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Digital Worksheet Transformation for Contextual Learning : Integration of PBL, SSI, and STEM

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Abstract: This study aims to examine the needs and expectations for the development of digital student worksheets based on Problem-based Learning (PBL), Socio-scientific Issues (SSI), and Science, Technology, Engineering, Mathematics (STEM), which can enhance students' critical thinking skills. This study employed a descriptive method using mixed approachs involving 105 respondents consisting of 73.3% teachers and 26.7% students from 20 provinces in Indonesia. Data were collected through an online questionnaire, in-depth interviews, curriculum analysis, and literature review, then analyzed using triangulation to validate the findings.The results showed that the majority supported the development of flipbook-based digital worksheets, featuring keyword search, links to videos or animations, and interactive quizzes. The integration of PBL enables students to solve real-world problems, such as the impacts of smoking habits or air pollution, while the SSI approach fosters social awareness. The STEM approach provides opportunities for students to conduct experiments and generate creative solutions relevant to everyday life. This study concludes that the development of PBL-SSI-STEM-based worksheets is not only aligned with deep learning but also provides meaningful learning experiences. These worksheets are expected to help students understand abstract concepts, enhance critical thinking skills, and prepare them to face global challenges through innovative technological approaches.

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Introduction

The human respiratory system is one of the essential topics in science education at the junior high school level. This material includes abstract concepts, such as the structure of respiratory organs, the function of the respiratory system, and health issues related to the system (Hsiao et al., 2022; Nielsen, 2020; Slovinsky et al., 2021). These conditions often pose challenges for students in understanding the material without the aid of effective learning media. Therefore, it is necessary to develop Student Worksheets specifically designed to visualize these concepts (Hanif, 2020; Hapsari et al., 2019; Newton & Zeidler, 2020). According to Rahmawati et al. (2023), the use of interactive science-based worksheets can enhance students' understanding of abstract concepts through engaging and structured presentations.

With the development of technology in the field of education, digital-based learning media have become increasingly relevant (Rehmat & Hartley, 2020; Saricam & Yildirim, 2021). Phandini et al. (2023) explained that digital media such as flipbooks provide flexibility for students to access learning materials anytime and anywhere. Additionally, features like

direct links to videos or animations and keyword searches make it easier for students to understand abstract and complex concepts. Fatmawati et al. (2023) added that digital-based worksheets can also increase student engagement by up to 86%, making learning more interesting and efficient.

However, the use of digital media alone is not sufficient to create meaningful learning experiences. Modern education requires approaches that not only deliver knowledge but also develop students' critical thinking skills, creativity, and analytical abilities (Ebal et al., 2019; Herman et al., 2020; Mohseni et al., 2020). Problem-based STEM (Science, Technology, Engineering, Mathematics) learning approaches enable students to develop creativity and critical thinking skills through learning that is relevant to real-world contexts (Astuti et al., 2021; Hasanah, Ritonga, et al., 2021; Lee et al., 2020). This approach becomes even more effective when combined with Problem-Based Learning (PBL) and Socio-scientific Issues (SSI) (Hiwatig et al., 2024; Meliani Hartato et al., 2024; Roehrig et al., 2021). According to Johnson et al. (2020), integrating STEM with SSI in problem-based learning not only enhances students' understanding of the material but also builds their awareness of social issues such as the dangers of smoking and air pollution.

Moreover, PBL-based learning provides students the opportunity to actively seek solutions to real-world problems relevant to their lives (Crespí et al., 2022; Neuwirth et al., 2021; Santos-Meneses et al., 2023). Supriatna et al. (2020) revealed that this approach can increase students' learning motivation while building soft skills, such as collaboration and communication. By linking learning to real-life contexts, students not only understand the material but also develop higher-order thinking skills that meet the demands of the 21st century (Akcanca, 2020; Amrulloh & Galushasti, 2022; Dare et al., 2021; Romero Ariza et al., 2024).

This study aims to develop a flipbook-based digital worksheets by integrating PBL, STEM, and SSI approaches in the human respiratory system material. The worksheets are designed to help students understand respiratory system concepts while building critical thinking skills through contextual issues such as the dangers of smoking and the impacts of air pollution. This study explores various aspects, including the design and content of the worksheets, the integration of the STEM approach, the presentation of SSI-based problems, the worksheets' ability to encourage students' critical thinking skills, and features in digital flipbook-based worksheets that facilitate student learning. The results of this study are expected to provide a comprehensive overview of the needs and expectations of teachers and students, serving as a basis for developing innovative, relevant, and engaging human respiratory system worksheets. These flipbook-based digital worksheets not only aim to enhance students' understanding of abstract material but also prepare them to become critical thinkers who are aware of their roles in addressing real-world challenges by optimizing the use of technology (Lee et al., 2020; Susanto et al., 2022).

Research Method

This study employed a descriptive method using mixed approachs that combined quantitative and qualitative data to gain a comprehensive understanding of expectations for the development of PBL-STEM-SSI-based worksheets for the human respiratory system material. The study involved 105 respondents, consisting of 73.3% teachers and 26.7% students from 20 provinces and 49 districts/cities in Indonesia. Respondents were purposively selected to represent diverse geographical areas, educational levels, and socioeconomic backgrounds.

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Data collection was conducted through multiple methods to support data triangulation. First, a quantitative survey was conducted using an online questionnaire containing questions about respondents' expectations regarding the design, features, and content of PBL-STEM-SSI-based worksheets. The survey was designed to measure respondents' preferences for visual design, accessibility, relevance of socio-scientific issues, and interactive features. Second, in-depth interviews were conducted with a subset of respondents selected randomly to explore their reasons behind specific preferences, particularly related to the worksheet design, interactive features, and relevance of the PBL-STEM-SSI approach in teaching the human respiratory system. These interviews were used to triangulate the data and validate survey findings. Third, an analysis of the junior high school curriculum was conducted to ensure that the human respiratory system material aligned with the PBL-STEM-SSI approach, including learning outcomes, objectives, and content scope. Fourth, a literature review was conducted to analyze sources related to PBL, SSI, STEM, and critical thinking skills to strengthen the theoretical foundation for developing the worksheets.

Data processing was conducted systematically to produce valid findings. Survey data were analyzed descriptively using frequency distributions and percentages to illustrate respondents' preferences. Data visualization, including bar charts, pie charts, and distribution maps, was used to provide a clearer overview. Interview results were analyzed thematically to identify patterns and main themes from respondents' answers, while also serving as data triangulation to reinforce and validate the quantitative analysis findings. Additionally, curriculum and literature analyses were conducted qualitatively to identify the relationship between the PBL-STEM-SSI approach, the human respiratory system material, and critical thinking skills.

Results and Discussion

The highest number of respondents came from Nanggroe Aceh Darussalam (18 teachers, 3 students) across several districts. North Maluku also had notable participation (5 teachers, 3 students), mainly from North Halmahera. In Sumatra, North Sumatra contributed 16 teachers from districts like North Labuhanbatu, Deli Serdang, and Medan. The Java region saw active involvement, with Central Java (10 respondents) and West & East Java (5 each) from cities like Garut, Tasikmalaya, Gresik, and Madiun. Eastern Indonesia, including South Papua, East Nusa Tenggara, and Kalimantan, also participated, with South Papua contributing two teachers from Asmat and Central Kalimantan recording one teacher and one student from Pulau Pisang.

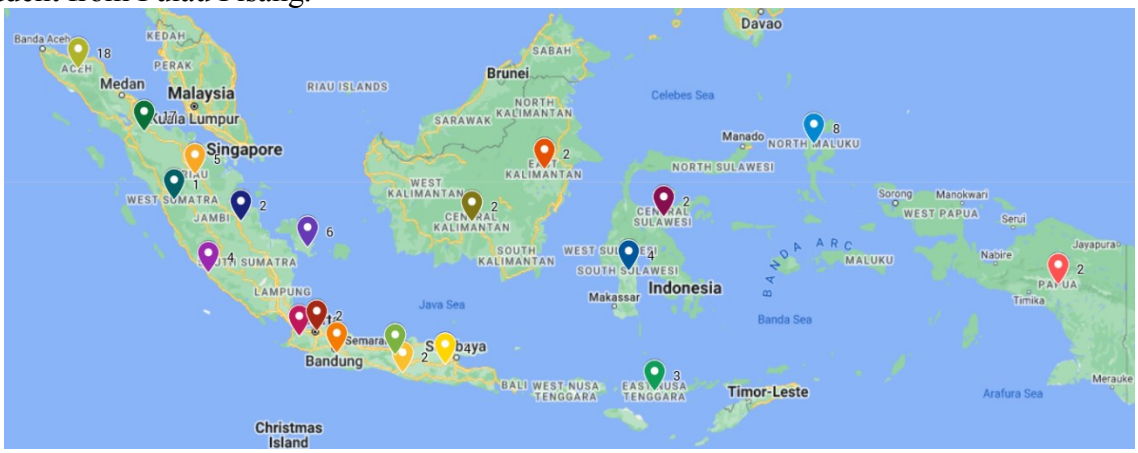

Figure 1. Map of Respondents' Distribution Across 20 Provinces in Indonesia

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This study reflects the geographical diversity of respondents, from Sabang to Merauke, highlighting the varied needs and expectations for developing PBL-STEM-SSI-based digital worksheets. The distribution of respondents, encompassing diverse educational levels, geographical environments, and socioeconomic backgrounds, provides critical insights for creating relevant, contextual, and innovative worksheets.

Experience in Using Worksheets in the Human Respiratory System Material

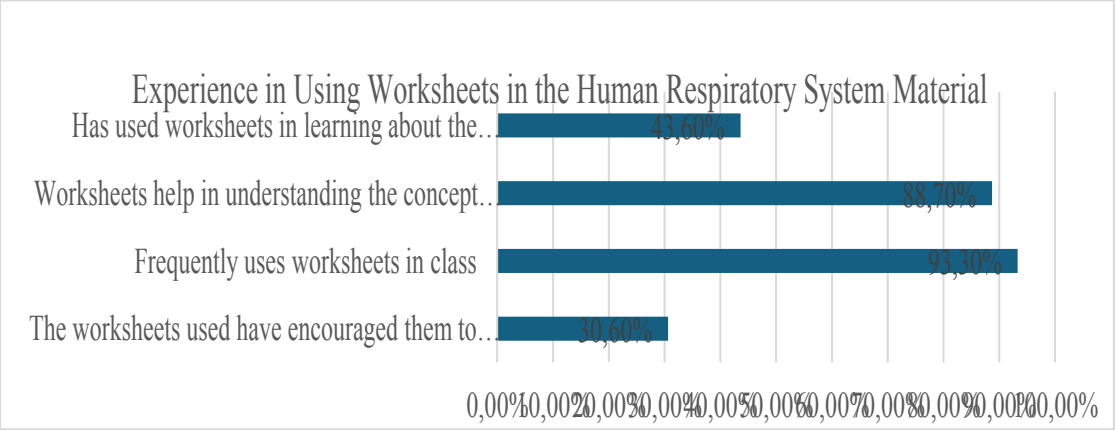

Figure 2. Experience in Using Worksheets in the Human Respiratory System Material

This indicates that worksheets are widely used in classrooms, presenting an opportunity for further enhancement. Most respondents found worksheets effective for material comprehension, though further analysis is needed to optimize their use. Variations in usage frequency suggest the need for more equitable implementation to ensure all students benefit equally. Worksheets have encouraged critical thinking, particularly on respiratory health issues like smoking and air pollution, demonstrating their effectiveness (Laksono & Wibowo, 2022; Romero Ariza et al., 2024). However, improvements are needed to better stimulate higher-order thinking skills.

The Importance of Worksheets for the Respiratory System Material

The analysis shows that most respondents find student worksheets effective for learning about the respiratory system, as they aid in understanding abstract concepts and fostering critical thinking. However, some suggest improving design and quality for a broader impact. Visually-based worksheets help students grasp complex structures through diagrams and case studies, such as smoking hazards (Al Wafi, 2022; Khoirunnissa et al., 2024). They reinforce key concepts, support case-based problem-solving (Bencze et al., 2020), and enhance collaboration skills (Al Wafi et al., 2022). Overall, worksheets strengthen understanding (Hernández-Ramos et al., 2021), critical thinking (Hacioğlu & Gülhan, 2021), and social awareness (Susilawati et al., 2021) by integrating Socio-scientific Issues (SSI).

Expectations for Content and Material in Worksheets for the Human Respiratory System

Most respondents expect worksheets to address the dangers of smoking among teenagers, reflecting their concern about its relevance to students. While smoking remains a priority topic, other health issues like air pollution are also important. No respondents dismissed real-world connections, emphasizing their importance in learning. Worksheets should include thought-provoking questions that analyze smoking's effects on the respiratory system, fostering critical thinking (Davut Gul & Akcay, 2020). Risk-based questions and case studies enhance engagement by linking concepts to real issues (Chen & Xiao, 2021; Hsiao et al., 2022). Clear, concise, and progressively structured content is essential, ensuring

accessibility and relevance to students' lives (Zeidler et al., 2019). A communicative and familiar presentation style further enhances student engagement.

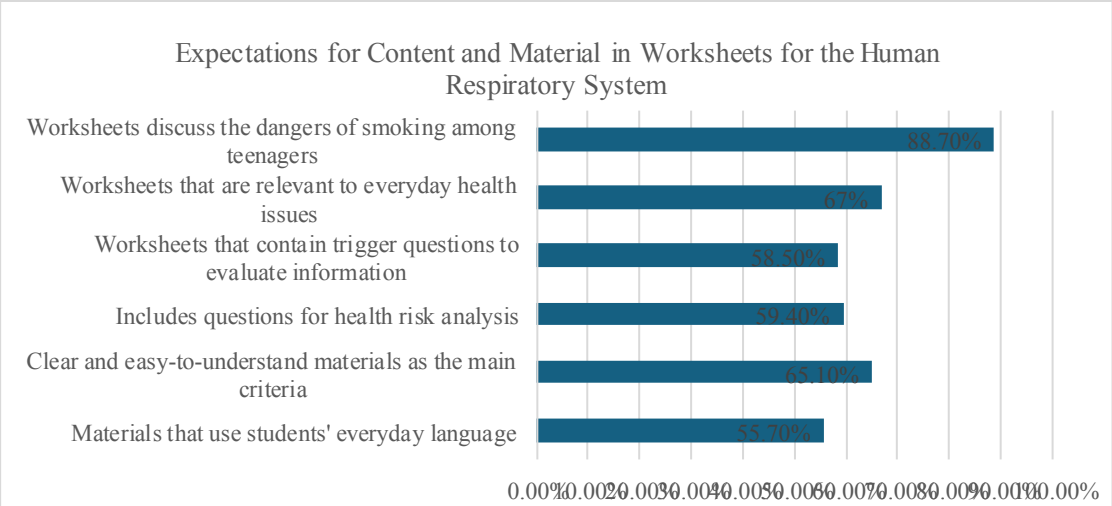

Figure 3. Expectations for Content and Material in Worksheets

Effectiveness of PBL-SSI-STEM in Enhancing Student Understanding

The study shows that respondents expect interactive worksheets to enhance critical thinking. Smoking hazards are highly relevant to students' lives, requiring engaging and contextual presentation. A teacher noted that visualizations and case studies on smoking's health effects improve understanding and participation. PBL, SSI, and STEM approaches are effective. Smith (2022) states that PBL fosters problem-solving through inquiry, while Ke (2021) highlights SSI's role in connecting science to real life. STEM encourages interdisciplinary thinking to solve complex problems (Hacioğlu & Gülhan, 2021; Sutaphan & Yuenyong, 2023).

The implementation of PBL-SSI-STEM-based worksheets in the classroom involves several key steps. First, students identify problems such as smoking hazards through articles, data, or videos. Second, students work in groups to discuss and analyze the impact of smoking on the respiratory system. Third, STEM project development takes place, where students design simple tools to help them understand scientific and technological concepts. Finally, students reflect on their learning and present their project outcomes through presentations or reports.

This approach provides multiple benefits for students. PBL-SSI-STEM-based worksheets helps strengthen conceptual understanding through visual illustrations and problem-solving activities. Additionally, analytical and problem-solving tasks train students to evaluate information and make data-driven decisions, thus fostering critical thinking skills. Through STEM projects, students can apply scientific concepts to real-world solutions (Wahono et al., 2021), enhancing their creativity and technical skills (Roehrig et al., 2021). The integration of SSI in worksheets nurtures students' social awareness of global issues such as smoking hazards, making learning more relevant to their everyday lives (Eidin & Shwartz, 2023).

Expectations for Practical Activities and Question Types in Worksheets

Respondents prefer simple experiments with accessible materials, highlighting the importance of tool availability in STEM-based learning. They support contextual experiments, like creating a smoke detection device, to enhance understanding of pollution's impact on respiration while developing critical thinking and practical skills (Yapıcıoğlu, 2021). Additionally, they favor real-life problem-solving questions, emphasizing the need for

diverse, case-based questions on smoking effects and air pollution to create meaningful learning experiences.

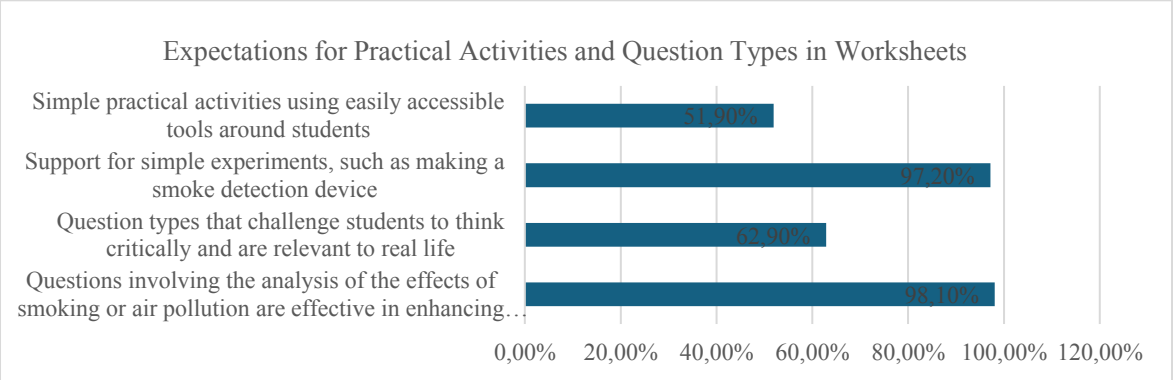

Figure 4. Expectations for Practical Activities and Question Types in Worksheets

Study results indicate that real-life-based experiments, such as investigating the effects of cigarette smoke or air pollution, are highly anticipated. Questions relevant to real health issues—particularly those that challenge students to think critically through case studies and problem-solving—are a top priority. Additionally, respondents expect the use of technology and collaborative projects as a learning variation to enhance students' skills (Sari et al., 2021). This supports the development of interactive, contextual, and 21st-century skill-oriented worksheets.

Relevance to Deep Learning

Study results indicate that both students and teachers expect real-life-based practical activities and contextual experiments that promote critical thinking, aligning with the principles of deep learning. A teacher interviewed stated that simple experiments, such as simulating the impact of cigarette smoke on the lungs, can help students understand abstract concepts more easily and in a more relevant way. Deep learning, as defined by Saricam & Yildirim (2021), engages students in activities that foster critical thinking, creativity, collaboration, and communication. This approach is supported by the integration of Socio-scientific Issues (SSI), which connects learning to global issues such as air pollution and smoking habits (Slovinsky et al., 2021), as well as Problem-Based Learning (PBL), which effectively builds critical thinking and problem-solving skills (Susanto et al., 2022). Additionally, Wahono (2021) emphasizes the importance of STEM education in providing cross-disciplinary experiences through the integration of science, technology, engineering, and mathematics.

Deep learning-based worksheets support contextual experiments (Hasanah, Ritonga, et al., 2021), such as simulating cigarette smoke effects, analyzing case studies, and creating educational projects like posters. Technology, including interactive videos and animations, helps visualize abstract concepts and boost engagement. This approach enhances conceptual understanding, critical thinking (Astuti et al., 2021), and social awareness. STEM projects foster creativity and 21st-century skills (Akcanca, 2020), making this worksheet model relevant for modern learning and real-world challenges (Rehmat & Hartley, 2020).

Expectations for Reflection, Design, and Media in Worksheets

Respondents prefer reflection activities involving visualization, creativity, and personal engagement, such as creating educational posters on healthy lifestyles for respiratory health. This helps students connect healthy habits with their impact on respiration. They also emphasize the importance of an engaging and easy-to-understand worksheet design. A colorful layout with clear anatomical illustrations enhances visual appeal and conceptual

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understanding. Additionally, images and videos are considered essential for grasping respiratory system concepts, highlighting the role of interactive visual media in supporting STEM learning.

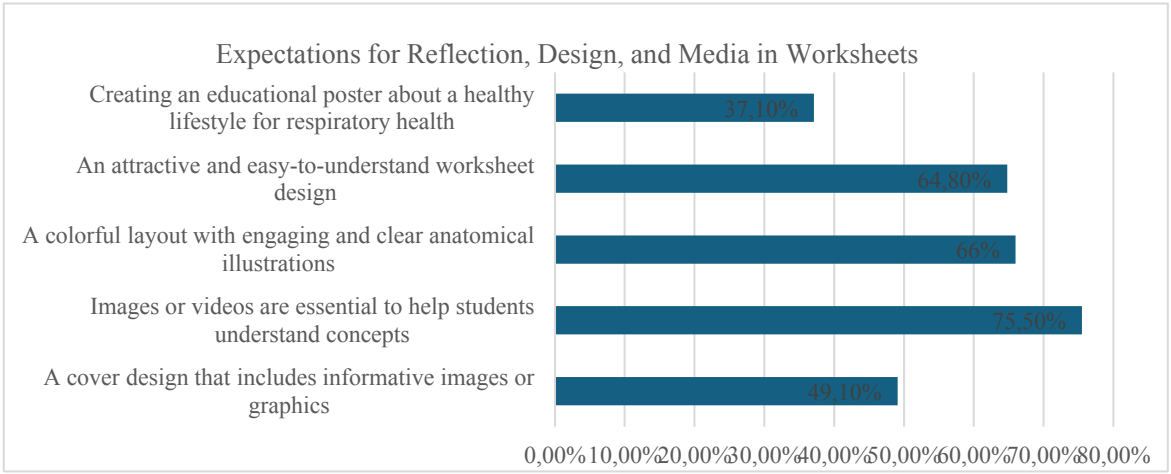

Figure 5. Expectations for Reflection, Design, and Media in Worksheets

The study highlights key elements for effective worksheet design. One teacher noted that reflection activities like creating posters or group discussions help students understand respiratory health while enhancing collaboration. Such activities, including writing personal health plans, make learning more relevant (Smith et al., 2022). Visually appealing design is also crucial, incorporating colors, clear anatomical illustrations, and interactive media like videos or infographics to simplify abstract concepts. Additionally, informative visual elements on the cover enhance appeal and provide a material preview. Prioritizing reflection, design, and media fosters deeper understanding and real-life connections, creating meaningful learning experiences (Widowati et al., 2021).

Expectations for Digital Worksheets in the Form of an Online Flipbook

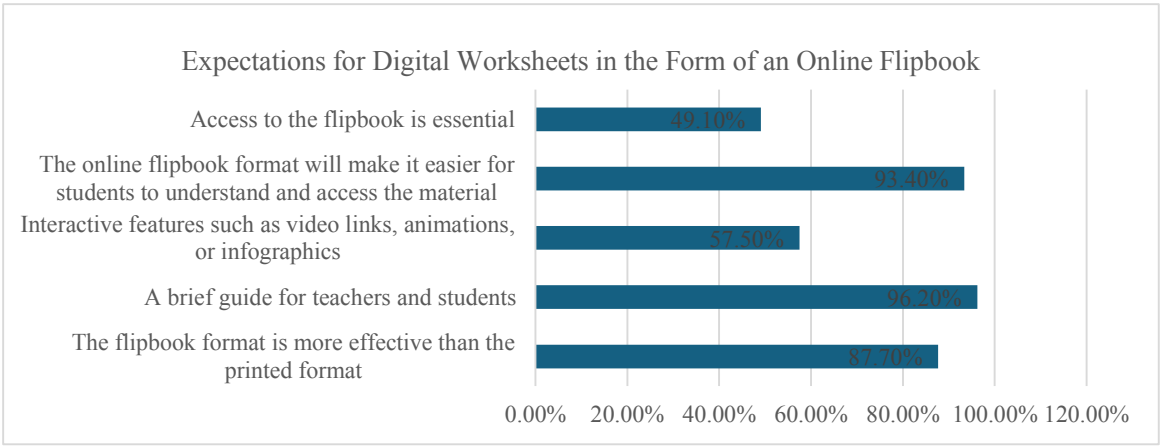

Figure 6. Expectations for Digital Worksheets in the Form of an Online Flipbook

Respondents consider flipbook access crucial, appreciating its interactive and flexible format for learning. Many believe the online flipbook enhances understanding and accessibility, highlighting its potential to improve learning effectiveness. Strong support exists for interactive features like videos, animations, and infographics to make learning more engaging. While the flipbook format is preferred over printed versions, respondents emphasize the need for brief guides to help teachers and students use it effectively.

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Relevance of Digital Flipbook to Modern Learning

The study shows that the digital flipbook is highly relevant to learning about the human respiratory system. One teacher mentioned that the digital flipbook can enhance students' understanding through the visualization of engaging and interactive concepts, as well as helping them relate the learning material to everyday experiences. Respondents highlighted the importance of interactive features, accessibility, and intuitive design that align with modern learning needs. The digital flipbook offers learning flexibility by allowing students to access materials through various devices such as laptops and smartphones, thus not being limited to the classroom (Fatmawati et al., 2023). Additionally, its intuitive design and navigation make students feel more comfortable, as the flipbook is not only aesthetically pleasing but also functional. Teachers and students also desire interactive elements, such as quizzes, explanatory videos, and animation simulations, to help understand abstract concepts more effectively (Hernández-Ramos et al., 2021). These features not only ease the learning process but also increase student engagement. With easy access to materials anytime and anywhere, the digital flipbook becomes a modern solution that supports flexible and interactive learning, in line with the needs of 21st-century education (Amalya et al., 2021).

Conceptual and Practical Implications

Although most respondents agree that worksheets (LKPD) are essential, the study indicates that not all students find the current worksheets effective. This highlights the need to improve both the content and design of LKPD to better align with 21st-century learning needs. Enhancements such as incorporating more visual illustrations, project-based activities, and clearer instructions can increase student engagement and comprehension.

Conceptually, the findings confirm that integrating Problem-Based Learning (PBL), Socio-Scientific Issues (SSI), and STEM into LKPD can create more meaningful learning experiences. Consistent with Yapıcıoğlu (2021), a STEM-based approach enables students not only to deepen their understanding of scientific concepts but also to develop critical thinking and innovation skills in solving real-world problems. These findings also support the theory that context-based learning can enhance student engagement and the relevance of subject matter to daily life.

From a practical perspective, implementing interactive and digital-based LKPD, such as digital flipbooks, offers significant benefits. Flipbooks can enhance flexibility, interactivity, and student engagement through features like videos, interactive quizzes, and responsive design. However, the successful implementation of this approach heavily depends on infrastructure support, teacher and student training, and accessibility across different devices. For schools in areas with limited internet access, providing an offline version should be considered to ensure that all students can utilize the digital LKPD effectively. Additionally, digital flipbooks can be integrated into project- and problem-based learning, helping students connect theoretical knowledge with real-life experiences. This contributes to the development of a technology-driven curriculum that not only enhances digital literacy but also fosters creativity and problem-solving skills. Thus, these research findings provide valuable insights into the development of more effective and relevant digital learning materials for science education in the modern era.

Conclusion

Based on the results of this study, it can be concluded that the majority supported the development of flipbook-based digital worksheets, featuring keyword search, links to videos or animations, and interactive quizzes. The integration of PBL enables students to solve real-world problems, such as the impacts of smoking habits or air pollution, while the SSI

approach fosters social awareness. The STEM approach provides opportunities for students to conduct experiments and generate creative solutions relevant to everyday life. This article concludes that the development of PBL-SSI-STEM-based worksheets is not only aligned with deep learning but also provides meaningful learning experiences. These worksheets are expected to help students understand abstract concepts, enhance critical thinking skills, and prepare them to face global challenges through innovative technological approaches.

Recommendation

Teachers are encouraged to actively integrate digital worksheets into their lessons by utilizing interactive features such as videos, infographics, and relevant audio elements to enhance student engagement. Additionally, providing clear and simple user guides will help both teachers and students navigate the worksheets effectively. Regular evaluation and refinement based on student and teacher feedback are essential to maintaining the worksheets' relevance and effectiveness in learning. Teachers can also facilitate collaborative and discussion-based activities using the worksheets to promote deeper understanding and critical thinking. Moreover, incorporating reflective exercises within the worksheets can further support students' metacognitive development and learning retention.

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