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Enhancing Fifth-Grade Students' Conceptual Understanding of the Human Respiratory System Through the PAREPIA Teaching Aid

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Abstract: This study aimed to examine the effectiveness of the **PAREPIA teaching aid** in enhancing fifth-grade students' conceptual understanding of the human respiratory system. A quantitative approach employing a quasi-experimental nonequivalent control group design was conducted with 64 fifth-grade students, comprising 32 students in the experimental class and 32 students in the control class. Data were collected using a 25-item multiple-choice test administered as a pretest and posttest. The data were analyzed using the Rasch Model with stacking analysis through Winsteps 4.8.2 to evaluate changes in students' conceptual understanding. The results showed that the experimental class achieved greater conceptual gains than the control class. The mean measure increased from 0.28 to 1.70 logits (+1.42 logits) in the experimental class, whereas the control class increased from 0.24 to 1.19 logits (+0.95 logits). These findings indicate that the PAREPIA teaching aid effectively facilitates students' conceptual understanding by providing interactive, hands-on learning experiences that help transform abstract concepts into concrete understanding. Therefore, the PAREPIA teaching aid is effective in improving fifth-grade students' conceptual understanding of the human respiratory system and contributes to enhancing the quality of elementary science education.

Keywords: Conceptual understanding; Elementary science education; Human respiratory system; PAREPIA teaching aid; Rasch model

Introduction

Natural and Social Sciences (IPAS) instruction within the *Kurikulum Merdeka* (Independent Curriculum) is designed to help students understand various natural and social phenomena through contextual learning experiences. The learning process is no longer oriented toward rote memorization of information; instead, it emphasizes students' ability to construct knowledge based on observation, inquiry, and problem-solving (Sakina et al., 2026). This shift requires teachers to facilitate learning that fosters critical thinking, scientific literacy, and problem-solving skills—competencies essential for navigating 21st-century challenges. Research indicates that the use of innovative instructional media creates more meaningful learning experiences, enabling students to more easily connect concepts with real-life phenomena (Hidayah et al., 2025; Nuraini et al., 2024). Aligning with these findings, Anas & Hartono (2024) explain that instructional media serve as tools that help students build understanding through more concrete learning experiences. Therefore, IPAS instruction needs to be designed innovatively to not only enhance learning outcomes but also cultivate students' ability to grasp concepts comprehensively.

The success of Natural and Social Sciences (IPAS) instruction is heavily influenced by students' ability to build conceptual understanding. Conceptual understanding goes beyond the mere ability to recall information; it encompasses the capacity to explain relationships between concepts, interpret phenomena, and apply existing knowledge to different situations.

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Students who lack a comprehensive grasp of concepts often struggle when faced with problems requiring scientific reasoning. Saputra & Mustika (2022) argue that conceptual understanding serves as a crucial foundation for developing higher-order thinking skills, as it requires students to connect prior knowledge with new information. These findings are supported by research from Khairini et al. (2021), which demonstrates that instruction actively involving students contributes more effectively to conceptual understanding than one-way instruction. Furthermore, the use of media and teaching materials tailored to the characteristics of the subject matter has been shown to help students construct concepts more effectively (Handayani et al., 2021). Consequently, enhancing conceptual understanding must be a primary focus in the implementation of IPAS instruction in primary schools.

One topic within the Natural and Social Sciences (IPAS) curriculum at the elementary school level that requires special attention is the human respiratory system. This topic demands that students not only identify the names and functions of respiratory organs but also understand the mechanisms of inhalation and exhalation, as well as the interrelationships between organ systems within the body. Due to the abstract nature of the subject matter, students often struggle to grasp the concepts when instruction relies solely on verbal explanations or textbooks. Maknun (2022) explain that the human respiratory system requires instructional media capable of visualizing organ structures and respiratory processes, thereby making it easier for students to understand the connections between concepts. Research by Sukmawati et al. (2025) further demonstrates that the use of teaching aids can transform abstract concepts into more concrete learning experiences through direct observation and demonstration. These findings indicate that teaching the respiratory system requires strategies that enable students to observe, explore, and link concepts to real-life phenomena.

Various efforts have been made to enhance the quality of IPAS instruction by developing media that foster more interactive learning experiences. Using media aligned with the material's characteristics has been shown to boost student participation during lessons while helping them build a deeper conceptual understanding. Hardiansyah & Mulyadi (2022) report that flipbook-based media increase student engagement by presenting material in a more appealing and accessible manner. Research by Alika & Radia (2021) also indicates that game-based learning media provide opportunities for active learning through exploration and problem-solving activities. Furthermore, Erlitaviana & Tyas (2025) reveal a positive correlation between the use of instructional media and learning motivation, which in turn leads to improved student learning outcomes. These findings suggest that the success of IPAS instruction depends not only on teaching methods but also on the teacher's ability to select media that suit both the subject matter and the students' needs. Therefore, the use of instructional aids serves as a potential alternative to help students understand the concept of the human respiratory system in a more concrete and meaningful way.

Various studies have reported that instructional innovations contribute positively to enhancing the quality of science education in primary schools. However, research focuses have varied widely, ranging from improving scientific literacy and developing teaching materials to implementing specific instructional models. Sukmawati & Zulherman (2023) reported that the implementation of the RADEC model improved students' scientific literacy skills through instruction that encouraged reading, analyzing, discussing, and creating solutions to problems. Other research has also shown that the use of local wisdom-based practical demonstration videos enhances scientific literacy skills by providing students with more contextual learning experiences (Arrauyani & Sukmawati, 2025). Furthermore, Novianti et al. (2023) found that analyzing conceptual errors provides deeper insight into the types of misconceptions experienced by students, thereby serving as a basis for determining more effective instructional strategies. These findings indicate that previous research has largely focused on developing scientific literacy and thinking skills, as well as identifying conceptual errors through various instructional approaches (Samsudin et al., 2023).

Although previous studies have contributed significantly to the development of science education, several important research gaps remain. Most existing studies have focused on improving scientific literacy, developing digital learning media, or implementing specific instructional models. In contrast, limited attention has been given to the integration of concrete instructional aids to improve elementary students' conceptual understanding of the human respiratory system, despite the abstract nature of this topic. Furthermore, previous studies have generally evaluated instructional effectiveness using conventional statistical approaches, providing limited information about changes in individual students' conceptual understanding. Fauziah & Sukmawati (2023) explained that the stacking technique within the Rasch Model enables a more comprehensive evaluation of individual learning progress before and after instruction. Likewise, Sukmawati et al. (2020) emphasized the importance of analyzing conceptual changes to identify misconceptions and evaluate the effectiveness of instructional interventions. Therefore, integrating

concrete instructional media with Rasch Model stacking analysis represents an important research opportunity that has received limited attention in elementary science education.

Addressing these research gaps, the present study offers several important contributions to elementary science education. Unlike previous studies that primarily emphasized scientific literacy, learning motivation, digital learning media, or instructional models, this study integrates a concrete instructional aid, namely PAREPIA (Human Respiratory Board), with Rasch Model stacking analysis to evaluate students' conceptual understanding of the human respiratory system. This integration constitutes the primary novelty of the study because it combines an innovative hands-on instructional medium with an objective measurement approach capable of capturing individual conceptual changes before and after instruction. PAREPIA was specifically designed to help students visualize the structures and mechanisms of the human respiratory system, enabling them to understand abstract concepts through direct observation and active learning experiences. Furthermore, this study focuses on conceptual understanding as the primary learning outcome rather than merely measuring learning achievement, motivation, or scientific literacy, which have been the main focus of previous studies. The use of Rasch Model stacking analysis also provides richer information regarding individual learning progress than conventional score-based evaluations. In addition, this study was conducted in a heterogeneous classroom that included students with special educational needs, thereby providing evidence of the practicality of implementing concrete instructional media an authentic elementary school setting. This research is important because conceptual understanding of the human respiratory system remains challenging for elementary school students due to the abstract characteristics of the topic. Without appropriate instructional media, students are more likely to develop misconceptions that may affect their subsequent science learning. Therefore, providing concrete instructional media accompanied by objective assessment methods is essential for supporting meaningful learning and improving students' conceptual understanding. The findings of this study are expected to contribute theoretically by extending evidence on the effectiveness of concrete instructional media analyzed using the Rasch Model and practically by providing teachers with an alternative instructional medium and assessment approach for elementary science learning. Furthermore, this study supports the achievement of Sustainable Development Goal 4 (SDG 4: Quality Education) by promoting innovative learning media and evidence-based assessment practices to improve the quality of science education in elementary schools. Based on this background, this study aims to analyze the effectiveness of PAREPIA learning media in enhancing fifth-grade students' conceptual understanding of the human respiratory system.

Method

This study employs a quantitative approach using a quasi-experimental design—specifically, a non-equivalent control group design. This design was selected because the researchers did not randomize the study subjects; instead, they utilized existing school classes as the experimental and control groups (Creswell & Creswell, 2021). The study aims to analyze the effectiveness of using the PAREPIA teaching aid on the understanding of human respiratory system concepts among fifth-grade elementary school students.

The research design involves two groups: an experimental class and a control class. The experimental class received instruction using the PAREPIA teaching aid, whereas the control class received instruction without it. Both groups were administered a pre-test prior to the intervention and a post-test after the completion of the instructional process. A comparison of the pre-test and post-test results was used to identify changes in the students' conceptual understanding following the intervention.

The research design can be described as follows.

O^1	X	O^2
O^3	X^1	O^4

Figure 1. Research design

The study was conducted at SDN Warakas 03, North Jakarta, during the even semester of the 2025/2026 academic year. The research population consisted of all Grade V students—totaling 64 students—divided into two classes. A saturated sampling technique was employed, as the entire population served as the research sample (Sugiyono, 2022).

Table 1. Research sample

Class	Number of Student	Description
V-A	32	Experimental Class
V-B	32	Control Class

Class V-A was designated as the experimental class and received instruction using the PAREPIA teaching aid, whereas Class V-B served as the control class and received instruction without the use of the teaching aid. The experimental class included three students with

special educational needs, while the control class included one student with special educational needs. These differences in student characteristics were considered during the interpretation of the research findings.

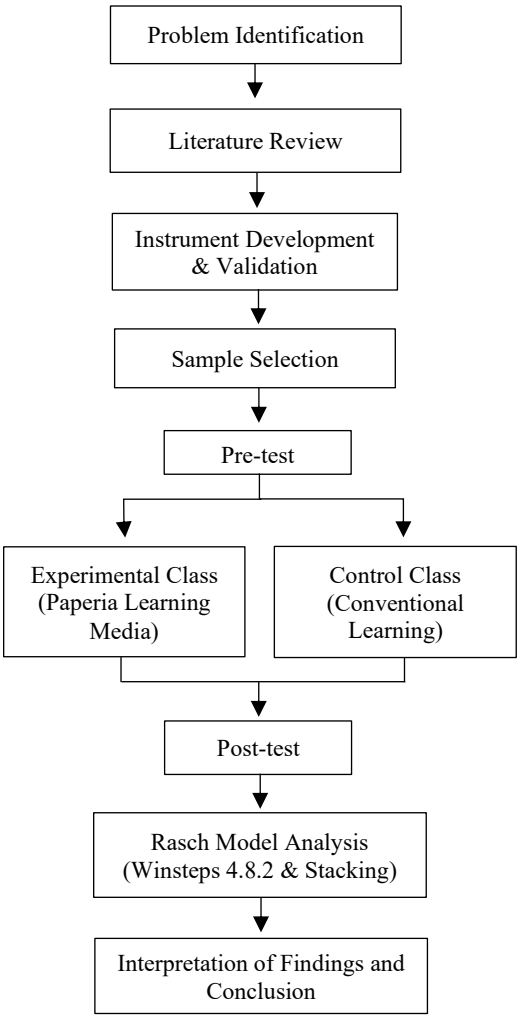

Figure 2. Research procedure flowchart

Figure 2 illustrates the overall research procedure employed in this study. The research began with problem identification and a literature review, followed by instrument preparation, sample selection, pre-test administration, learning implementation in the experimental and control classes, post-test administration, and data analysis using the Rasch Model with the stacking technique.

The implementation of the PAREPIA teaching aid during instruction on the human respiratory system in the experimental class is illustrated in Figure 3.

The research instrument consisted of a 25-item multiple-choice test developed based on indicators of conceptual understanding of the human respiratory system. The assessed indicators included students' ability to understand the basic concepts of the human respiratory system, identify the functions of respiratory organs, explain the mechanisms of inspiration and expiration, and analyze phenomena related to the human respiratory system. Data collection was conducted by administering pretests and posttests to the research participants. The pretest was administered before the implementation of the PAREPIA learning media to determine students' initial conceptual understanding, whereas the posttest was administered after the learning activities to evaluate improvements in students' conceptual understanding following the use of the PAREPIA learning media.

Figure 3. Implementation of the PAREPIA teaching aid in human respiratory system instruction in the experimental class

The collected data were analyzed using the Rasch Model with the assistance of Winsteps software version 4.8.2. The Rasch Model was selected because it provides objective measurement by estimating person ability and item difficulty on the same logit scale. Furthermore, Rasch analysis enables researchers to evaluate instrument quality, examine person and item reliability, determine separation indices, identify the fit of respondents and test items to the measurement model, and analyze students' learning progress using the stacking technique (Ramadhanti & Sukmawati, 2025; Saputri & Sukmawati, 2024).

The analysis was based on values for person reliability, item reliability, person separation, item separation, INFIT MNSQ, and OUTFIT MNSQ. Criteria 1OUTFIT MNSQ range of 0.5–1.5, indicating that the data remained consistent with the measurement model (Linacre, 2023).

Additionally, this study employed a stacking technique to analyze changes in student ability between the pretest and posttest. The stacking technique allows for a detailed observation of changes in individual measure values, thereby illustrating the improvement in student ability following instruction. The analysis results were subsequently used to evaluate the effectiveness of the PAREPIA teaching aid on conceptual understanding of the human respiratory system.

Result and Discussion

Data analysis was conducted using the Rasch Model with a stacking technique via the Winsteps application. The stacking technique was employed to compare pretest and posttest results, allowing changes in student ability to be observed through measure values before and after instruction. The analysis covered an experimental class that received instruction using PAREPIA teaching aid and a control class that received instruction without the use of such aids. To provide a clearer overview of the research implementation, Figures 4–7 present the main stages of the learning activities, including the administration of the pretest, the implementation of learning using the PAREPIA teaching aid, and the posttest.

Figure 4. Pretest implementation

Before the learning intervention, students in both the experimental and control classes completed a pretest to measure their initial understanding of the human respiratory system concepts. The pretest was administered individually under the teacher's supervision using the same instrument that would later be used in the posttest. The results of the pretest served as baseline data for comparing students' conceptual understanding before and after the implementation of the instructional intervention.

Following the pretest, the teacher introduced the PAREPIA teaching aid and explained its components, functions, and procedures for use during the learning activities. The explanation ensured that students understood how each component represented the organs of the human respiratory system and how the teaching aid would be used throughout the lesson. This introductory stage provided students with a common understanding before they actively participated in learning activities.

Figure 5. Teacher explaining the PAREPIA teaching aid

Figure 6. Students using the PAREPIA teaching aid

After receiving the teacher's explanation, students actively interacted with the PAREPIA teaching aid by identifying the respiratory organs, explaining their functions, and demonstrating the breathing process. Students manipulated the learning media while discussing concepts with their peers and responding to the teacher's questions. These activities encouraged active participation and enabled students to transform abstract concepts into concrete learning experiences, thereby facilitating a better understanding of the human respiratory system.

Figure 7. Posttest implementation

After all learning activities had been completed, students individually completed the posttest using the same instrument administered during the pretest. The posttest measured students' conceptual understanding after participating in the instructional activities. The comparison between pretest and posttest results was subsequently analyzed using the Rasch Model with the stacking technique to evaluate changes in students' abilities following the implementation of the PAREPIA teaching aid.

Table 2. Comparison of mean measure (pretest and posttest) for experimental and control classes

Class	Mean Measure Pretest	Mean Measure Postest	Difference (Logit)
Experimental	0.28	1.70	+1.42
Control	0.24	1.19	+0.95

Based on Table 2, an increase in the mean measure value occurred in both classes following instruction. The experimental class, which utilized PAREPIA teaching aid, experienced an increase in mean measure from 0.28 logits to 1.70 logits, representing a gain of 1.42 logits. Meanwhile, the control class saw an increase in mean measure from 0.24 logits to 1.19 logits, a gain of 0.95 logits. These results indicate that the improvement in the understanding of respiratory system concepts was greater in the experimental class than in the control class.

The greater increase in the experimental class indicates that students experienced more substantial conceptual development following instruction using the PAREPIA teaching aid. Compared with the control class, the larger gain in mean measure suggests that the instructional intervention provided additional support for understanding the relationships among respiratory organs and their functions. This result demonstrates that students who learned through direct interaction with the teaching aid achieved greater conceptual progress than those who received conventional instruction.

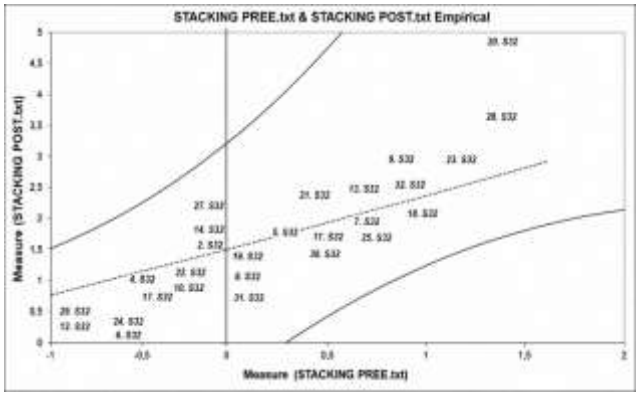

Figure 8. Empirical line plot of the experimental class stacking analysis

Based on Figure 8, the majority of the points lie above the identity line, indicating that the post-test measure values are higher than the pre-test measure values. This suggests that the students' abilities in the experimental class improved after participating in instruction using the PAREPIA teaching aid.

The distribution of person measures indicates that improvement occurred across most students rather than only a small number of individuals. Although several students remained close to the identity line, the overall pattern demonstrates that the instructional intervention contributed to positive conceptual development for the majority of the experimental class. The empirical plot therefore provides visual support for the increase in the mean measure presented in Table 2.

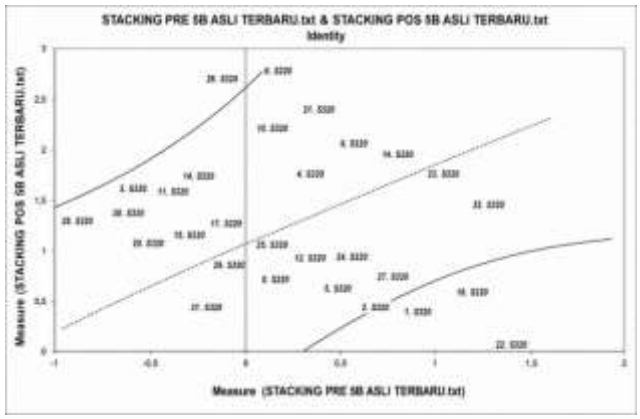

Figure 9. Empirical line plot of the control class stacking analysis

Based on Figure 9, an improvement in student ability in the control class is also evident from the shift in measure values between the pretest and posttest. However, the distribution of data points tends to be closer to the identity line compared to the experimental class, indicating a relatively smaller improvement.

Compared with the experimental class, the control class exhibited a smaller upward shift in person measures, indicating that improvements in conceptual understanding were less pronounced. Although conventional instruction contributed to learning gains, the distribution of scores suggests that the improvement was not as consistent across students as that observed in the experimental class.

Based on Table 3, the experimental class demonstrated higher person reliability (0.73) and person separation (1.63) than the control class, which obtained a person reliability of 0.61 and a person separation of 1.25. Similarly, the item reliability in the experimental class reached 0.89 with an item separation of 2.78, whereas the control class obtained an item reliability of 0.50 and an item separation of 1.01. The mean Infit and Outfit Mean Square values for both person and item

analyses were close to the ideal value of 1.00, indicating that the response data adequately fit the Rasch model and that the measurements were sufficiently stable for further interpretation.

Table 3. Summary statistics of Rasch analysis for the experimental and control classes

Aspect	N Input	Mean Measure	Infit MNSQ	Outfit MNSQ	Separation	Reliability
Person (Experiment)	64	0.93	0.99	0.99	1.63	0.73
Item (Experiment)	25	0.00	1.00	0.99	2.78	0.89
Person (Control)	64	0.65	1.00	0.95	1.25	0.61
Item (Control)	25	0.00	1.00	0.95	1.01	0.50

Note. The N Input value of 64 in the person analysis represents stacked observations from 32 students measured at two testing occasions (pretest and posttest). Therefore, it does not indicate 64 different students but rather repeated measurements of the same participants.

Overall, the Rasch statistics demonstrate that the measurement quality in the experimental class was stronger than that of the control class. The higher person and item reliability values indicate more consistent measurement, while the higher separation indices suggest that differences in students' abilities could be identified more clearly. These results strengthen the interpretation that the observed improvements in the experimental class reflect genuine changes in conceptual understanding rather than inconsistencies in measurement.

The findings obtained from the Rasch analysis were further interpreted by relating them to previous studies and relevant learning theories to explain the effectiveness of the PAREPIA teaching aid in improving students' conceptual understanding of the human respiratory system.

The research results indicate that the use of the PAREPIA teaching aid led to a greater improvement in the understanding of the human respiratory system's concepts compared to instruction without such aids. The increase in the mean measure for the experimental class suggests that the use of concrete media helped students gain a more comprehensive understanding of the relationships between organs and the mechanisms of the respiratory system. This finding indicates that students benefited from direct interaction with learning materials, enabling them to construct scientific concepts more effectively through meaningful learning experiences (Ahmad et al., 2015; Wang et al., 2015). This interpretation is consistent with Singh et al. (2026), who explain that active learning activities improve students' conceptual understanding because learners actively process and organize new information (Otto et al., 2025). This outcome is likely attributable to the fact that students did not merely receive verbal explanations but also engaged in activities involving the observation, demonstration, and discussion of each organ's function using the teaching aid. Such hands-on learning experiences facilitated the development of conceptual understanding more effectively than instruction relying solely on teacher explanations. These findings align with Apipatunnisa et al. (2022), who explain that instruction fostering analytical skills and conceptual understanding leads to better student development. Instruction is also more effective when supported by appropriate instruments and learning strategies that facilitate the gradual construction of knowledge (Marshall, 2026; Maurer et al., 2026). Furthermore, Purnamasari et al. (2026) explains that instruction supported by measurable and validated instruments provides a more objective assessment of student capabilities (Danielis et al., 2025). Therefore, the increase in the mean measure for the experimental class demonstrates that the use of the PAREPIA teaching aid contributed to helping students build a better understanding of the human respiratory system's concepts.

Stacking analysis results reveal that the majority of students in the experimental class experienced an improvement in their abilities after participating in lessons using the PAREPIA teaching aid. This is evident from the fact that most student data points lie above the identity line, indicating that the change in ability occurred across the majority of the student body rather than being limited to a few individuals. These findings indicate that the use of the teaching aid not only enhanced overall learning outcomes but also had a relatively uniform impact on improving students' conceptual understanding (Oketch et al., 2025). This suggests that learning experiences involving observation, demonstration, and discussion with the aid of the teaching tool helped students grasp concepts more consistently. These results are supported by Ifdaniyah & Sukmawati (2024), who demonstrated that stacking analysis within the Rasch Model can depict changes in individual student ability before and after instruction. Furthermore, Bond et al. (2021)explained that changes in logit values in Rasch analysis reflect changes in ability more objectively, allowing for a more detailed observation of each student's progress.

Although both classes experienced improvements in ability, the patterns of change exhibited by each class differed in character. The control class displayed a more diverse distribution of abilities compared to the

experimental class. This indicates that while conventional instruction still contributes to improved conceptual understanding, the resulting changes in ability were not uniform across all students. In contrast, the use of PAREPIA instructional aids led to more consistent ability improvements among the majority of students (Funa, 2026). Thus, the effectiveness of using these instructional aids is demonstrated not only by the magnitude of the increase in the mean measure but also by a more uniform pattern of individual ability changes. These findings align with Hamdu et al. (2023), who explain that Rasch analysis can detail changes in each student's conceptual understanding through shifts in logit values, allowing for a more objective observation of individual ability development. Furthermore, Izzati & Sukmawati (2024) explain that Rasch analysis provides deeper insight into changes in student ability following the implementation of instructional media than a simple comparison of pretest and posttest scores. This view is reinforced by Sujatmika et al. (2025), who states that Rasch-based measurement offers more accurate estimates of student ability, enabling a more comprehensive interpretation of changes in learning outcomes.

In addition to the use of instructional aids, student characteristics must also be considered when interpreting research findings. The experimental class included three students with special needs, whereas the control class had only one. This difference in characteristics could potentially influence learning dynamics, given that each student possesses unique abilities and learning needs (Woldegiorgis, 2025). Nevertheless, the experimental class demonstrated a greater improvement in proficiency compared to the control class. These findings indicate that the use of PAREPIA instructional aids can help create a learning experience that is more accessible to students with diverse characteristics. This aligns with Wardani et al. (2023), who explain that the success of science education in elementary schools depends on selecting teaching methods, media, and strategies that accommodate student characteristics. Similarly, Armadhani et al. (2025) state that instructional media designed to suit the nature of the subject matter can boost student engagement during the learning process, thereby enhancing conceptual understanding. Zahro et al. (2025) also notes that the use of interactive media in science lessons helps students grasp abstract concepts through clearer visualization and more meaningful learning activities.

Conclusion

The findings of this study indicate that the use of the PAREPIA teaching aid effectively improved fifth-grade elementary students' conceptual understanding of the human respiratory system. Rasch Model analysis showed that the experimental class achieved greater learning gains than the control class, indicating that the use of PAREPIA supported more meaningful concept acquisition. Therefore, the PAREPIA teaching aid has the potential to be implemented as an instructional medium to facilitate science learning in elementary schools. Future research is recommended to examine the effectiveness of the PAREPIA teaching aid in different science topics, educational settings, and student populations to further validate its applicability and educational impact.

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Conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing—original draft preparation, F.R.A.; writing—review and editing, supervision, W.S. All authors have read and agreed to the published version of the manuscript.

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The author declares no conflict of interest.

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