Physics Workbook on Simple Harmonic Motion: Student Perception

Metta Liana[1*], and *Emmiliannur* Emmiliannur[2]

[1]Faculty of Teacher Training and Education, Universitas Maritim Raja Ali Haji, Jl. Raya Dompak, Tanjungpinang, Indonesia
[2]Departement of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka, Air Tawar, Padang, Indonesia

Abstract. In the 21st century, increasing technology and knowledge integration in human activities necessitates a workforce capable of adapting to evolving changes and equipped with essential 21st-century skills. Among these skills, critical thinking and problem-solving stand out as pivotal components. Consequently, to prepare high school students as future contributors to the workforce, they must possess these skills. An effective strategy to cultivate critical thinking and problem-solving skills is the implementation of workbooks in the learning process. These workbooks should feature teaching materials that incorporate multiple multimodal representations. This quantitative research employs primary data collection and survey methodology, utilizing a Likert scale questionnaire distributed to class X students in high schools within Bandung City. The study involves 35 respondents, addressing six questions. The finding reveals a strong consensus among respondents regarding the effectiveness of the workbooks in well-training critical thinking. Additionally, respondents' express agreement on the efficacy of workbooks in honing problem-solving skills. It is important to note this research focuses specifically on the study of workbooks related to simple harmonic material.

1 Introduction

The 21st century is a century of knowledge and technology where information is widely spread, and technology continues to develop which helps many human activities. The development of technology and a variety of free resources in the cross-border interaction environment has brought about various significant changes that have ever happened before. In utilizing technology, higher human abilities are needed so that it can be of optimal and maximum benefit [1]. Various countries in the world are competing to increase their competitiveness to be able to adapt to new environments and be able to become the best community whose existence is taken to account in world relations. A country's competitiveness does not lie in the natural resources (NR) it has but lies in the quality of human resources (HR) with the knowledge and competence they must transform various assets and resources in the surrounding environment.

* Corresponding author: mettaliana@umrah.ac.id

Indonesia has made various efforts to face the challenges of the technological era, both internally and externally. Efforts to face internal challenges by preparing quality Indonesian HR so that they have competence and skills to face the increasingly rapidly developing technological era. HR are prepared by providing natural knowledge that underlies technological development. For example, if high school students are only armed with knowledge, then that knowledge will expire and be replace with the latest knowledge [1]. These high school students also have potential or learning in other areas that also need proportional attention to develop optimally [2]. Therefore, the provisions that must be provided in preparing future HR and the next generation (especially student) must have critical thinking skills [3] and problem-solving.

These skills are known as 21st-century skills. Per the 21st Century Partnership Learning Framework, there are a few competencies that human resources must have in the 21st century. These two skills are not innate from birth, so these skills can be applied, trained, and developed through the learning process. To realize this, education has an important role in preparing human resources who have superior competence in the future.

Bloom's taxonomy, introduced several decades ago, brought critical thinking to the forefront by categorizing major cognitive processes into six classes [4]. The initial three classes encompass knowledge, involving the capacity to recall previously acquired information; comprehension, focusing on the ability to understand the meaning, articulate, and restate ideas; and application, which centres on the skill to apply learned material in novel situations. These three classes collectively constitute the lower level of thinking, primarily engaging in processes related to remembering, relating, and applying information, respectively [4].

According to several previous studies, critical thinking can be defined as follows: (1) reasonable and reflective to decide what to believe or do [5]; (2) the skills and inclination to involve oneself in some activities with reflective scepticism [6]; (3) the aptitude for critical thinking encompasses problem-solving, concluding, foreseeing outcomes with consideration of probability, and the capacity to make informed decisions [7]; (4) the process of critical thinking involves the interpretation, analysis, evaluation, and inference, encompassing the elucidation of evidence, methodologies, concept, criteria, or contextual consideration or decide self-regulation in deciding something [8]. Critical thinking skills have a lot of factors. The primary determinant is curriculum, typically designed with an inclusive scope of instructional content. The secondary factor pertains to educators' proficiency in grasping learning models conducive to enhancing critical thinking skills. The last factor is the student adapts to practice critical thinking skills [1].

Problem-solving is a sophisticated cognitive skill for students in our increasingly complex world [9,10]. It involves the capacity to discern the nature of a problem, break it down analytically, and formulate a strategic plan to address the associated challenges [9]. This cognitive process is integral to goal achievement and fosters the development of practical skills for real-world problem resolution [11]. Additionally, problem-solving significantly influences the construction of thoughts and knowledge, providing students a platform to collaborate with peers, engage socially, exchange innovative ideas, think critically, and organize creative solutions collaboratively[12,13].

The value of students' problem-solving skills extends beyond academic performance, encompassing their comprehension and engagement in learning activities at each stage of the problem-solving process [14]. Proficiency in problem-solving entails a comprehensive understanding of the issues at hand and the sequential steps involved, forming the bedrock for informed decision-making and subsequent problem-solving strategies [15]. This understanding is crucial for effective knowledge construction and meaningful learning experiences in various disciplines, including statistical learning [16]. Moreover, students' comprehension is pivotal in determining their learning outcomes and enthusiasm. A thorough

understanding of a problem precedes the formulation of informed decisions and solutions, drawing upon the students' existing knowledge base [17]. In essence the ability to grasp the intricacies of a problem is fundamental for successful problem resolution and underscores the importance of prior knowledge in decision-making [15,18].

Existing research underscores a noteworthy observation that students completing their secondary education demonstrate commendable proficiency in theoretical knowledge but exhibit a deficiency in problems [19]. Gunawan et al. investigation in Indonesia further substantiates this by revealing a subpar average score in critical thinking skills among students, necessitating a comprehensive analysis for enhanced development [20]. The evident inadequacy in the problem-solving capabilities of these graduates raises concerns about their adaptability to societal demands. This issue is particularly salient in the context of the 21st century, characterized by globalization, free trade, and regional autonomy, demanding a workforce equipped to navigate diverse challenges [1]. Furthermore, research conducted by Sinaga et al. shows that students' abilities in the problem-solving process depend on how well the students understand and define a problem [21]. As they understand the process, their 21st century skills will improve. The imperative for individuals to thrive in various circumstances underscores the pressing need for fortifying problem-solving skills among graduating students.

Integrating 21st-century skills into the educational process can be effectively facilitated through instructional materials incorporating diverse representations, particularly in natural sciences such as physics, chemistry, and biology, which explore physical phenomena. Drawing on Lemke's research, it is evident that students can enhance their critical thinking and problem-solving abilities by constructing and developing their cognitive processes. These representations extend beyond verbal communication, encompassing visual elements such as images, diagrams, tables, and text [22]. Concept presentation employs multiple modes, called multi-presentations, to render concepts more meaningful. This aligns with the findings of Sinaga et al., indicating that students possess varying abilities in grasping the concepts of learning materials. Thus, when students encounter difficulty comprehending a concept through one presentation, introducing alternative representations proves beneficial [23]. Additionally, Gobert and Clemet's research underscores the efficacy of depicting phenomena through various visual modes, suggesting that such approaches contribute to enhanced student learning compared to tasks presented in singular formats [24].

Based on these three main points, teaching materials are needed to develop students' skills in critical thinking and problem-solving using a teaching module/ workbook that applies the multimode representation method. Research conducted by Liana et al. shows that by using workbooks for middle school students, it capable or can be used as facilities used at the educational level to train critical thinking and problem-solving skills [25]. This research aims to determine how middle school students respond after using workbooks with multimode representation to improve critical thinking and problem-solving skills.

2 Research Method

This research is classified within the realm of descriptive research, employing surveys as the primary method for data collection. The survey instrument is utilized to gather information from either a subset or the entire population, specifically focusing on the attitudes and responses [26,27] of high school students after they utilize a physics workbook incorporating multimode representation in the context of the subject of simple harmonic motion. The study targets class X high school students in Bandung City who have undergone physics instruction utilizing workbooks dedicated to simple harmonic motion, amounting to 35 participants. Data acquisition is executed through administering a Likert scale questionnaire disseminated

directly to the respondents and comprises 26 questions organized into 6 distinct components. These components are assessed according to the numerical indicators delineated in Table 1.

Table 1. Question components in the questionnaire.

No	Student Perception Questionnaire Competency	Item Number
1	Critical thinking skills competency [1,4,22]	1, 2, 3, 4, 5, 6, 7
2	Workbook presentation [28]	8, 9, 10, 11
3	Problem solving skills competency [15,21]	12, 13
4	Writing and grammar [28]	14, 15, 16
5	Multimode representation [22,29–31]	17, 18, 19
6	Motivation to learn [29,30]	20, 21, 22, 23, 24, 25, 26

These 6 components are developed by previous research for seeking the student's response after using the workbook. After the collection of responses from participants regarding each questionnaire item, data processing ensues [32]. The analysis of the gathered data is conducted by interpreting the responses following the predefined intervals established by the Likert scale [32], as outlined in Table 2. The evaluation weight is computed to derive a comprehensive assessment, facilitating the generation of interpretative outcomes for each assessment component [27,33].

Table 2. Assessment interval.

Interval	Interpretation Score
0% - 24,99%	Strongly disagree
25% - 49,99%	Disagree
50% - 74,99%	Agree
75% - 100%	Strongly agree

3 Result and Discussion

Table 3. Student responses regarding the components of critical thingking skills in the workbook developed.

Item	Statement	% Score	Interpretation Score
1	Workbook can practice my basic clarification skills	75,71	Strongly agree
2	Workbook can train basic skills in making decisions or supporting my decisions or supporting me	76,43	Strongly agree
3	Workbook can train my inference skills	73,57	Agree
4	Workbook can train my advanced clarification skills	75,00	Strongly agree
5	Workbook can train my strategy and tactics	74,29	Agree
6	Workbooks make physics lessons more meaningful because they present everyday phenomena	80,00	Strongly agree

7	Workbook made me aware of the importance of physics in life	72,14	Agree
Average responds		75,31	Strongly agree

Based on Table 3, students strongly agree that the workbook can train critical thinking skills. It is proven by the positive answers given by students that the workbook can contain activity components to practice critical thinking skills. The workbook allows students to develop critical thinking skills [14,34]; this aligns with research by Fadlillah et al. that critical thinking can improve students' logical skills, which is one of the skills of the 21st century [4].

Table 4. Student responses regarding the presentation components of the workbook.

Item	Statement	% Score	Interpretation Score
8	The appearance of this workbook is very attractive	75,71	Strongly agree
9	The descriptions of activities in the workbook are arranged systematically so that they are easy to understand	95,00	Strongly agree
10	Workbook layout makes it easier for me to do each activity	75,00	Strongly agree
11	The composition of the use of images and writing in this workbook is appropiate to your needs	70,00	Agree
Average responds		78,93	Strongly agree

Additionally, the layout is conducive to efficient student engagement. This favorable response is inherently linked to the deliberate composition of the visual and textual elements within the workbook, thoughtfully structured to cater to the student's learning needs. The juxtaposition of image and text directly results from the workbook's development methodology, grounded in the deliberate incorporation of multi-mode representation principles. Effective educational materials, exemplified by the workbook under scrutiny, adhere to stringent criteria, including accurate and lucid conceptual explanations, methodical sequencing of content, encompassing both inductive and deductive reasoning, maintaining an appropriate depth and breadth of subject matter in alignment with students' developmental stages, and seamlessly integrating verbal and visual representations throughout while maintaining a coherent sequence in the utilization of diverse modes of representation. The results of research by Utami et al. also explained that students agreed that using workbooks was easy to understand and enabled students to learn effectively [35].

Table 5. Student responses regarding the components of problem solving skills.

Item	Statement	% Score	Interpretation Score
12	Workbook can practice problem solving skills using complete, sequential prblem solving stages	76,43	Strongly agree
13	In the narrative in the workbook there are no terms that I don't know the meaning of	67,14	Agree
Average responds		71,79	Agree

In addition to fostering critical thinking skills, students concur that the developed workbook effectively cultivates problem-solving abilities through a comprehensive, sequential, and systematic approach to problem resolution [14]. Furthermore, students systematically assess their problem-solving proficiencies through the questions posed after each lesson within the workbook [36]. Students receive grades and constructive instructor feedback upon completing the workbooks, facilitating subsequent review and comprehension. Additionally, students affirm that the workbook's narrative lacks unfamiliar terms, enhancing overall comprehension and promoting a conducive learning environment.

Table 6. Student responses on writing and grammar components.

Item	Statement	% Score	Interpretation Score
14	The workbook display is very attractive	78,57	Strongly agree
15	The descriptions of activities in the workbook are arraged systematically so that they are easy to understand	76,43	Strongly agree
16	The composition of the use of images and writing in this workbook is appropiate to your needs	75,71	Strongly agree
Average responds		76,90	Strongly agree

According to the findings presented in Table 6, students express a robust consensus regarding the writing and grammar components. Specifically, students strongly agree that the sentences employed in the workbook are readily comprehensible. Additionally, students attest to the simplicity and readability of the utilized fonts and the clarity of symbols incorporated in the workbook. Workbooks should be arranged structured to make it easier for students to understand the material provided so that it is interesting [37].

Table 7. Student respnses about multimode representation components.

Item	Statement	% Score	Interpretation Score
17	The multimode representation (verbal, mathematical, images, graph, and diagrams) in this workbook helped me understand various concepts	75,71	Strongly agree
18	The multimode representation (verbal, mathematical, images, graph, and diagrams) in this workbook help me understand various natural phenomena scientifically	70,00	Agree
19	The multimode representation (verbal, mathematical, images, graph, and diagrams) in this workbook are as needed	68,57	Agree
Average responds		71,43	Agree

Derived from the outcomes of data processing of employed multi-mode representation components within the developed workbook, it is discerned that students express concurrence regarding the efficacy of multi-mode representation-encompassing verbal, mathematical, images, graphs, and diagrams. This consensus affirms that integrating diverse modes of representation in the workbook significantly contributes to students' comprehension of

various concepts [38]. Moreover, students acknowledge the utility of this approach in facilitating a scientific understanding of phenomena, emphasizing its sufficiency in aiding their comprehension [37].

Table 8. Student responses about the components of learning motivation.

Item	Statement	% Score	Interpretation Score
20	Workbook can improve my way of learning	78,57	Strongly agree
21	Workbook encourages me to discuss with other friends	80,00	Strongly agree
22	Workbook can increase your desire to learn	75,00	Strongly agree
23	Workbook makes learrning physics fun	78,57	Strongly agree
24	Workbook allows me to study independently at home/ at school/ wherever I am	77,14	Strongly agree
25	Workbook stimulated my curiosity	75,71	Strongly agree
26	Workbook can make my learning more confused	80,00	Strongly agree
Average responses		77,86	Strongly agree

As indicated by the data presented in Table 8, students express a robust consensus, strongly affirming that a developed workbook serves as a potent motivator, encouraging sustained and active engagement [39] in the study of physics, both within the school environment and beyond, encompassing home or other locations. Additionally, utilizing this workbook enhances students' focus during the learning process. Incorporating assignments within the workbook, specifically those necessitating discussion, catalyses heightened interest in the study of physics, fostering an increased enthusiasm for the subject. Moreover, the questionnaire administered post-utilization of the workbook serves as a valuable tool for eliciting students' suggestions and input, thereby contributing to ongoing enhancements in educational material development.

4 Conclusion

Based on the result of the research conducted, in several component groups studied, students strongly agreed that critical thinking skills could be trained well after using workbooks in the learning process. This is because the workbook presented is equipped with sequential critical thinking indicators. Students also strongly agreed that the workbook presented contains problems that can be solved using problem-solving stages. Critical thinking and problem-solving skills can be easy to understand and interesting for students. However, for multimode representation, students' responses were in the agreed category. This indicates that some students still think that more than multimode representation is needed to help students understand concepts. Students generally agreed that physics workbooks using multimode representation can increase learning motivation for the learning motivation component. Overall, students responded positively that workbooks using multimode representation can train critical thinking and problem-solving skills. So, this workbook is appropriate for a learning process that facilitates 21st century skills. This research only examines high school students' responses to simple harmonic movement material. For future research, it is hoped that they can research different materials or fields of science.

References

1. M. M. Chusni, S. Saputro, Suranto, and S. B. Rahardjo, Journal of Critical Reviews **7**, 1230 (2020)
2. R. Denya Agustina, M. Minan Chusni, and M. Ijharudin, in *J Phys Conf Ser* (Institute of Physics Publishing, 2019)
3. L. Mutakinati, I. Anwari, and Y. Kumano, Jurnal Pendidikan IPA Indonesia **7**, 54 (2018)
4. A. Fadlillah, O. Purwati, and S. Setiawan, *Critical Thinking on the Perspective of Indonesian Students in Language Learning* (2019)
5. R. H. Ennis, Educational Leadership **43**, 44 (1985)
6. J. E. McPeck, Educational Researcher **19**, 10 (1990)
7. D. F. Halpern, American Psychologist **53**, 449 (1998)
8. P. A. Facione, *Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction* (The California Academic Press, Millbrae, CA, 1990)
9. M. E. Oliveri, R. Lawless, and H. Molloy, ETS Research Report Series **2017**, 1 (2017)
10. S. Sutarno, A. Setiawan, I. Kaniawati, and A. Suhandi, J Phys Conf Ser **895**, 1 (2017)
11. P. C. Mefoh, M. B. Nwoke, J. C. Chukwuorji, and A. O. Chijioke, Think Skills Creat **25**, 47 (2017)
12. A. Fitriani, S. Zubaidah, H. Susilo, and M. H. I. AL Muhdar, Eurasian Journal of Educational Research **20**, 45 (2020)
13. K. Sutarmi and I. M. Suarjana, Jurnal Ilmiah Sekolah Dasar **1**, 75 (2017)
14. O. Melawati, E. Evendi, A. Halim, Y. Yusrizal, and E. Elisa, Jurnal Penelitian Pendidikan IPA **8**, 346 (2022)
15. C. A. Toll, Read Teach **70**, 413 (2017)
16. C. Wang, J. Li, H. Li, Y. Xia, X. Wang, Y. Xie, and J. Wu, BMC Med Educ **22**, 469 (2022)
17. T. Laurens, F. A. Batlolona, J. R. Batlolona, and M. Leasa, EURASIA Journal of Mathematics, Science and Technology Education **14**, (2017)
18. R. E. Simamora, E. Surya, and D. Rotua Sidabutar, Article in International Journal of Sciences Basic and Applied Research **33**, 321 (2017)
19. A. Malik, M. Minan Chusni, and Yanti, in *J Phys Conf Ser* (Institute of Physics Publishing, 2019)
20. Y. Yuliana Gunawan and F. Nurosyid, ITALIENISCH **12**, 137 (2022)
21. B. Sinaga, J. Sitorus, and T. Situmeang, Front Educ (Lausanne) **8**, (2023)
22. J. L. Lemke, in *Reading Science Critical and Functional Perspectives on Discourses of Science* (Routledge, Canada, 1998), pp. 87–113
23. P. Sinaga and A. Suhandi, International Journal of Sciences: Basic and Applied Research (IJSBAR) International Journal of Sciences: Basic and Applied Research **15**, 80 (2014)
24. J. D. Gobert and J. J. Clemet, J Res Sci Teach **36**, 39 (1999)
25. M. Liana, P. Sinaga, and E. Emiliannur, Jurnal Penelitian Pendidikan IPA **9**, 7503 (2023)
26. O. D. Apuke, Kuwait Chapter of Arabian Journal of Business and Management Review **6**, 40 (2017)
27. J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Method*, 5th ed. (SAGE Publications, Singapore, 2018)
28. V. Prain and B. Waldrip, Canadian Journal of Science, Mathematics and Technology Education **8**, 5 (2008)

29. A. Putri, D. Lengkana*, and T. Jalmo, Jurnal Pendidikan Sains Indonesia **10**, 606 (2022)
30. M. Azizah, K. Herlina*, A. Abdurrahman, and N. A. Himawan, Jurnal Pendidikan Sains Indonesia **11**, 512 (2023)
31. D. Rosengrant, E. Etkina, and A. Van Heuvelen, in *AIP Conf Proc* (AIP, 2007), pp. 149–152
32. S. Sugiyono, *Metode Penelitian Kuantitatif Kuantitatif Dan R&D* (Alfa Beta, Bandung, 2013)
33. L. Gideon, *Handbook of Survey Methodology for the Social Sciences* (Springer New York, New York, NY, 2012)
34. M. Menap, F. Bayani, and S. Prayogi, Jurnal Penelitian Pendidikan IPA **7**, 118 (2021)
35. A. R. Utami, D. Aminatun, and N. Fatriana, Journal of English Language Teaching and Learning **1**, 7 (2020)
36. B. Fatmawati, M. K. Wazni, and N. Husnawati, Jurnal Penelitian Pendidikan IPA **7**, 701 (2021)
37. F. Jeppsson, K. Danielsson, E. Bergh Nestlog, and K.-S. Tang, Educ Sci (Basel) **12**, 221 (2022)
38. A. Doyan, M. M. Rahman, and S. Sutrio, Jurnal Penelitian Pendidikan IPA **7**, 175 (2021)
39. N. Khaira, Y. Yusrizal, A. Gani, M. Syukri, E. Elisa, and E. Evendi, Jurnal Penelitian Pendidikan IPA **6**, 143 (2020)