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Article

EyeBeam Box: Integrated Science Learning Innovation the Concept of Light Refraction and Eye Structure in the Process of Seeing

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ABSTRACT

Science education in schools is still dominated by the use of textbooks, so students only imagine concepts without the support of three-dimensional media that clarify abstract phenomena. This condition leads to a low level of conceptual understanding. In the digital age, there is a need for innovative learning media that is interactive, realistic, and links theory with real-world applications. This study aims to develop contextual and enjoyable learning media for the concept of the visual process. EyeBeam Box is designed as a visual simulation box that replicates the path of light from external objects to the formation of shadows on the retina, mimicking the function of the eye lens. The research method uses a 3D Research and Development (R&D) model (Define, Design, Develop) according to Thiagarajan, limited to the 3D stage. The validation results showed that the EyeBeam Box obtained a score of 4.61 in the "very good" category (4.21–5.00), so it was declared feasible and ready for testing. This media is able to make abstract material more concrete and contextual and improve students' conceptual understanding of the process of seeing. This media should be used in conjunction with student worksheets so that students can collect observation data.

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INTRODUCTION

Education is an effort undertaken with the aim of improving a person's potential in academic and non-academic areas (GH & Zuhrah, 2024). Science education in schools should emphasize the process of building conceptual understanding through direct experience and contextual activities. However, the reality in the field shows that the learning process is still dominated by the use of books and one-way lecture methods that are teacher-centered (Sari & Prasetyo, 2022). Students are only asked to memorize abstract concepts without the support of concrete and interactive learning media, resulting in a lack of understanding of scientific phenomena (Rahmawati et al., 2023). One of the materials that is often considered difficult is the concept of the human eye's visual process, because it involves the relationship between biological structure and the physical principle of light refraction.

Along with the advancement of digital technology in education, the use of learning media has become an important component in the learning process. The demand for innovation in

learning media has also increased significantly. Interactive media is believed to be able to help students understand abstract concepts more easily through realistic visualizations and simulations (Kurniawan & Fitriani, 2021). The integration of biology and physics in the concept of learning the process of seeing is also a form of integrative science learning approach that can foster the integration of scientific thinking in students (Putra et al., 2022). Therefore, the development of learning media that is not only attractive but also contextual and relevant to everyday life is an important requirement in science learning today. Although schools may have visual aids or diagrams of the eye, most of these conventional media are static (non-functional models or 2D images). The main limitation of this 2D media is its inability to demonstrate the dynamic process of light movement and refraction in real time. Students cannot visually see how light enters, is refracted by the lens, and finally reaches the retina to form an image that is physically real and inverted. Reliance on imagination to visualize this critical process often results in deep misconceptions among students. Therefore, media that combines concrete visualization (physical models) with process functionality (light simulation) is needed to create a bridge between abstract theory and physical reality. This study formulates how to design science learning media that can illustrate the process of seeing in a concrete and interactive manner, thereby helping students understand the concept more deeply and enjoyably. The study focuses specifically on developing a visual aid that replicates the path of light from an external object to the formation of an image on the retina, in accordance with the mechanism of the human eye.

This study developed the EyeBeam Box, a box-shaped learning medium that visualizes the path of light from an external object to the formation of an image on the retina. This medium is designed to replicate the function of the human eye lens in a simple but realistic way, allowing students to directly observe the process of light refraction and image formation. The novelty of this research lies in the integration of the concept of physical optics with the anatomical structure of the human eye in a contextual and realistic simulation-based learning medium. Unlike conventional learning media that only use two-dimensional images, EyeBeam Box allows students to observe and manipulate light paths directly. From the results of the validation instrument given to three experts, 92% stated that the EyeBeam Box learning media helped them in explaining the integration of two science concepts. This is expected to improve conceptual understanding while fostering an interest in learning science in a fun and practical way.

METHOD

This research uses the Research and Development (R&D) method with a 3D model, which consists of three main stages, namely define, design, and develop. This model is adapted from the general R&D development model because it is considered suitable for producing learning media that not only focuses on the final product but also includes a systematic process of needs analysis, design, and feasibility testing. In the define stage, researchers identify the needs, problems, and characteristics of the students and the material to be developed (Judijanto et al. 2024). The goal is for the resulting media to help students understand the learning material more easily. The next stage, design, focuses on creating a preliminary design or prototype of the learning media being developed, namely EYEBEAM BOX. Next, in the develop stage, the development process is carried out to produce a final product that is ready to be tested for feasibility. At this stage, the researchers involved three experts who are science teachers at the junior high school level to validate the learning media. The validation instrument covers six aspects of assessment, namely material suitability, tool durability, tool accuracy, tool efficiency, aesthetics, and tool safety, which are assessed using a Likert scale with a range of 1–5, where a higher score indicates a better level of media feasibility.

Averange Rating per Validator

$$Final\ Score = \frac{\sum score\ obtained}{\sum item\ score}$$

Final Value of Validation Test

$$Final\ Value\ of\ Validation\ test = \frac{\sum validator\ final\ value}{\sum validator\ final\ value\ item}$$

Score Interval	Information
1,00-1,80	Very bad
1,81-2,60	Bad
2,61-3,40	Natural
3,41-4,20	Good
4,21-5,00	Verygood

Table 1. Score Interval

RESULT AND DISCUSSION

Define (Definition/Analysis)

This definition stage helps to determine and explain requirements and gather information related to the things that will be developed in the product to be created (Riani Johan et al., n.d.). The Define stage is a very fundamental initial phase in the Research and Development (R&D) product development model, particularly the 3D model (Define, Design, Develop). This stage focuses on in-depth analysis to identify and limit existing learning problems, as well as formulate specific and solution-oriented product requirements. The main objective of the Define Stage is to formulate the right solution by specifically defining the required product characteristics, after conducting an in-depth analysis. This objective begins with determining the media requirements in the field. During the initial analysis stage, it was found that science education is currently dominated by the use of textbooks, which makes it difficult for students to visualize abstract phenomena such as visual processes, resulting in a low level of conceptual understanding. Therefore, the author developed innovative learning media that is interactive, realistic, and contextual in nature to connect theory with real-life practice and to attract students. Thus, the objective of this stage is to clearly define the visual simulation product for the concept of the visual process, which is then realized in the EyeBeam Box learning innovation product as a simulation box that mimics the path of light from an object to the formation of an image on the retina.

Design (Designing)

The Design stage in the 3D RND research method is the phase in which researchers design learning product prototypes based on the results of the needs analysis in the Define stage, including test preparation, media format selection, and initial product design. The objectives of this stage are to produce initial designs for learning products to be developed and to prepare a conceptual framework for learning models and tools(Hudaya Salsabila et al., 2023).

In this study, we developed the Eyebeam Box learning media, which is learning media packaged in a box containing a 3D visualization of the eye, the functions of the eye parts, a visualization of the eye nerves and brain, an explanation of the functions of the eye parts, and a flashlight for simulating the formation of images on the retina. As we can see in Figure 1.

Figure 1. Eyebeem Box when opened

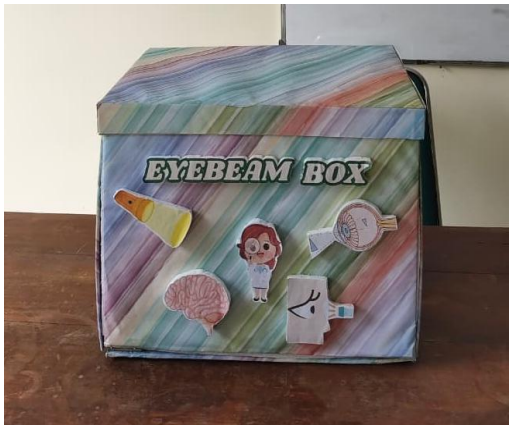

Figure 2. Eyebeem Box when closed

Figure 1 shows the innovation of the eyebeam box learning tool, where teachers or students can turn on the flashlight provided and shine the light on the eye visualization from the front, so that the light passes through the parts of the eye, which can be seen from the side. The functions of each part of the eye are explained on the walls of the box, so that teachers or students do not need to worry about explaining the parts of the eye and their functions in the process of seeing, until finally the light reaches the retina and forms a real, inverted, and reduced image of the original object. Then the image is processed by the brain through the optic nerves until finally the image can be defined. The Eyebeam box is equipped with a barcode scanner that contains a digital visualization of the journey of light, which helps students understand the process of seeing. This Eyebeam box learning medium is expected to be an attractive, conceptual, and flexible learning medium that can be easily carried anywhere because it is designed using a wooden box so that it is durable and long-lasting. This can be seen in Figure 2, which shows the Eyebeam Box when closed. Based on this design, we can see that teachers or students will easily visualize the process of seeing with the complete equipment collected in one box.

Development

The EyeBeem Box learning media then underwent a feasibility test to determine whether the learning media that had been prepared was suitable for use in the classroom learning process. The feasibility test conducted by several validators covered aspects of material suitability, tool durability, tool accuracy, efficiency, aesthetics, and tool safety. The validators of the EyeBeem Box learning media consisted of three validators who were junior high school science teachers. The validation of this learning media was carried out by showing the media and its explanation to the validators by sending a Google form as a validation sheet. After all validators filled out the validation questionnaire, the next step was data processing. The data obtained from the evaluation was then processed into quantitative data and presented in the form of percentages. In addition, there were also evaluations from the validators in the form of comments or suggestions and proposed product revisions, which were then described descriptively and used as material for product improvement. Here are the results from the three validators:

Assessment Aspects	Assessment Criteria	Validator 1	Validator 2	Validator 3
Material Suitability	The media accurately depicts science concepts at the junior high school/MTs level.	5	5	5

	There are no scientific misconceptions.	5	4	4
	The media helps explain difficult concepts visually.	5	4	4
Tool Durability	These teaching aids are weather resistant.	4	5	5
	These teaching aids are easy to maintain.	4	5	5
	These teaching aids are easy to use.	4	5	5
Tool Accuracy	The teaching aids are made in accordance with the applicable curriculum.	5	5	5
	The teaching aids are able to explain concepts in accordance with the material achievement indicators.	5	5	4
Tool Efficiency	The tools are easy to assemble.	5	4	4
	The tools are easy to use independently.	5	5	5
	The use of teaching aids does not take long.	5	5	5
Aesthetics	The teaching aids have simple shapes and colors.	4	5	5
Tool Safety	They have safety tools/materials.	4	5	4
	The construction of the teaching aids is safe for students.	5	4	5
	The teaching aids are easy to take out and store in their place.	4	5	5

Table 2. Results From the Three Validators

The following is a diagram of the results from several validators:

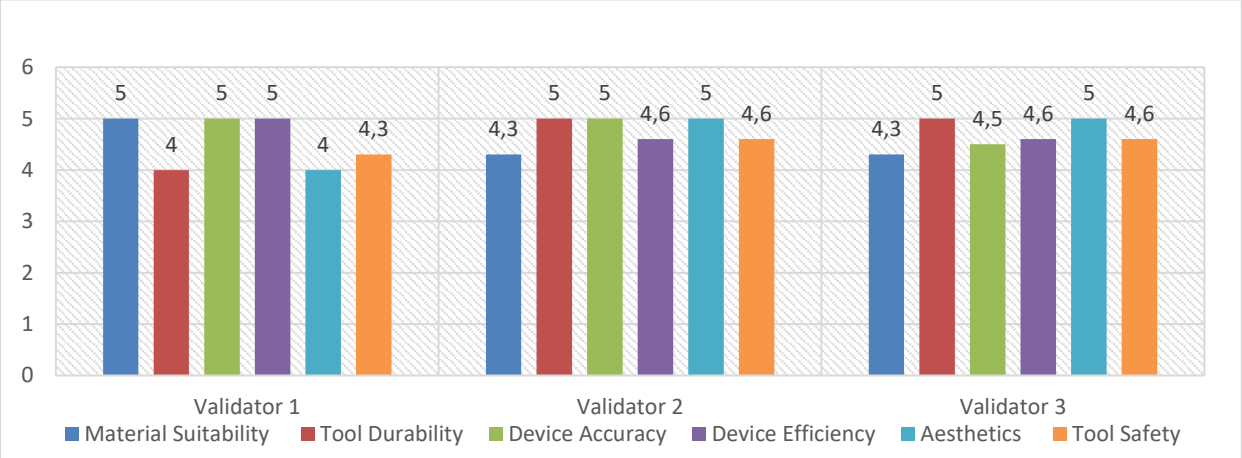

Figure 3. Validation results diagram

Based on the diagram presenting the results of learning media validation by three validators, it can be concluded that the overall quality of the product is in the very good and very feasible category, with most aspects scoring above 4, even reaching a perfect score of 5. The consistency of these high scores indicates that the product has successfully met the criteria set in the six dimensions of assessment: material suitability, tool durability, tool accuracy, Tool efficiency, aesthetics, and tool safety. Specifically, Validator 1 gave the highest rating (score of 5) to three fundamental aspects, namely material suitability, tool accuracy, and tool efficiency. This perfect score indicates that the material presented by the product is highly relevant, the tools function with great precision, and their performance is effective. Meanwhile,

other supporting aspects, such as tool durability and aesthetics, received a score of 4, indicating that the physical aspects and appearance are good. The tool safety aspect scored slightly higher at 4.3, confirming that the product is relatively safe to use.

Meanwhile, Validator 2 showed exceptional appreciation for the physical aspects of the product, as evidenced by a perfect score of 5 for tool durability, proving that the product is considered very sturdy and durable. The remaining five aspects, namely tool accuracy, tool efficiency, aesthetics, and tool safety, all received very high and consistent scores of 4.6, except for material suitability, which was rated 4.3. The consistency of the 4.6 score reflects that the second validator rated this product as close to perfection in almost all technical and visual criteria. Finally, Validator 3 reinforced the assessment of the product's core quality by giving a score of 5 for tool accuracy and material suitability. This confirms that the functionality and content of the product are key selling points recognized by the majority of validators. Other operational and supporting aspects were also rated as very satisfactory, with tool durability and tool safety both receiving a score of 4.6, while tool efficiency and aesthetics were slightly lower with a score of 4.5.

From these results, the final validator test scores are as follows

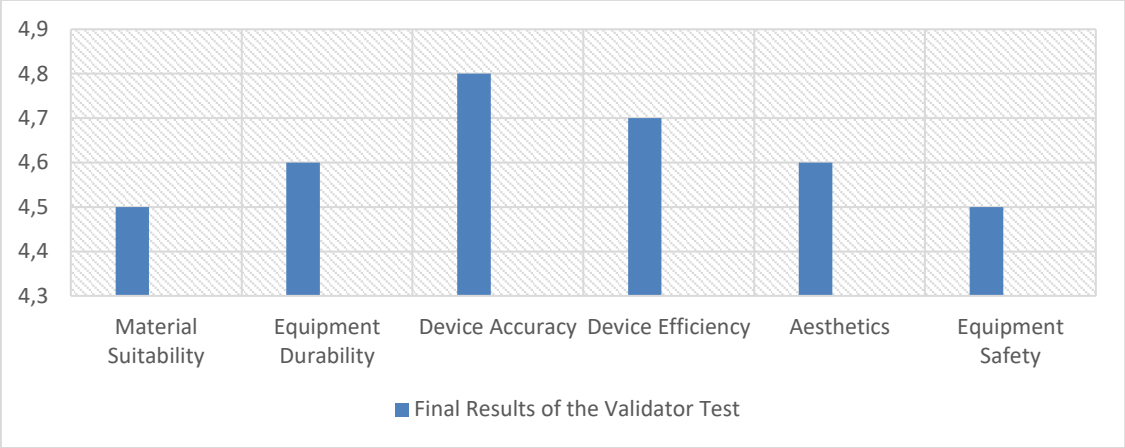

Figure 4. Final Results of the Validator Test

Based on the validators' assessment of the developed media tool, the final feasibility test scores are shown in the bar chart. The average results of the validators' assessments for each aspect are as follows: material suitability 4.45, tool durability 4.60, tool accuracy 4.80, tool efficiency 4.70, aesthetics 4.50, and tool safety 4.40.

The validation results from three validators show that the developed learning media obtained an average score of 4.61. Based on the eligibility criteria with a score interval of 4.21–5.00, it is classified as “Very Good.” This indicates that the media has met all assessment aspects, including content, durability, functional accuracy, efficiency of use, aesthetics, and safety. In terms of content, the media is considered relevant to basic competencies, learning objectives, and the developmental level of students. The durability aspect shows that the media is of good quality and can be used repeatedly. Functional accuracy shows that each part of the media works according to its intended purpose, while efficiency of use indicates that the media is easy to use by teachers and students without requiring complicated instructions. In terms of aesthetics, the media is attractive and able to motivate students to learn, while in terms of safety, the media does not contain any elements that are harmful to users. With all these aspects fulfilled, it can be concluded that the learning media developed is suitable for use in learning activities as a means to support effective, interesting, and contextual understanding of concepts for students. The use of sturdy wood for the learning media container and the addition of a digital barcode feature make this media adaptable to developments in modern educational

technology. In the context of 21st-century learning, innovations such as EyeBeam Box are important for supporting active, creative, and collaborative learning.

In addition to the quantitative data obtained from the evaluation results of the three validators, there is also qualitative data in the form of comments or suggestions for product revisions. These are then explained and defined descriptively and qualitatively to be used as material for revisions during the product improvement stage. Based on the comments or suggestions from validator 1, in terms of materials, the sides of the information board were considered unattractive because the use of *styrofoam* was still clearly visible. This could affect the overall appearance of the media, which should give a neat and professional impression. The validator also suggested that the sides of the information board be made more colorful and equipped with images relevant to the material to avoid a monotonous impression. The addition of visual elements such as illustrations or supporting photos can help attract students' attention and increase their interest in reading. In addition, the validator also suggested adding *a quiz barcode* containing interactive exercises or questions. The addition of this feature can provide a more interesting learning experience and increase student engagement in learning.

The comments and suggestions provided by validator 2 indicate that, in general, the integration of concepts in the learning media is not yet optimal. Most of the content of the media is still dominated by biological concepts, while physical concepts are not yet clear and will only appear when accompanied by additional explanations from the teacher. This shows that the relationship between the two disciplines in the media has not been fully integrated. The validator suggests that the integration of physics concepts be expanded, not only limited to the material on light refraction, but also covering other properties of light. In addition, the media should be equipped with captions or written explanations that explicitly explain the relationship between biology and physics concepts. The validator also suggested adding *a* video *barcode* containing visual explanations of physics concepts. With these videos, students can understand the relationship between concepts in a more concrete and interesting way.

Meanwhile, validator 3 provided input regarding the functional aspects and visual appearance of the media. According to validator 3, because this media aims to explain the process of seeing, the lights that illustrate the flow of impulses to the brain and the brain's response to the effectors should not be turned on simultaneously. Although the time difference is short, this is important to provide a more realistic and easy-to-understand illustration of the impulse flow process for students. The validator also suggested that the parts of the eye, especially the lens, be made clearer and more detailed. This is because these parts often take longer for students to understand. Adding visual details to the structure of the eye will help reinforce conceptual understanding and make it easier for teachers to explain the processes that occur during vision.

This assessment is based on the criteria for selecting learning media, namely (1) Learning objectives, learning media must be aligned and effective in supporting the achievement of predetermined learning objectives. (2) Effectiveness: From the various options available, it is necessary to consider which media are most effective in helping to achieve learning objectives. (3) Characteristics of learners: In selecting media, it is necessary to consider whether the media are appropriate for the characteristics of the students, such as their thinking abilities, learning experiences, and interests. All of these considerations must be taken into account so that the media is truly relevant to the learners. (4) Availability of media. If the media is not yet available, it is necessary to consider how to obtain it, whether by making it yourself, collaborating with students, borrowing, renting, purchasing, or obtaining assistance from other parties. (5) Technical quality. The media used should be of good quality, suitable for educational purposes, and sufficiently durable. (6) Procurement costs. If the media requires procurement costs, it is necessary to analyze whether the available funds are sufficient and commensurate with the benefits obtained. Other alternative media that are more economical

but still effective should also be considered. (7) Flexibility and ease of use: Good media should be flexible, meaning it can be used in various conditions and is safe to use. In addition, the ability of users to operate the media should also be considered to ensure optimal utilization. (8) Time allocation: The availability of time for the learning process also influences the selection of media (Yespa Warinta et al., 2024).

Based on various views regarding the criteria for selecting learning media, teachers need to consider a number of important aspects so that its use can support and optimize student learning outcomes. The selection of media must be tailored to the learning objectives to be achieved, content that is relevant to the curriculum, and the availability of media in schools or on the market. If the required media is not yet available, teachers can take the initiative to design and develop it independently according to the needs of the class. In addition, the flexibility of the media also needs to be considered so that it can be used in various learning situations. The selected media should be durable, have a cost that is comparable to its benefits, and the message conveyed must be in line with the material being taught. By considering these factors, teachers can choose learning media that is appropriate, effective, and efficient in order to support the achievement of learning objectives optimally (Miftah & Rokhman, 2022).

The EyeBeam Box media is recommended for use in conjunction with the Student Worksheet (LKPD), which is crucial and has strategic pedagogical implications. This use confirms that simulation media does not only function as a passive demonstration tool, but also as an active, student-centered investigation instrument. The LKPD serves as an analytical and methodological framework that guides students in structuring their observation activities. Through the LKPD, students are directed to collect empirical data in a structured manner, such as recording details of light paths and shadow properties observed directly from the EyeBeam Box simulation. This process effectively encourages students to practice Science Process Skills, namely observing, recording, analyzing data, and drawing logical conclusions that connect what they see (concrete visualization) with scientific principles (abstract concepts). Thus, the LKPD ensures that this media innovation is not only visually appealing, but also pedagogically effective in promoting deep and active conceptual understanding.

CONCLUSION

The development of the EyeBeam Box learning media is an innovation in science education that combines the concepts of physics and biology, particularly regarding light refraction and the structure of the eye in the process of vision. Based on the results of validation by three validators, this media received an average score of 4.61 in the “very good” category, indicating that the EyeBeam Box is suitable for use in the learning process. This media is able to transform abstract concepts into more concrete and contextual ones, thereby improving students' conceptual understanding of the material on the process of seeing. In addition, the interactive and easy-to-use design of the EyeBeam Box provides an enjoyable learning experience and can foster an interest in science among junior high school students. Thus, the EyeBeam Box is a viable alternative as an innovative, effective, and relevant learning media to be applied in science education in junior high schools.

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