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# Analysis of Student Needs for Student Worksheet in Quantum Physics Course

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## Abstract

Background: Quantum Physics is a complex course that requires students to understand abstract concepts, mathematical formalism, and the interpretation of microscopic phenomena. Objective: This study aimed to analyze students' needs for a Student Worksheet (SW) as a basis for developing instructional materials for Quantum Physics. Methods: A quantitative descriptive approach was employed. The respondents were 40 students from the Physics Education Study Program at Universitas Jambi, cohort 2023, who were enrolled in the Quantum Physics course. Data were collected using an initial observation sheet and a needs-analysis questionnaire and were analyzed descriptively using percentages. Results: More than half of the students reported difficulties in understanding Quantum Physics, particularly because the instructional materials were in English and did not fully meet their learning needs. All respondents expressed interest in using an SW and indicated a need for supplementary instructional materials; 95% stated that an SW was needed to support independent learning. All respondents also reported that using an SW made the material easier to understand. Conclusions: The findings indicate a strong need for a systematically designed SW that uses accessible language, provides step-by-step mathematical explanations, and integrates visual representations, conceptual activities, exercises, and support for independent learning. These findings provide an initial specification for developing a Quantum Physics SW rather than evidence of the product's causal effectiveness.

**Keywords:** Student Worksheets; Quantum Physics; Instructional materials.

## Cite This Article

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## INTRODUCTION

Quantum Physics is an important component of physics education because its concepts and formalism underpin the development of modern physics and quantum technologies. At the university level, the course also occupies an important position in physics education curricula. An analysis of quantum mechanics curricula across institutions shows that quantum concepts constitute a core component of physics education, although instructional approaches, topic sequencing, and allocated instructional time vary considerably (1). This condition indicates that Quantum Physics instruction needs to be deliberately designed in accordance with students' characteristics and the demands of the subject matter.

Quantum Physics is widely recognized as challenging because it is abstract, distant from everyday experience, and strongly connected to mathematics. Borish and Lewandowski (2) showed that students perceive quantum mechanics as highly mathematical and abstract. Corsiglia et al. (3) also found that students enter quantum mechanics instruction expecting the subject to be less intuitive than other areas of physics. At the conceptual level, learning quantum physics further requires students to reconsider some of the classical intuitions they have previously developed (4).

These difficulties occur across a range of specific topics. Students experience difficulties with change-of-basis problems in quantum mechanics, including understanding the meaning of a basis and expansion coefficients (5,6). Difficulties have also been reported in solving problems involving the Dirac delta function (7), understanding the structure of equations and eigentheory (8), and making sense of degenerate perturbation theory (9). These findings suggest that learning barriers are not merely related to computational skills but also to students' ability to connect symbols, mathematical operations, and their physical meanings.

In Quantum Physics learning, the ability to move between representations becomes increasingly important. The same concept may be presented through verbal descriptions, equations, state vectors, Dirac notation, wave functions, graphs, or position- and momentum-space representations. Marshman et al. (10) showed that advanced students still experience difficulties translating state vectors expressed in Dirac notation into wave functions in position or momentum representations, and vice versa. Riihiluoma et al. (11,12) also identified differences in how students interpret probability expressions and Dirac notation in spins-first and wave-functions-first approaches. Malik and Christensen (13) demonstrated that solving change-of-basis problems also requires metarepresentational competence.

These findings on representations are consistent with broader research on the use of multiple external representations in physics learning. Lichtenberger et al. (14) showed that diagrams, graphs, manipulatives, and equations can provide complementary information. However, their effectiveness depends not simply on the number of representations provided, but on how students are guided to connect and compare them. Therefore, Quantum Physics instructional materials should support students in translating between and interpreting representations rather than merely presenting images and equations side by side.

In addition to representations, structured learning activities can function as scaffolding. Hu et al. (15) showed that inquiry-based tutorials designed around students' difficulties can support functional understanding of quantum concepts.

Passante and Kohnle (16) demonstrated that simulation-based homework activities can help students distinguish quantum uncertainty from measurement uncertainty. Didiş Körhasan and Pospiech(17) found that peer discussion and metacognitive evaluation can support the construction of quantum knowledge. Donhauser et al. (18), through a synthesis of 50 studies, also showed that research-based instructional strategies provide diverse opportunities for improving quantum learning.

A Student Worksheet (SW) has the potential to provide such structured learning activities. Research on worksheets in physics learning indicates that worksheets can guide learning activities and support learning outcomes (19,20). A study of students' perceptions at Universitas Jambi in a Solid-State Physics course also showed that worksheets were perceived as relevant learning tools (21). Studies developing worksheets based on STEM, guided inquiry, simulation, and scientific approaches further indicate that worksheets can be designed to facilitate more active and structured learning activities (22–24).

However, a Quantum Physics SW should not be understood merely as a collection of exercises. Recent research on students' learning difficulties indicates the need for instructional materials that connect phenomena, concepts, representations, and mathematical formalism. The development of quantum tutorials based on students' difficulties also highlights the importance of carefully sequenced questions and activities (15,25,26). Therefore, a user needs analysis is an important stage before developing an SW so that product specifications are grounded in empirical needs rather than solely in developers' assumptions.

This study aimed to analyze the needs of students in the Physics Education Study Program at Universitas Jambi for an SW in the Quantum Physics course. Specifically, the study identified students' difficulties, the availability of and experience with SWs, perceptions of the benefits of SWs, needs for independent learning, and desired instructional-material characteristics. The findings were used to establish the initial specifications for a Quantum Physics SW.

## METHODS

### *Study design and setting*

This study employed a quantitative descriptive design to characterize students' needs for an SW in the Quantum Physics course. The study was not designed to test the effectiveness or causal effects of SW use, but rather to identify learning conditions and the required instructional-material specifications.

### *Population, samples and sampling*

The participants were 2023-cohort students in the Physics Education Study Program at Universitas Jambi who took the Quantum Physics course in 2025. The sample consisted of 40 students selected using purposive sampling. Eligible respondents were students who were currently taking or had completed the Quantum Physics course and therefore had direct experience with the learning resources and instructional processes under investigation

### *Instruments and criteria*

The instruments consisted of an initial observation sheet and a needs-analysis questionnaire. The questionnaire addressed students' difficulties in understanding Quantum Physics, the availability of SWs, their ability to understand the material without an SW, perceived ease of understanding after using an SW, the need for an SW as a learning resource, the need for independent learning support, prior experience using SWs, and interest in using an SW. The original manuscript did not provide sufficient information regarding the total number of items, content-validation procedures, reliability, or the instrument-development process. These details should be completed from the original research records before final submission.

### *Procedure and data collection*

Data were collected by administering the needs-analysis questionnaire to 40 respondents. The research procedures comprised identifying learning problems, developing the instrument based on needs indicators, collecting data, analyzing response percentages, interpreting the identified needs, and formulating the initial characteristics of the SW. The original manuscript mentioned the possibility of interviews but did not report interview data in the Results section. Therefore, interviews were not treated as a data source in the revised manuscript.

### *Statistical analysis*

The data were analyzed descriptively using response frequencies and percentages. The percentage was calculated as :

$$P = (f/N) \times 100\%$$

where P is the percentage, f is the frequency of respondents in a particular category, and N is the total number of respondents. Because several percentages in the original table were inconsistent with the sample size of 40, the corresponding values should be verified against the raw data before submission.

### *Ethical concideration*s

Participation in this study was voluntary. Before completing the questionnaire, respondents were informed about the purpose of the study, the use of the collected data, and their right to participate or decline participation. No directly identifiable information was collected, and all responses were treated confidentially and used solely for research purposes. Completion and submission of the questionnaire were considered as respondents' consent to participate in the study.

## RESULTS

The needs-analysis results showed that more than half of the students reported difficulties in understanding Quantum Physics. These difficulties were mainly associated with the instructional materials used, which were perceived as not fully accessible to the students' learning needs. The respondents also expressed a strong need for supplementary instructional materials in the form of an SW.

**Table 1.** Results of the needs questionnaire for an SW in the Quantum Physics course

| No. | Indicator | Ya | Tidak |
|---|---|---|---|
| **1** | Interested in using an SW to learn Quantum Physics | 100% | 0% |
| **2** | Students and lecturers have an SW | 80% | 20% |
| **3** | Able to understand Quantum Physics without an SW | 85% | 15% |
| **4** | Easier to understand after the lecturer uses an SW | 100% | 0% |
| **5** | Need an SW to support learning activities | 100% | 0% |
| **6** | Need an SW to support independent learning | 95% | 5% |
| **7** | Have never used an SW | 40% | 60% |
| **8** | Interested in using an SW for learning | 100% | 0% |

## DISCUSSION

### *Students' Difficulties in Learning Quantum Physics*

The finding that more than half of the students experienced difficulties in understanding Quantum Physics is consistent with the characteristics of quantum learning reported in recent studies. Students face challenges when connecting mathematical formalism with physical meaning, particularly in change of basis, Dirac notation, the Dirac delta function, eigenvalues, and perturbation theory (5,7,9). Thus, the difficulties identified among the respondents should not be interpreted simply as a lack of practice, but as an indication of the need for scaffolding that helps students coordinate physical and mathematical reasoning.

The use of English-language instructional materials should also be interpreted cautiously. The data indicate that students perceived the language of the learning resources as a barrier; however, the study did not directly assess their language proficiency. Therefore, the appropriate conclusion is that students perceived the available materials as not fully accessible, with language identified as one contributing factor. An Indonesian-language SW may represent one possible design response, provided that scientific terminology remains accurate.

### *The SW as Scaffolding*

All students (100%) stated that they needed an SW to support learning, and 95% indicated a need for an SW to support independent learning. At the same time, 85% reported that they could understand Quantum Physics without an SW. This pattern should not necessarily be viewed as contradictory. Pedagogically, an SW can be positioned as scaffolding that organizes learning steps rather than as the sole source of knowledge. Findings on inquiry-based tutorials and structured questions in quantum learning support this interpretation (15,26).

This finding is also consistent with a study of students' perceptions of worksheets at Universitas Jambi, which showed that students had prior experiences and perceptions of worksheets as learning tools (21). Accordingly, the need for an SW identified in this study can be understood as a need for a more structured and accessible learning framework, particularly for students who are less familiar with worksheet-based learning.

### *The Need for Multiple Representations*

Students expressed a need for formula explanations, illustrations, simulations, and additional exercises. This need has direct implications for SW design. A Quantum

Physics SW should not merely present mathematical equations but should connect equations with visual representations, graphs, symbols, and verbal explanations. Marshman et al. (10) showed that students continue to experience difficulties translating quantum states across representations. Lichtenberger et al. (14) emphasized that multiple external representations can provide complementary information, although their benefits depend on how students are guided to connect the representations.

Accordingly, SW activities can be designed to: (1) identify a phenomenon or problem; (2) read and explain a visual representation; (3) write or interpret an equation; (4) connect graphs with equations; and (5) provide a physical interpretation of mathematical results. Such a design is stronger than simply adding images because it requires students to translate between representations.

The Need for Conceptual Activities, Simulations, and Exercises students' need for simulations and additional exercises is also supported by research on activity-based quantum learning. Passante and Kohnle (16) showed that interactive simulation-based activities can help students explore relationships among quantum states, experimental settings, and outcome distributions. Hu et al. (15) used inquiry-based tutorials to provide gradual support for understanding quantum concepts. Keebaugh et al. (25) also showed that interactive tutorials can be developed based on students' difficulties with many-particle wave functions.

However, simulations should not become an end in themselves. They should be embedded in the SW alongside prediction, observation, explanation, and reflection questions. In this way, students do not merely run a simulation but use the simulation outcomes to construct and test their understanding.

### *Implications for SW Specifications*

Based on the findings and the literature, the recommended initial SW specifications comprise six characteristics. First, the language should be clear Indonesian while maintaining accurate physics terminology. Second, the material should be presented progressively, from phenomena or problems to concepts and mathematical formalism. Third, the SW should integrate multiple representations. Fourth, exercises should progress from conceptual questions and representation interpretation to mathematical application and problem solving. Fifth, simulations or visualizations should be used when they clarify the phenomenon. Sixth, guidance and reflection should be provided to support independent learning.

These specifications are consistent with evidence that worksheets can guide learning activities (19,20), while research-based quantum tutorials use students' difficulties as a basis for designing learning activities (15,18). Thus, the needs-analysis findings provide a clear bridge from empirical learning problems to product design.

### *Study Limitations*

This study has several limitations. First, the respondents were limited to 40 students from one study program and one cohort, so generalization should be made cautiously. Second, the instrument primarily measured perceived needs rather than conceptual or mathematical ability directly. Third, the study did not examine the validity, practicality, or effectiveness of an SW. Fourth, several important methodological details—particularly instrument validity and reliability and the raw

data underlying certain percentages—were not available in the source manuscript. These limitations should be addressed before submission.

## CONCLUSIONS

The needs analysis indicates that students have a strong need for an SW as supplementary instructional material in the Quantum Physics course. All respondents expressed interest in using an SW and indicated that it was needed to support learning, while 95% stated that an SW was needed to support independent learning. All respondents also reported that using an SW made the material easier to understand. These findings should be interpreted as students' perceptions of the benefits of an SW rather than as evidence of causal effectiveness.

The main implication is that a Quantum Physics SW should be designed as a systematic scaffolding tool. The initial specifications include accessible language, step-by-step mathematical explanations, multiple representations, illustrations or visualizations, simulations accompanied by guiding questions, sequenced exercises, problem-solving activities, and support for independent learning. Future research should develop a prototype based on these specifications and evaluate its validity, practicality, and effectiveness.

## CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## FINDING

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## DECLARATION OF ARTIFICIAL INTELLIGENCE USE

This study used an artificial intelligence (AI) tool during manuscript preparation. An AI-based language model, ChatGPT, and Quilbort was employed for language refinement, including improving grammar, sentence structure, readability, and clarity of the manuscript. AI was not used for data collection, data analysis, modeling, data preprocessing, data visualization, simulation, interpretation of research findings, or drawing scientific conclusions.

We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

## REFERENCES


1. Buzzell A, Atherton TJ, Barthelemy R. Quantum mechanics curriculum in the U.S.: Quantifying the instructional time, content taught, and paradigms used. Phys Rev Phys Educ Res. 2025;21:10102. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010102
2. Borish V, Lewandowski HJ. Student reasoning about quantum mechanics while working with physical experiments. Phys Rev Phys Educ Res. 2024;20:20135. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020135
3. Corsiglia G, Pollock SJ, Passante G. Intuition in quantum mechanics: Student perspectives and expectations. Phys Rev Phys Educ Res. 2023;19:10109. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.19.010109
4. Patterson Z, Ding L. Epistemic framing analysis of secondary students during instruction on quantum physics. Phys Rev Phys Educ Res. 2025;21:10116. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010116
5. Corsiglia G, Schermerhorn BP, Sadaghiani H, Villaseñor A, Pollock S, Passante G. Exploring student ideas on change of basis in quantum mechanics. Phys Rev Phys Educ Res. 2022;18:10144. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.18.010144
6. Schermerhorn BP, Corsiglia G, Sadaghiani H, Passante G, Pollock S. From Cartesian coordinates to Hilbert space: Supporting student understanding of basis in quantum mechanics. Phys Rev Phys Educ Res. 2022;18:10145. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.18.010145
7. Tu T, Li CF, Xu JS, Guo GC. Students' difficulties with the Dirac delta function in quantum mechanics. Phys Rev Phys Educ Res. 2023;19:10104. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.19.010104
8. Stephens Serbin K, Wawro M. Pedagogical moves related to analogy that support a unified understanding of eigentheory concepts in a quantum mechanics class. Phys Rev Phys Educ Res. 2024;20:20137. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020137
9. Keebaugh C, Marshman E, Singh C. Challenges in sensemaking and reasoning in the context of degenerate perturbation theory in quantum mechanics. Phys Rev Phys Educ Res. 2024;20:20139. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020139
10. Marshman E, Maries A, Singh C. Using multiple representations to improve student understanding of quantum states. Phys Rev Phys Educ Res. 2024;20:20152. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020152
11. Riihiluoma WD, Topdemir Z, Thompson JR. Symbolic forms analysis of expressions for probability in Dirac and wave function notations for spins-first students. Phys Rev Phys Educ Res. 2025;21:10105. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010105
12. Riihiluoma WD, Topdemir Z, Thompson JR. Comparative analysis of spins-first and wave functions-first students' understanding of expressions in quantum mechanics. Phys Rev Phys Educ Res. 2025;21:10113. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010113
13. Malik I, Christensen W. Metarepresentational competence in quantum mechanics change of basis problems. Phys Rev Phys Educ Res. 2026;22:10130. Available from: https://doi.org/10.1103/1pby-45md

14. Lichtenberger A, Kokkonen T, Schalk L. Learning with multiple external representations in physics: Concreteness fading versus simultaneous presentation. J Res Sci Teach. 2024;61(9):2258–90. Available from: https://doi.org/10.1002/tea.21947
15. Hu P, Li Y, Singh C. Investigating and improving student understanding of the basics of quantum computing. Phys Rev Phys Educ Res. 2024;20:20108. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020108
16. Passante G, Kohnle A. Interactive homework to support student learning of measurement uncertainty in quantum mechanics. Phys Rev Phys Educ Res. 2024;20:20131. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020131
17. Didiş Körhasan N, Pospiech G. Examination of students' quantum physics knowledge construction with peers and metacognitive evaluations. Phys Rev Phys Educ Res. 2024;20:20153. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020153
18. Donhauser A, Bitzenbauer P, Qerimi L, Heusler S, Küchemann S, Kuhn J, et al. Empirical insights into the effects of research-based teaching strategies in quantum education. Phys Rev Phys Educ Res. 2024;20:20601. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.20.020601
19. Putri AD, Murtiani, Desnita, Dewi WS. Meta analysis of the effect of using student worksheets on aspects of knowledge in high school physics learning. Pillar Phys Educ. 2021;14(3):213–9. Available from: https://doi.org/10.24036/11885171074
20. Putri IY, Desnita, Putra A, Murtiani. Meta analysis of the effect of student worksheet use on student learning outcomes. Pillar Phys Educ. 2022;14(4):251–8. Available from: https://doi.org/10.24036/12191171074
21. Darmaji D, Pujaningsih FB, Tambunan JL. Study of student perception of student work sheet in introduction to solid substance physics course. EduFisika J Pendidik Fis. 2022;7(2):177–84. Available from: https://doi.org/10.59052/edufisika.v7i2.22769
22. Anugrah A, Herlina K, Suyatna A. Inquiry-integrated STEM on electronic student worksheet: An effort to stimulate creative thinking and collaborative skills. J Ilm Pendidik Fis Al-Biruni. 2023;12(2):251–63. Available from: https://doi.org/10.24042/jipfalbiruni.v12i2.17306
23. Nadiana S, Masta N, Malau ND, Faradiba F. The development of work and energy student worksheet based on scientific approach. Proceedings of the 3rd International Conference of Education and Science (ICES 2021). Jakarta, Indonesia: EAI; 2022. Available from: https://doi.org/10.4108/eai.17-11-2021.2318669
24. Sudirman S, Qaddafi M. The application of student worksheets based on PhET simulation to increase the concept understanding in Hooke's law. J Pendidik Fis. 2023;11(1):73–85. Available from: https://doi.org/10.26618/jpf.v11i1.9505
25. Keebaugh C, Marshman E, Singh C. Improving student understanding of fermionic and bosonic wave function. Phys Rev Phys Educ Res. 2025;21:10123. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010123
26. Li Y, Singh C. Improving student understanding of quantum measurement in infinite-dimensional Hilbert space using a research-based multiple-choice question sequence. Phys Rev Phys Educ Res. 2025;21:10104. Available from: https://doi.org/10.1103/PhysRevPhysEducRes.21.010104