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From Abstract to Concrete: Designing Animated Learning Media and Olfactory Virtual Lab to Demonstrate Nose Fatigue Phenomenon in the Sensory System

Risya Pramana Situmorang[1*], IE Johanes Juan Yutama Putra[2], Sefni Oemolos[3]

[1]Biology Education Study Program, Faculty of Biology, Universitas Kristen Satya Wacana, Salatiga, Indonesia
[2]Master of Biology Study Program, Faculty of Biology, Universitas Kristen Satya Wacana, Salatiga, Indonesia
[3]Higher and Postsecondary Education, Mary Lou Fulton Teachers College, Arizona State University, Tempe, Arizona, United States

*Corresponding author's email: risya.situmorang@uksw.edu

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Abstract. Science education frequently encounters challenges when teaching abstract concepts like olfactory mechanisms and nose fatigue phenomena, primarily due to limitations in interactive media and practical activities. This study developed an innovative learning solution featuring integrated animated videos and a virtual laboratory to make nose fatigue concepts more tangible and interactive. Following the ADDIE framework (analysis, design, development, implementation, evaluation), our team created and validated these materials with media experts, content specialists, and educational practitioners. The validation process yielded excellent results across all quality dimensions. The animated video scored exceptionally well for its visual presentation, technical quality, and creative delivery. Similarly, the virtual laboratory earned high scientific accuracy and system stability marks. While the materials meet established educational media standards, reviewers suggested improving technical language clarity and enhancing interactivity. This research successfully bridges conceptual understanding with virtual experimentation, offering an effective approach to teaching sensory systems. The solution also accommodates content expansion for clinical applications. Ultimately, it presents a modern science learning model that addresses 21st-century educational needs, emphasizing scientific literacy and practical skill development.
Keywords: science learning media, educational animation, olfactory virtual lab, nose fatigue phenomenon

Introduction

Olfactory or nose fatigue is a common phenomenon in which prolonged exposure to odour stimuli leads to a temporary decline in scent perception. This condition frequently occurs in laboratories, perfume industries, and workplaces with strong chemical odours. Olfactory fatigue can disrupt work efficiency by impairing odour detection and increasing the likelihood of misidentifying scents (Werner & Nies, 2018). The severity of olfactory fatigue depends on the intensity and duration of odour exposure, with stronger and longer exposures accelerating sensory adaptation. Furthermore, environmental factors, including odorant concentration (measured in ppm), exposure time (in seconds), air humidity, and ventilation, collectively influence the degree of olfactory desensitisation (Ferdenzi et al., 2014). Understanding this phenomenon is crucial for preventing declines in olfactory sensitivity, minimising errors in odour evaluation, and mitigating negative effects on health and productivity (Mignot et al., 2022).

In biology education, studying olfactory fatigue provides an opportunity to explore three fundamental scientific concepts at the secondary school level: (1) the conversion of chemical-physical signals into neural impulses, (2) neuronal adaptation mechanisms, and (3) sensory system homeostasis (Garcia-Ruiz et al., 2021). However, traditional teaching methods often fail to effectively convey such contextual scientific issues, as they cannot demonstrate the' dynamic and quantitative aspects of physiological processes.

A preliminary study at SMP Theresiana 01 Semarang found that students' cognitive performance in understanding organ systems, particularly sensory systems, was relatively low. Approximately 78% of students struggled to visualise abstract biological processes when taught using conventional lecture methods. This learning difficulty may be further compounded by the absence of laboratory activities directly investigating olfactory fatigue, as these concepts require advanced visualisation tools and interactive simulations. Supporting this finding, a systematic literature review by Sapriati et al. (2023) demonstrated that students' conceptual understanding improves significantly when they engage with interactive simulations that illustrate quantitative relationships between stimuli and sensory responses.

An innovative solution to overcome learning challenges regarding olfactory fatigue phenomena involves the integration of animated videos and interactive virtual laboratory platforms. Unlike conventional instructional videos that primarily focus on presenting static anatomical structures (García-Robles et al., 2024), animated videos enable the deconstruction of abstract processes into more structured visual components(Mayer & Moreno, 2018; Mayer, 2020). The limitations of real experiments in secondary school laboratories, which require specialized equipment for recording neural activity, can be addressed through virtual labs that provide simulations, allowing students to manipulate relevant variables(Pavlou & Zacharia, 2024). Virtual laboratories serve as inquiry-based learning environments that enable students to analyze relationship patterns through real-time graphing and conduct repeated experiments under different conditions within short timeframes (Muilwijk & Lazonder, 2023; Wörner et al., 2022).

Integrating animated videos and virtual labs as multiple representations creates a systematic learning sequence, beginning with conceptual foundation building through animated videos (Vogt et al., 2020), followed by experimental verification of concepts through virtual lab activities. Research by Faresta et al. (2023) demonstrates that blended digital media enhances students' conceptual understanding through abstract process visualization and data analysis skills. Exploring parameters available in virtual labs can also increase intrinsic motivation by enabling repetitive experimental verification (Shambare & Jita, 2024).

This study's uniqueness lies in its specific focus on olfactory fatigue as a model phenomenon for studying sensory adaptation, contrasting with previous studies in Mukhtar et al. (2025) a literature review that only presented static anatomy or general health education. The design of this integrated animation media and virtual lab is expected to improve cognitive outcomes and equip students with scientific investigation skills through experimental simulations that would be impossible to conduct in school laboratories. The primary objective of this research is to develop a science education product consisting of animated videos integrated with a virtual lab focusing on the medical condition of olfactory fatigue in the nasal organ system.

Methods

This study employed a research and development (R&D) approach, adapting the ADDIE model (analysis, design, development, implementation, evaluation). Due to temporal constraints and research scope limitations, the implementation was restricted to the development phase. The work of Almanasreh et al. (2019) demonstrates that limiting the process to the development phase remains valid when meeting expert validation requirements, specifically a content validity ratio (CVR) ≥0.7 as evaluated by at least two experts (Yusoff, 2019). Furthermore, the product design followed implementation protocols aligned with the design-based research framework (Scott et al., 2020), incorporating considerations of usage duration and potential integration into the curriculum. This approach ensures the developed materials are theoretically grounded and practically applicable within educational settings.

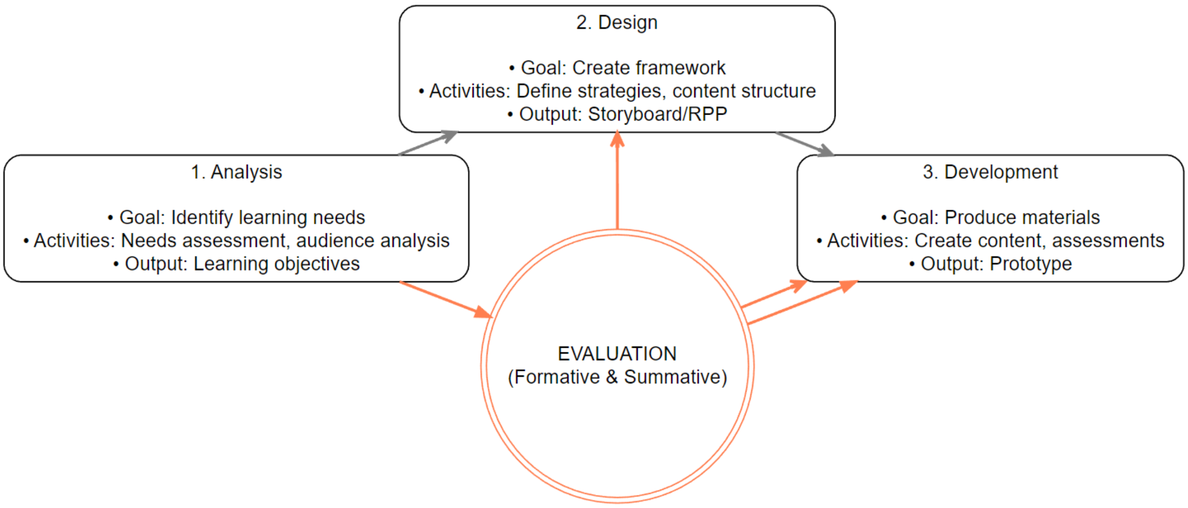


Figure 1. Development of instructional media product using analysis, design, and development framework

The study employed a Research and Development (R&D) approach following the ADDIE model (analysis, design, development, implementation, evaluation) as outlined by Branch (2010). As shown in Figure 1, the research focused specifically on the Analysis, Design, and Development phases. The initial Analysis phase involved comprehensive problem identification through teacher interviews, classroom observations, and literature review to establish the need for developing instructional media. Interviews with science teachers at SMP Theresiana 01 Semarang revealed significant challenges in students' understanding of physiological processes, particularly sensory systems, primarily due to limited instructional time and inadequate learning resources. These findings prompted the development of an engaging educational video that incorporates fun facts about anosmia, or "nose blindness," as a conceptual anchor for teaching sensory physiology.

During the design phase, the research team translated these needs into concrete media specifications, creating detailed blueprints for the animated video and virtual lab components. The design process began with careful alignment to curriculum standards (capain pembelajaran or CP) for Phase D science (Grade IX), followed by storyboard development that integrated animated visuals, narrative structure, and explanatory audio. The designs underwent rigorous validation through expert review (assessing content accuracy and media quality) and practitioner evaluation (conducted by experienced science teachers) to ensure academic rigour and pedagogical appropriateness. This validation process served as a critical quality control measure before proceeding to media production in the development phase, ensuring the materials would effectively address the identified learning gaps while maintaining scientific accuracy and educational relevance. The ADDIE framework's iterative nature allowed for continuous refinement throughout these stages, with each phase building systematically upon the previous one to create theoretically grounded and practically viable instructional materials.

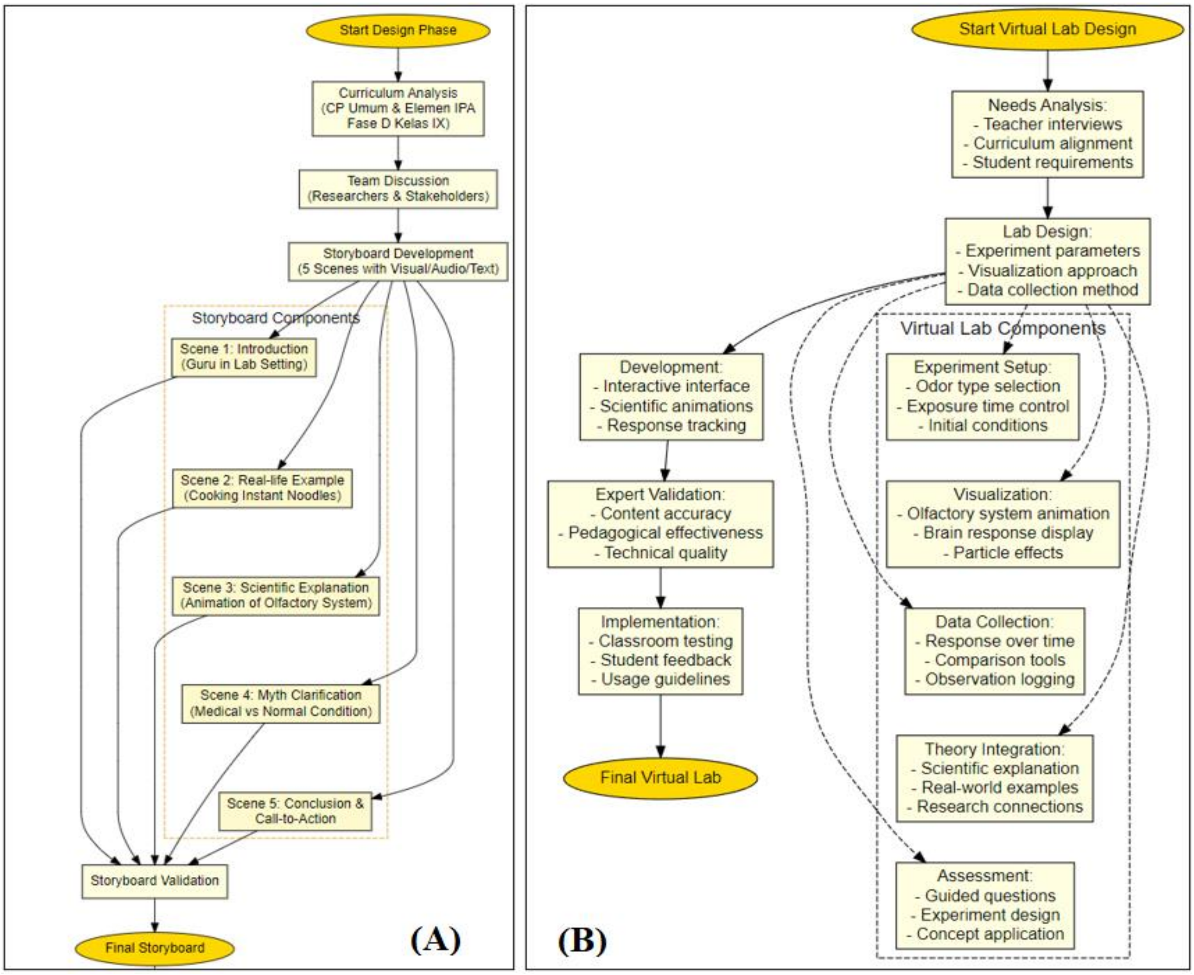


Figure 2. Storyboard development process for (A) instructional video and (B) nose fatigue virtual lab

The development phase involved creating products based on refined designs, including content evaluation and material preparation. While the products developed in this study (animated video and virtual lab) were not yet pilot-tested during the Implementation phase, the research focused on their comprehensive development. The animated video incorporated fun facts about the sensory system, specifically addressing nose blindness/fatigue, following the ADDIE development framework. The instructional media design process began with creating a storyboard to guide the animated video and virtual lab development.

Following the completion of the storyboard, researchers produced the nose blindness animation. The video production was subsequently subjected to a rigorous validation process involving instructional media experts and science teachers. This dual-validator approach provided complementary perspectives to ensure media quality and effectiveness: media specialists assessed visual-content alignment, technical quality (resolution, audio), and pedagogical structure, while practitioners (teachers) evaluated classroom applicability, including user-friendliness, curriculum alignment, and potential student engagement.

Validation assessed eight key aspects through a Likert scale (1-5) questionnaire: visual communication, video quality, layout, language use, content accuracy, effectiveness, educational value, and learner engagement potential. The questionnaire used a balanced scale (containing positive and negative statements) to minimize response bias (Zeng et al., 2025). Validation analysis for the animated video involved three instructional media experts and a biology content specialist, utilizing Aiken (1985) validity index formula as follows:

$$V = \frac{\sum S}{n(c-1)}$$

V = Aiken's validity index
S = Score assigned by each validator minus the minimum possible score
n = Number of validators
c = Number of rating categories available to raters

Following the validation questionnaire analysis by three expert validators, the results were categorized using Aiken's validity index thresholds adapted from Zan & Asrizal (2024) , as presented in Table 1. The validation outcomes determine whether the animated video meets established quality standards for instructional media.

Table 1. Interpretation/categories of validity for instructional video development using Aiken's index (Aiken, 2003)

Validity Index Range	Validation Category
<0.60	Invalid
0.60-0.69	Marginally Valid
0.70-0.79	Moderately Valid
0.80-0.89	Valid
≥0.90	Highly Valid

We implemented formative evaluations throughout the development process, from design to production stages, to refine the product iteratively. This systematic approach enabled continuous improvements, ensuring the final learning media demonstrated pedagogical soundness and content relevance. The formative evaluation allowed researchers to identify and address limitations at each development phase, yielding a more rigorously tested and educationally appropriate product.

Results and Discussion

This study developed innovative learning media consisting of fun fact learning videos and virtual lab simulations addressing nose blindness/fatigue phenomena using the ADDIE development model. The development process commenced with needs analysis through educator interviews and media design aligned with the curriculum. Subsequent stages involved expert validation to ensure academic quality and instructional alignment. The results demonstrate that combining instructional videos with virtual labs can serve as an effective educational alternative for presenting scientific concepts engagingly and interactively. The following sections detail each development stage and its outcomes.

Analysis Phase

Needs analysis conducted through interviews with science teachers revealed significant challenges in teaching sensory systems, particularly regarding olfactory fatigue and smell mechanisms. Table 2 summarises the interview findings regarding problem and needs analysis.

Table 2. Science teacher interview results on problem and needs analysis

No	Question	Response Interpretation
1	What common classroom challenges do you encounter?	Learning outcomes for grades 7-9 remain low, particularly for abstract organ system concepts. The most severe difficulties occur in grade 9 sensory system instruction.
2	Beyond abstract content, what other factors contribute to low understanding?	Lack of laboratory activities compounds the problem, though time constraints and limited teaching resources also present barriers.
3	Have you used instructional videos for this content?	Sensory system videos haven't been adopted as their illustrations often confuse students. Printed internet images serve as our primary visual aids instead.
4	Which sensory organs pose particular comprehension challenges?	Students struggle most with nasal anatomy, especially odor detection mechanisms. Many relate this to Covid-19 anosmia cases when encountering strong odors.

The interviews identified low student achievement as a result of content abstraction and insufficient practical activities. Although instructional videos were considered, teachers preferred printed internet images due to digital resource limitations. Students' difficulties connecting olfactory mechanisms to real-world contexts like Covid-19 anosmia indicate the need for more concrete, life-relevant teaching approaches. These findings underscore the need to develop more effective instructional media to facilitate understanding of abstract biological concepts like sensory systems.

The olfactory system presents unique neurobiological characteristics compared to other sensory modalities. Unlike other sensory pathways, olfactory signals bypass the thalamus, travelling directly to cortical regions (Alfonso-Prieto, 2021; Keller & Vosshall, 2016). This distinctive neural architecture provides insights into odour detection, intensity discrimination, and behavioural responses. Effective instruction should help students recognise that smell perception involves chemical detection, complex neurological processing, and cerebral interpretation.

Given this content's abstract nature, student understanding requires concrete instructional supports like videos or laboratory activities. These findings align with identified challenges where poor comprehension of organ systems, particularly sensory systems, results from inadequate visual representation and hands-on experiences. Therefore, this study developed instructional videos about nose blindness/fatigue to help ninth graders understand olfactory mechanisms and related medical conditions like Covid-19 anosmia (Archila et al., 2021). The developed media aims to enhance comprehension by visualising abstract physiological processes, making them clearer and more accessible to learners.

Design Phase

Researchers developed the initial storyboard and animation blueprint for the instructional video during the design phase. This stage involved collaborative discussions with research team members to ensure alignment in perspectives regarding video development. The storyboard and animation design were carefully structured to align with the general and specific learning objectives (CP) for Phase D Science (Grade IX). The detailed storyboard and animation framework are presented in Table 3.

Table 3. Storyboard and animation framework

No.	Scene Description	Dialogue	Animation Blueprint
1	A teacher appears on screen, delivering a monologue.	"Hello everyone! I hope you're all doing well and staying motivated to learn! Today, we'll explore a fascinating fact about one of our often-overlooked senses—the nose."	
2	The teacher moves to the lower part of the screen.	"Have you ever noticed how when you cook instant noodles, the smell is incredibly strong at first, but after a few minutes, it seems to fade away?"	

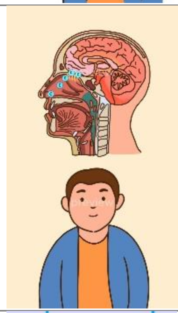
No.	Scene Description	Dialogue	Animation Blueprint
3	The scene shifts to a confused individual reacting to the diminishing smell. Text appears: "This condition is called olfactory/nose fatigue."	"This phenomenon is called olfactory or nose fatigue. It's a natural response where our nasal nerves intentionally 'turn off' or suppress the perception of a continuous smell to prevent sensory overload."	
4	The teacher reappears as in Scene 1.	"While olfactory fatigue might seem like a medical condition, don't worry—it's not a disease! It's the body's way of preventing dizziness from prolonged exposure to the same odor."	
5	Closing scene with the teacher.	"So, there you have it—one of the body's hidden wonders! Our noses need breaks, too. We hope this helps you appreciate just how sophisticated our sensory system is. See you in the next Fun Fact Learning session!"	

Table 3 presents the storyboard of a Fun Fact Learning-themed instructional video about nose fatigue (olfactory fatigue), designed with an interactive and informative approach. The learning video consists of five main scenes, beginning with a teacher introducing the concept in a laboratory setting, followed by a concrete example through instant noodle cooking activities, a scientific explanation of olfactory fatigue mechanisms with nasal anatomy animations, clarification of medical condition misconceptions, and concluding with a summary encouraging students to appreciate the complexity of the olfactory system. Each scene combines visual elements (illustrations, animations), audio (personal narration by the teacher), and supporting text to facilitate multisensory understanding. For instance, Scene 3 features an animation of odor particles flowing from the nose to the olfactory bulb and brain, designed to help students visualize this abstract biological process.

The research team carefully crafted the storyboard to deliver educational content with student-engaging design elements, incorporating three key strengths: (1) contextualization through relatable everyday examples like instant noodle aroma, (2) scientifically accurate animations of the olfactory system, and (3) a clear pedagogical structure progressing from introduction through exploration to reflection. However, integrating a virtual lab component could significantly enhance the nose fatigue video's effectiveness, creating a more comprehensive and interactive learning experience. The video is an effective introductory medium to explain basic concepts, real-world examples, and biological mechanisms of nose fatigue through engaging narration and visualizations.

At the same time, the virtual lab allows students to validate these concepts through simulated experiments (Reginald, 2023; Zhang & Liu, 2023).

The combined use of instructional video and virtual lab is expected to strengthen theoretical understanding while developing scientific skills such as observation, data analysis, and problem-solving. Additionally, this integration accommodates diverse learning styles, catering to visual learners through the video and kinesthetic learners through virtual experimentation. The design of the virtual lab nose fatigue is presented in Figure 3.

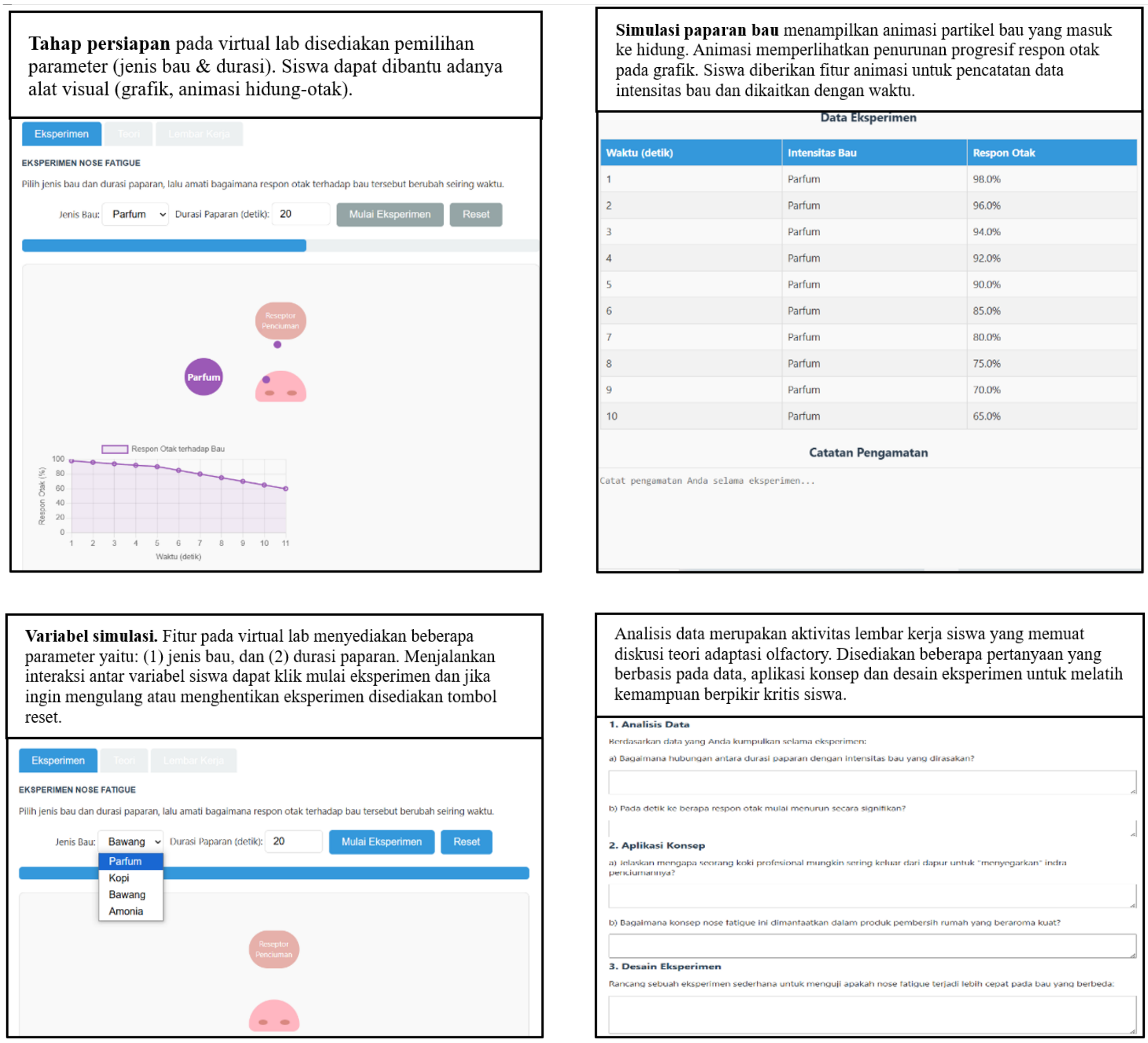


Figure 3. Virtual lab simulation of olfactory fatigue

Figure 3 presents a virtual laboratory simulation designed to investigate the phenomenon of olfactory fatigue (nose fatigue). The simulation allows students to select experimental parameters, a feature shown to increase engagement and ownership of learning (Aljahany et al., 2021; Pang et al., 2025), including odor type (such as perfume, rose, or onion) and exposure duration, while providing visual tools like real-time graphs and animations that demonstrate the brain's response to specific odors over time. As the virtual experiment progresses, students observe animated odor particles entering the nasal cavity and the corresponding progressive decline in neural response (Yildirim et al., 2025), all displayed dynamically. The simulation also includes features for recording odor intensity data and correlating it with exposure duration, which can be analyzed using the provided data tables.

Following data collection, students are guided through a structured analysis using worksheets containing conceptual, application-based, and experimental design questions. These questions are carefully crafted to develop critical thinking skills by examining the relationship between exposure duration and perceived intensity, identifying affected brain regions, and applying olfactory fatigue concepts to real-world scenarios, such as in the fragrance or cleaning product industries. The virtual lab emphasizes interactive learning, encouraging students to explore further through self-designed experiments. Combining hands-on virtual experimentation with in-depth analysis makes this simulation an effective educational tool (Cao & Hsu, 2023; Kefalis et al., 2025) that enhances understanding of olfactory adaptation, bridging theoretical knowledge with practical applications in sensory biology.

Development Phase

The development phase focused on expert validation of the Fun Fact Learning video addressing nose blindness, conducted by three validators comprising instructional media experts and science teachers. The evaluation encompassed eight key aspects: visual communication, video quality, layout design, linguistic appropriateness, content accuracy, effectiveness, educational value, and learner engagement. All validators unanimously concluded that the developed video was ready for implementation without requiring revisions.

Table 4. Expert validation results for *fun fact learning* video on nose blindness

No	Criterion	Mean (r)	Aiken's Index (V)	Validity Category
1	Visual-Content Alignment	4.67	0.92	Highly Valid
2	Simulation Interactivity	4.33	0.83	Valid
3	Technical Quality (Resolution, Audio)	4.67	0.92	Highly Valid
4	Accuracy of Phenomenon Illustration	4.67	0.92	Highly Valid
5	User-Friendly Navigation	4.33	0.83	Valid
6	Creativity in Fun Fact Delivery	4.67	0.92	Highly Valid
7	Duration-Content Suitability	4.33	0.83	Valid

As evidenced in Table 4, the validation results demonstrated that most criteria achieved highly valid status (Aiken's $V \geq 0.83$), particularly in visual-content alignment ($V = 0.92$), technical quality ($V = 0.92$), illustrative accuracy ($V = 0.92$), and creative presentation ($V = 0.92$). These outcomes confirm that the video effectively communicates nose blindness concepts through engaging visuals, clear audio, and relatable analogies. Criteria such as interactivity ($V = 0.83$), navigation ($V = 0.83$), and duration ($V = 0.83$) were rated as valid, suggesting room for enhancement through additional interactive elements (e.g., embedded quizzes) or adjustable duration settings to optimise student engagement. Overall, the video meets established standards for instructional media readiness while remaining receptive to refinements that could enhance the immersive learning experience.

Table 5. Practitioner validation results for the fun fact learning video on nose blindness/fatigue

No	Assessment Criteria	Mean (r)	Aiken's Index (V)	Validity Category
1	Visual Communication	4.47	0.89	Valid
2	Video Quality	4.70	0.94	Highly Valid
3	Layout Design	4.47	0.89	Valid
4	Linguistic Appropriateness	4.70	0.94	Highly Valid
5	Content Accuracy	4.43	0.89	Valid
6	Potential Effectiveness	4.70	0.94	Highly Valid
7	Educational Value	4.17	0.83	Valid
8	Learner Engagement	4.17	0.83	Valid

The practitioner validation (conducted by science teachers) of the Fun Fact Learning video on nose blindness/fatigue, as presented in Table 5, demonstrates that all assessed aspects meet validity standards. Three key criteria, video quality (V = 0.94), linguistic appropriateness (V = 0.94), and potential effectiveness (V = 0.94), achieved a highly valid status. The remaining five criteria, visual communication, layout design, content accuracy, educational value, and learner engagement, were rated as valid, with scores ranging from 0.83 to 0.89. These results indicate that the video has been designed with compelling visuals, systematic content delivery, and clear language use, making it highly effective for facilitating student understanding of complex sensory system concepts.

However, there is room for improvement, particularly in educational value and learner engagement (V = 0.83). Suggested enhancements include incorporating real-world applications (e.g., linking nose fatigue to post-covid-19 anosmia) and integrating interactive elements such as brief quizzes or reflection questions to promote active participation. Overall, the video meets high validity standards and is ready for deployment as an innovative instructional tool, pending minor refinements to optimise its educational impact.

Digital videos have proven to be effective tools for delivering and reinforcing scientific concepts. Research indicates that videos enhance student engagement and positively influence learning outcomes (Noetel et al., 2021). Since today's students are digital natives, passive video content consumption is insufficient; interactive and controllable elements are essential (Noetel et al., 2021). Since today's students are digital natives, passive video content consumption is insufficient; interactive and controllable elements are essential (Okuley et al., 2025). The developed nose fatigue video features animations illustrating how prolonged exposure to strong odours leads to gradual sensitivity reduction due to olfactory adaptation.

The video's visualisations emphasise active student engagement in processing information, fostering analytical skills and transferable competencies like collaboration and digital literacy (Matsiola, 2024; Pellas, 2025). Studies show that students who engage with instructional videos exhibit higher knowledge retention and transfer scores than those who do not (Jing et al., 2024). The video's unique focus on everyday phenomena, such as nose fatigue, captures student attention, triggering positive emotions and sustained concentration. This learning process aligns with research demonstrating that relatable contexts enhance student focus and careful observation (Adler et al., 2025; de Jong et al., 2023).

Effective knowledge transfer in education requires more than passive video viewing, despite videos' demonstrated capacity to provide concrete visual evidence that reinforces key concepts and stimulates experimental inquiry (Karubanga et al., 2017; Zoundji et al., 2018). The nose fatigue learning module combines video content with complementary virtual laboratory activities to maximise instructional impact. This integrated approach enables students to actively verify theoretical concepts through interactive experimentation, simulating exposure to different odours and observing real-time olfactory receptor responses. The virtual lab environment promotes higher-order thinking by requiring students to validate theories and verify concepts through quantitative data analysis. The instructional materials underwent rigorous validation through iterative review cycles with media specialists (Table 5) and biology content experts (Table 6) to ensure pedagogical and scientific quality.

Table 6. Media expert validation results for virtual lab using Aiken's validity index (V)

No	Criterion	Mean (r)	Aiken's Index (V)	Validity Category
1	Curriculum Alignment	4.67	0.91	Highly Valid
2	Content Depth and Accuracy	4.33	0.83	Valid
3	Simulation Interactivity	4.33	0.83	Valid
4	System Stability (No Lag/Error)	4.67	0.91	Highly Valid
5	Learning Objective Achievement	4.67	0.91	Highly Valid

The validation results confirm that the virtual lab nose fatigue simulation meets high-quality standards across all evaluated criteria. Three of the five assessment categories achieved a highly valid rating with a score of V=0.91, specifically in curriculum alignment, system stability without technical issues, and successful learning objective attainment. These findings demonstrate that the simulation successfully fulfils curriculum requirements while operating effectively from both technical and educational standpoints.

The remaining two criteria, which examined content depth, accuracy, and simulation interactivity, received a Valid rating of V=0.83. While still meeting validation standards, these areas present opportunities for refinement. Enhancing the variety of experimental scenarios could improve interactivity, while incorporating more detailed scientific explanations of nose fatigue mechanisms would strengthen content depth. Although the current version proves valid and ready for classroom implementation, these targeted improvements could further optimise the simulation's educational impact.

The primary strength of the virtual lab nose fatigue simulation lies in its balance between content accuracy and user experience. In terms of content, the simulation ensures scientific precision in depicting nose fatigue mechanisms, supported by interactive visualisations such as olfactory nerve response graphs and odour particle animations. From a user perspective, the stable and intuitive interface enables students to experiment independently (Potkonjak et al., 2016), by selecting odour types or adjusting exposure duration before receiving immediate feedback. The validation results align with 21st-century learning principles emphasising technology-based media to develop students' analytical and collaborative skills, as evidenced by high scores in interactivity and learning objective attainment criteria.

Overall, the validation by instructional media experts confirms that the Virtual Lab Nose Fatigue is suitable for implementation as an innovative learning tool. For further refinement, considerations could include: (1) structured teacher guides to integrate the simulation with other pedagogical methods (de Jong et al., 2013; Zhang & Liu, 2023); (2) automated real-time assessments to evaluate student comprehension (Petrović & Kovačević, 2022), and (3) expanded knowledge transfer across disciplines with analogous contexts (Raman et al., 2022), such as applying nose fatigue concepts to the food or perfume industries. These enhancements would preserve the simulation's validated strengths and broaden its relevance for diverse educational contexts.

Table 7. Biology expert validation for virtual lab using Aiken's index (V)

No	Criterion	Mean (r)	Aiken's Index (V)	Category
1	Scientific Accuracy	4.67	0.92	Highly Valid
2	Content Depth	4.33	0.83	Valid
3	Curriculum Relevance	4.67	0.92	Highly Valid
4	Language & Communication	3.67	0.67	Moderately Valid
5	Contextual Application	4.67	0.92	Highly Valid

The material expert validation results for the virtual lab nose fatigue indicate that the learning content excels in scientific accuracy and curriculum alignment (particularly for science subjects), as reflected by Aiken's Index score of 0.92 for both criteria. The validation confirms that the explanations of nose fatigue mechanisms, including olfactory receptor adaptation and diminished neural response to sustained odour exposure, are robust. The material aligns with biology topics and bridges theoretical concepts with real-world applications, such as the phenomenon of nose fatigue experienced by perfume industry workers or individuals cooking in kitchens. While content depth was rated as Valid (V=0.83), opportunities remain to enrich discussions with specific case studies, such as the effects of odour concentration or individual response variations to particular odours.

The virtual lab for simulating nose fatigue offers significant advantages by enabling the manipulation of variables that are difficult to control in a physical laboratory (Brinson, 2015; Post et al., 2019). It simultaneously establishes itself as an innovative and effective tool for teaching the human olfactory system, with overall evaluations confirming its effectiveness. Through interactive simulations, students not only grasp abstract concepts but can also independently explore scientific principles, thereby honing essential self-regulated learning skills, including planning, progress monitoring, and outcome evaluation (Gericke et al., 2023; Reginald, 2023). However, beneath this potential, evaluation has revealed a fundamental challenge, with the language and communication aspect scoring relatively lower (V=0.67). This finding indicates that the technical terminology used actually becomes a barrier to student comprehension, a common challenge in STEM education (Seitenova et al., 2023).

The inherent characteristics of the virtual lab itself exacerbate this difficulty. Simulations often produce overly perfect data, obscuring real-world cause-and-effect relationships (Dyrberg et al., 2017). This issue makes it hard for students to understand the context of equipment setup and the data obtained. Therefore, the success of this virtual lab is highly dependent on efforts to refine its design to match students' backgrounds and learning needs (Špernjak & Šorgo, 2018). To overcome the language barrier, it is necessary to simplify technical terms by developing a visual glossary with annotated nasal anatomy diagrams, integrating audio narrations that use everyday analogies, and creating interactive infographics that compare nose fatigue to other sensory adaptations (Ge et al., 2017; Tippett, 2016). These refinements are designed to enhance understanding while maintaining scientific depth. Furthermore, to bridge the gap between virtual perfection and laboratory reality, future enhancements could integrate videos demonstrating real experiments (Moustafa et al., 2023) and project-based group activities to provide a more authentic and collaborative context (Nischal et al., 2024). By combining these proposed language improvements with expanded practical examples, the nose fatigue virtual lab can transform into a more inclusive and impactful learning resource, perfectly aligned with the needs of the 21st century for building scientific literacy and analytical competencies.

Conclusion

Based on the development research results of the fun fact learning video on nose blindness and the virtual lab nose fatigue, media and subject matter experts validate that these learning media, an animated video and virtual lab on nose fatigue, meet high validity standards. For the instructional video, media experts rated it as highly valid (Aiken's index ≥0.92) in visual suitability, technical quality (resolution and audio), and creative presentation, while interactivity and navigation were rated valid (V=0.83). Science teachers (practitioners) further validated the video's strengths in potential effectiveness (V=0.94), language clarity (V=0.94), and visual communication (V=0.89). However, improvements are needed in educational value and student engagement (V=0.83). For the virtual Lab, subject matter experts rated scientific accuracy and curriculum relevance as Highly valid (V=0.92), though language and communication require refinement (V=0.67). Media experts also confirmed the lab's system stability (V=0.91) and learning objective attainment (V=0.91), but noted that simulation interactivity needs enhancement (V=0.83). Overall, both products meet the criteria for innovative learning media, with recommendations for improvement, such as simplifying technical language and adding interactive features to boost student engagement. The combination of video and virtual lab not only aids in understanding abstract concepts but also demonstrates real-world relevance, bridging theory with practical applications.

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