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Development and Feasibility Validation of BreathQuest: A Project-Based Interactive Animation Application for Teaching the Human Respiratory System

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ABSTRACT

Abstract concepts in the human respiratory system are hard for students to understand because conventional teaching lacks engagement. The gap between conceptual understanding and visual performance is large, underscoring the need for more innovative, interactive learning tools. Thus, the purpose of this study is to develop and explore the feasibility of a mobile Android interactive animation Project-Based Learning (PjBL)-embedded Android application named BreathQuest. The development process was conducted by type R&D with the Thiagarajan 4D model (Define, Design, Develop, Disseminate) in three-stage studies that are curriculum analysis, a design prototype (design using Adobe Animate 2D software), validation by experts (consisting of Subject matter and Media Specialists), and a one-to-one trial to five pupils. Aiken's V coefficient was calculated to assess validity. Results: Overall, high validity and feasibility, with Aiken's V coefficients ranging from 0.75 to 0.95 (Product design = 0.95, Alignment with Goals = 0.95, Ease of use = 0.90, Content = 0.85, and Interactivity = 0.75). The overall feasibility percentage for all articles was 88%. User feedback suggested that the app is visually appealing. However, there were many areas for improvement in file size, animation speed, and interoperability. BreathQuest includes core PjBL features, such as project guidelines and interactive diagrams, while allowing students to create digital posters and models. In summary, BreathQuest is a credible and workable educational tool that integrates interactive animations into PjBL to address some of the difficulties teachers face in biology education. Future research should assess its impact on learning and motivational constructs in more naturalistic classroom environments.

INTRODUCTION

Interest in the human body stems from its importance as a subject of study in anatomy and physiology. Not only does it give individuals insight into how the body works, particularly its structure and

function, but it also helps everyone maintain health and prevent disease (Tesfaye et al., 2021). Understanding the respiratory system can broaden our knowledge, for example, by clarifying what a clean air dose is and how exercise affects human lung capacity (Ha et al., 2023). Despite these sound benefits and true-to-life relevance, empirical findings suggest otherwise.

However, the research findings indicate that many students cannot accurately depict the gas exchange process (Cahaya et al., 2024; Konu Kadirhanogullari & Ozay Kose, 2024). Even after instruction, more than half of them still struggle, revealing a lack of graphic-pictorial skills among the students (Tapia et al., 2019). This low ability to illustrate biological processes confirms the existence of profound content and conceptual problems, as they have difficulty translating their conceptual understanding into visual form. There is a clear visual need among students to help them master biological concepts (Zhang & Jenkinson, 2024), as conventional teaching approaches have proven inadequate for addressing this issue. Modifications to teaching methods are required, such as strengthening theoretical sessions, designing participatory practical sessions, using heterogeneous collaborative work groups, and increasing the use of ICT and graphic materials to illustrate abstract concepts (Situmorang et al., 2024; Zafeer et al., 2025).

Using digital technology to teach human anatomy topics can greatly enrich teaching and learning. Integrating this technology helps students visualize anatomical structures more effectively and makes learning more interactive and engaging (Graziani et al., 2024). Interactive animations provide an opportunity to overcome some learning challenges by introducing new ways to represent biological phenomena. Interesting presentations in animated media will stimulate students' interest in learning and lead to greater satisfaction with learning. Engaging and challenging learning activities presented through animations will encourage students' motivation to learn (Jeno et al., 2023; Meyerhöffer & Dreesmann, 2020). High motivation levels will impact students' self-regulation in independent learning, and a strong desire to achieve better academic performance. However, this large gap persists, as knowledge of the influence of various multimedia design principles (e.g., modality, personalization, contiguity) on affective outcomes such as motivation, self-efficacy, and anxiety is very limited, as most meta-analyses omitted affective measures because they were not reported (Cromley & Chen, 2025).

Studies have shown that interactive animations can facilitate students' understanding of complex scientific

concepts. Research by Rotbain et al. (2008) showed that interactive animations can facilitate students' understanding of complex scientific concepts. Karamustafao (2012) found that using animations can facilitate students' building of a conceptual understanding of complex scientific concepts. Recent research by Kovacic (2023) has extended this understanding by showing how animations help in conceptual understanding and the visualization and comprehension of multispecies life and deep biological processes. Despite these advancements, there remains a notable gap in the development of educational media that effectively combines interactive animations with activity-oriented pedagogical approaches. This gap underscores the need for further research to explore how such integrations can be optimized to enhance learning outcomes.

Interactive animations, particularly in pedagogical applications like BreathQuest, can significantly benefit biology education. These animations help students understand complex concepts and encourage them to develop critical and creative thinking skills through investigation-based projects. Educational innovations are needed to help build students' understanding of complex concepts in the human respiratory system. Increasing students' conceptual knowledge requires scientific models to provide meaning for students (Gnidovec et al., 2020). Additionally, the interesting visualization process of abstract concepts will affect students' emotions and encourage them to interpret observations through scientific explanations (Ha, 2023; Hoogendijk et al., 2020).

The widespread use of smartphones among students has driven their use for pedagogical purposes. The development of mobile phone technology has enabled broader access for a larger population. A survey conducted by Machmud (2018) regarding high school students in Indonesia found that, on average, they used smartphones for learning. As smartphone adoption among students increased, schools' attitudes toward mobile device ownership also changed. For example, based on an interview with the principal of SMA Negeri 1 Bringin, the school no longer prohibits the use of smartphones, as these devices are considered a necessity, especially as a support for the learning process.

The interactive biology animation developed, called BreathQuest, is an Android-based application. This interactive application integrates the Project-Based Learning pedagogical model to support learning. Using learning applications for project-based activities can help students build knowledge grounded in both conceptual and practical understanding. Questions or problems trigger projects that challenge students to investigate and make

decisions (Yeh & Chen, 2019). Students will undertake projects with varying time scales according to the complexity of the material they are studying. The project activities carried out by students will result in creative and critical works related to biological learning phenomena. Students will design activities to prove concepts in the respiratory system. Students will plan activities in the next stage using the project-based investigative biology animation application.

Students using BreathQuest will engage in a multi-step learning process designed to deepen their understanding of biological concepts. First, students will observe and record key concepts related to the respiratory system, such as gas exchange, lung capacity, and the role of alveoli, through interactive animations and simulations. These observations will then be matched with their original project plans so that they can better appreciate where their hypotheses have gaps. This process is defined primarily by collaboration, in which students have time to work together to discuss their findings, connect ideas, and develop problem-solving strategies (Fuentes & Entezari, 2020). The projects will be done in groups, so all group members will demonstrate their ability to work with a concept and apply scientific principles.

As an outcome of this research, the Android application must be developed as a project-based learning title called BreathQuest. An Android-based application, BreathQuest, was designed as the physical output of this study to demonstrate how a project-based learning model can be implemented to teach the human respiratory system. Thus, this research aims to establish the validity of BreathQuest (expert ratings on material content, media presentation, and instructional design) and to test its feasibility (practicability) using teacher- and student-response questionnaires in a limited-scale context. In turn, this research focuses on these developmental product standards to ensure that BreathQuest is not only conceptually sound and pedagogically well-structured but also practically applicable and user-ready as an interactive, hands-on educational classroom tool.

RESEARCH METHODS

Study Design

This research is a type of Research and Development (R&D), a method used to produce a specific product. The research design employs the Thiagarajan (4D) model. The 4D development model consists of four stages: define, design, develop, and disseminate (Thiagarajan, 1974). The subjects of this study are 11th-grade science students at SMA Negeri 1 Bringin, located in Semarang Regency. The biology learning media for the respiratory system material is developed using the 4D model design. According to Thiagarajan (1974), the

development process of this model consists of four stages: defining, designing, developing, and disseminating. Based on Figure 1, the following is a description of the stages of the 4D development model in the context of developing the human respiratory system material:

Define

In the define stage, several analyses are conducted to understand the needs and issues related to the human respiratory system material. The first stage of defining begins with front-end analysis, which involves identifying the underlying problems faced in teaching the human respiratory system. For example, the teaching methods used are less interactive and less challenging for students to understand. The result of this analysis is the problem background and alternative solutions, including the need to develop more effective learning media. The second stage is learner analysis, which involves collecting data about students' learning needs through surveys or interviews. The results of this analysis will reveal information about students' learning preferences and the areas where they experience challenges. Knowing learners' likes and dislikes can significantly aid in designing personalized learning experiences that better meet their needs (Pepin et al., 2013).

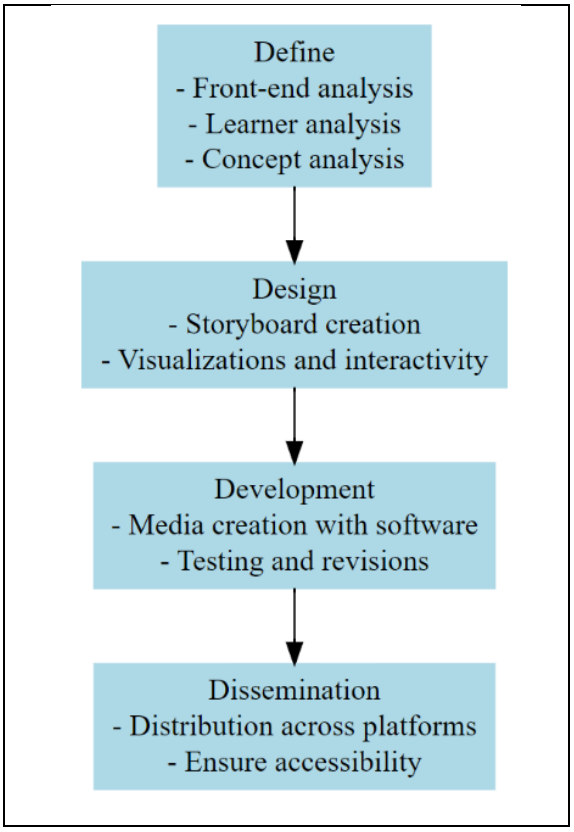

Figure 1. Stages of implementation of the 4D development model.
Adapted from: Thiagarajan(1974)

Design

In the design phase, the BreathQuest application prototype is prepared. In this stage, the researcher creates a prototype or product design. The researcher developed an initial prototype of BreathQuest based on a content framework derived from curriculum analysis, expert opinion, and a project-based learning model. (Kalyani, 2024). This phase ensures that BreathQuest aligns with the previously established content framework.

Through animations and interaction, BreathQuest teaches the key features of gas exchange in the alveoli and details the anatomy and functions of the respiratory organs, including the nose, trachea, bronchi,

and alveoli. The application also includes a practice and evaluation section to assess students' understanding. In line with the project-based learning approach, BreathQuest provides structured project guidelines detailing the steps, tools, materials, and objectives students need to accomplish. With these features, the BreathQuest storyboard ensures that the application is pedagogically practical, engaging, and aligned with the principles of project-based learning.

Development

The third stage is concept analysis, which aligns existing material with the curriculum and maps content for pedagogical and media use. When entering the design phase, learning media are planned in detail by creating a storyboard or an initial sketch, accompanied by visual design of respiratory organs, an animation of the breathing process, and interactive elements that support research showing that students achieve when involved in active, hands-on science activities (Mullen et al., 2017). The development stage involves creating the media using Adobe Animate 2D software, followed by validation by subject and media experts to ensure feasibility and alignment with specifications (Fisch et al., 2016). Quantitative descriptive analysis is used to process questionnaire data from experts, calculate feasibility percentages, and convert them into qualitative data based on evaluation criteria to refine the product design.

The development stage involves creating the learning media in accordance with the planned design. RespireBio is produced using Adobe Animate 2D software. Subject-matter and media experts will then test the resulting product to ensure its validity and alignment with the established specifications. Expert validation aims to assess the feasibility of the product design and inform improvements based on the evaluation results. The method used is quantitative descriptive analysis to analyze data obtained from the questionnaire evaluation scores completed by the subject matter experts and media experts during the product validation process. This type of evaluation process, using quantitative methods to assess feasibility, aligns with best practices in educational software validation (Buendia & Hervas, 2006). The expert validation process aims to assess the feasibility of the product design and inform improvements based on the results. The formula for calculating the percentage of quantitative data is used to obtain the feasibility percentage, which will then be converted into qualitative data based on the product feasibility evaluation criteria. The following is the formula for calculating the feasibility percentage.

$$\text{Feasibility Percentage (\%)} = \frac{\text{Expected Score}}{\text{Obtained Score}} x\ 100\%$$

Based on the table, the feasibility assessment criteria are used to classify the product's feasibility, and the results have been validated by two subject experts and two media experts. A qualitative descriptive analysis is used to process data from the suggestions and feedback provided by the experts. After the experts have assessed the product, content validation is conducted to ensure the suitability and relevance of the questionnaire to the research objectives and to ensure that the data obtained is valid. The Aiken's V validity value is calculated using the following formula.

$$V=\frac{\sum s}{N\,(c-1)} A = \pi r^2$$

where $\sum s$ represents the score given by the expert, l is the lowest rating score (set to 1), c is the highest rating score (set to 5), and N is the number of evaluators or respondents. Aiken's V validity value is interpreted as follows: an index of 0.4 or less is considered low validity, an index between 0.4 and 0.8 is considered valid, and an index above 0.8 is considered highly valid. The BreathQuest application, as the developed product, underwent several iterations of testing and revisions in response to feedback to ensure its feasibility and alignment with the research objectives.

RESULTS AND DISCUSSION

This section discusses the research results from the development application of BreathQuest, including app development, expert validation, and a limited user trial. At this stage, the final BreathQuest prototype was created along with validation outputs from media and subject matter experts, which showed that feasibility was high and instrument validity was very good. In addition, one-to-one trials with students yielded several suggestions for improvement (changes to animation speed, navigation/button sizes, file size) that could be incorporated into the product's design and usability before introduction.

Define Phase

A recent analysis identified challenges in teaching human respiration, finding that many students have difficulty with higher-order concepts and that their interest is very low. Interviews identified two main problems: difficulty understanding scientific words and processes, such as gas exchange at the level of an alveolus, and little student interest in the subject because teachers were dull. Without clearly defined animations or diagrams to aid understanding of complex innate processes, such as oxygen and carbon dioxide diffusion, students were unable to visualize them deeply enough, leading them to memorize merely (Kazanidis et al., 2018). In addition, methods by which instructors read students as well-disposed to feedback and unable to deliver essentially expelled dialogical spaces from readings. Substantiation through real-life examples,

relating methods to the material, and adding interactivity would bring it to life and better fuel curiosity.

The invisibility of processes in the alveoli, such as gas diffusion, makes it challenging for students to visualize the enigmatic process under investigation, as Kovacic (2024) notes, given what an individual can perceive from their human perspective. In biology learning, interactive animations (BreathQuest) serve not only as visually appealing materials but also as epistemic bridges, allowing users to experience phenomena that are otherwise invisible (e.g., the placement of oxygen molecules). Therefore, animation is a prime solution for tackling the source of students' conceptual visualization problems rather than simply adding to traditional teaching methods.

The standard way the grade XI Biology syllabus is taught is to focus on Respiratory and gas-exchange mechanisms, using scientific terms such as alveoli, bronchioles, etc. The define phase is conducted to develop engaging learning media as a solution to this problem, such as animations, videos, and interactive apps to present complex concepts and increase learning enthusiasm (Hillmayr et al., 2020). Adjusting the content of the material to align with the curriculum and the interactive features of learning media enables student participation, improves their understanding, and increases students' interest in the subject matter. This method enables students to use their knowledge rather than memorize it.

Design Phase

In the design phase, the researcher has developed an initial prototype of BreathQuest, an educational medium based on a content framework derived from curriculum analysis, subject-matter expertise, and a project-based learning approach. This phase ensures that BreathQuest aligns with the content framework established earlier. Immersive technologies are used to enable learning interactions that cannot be achieved in traditional settings, enhancing educational potential through the structured visualization of an application's flow and components via a storyboard (Cummings & Bailenson, 2016). Using an opening animation along with learning objectives in accordance with the lesson, and a perception phase that utilizes related examples from day-to-day life, questions are used to connect prior knowledge to new information, making it easier for one to plan (and communicate through) ideal concepts using a storyboard (Radianti et al., 2020).

BreathQuest uses animations and interactive content to teach core principles of the respiratory system: gas exchange in the alveoli; and the anatomy and function of the human respiratory organs, including the nose, trachea, bronchi, and alveoli. The

application also includes a practice and an evaluation menu, where students can assess their knowledge. In accordance with the project-based learning method, BreathQuest offers step-by-step instructions specifying the process students must follow, using the tools and materials available to them, to achieve the learning objective. These features, used in combination, create a BreathQuest storyboard that ensures pedagogical usability, engagement, and alignment with project-based learning principles. The storyboard design for respirebio application development is presented in Figure 2.

Develop Phase

In addition, an educational media application named BreathQuest was also created using Adobe Animate throughout the process. With billboard software as the basis for the storyboard, app design could inform product design and stay within an overarching creative framework, matching pre-established genres defined by a previously published building template. After designing the media and the supporting steps, the researchers had the prototype reviewed by experts and subjected it to developmental testing. Another technique for validating or assessing the feasibility of a product's design is expert evaluation. This assessment was conducted by an expert panel comprising media specialists and subject-matter experts in biology. Expert evaluation is one of the most critical sections of training design in the ADDIE model, ensuring that training meets all testing standards and educational goals (Branch, 2009). Validation data is presented in Table 1.

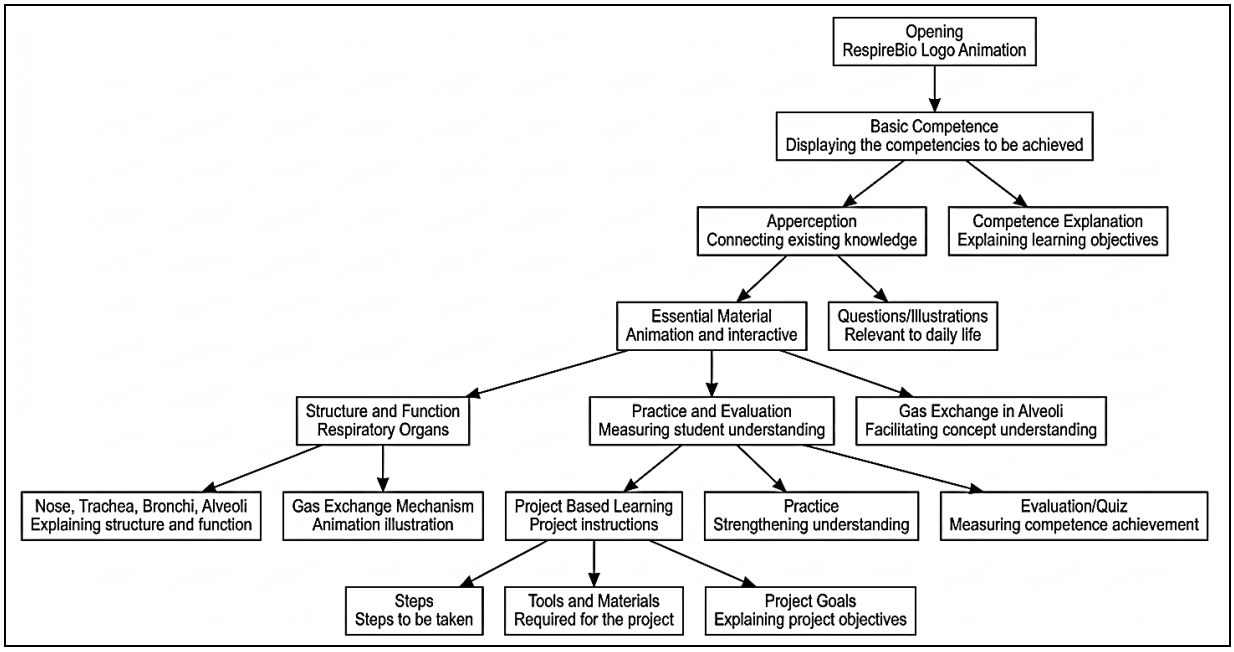

Figure 2. Storyboard design for respirebio application development

Table 1. Aiken's V validity calculation results

Assessment Item	Expert 1 Score	Expert 2 Score	Expert 3 Score	Expert 4 Score	Σ s	Aiken's V	Interpretation
Product Design	5	4	5	5	19	0.95	Highly Valid
Content Material	4	4	5	4	17	0.85	Valid
Interactivity	4	3	4	4	15	0.75	Valid
Alignment with Goals	5	5	5	4	19	0.95	Highly Valid
Ease of Use	5	4	4	5	18	0.90	Highly Valid

According to the expert validation results, the BreathQuest product has a 88% feasibility. Interactivity and usability are just a few of the key functionalities that require special attention, including hardware adaptations such as faster animation speed controls and larger navigation buttons. Furthermore, the instrument validity assessment (Aiken's V) indicates that all items are highly valid, with values exceeding 0.8. The results establish BreathQuest's feasibility and validity, though some refinements are needed for quality and maintainability. Changes made based on feedback will lead to a more effective product, with greater acceptance among users alike.

Developmental testing assesses the product design against actual end users. During this phase, data were compiled on the responses, reactions, and comments of the target users of BreathQuest. To do this, feedback from the first 5 students' one-on-one evaluations was collected to establish a foundation for product improvement. Based on the feedback, the student said the media was still a work in progress, as the feedback on the responses revealed it was a large enough file to be problematic, even though it looked finished. So, the researchers had to find ways to maximize the media presentation while keeping its size limits in mind (Mayer, 2014). The findings from the preliminary trial were then used to modify BreathQuest instructional media to meet users' needs fully.

The interactive learning media of BreathQuest, shown in Figure 3, include the results achieved at all points in its development. Competencies define what learners need to know and the context in which they are expected to learn it. Not only does competency-based learning ensure that students develop concrete skills aligned with learning goals, but it also fosters higher levels of engagement and understanding (Maladzhi & Bello, 2026). The second one involves presenting material in a visual, interactive way that supports student understanding and increases engagement. Tam (2026) found that multimedia-rich, interactive presentations captured learners' attention, thereby enhancing learning retention.

Figure 3. The interactive learning media of BreathQuest. (a) A description of the basic competencies related to the material to be presented; (b) part of the interface that shows the structure of the lung; (c) the interface used to start the evaluation or quiz. There are columns to fill in the name and class, and the "Start" button to start the evaluation; (d) Display the evaluation results or quiz. The message "Correct Answer!!!" with the score is displayed on the right side of the screen

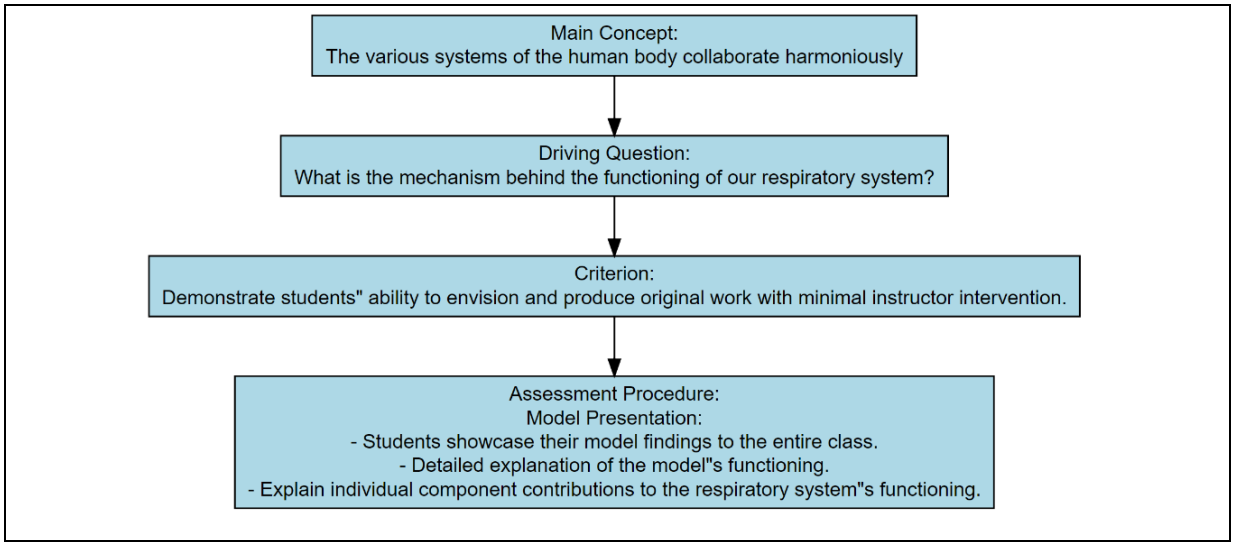

Figure 4. Learning plan on the human respiratory system

This third element provides a trigger that can initiate assessment; it allows students to apply their knowledge through quizzes or evaluations designed to measure comprehension. According to Yao et al. (2024), formative assessments, such as quizzes and benchmark tests, are essential for identifying learning gaps, thereby enabling timely interventions. Fourth, it can evaluate results, providing students with immediate feedback and assessments of outcomes to support continuous learning and

skill development**.** Figure 4 shows the main concept flow of how a system works in the body, with all its components working harmoniously. The question also asked how the respiratory system works. For the assessment, students will be evaluated based on their models, in which they explain how the model works and what each part contributes to its functioning and to the system's respiration. Students then move on to projects following their engagement with BreathQuest. For instance, this interactive human body depicts the interconnectedness of the body's systems (no system functions independently or in isolation, but rather holistically). The umbrella question: "How does the respiratory system work?" Adventurous sentence-level tasks bring this down to a level of detail that may be relevant when considering this fundamental aspect of human biology.

Students think about the process of rethinking and creating under guided instruction, focusing on specific critical and creative thinking skills rather than receiving information from the teacher. During the evaluation component of the activity, students showcase their models to one another, explaining how they work and what each component represents in terms of its role within the respiratory system. A well-rounded evaluation of students should analyze their communication skills, conceptual understanding, and analytical abilities. Summary of One-to-One Evaluation Results on RespireBio Animation Media is presented in Table 2.

Table 2. Summary of one-to-one evaluation results on respirebio animation media

Evaluation Aspect	Suggestions/Comments
Design and Appearance	1. It has an interesting animation design, and the colors are pleasing to the eye. However, a better approach would have been to add more interactivity in some parts. 2. Several of the slides are small and could use slightly larger text for easier readability (Amelia/Pseudonym). 3. While the animations are fine here, some of the sound effects in certain sections can be jarring (Aisyah/Pseudonym). 4. It is not terrible, but the color scheme needs an update for contrast (Noor /Pseudonym) 5. Some animations feel overly fast and could use a bit of slowing down (Latif/Pseudonym).
Content	1. The text itself is clear, but some scientific terms might need clarification (Ahmad/Pseudonym). 2. More illustrations can help in understanding the concepts conveyed (Amelia/Pseudonym) 3. It is hard to read; please explain more details (Aisyah/Pseudonym). 4. The content is fine at the moment; however, some parts could go into more detail (Noor/Pseudonym). 5. Some sections call for further clarification of explanations (Latif/Pseudonym).

In BreathQuest (integrated with project-based learning), students create a digital model of the human respiratory system. The digital design tools and sketch editor allow students to quickly replicate the diagrams, tracing the outlined, colored blocks that make up a floor plan of sorts, the brightly colored, labeled icons, and the ghosts of worlds past nudging toward worlds we are drawing here. Students can use it for interactive learning and explain organ functions and the breathing process to their fellow students. Collaboration and feedback tools play a major role in constructive feedback. Provides QR Code Integration, connecting additional resources to BreathQuest for easier access, and can be saved in the Cloud for immediate reference. Digital posters, infographics, and interactive presentations enable them to conceptualize the respiratory system while also enhancing their design, presentation, and tech skills.

Others argue that animation speed can be too fast and bewildering for students. This issue can be addressed by including a user-controlled replay option, as learners often work at their own pace and revisit material. All of this is meant to make learning preferences more adaptable, thereby leading to better outcomes (Offer-Boljahn et al., 2022). To make the learning experience more enjoyable, an improvement could be to neaten up/change the color scheme and contrast to aid usability. The BreathQuest design aligns with project-based learning (PjBL), an instructional strategy that supports hands-on, collaborative, and technology-enhanced instruction. Other evidence of the combination and impact of PjBL with digital tools supports this implication, as it was found to lead to higher academic achievement and a deeper understanding of the concept (Šmitienė et al., 2026).

Integration of Project-Based Learning (PjBL) in BreathQuest

BreathQuest is integrated with a project-based learning (PjBL) program that encourages proactive student engagement and a deeper understanding of the human respiratory system. This PjBL has a strong relationship in the BreathQuest application, which promotes meaningful student interactions and boosts motivation by combining real-world applications with principle-aligned digital academic content. PjBL activities encourage students to start their exploration with a driving question, like "How do the systems of the body interact to maintain homeostasis. When students follow PjBL, the approach revolves around problems relevant to students, and students work on solutions while assessing their insights (Ospankulova et al., 2025). The question is an essential component of research and projects because it demonstrates students' grasp of what they read. It helps elevate critical thinking and

problem-solving skills by making theoretical knowledge applicable to real-world contexts; thus, it could be an effective strategy in science education (Bell, 2010; Maros et al., 2023).

To engage students even more, BreathQuest features project ideas on the respiratory system to support deeper understanding. One of these has students constructing a 3D model of the respiratory system with straws, balloons, and bottles. Students can reference the animations and create diagrams based on the data simulation in BreathQuest to ensure their models are accurate. This type of active learning helps students better understand the structure and function of the respiratory organs. Baljon et al. (2023) claimed that students who engage in hands-on activities that require them to embody the skills taught retain far more complex scientific concepts and other forms of knowledge.

As shown in Figure 5, integrating BreathQuest and project-based learning enables students to develop digital models of the human respiratory system. BreathQuest, with its digital design tools and sketch editor, enables students to quickly draw diagrams and sketches, including variables, colors, and creative elements such as icons and basic animations. The interactive presentation mode explains the various functions of organs and the process of breathing. In addition, its feedback and collaboration functions enable positive drawback and teamwork (Hwang et al., 2015). BreathQuest includes technology integration, such as QR codes and links to supplemental resources, as well as the ability to save projects in the cloud for easy access and collaboration. Using digital posters, infographics, or interactive visuals can help students understand the respiratory system better while improving their design, presentation, and technology skills.

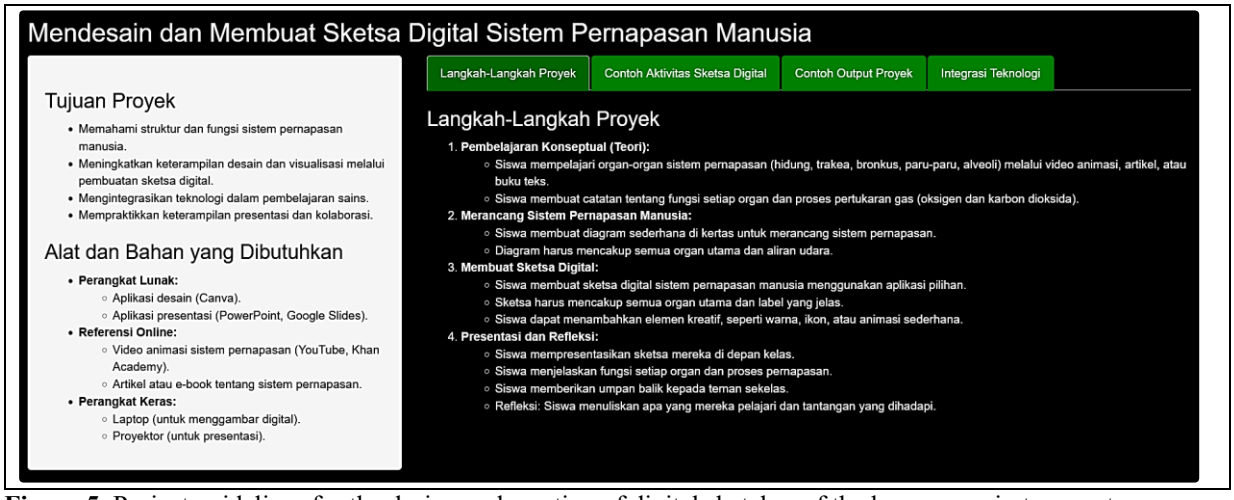

Figure 5. Project guidelines for the design and creation of digital sketches of the human respiratory system

This observation that students with low prior knowledge fared better than those with high prior knowledge is consistent with the findings of Hsu et al. (2025), which reported that animations are more beneficial for learning from graphs or simulations among students with low prior physics knowledge. When information is presented sequentially and without gaps, animations are likely to promote the construction of more coherent mental models in students with low prior knowledge, compared with static graphics, in which so-called scaffolded (stepwise) illustrations for procedural concepts such as the breathing mechanism cannot be provided. Conversely, since low-knowledge students may be distracted by the need to manipulate simulation parameters, animations would be better suited to this group. This result supports the rationale for developing BreathQuest as an interactive animation facilitator specifically to help students with poor conceptual understanding visualize abstract processes in the respiratory system.

The second project allows students to design posters (digital or physical) where they explain what gas exchange is, the role of the alveoli, and which diseases can affect respiration. Incorporate QR codes connected to other sources or animations using BreathQuest's interactive features so that students can gather data. This project promotes the creative synthesis of information while developing the student group's communication and presentation skills. Moreover, interactive poster presentations have led to improved scientific literacy and the important domains of collaboration & creativity (Pranata & Kusayang, 2024), which is also a benefit of using project-based learning. Figure 6 shows a poster about gas exchange in the respiratory system and its health impacts.

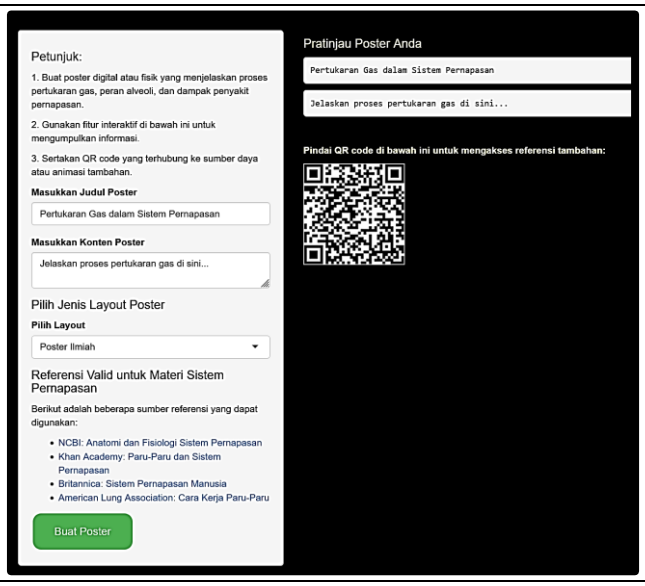

Figure 6. Creation of a poster on the respiratory system related to gas exchange processes and their impact on health

Based on Figure 6, the app supports students in planning the flow of their project for creating interactive posters that explain gas exchange in the respiratory system. The user guide on the left-hand side provides model instructions for crafting the poster, including digitizing/drawing paper and creating a QR code link to further resources. This content is complemented by interactive features (diagrams and animations) to understand better the process (Jannah et al., 2022; Valeeva et al., 2023), particularly the gaseous exchange of O_2 and CO_2 in the alveoli. Students can also determine poster layouts, such as the Scientific Poster, which is dedicated to presenting data visually and systematically. The app contains all content sourced from reliable, trusted sources such as NCBI, Khan Academy, Britannica, and the American Lung Association. Students include a QR code to provide access to additional material (such as scientific articles or videos) that will help clarify the existing topic for the audience.

The app also includes a poster preview function that lets students get a sense of how their work will look once it has been published, and it has created a pull-down pull-a-poster button at the bottom of the interface so users can confirm and generate the poster. On this page, when students click this button, they will open the online Canva design tool, which offers three layout options: poster, infographic, and presentation. Also, this seems to offer a special kind of flexibility that enables students to organize their designs based on what they need and like, and to create a finished poster for a research project or presentation (Canva), combining visual and interactive elements to understand the respiratory system better. This information aligns with past research, which suggested that Canva and Heyzine, two platforms for designing digital teaching materials and presentations, provide attractive layouts and help students better understand the content (Aruan et al., 2025).

When training the respiratory mechanism, BreathQuest media is intended to promote student empowerment. The apps give students a chance to take ownership of their learning, allowing them to explore and engage confidently with the BreathQuest application, using what they have learned creatively to make meaningful comparisons between situations, including how they can visualize their solution thoroughly. Digital posters, as visual and interactive tools in science education, help improve information retention and student engagement (Crompton & Burke, 2018). Likewise, video-based learning study results show that–if properly designed–multimedia content can achieve a much higher knowledge score (Adinugraha, 2022). Moreover, incorporating technology has been found to promote engagement, such as

through QR codes for accessing out-of-class resources, which supported Kearney et al.'s (2012) findings, emphasizing the advantages of technology in providing access to information and facilitating independent learning. Therefore, this application helps students collaboratively create educational posters and provides a more engaging, thorough learning experience.

By integrating these project-based activities, the BreathQuest app encourages critical thinking, collaboration, and creativity while providing students with a deeper understanding of the respiratory system. Critical thinking can arise when students evaluate how respiratory components function and how they support one another. Besides that, creativity can be trained through team collaboration, student support, and a commitment to the idea, resulting in a solution grounded in their knowledge. This is based on PjBL, real-life application, and student-centered learning (Kokotsaki et al., 2016). The teacher in this approach plays a more guiding role, suggesting, helping, and scaffolding, but does not take center stage in class. These learning activities mean that students have become human beings with the right to develop according to their own wishes and talents (Kristanto et al., 2025). Also, interactive and experiential projects have proved to motivate the students. These types of activities draw students from abstract ideas to concrete results, making learning experiences more meaningful (Kibga et al., 2021; Schwichow et al., 2016).

CONCLUSION

This research successfully developed BreathQuest, an Android-based application that integrates project-based learning (PjBL) to improve learning of the human respiratory system. The application leverages the 4D development model (Define, Design, Develop, and Disseminate) to also address challenges with traditional teaching through interactive animations, investigative projects, and digital tools. The feasibility (88%) and validity (Aiken's $V > 0.8$) support the suitability of the application for educational purposes, which was confirmed by expert validation. Limited testing with students indicated that the app is visually oriented and helps engage a learner in interactive learning. However, during development, the primary product needs technical improvements, such as optimizing file sizes, adding animation speed controls, and improving accessibility. Based on positive, constructive feedback from students and teachers as practitioners in education, the product was revised and improved. The use of project-oriented tasks, such as designing 3D models and digital posters, not only deepened students' knowledge of the respiratory system but also encouraged critical thinking, collaboration,

and creativity. The study's application has not yet been assessed and tested under real classroom conditions (ideal class size) to evaluate its impact on students' conceptual understanding; this is a significant area for further research. Wider trials are suggested to assess the application's effect on learning gains and to investigate features that enable its integration with other pedagogies in biology education. Ultimately, BreathQuest provides compelling evidence that digital tools can enhance learning and offer a vision for the future of educational technology.

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