudayaan (Jurdikbud)*, 3(3), 156–165.

Evains, A. C., Anggereni, S., & L, M. S. (2024). Enhancing Science Process Skills in Physics Education: The Impact of the Phyphox Smartphone Application in High School Laboratories. *Impluse: Journal of Research and Innovation in Physics Education*, 3(1), 9–18.

Farhana, H., Mustamin, Soiswaty, D. P., Ariani, A., Surachman, A., Nur, H., & Kudus. (2025). *Pengembangan Bahan Ajar Inovatif*. PT. Ganesha Kreasi Semesta.

Fauzi, A., Rahmatih, A. N., Indraswati, D., & Sobri, M. (2021). Penggunaan Situs Liveworksheets untuk Mengembangkan LKPD Interaktif di Sekolah Dasar. *Jurnal Pengabdian Masyarakat*, 2(3), 232–240.

Fauziah, A., & Rusilowati, A. (2025). Pengembangan Bahan Ajar Digital Interaktif menggunakan Canva pada Materi Energi untuk Peserta Didik Tunarungu. *Unnes Physics Education Journal*, 14(1), 43–58.

Fitriana, D. N. (2025). Peran Inovasi Digital dalam Pengembangan Teknologi Pendidikan di Era Transformasi Pembelajaran. *Indonesian Journal of Education*, *1*(1), 41–48.

Ginanto, D., Kesuma, A. T., Anggraena, Y., & Setiyowati, D. (2024). *Panduan Pembelajaran dan Asesmen 2024.* Kemendikbudristek: Badan Standar, Kurikulum, dan Asesmen Pendidikan.

Ignacio, J. D., & Yabut, J. D. (2025). Integrated Science Process Skills of Science , Technology and Engineering Students: Challenges and Opportunities for Improvement. *Jurnal Ilmiah Pendidikan MIPA*, *15*(148), 229–240.

Kamlasi, A. Y., Kollo, F. L., Kemil, T., Dorkas, M., Kale, A., Ratu, M., Fadil, R., Erwin, M., & Kevy, B. (2025). Inovasi Metode Pembelajaran Inquiry untuk Penguatan Nilai-Nilai Karakter Kewarganegaraan pada Siswa Sekolah Menengah Pertama. *Haumeni Journal of Education*, 5(3), 125–136.

Khairunnisa, K., Ita, I., & Istiqamah, I. (2020). Keterampilan Proses Sains (KPS) Mahasiswa Tadris Biologi pada Mata Kuliah Biologi Umum. *Jurnal Biologi-Inovasi Pendidikan*, 1(2), 58-

65.

Kurniahtunnisa, Wola, B. R., Harahap, F., Tumewu, W. A., & Warouw, Z. W. M. (2024). Research Trends of Science Process Skills In Indonesian Science Education Journals. *Journal of Turkish Science Education*, 21(4), 668–687.

Mahombar, A., & Mihardi, S. (2025). Dampak Penggunaan E-LKPD Interaktif Menggunakan Liveworksheets Terhadap Pemahaman Konsep Fluida. *Jurnal Penelitian Pendidikan Fisika*, 10(3), 187–192.

Noprianda, A., Wahid, M. A., & Nasir, M. (2023). The Development of Inquiry-Based Worksheets (LKPD) on Fluid Dynamics for Senior High School Student. *Jurnal Pendidikan Fisika dan Fisika Terapan*, *9*(2), 39–45.

Novitra, F., Abdullah, M. N. S., Özdemir, E., Riyasni, S., Emiliannur, Festiyed, & Metra, P. (2025). Design of Dual Space Inquiry Framework For Facilitating Flexible Learning In Digital Technology Era. *International Journal of Educational Research Open*, 8, 100424.

Novitra, F., Sundari, P. D., Muslim, Suherman, D. S., Anshari, R., Hidayati, & Dwirida, L. (2026). Mobile Learning-Enhanced Dual Space Inquiry Framework for Scientific Higher-Order Thinking: A Mixed Methods Investigation. *International Journal of Social Sciences and Humanities Open*, 13, 103032

Plomp, T., & Nieveen, N. (2013). Educational Design Research. *Netherlands Institute for Curriculum Development: SLO*, 1–206.

Purwanto, N. (2013). *Prinsip-Prinsip dan Teknik Evaluasi Pengajaran*. Bandung: PT Remaja Rosdakarya.

Rezba, R. J., Sprague, C. S., McDonnough, J. T., & Matkins, J. J. (2007). *Learning and Assessing Science Process Skills Fifth Edition*. United Stated of America: Kendall/Hunt Publishing Company.

Sambiri, U., Saputra, A., & Isra, H. H. (2024). Analisis Hubungan Keterampilan Proses Sains Terhadap Hasil Belajar Fisika Pada Mahasiswa Pendidikan Fisika Universitas Khairun. *Jurnal Sainstific Pendidikan MIPA* , *9*(1), 31–36.

Sugiyono. (2023). *Metode Penelitian Kuantitatif Kualitatif dan R & D*. Bandung: Alfabeta.

Sulistiyono, S., & Arini, W. (2025). Keefektifan Pendekatan Saintifik Terhadap Keterampilan Proses Sains Siswa SMA Kelas XI Pada Materi Fluida Statis. *Jurnal Perspektif Pendidikan*, 19(1), 48–54.

Syafrudin, Rayendra, Zen, Z., & Zuwirna. (2025). Development of E-LKPD Based on Technology Pedagogical and Content Knowledge (TPACK) in High School Mathematics Subjects. *Jurnal Penelitian Pendidikan IPA*, 11(7), 221–229.

Yuliaristiawan, E. D., & Praherdhiono, H. (2024). Penerapan Model Plomp Berbantuan Padlet Untuk Pembelajaran IPA. *Journal of Educational Technology Studies and Applied Research*, *01*(2), 1–7.

Yuliastutik, Y., & Mahbubah, S. (2024). Pendekatan Saintifik Dalam Meningkatkan Kreativitas Siswa. *Jurnal Studi Keislaman*, *6*(01), 78–85.

Zulfa, L., Fauzi, H., & Kamal, R. (2025). Analisis Sistematis Strategi Pembelajaran Inkuiri terhadap Pengembangan Keterampilan Abad 21. *Jurnal Ilmu Sosial, Pendidikan dan Humaniora*, 4(1), 382–390.