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The Vision Mechanism: From Light to the Brain

BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: 2023-1-DE03-KA220-SCH-000126516

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Introduction

This document describes the Augmented Reality (AR) exercise titled The Vision Mechanism: From Light to the Brain, designed for students aged 17–19 within the framework of the BioS4You AR 2.0 project.

The aim of this exercise is to help students understand how vision arises from the intersection of physical phenomena and biological processes through a clear, sequential, and interactive learning experience. Using Delightex Studio – Spaces (Marker), students access an AR environment where they navigate through progressive scenes showing how light is refracted by the eye, converted into electrical signals by photoreceptors, and transmitted along neural pathways to the visual cortex on a real-world surface (such as a desk or classroom table). By interacting with each scene, students progress through a step-by-step visualization that demonstrates the complete mechanism of human vision from light entry to cortical perception.

This document follows the standard BioS4You AR Exercise template and is organized into the following sections:

- General Information: title, authors, target group, duration, keywords, and topics
- Pedagogical Specifications: learning objectives, methodology, integration with curriculum
- Technical Specifications: hardware, software, AR experience design

The exercise has been developed using the 3E approach (Explore – Execute – Enhance), encouraging students to explore, interact with visual representations, and reflect throughout the learning process.

Thanks to AR, students are immersed in an enriched environment where text, images, 3D models, and animations appear in the real world. This combination of digital media and physical space helps to visualize invisible processes (light refraction, phototransduction, neural signal transmission), strengthen interdisciplinary connections between physics (optics), biology (retinal anatomy), and neuroscience (visual pathways), and support a deeper understanding of how perception originates from the physical interaction of light with biological structures.

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General Information

Name of the exercise:

The Vision Mechanism: From Light to the Brain
Biology of vision and optics; signal transduction; from the eyeball to the visual cortex

The title reflects both the scientific content and the immersive nature of the exercise. The Vision Mechanism emphasizes the systematic process through which light becomes perception, while From Light to the Brain conveys the complete pathway from physical stimulus to neural interpretation through progressive scene navigation from light refraction to cortical processing.

The subtitle Biology of vision and optics; signal transduction; from the eyeball to the visual cortex highlights the interdisciplinary perspective of the exercise: the physical side, where light rays are refracted by the cornea and lens to focus on the retina, the biological side, where photoreceptors (rods and cones) convert light into electrical signals, and the neurological side, where signals travel through the optic nerve and optic chiasm to reach the visual cortex. This structure makes the topic interdisciplinary and accessible for an international audience of 17–19 year old students, integrating physics (optics), biology (retinal anatomy), and neuroscience (visual pathways) in a single interactive scenario implemented through Delightex Studio – Spaces (Marker).

Description of the exercises:

The Vision Mechanism: From Light to the Brain is designed for students aged 17–19 to explore the fundamental principles of human vision through Augmented Reality. The main objective is to help students understand how light reflected from objects is transformed into perception through a sequence of physical, biological, and neurological processes: light refraction by the eye's optical system, signal transduction by retinal photoreceptors, and neural transmission along visual pathways to the cortex. Using Delightex Studio – Spaces (Marker), students navigate through 5 sequential AR scenes placed on a real-world surface (such as a desk or classroom table). The first scene introduces the topic with a title and START button. The second scene shows how light rays are refracted by the cornea and crystalline lens to focus on the retina. The third scene illustrates how photoreceptors (rods and cones) convert light into electrical signals, with animated spark effects representing this

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transduction. The fourth scene displays the complete visual pathway from retina through optic nerve and optic chiasm to the visual cortex, with animated spheres simulating signal flow. The fifth scene presents an integrated quiz where students answer a question about which structure focuses light on the retina (cornea, retina, or iris), with immediate automatic feedback provided by Delightex's native quiz module. The exercise follows the 3E approach (Explore – Execute – Enhance): students explore the visual mechanism step-by-step, execute interactions by tapping buttons to progress through scenes, and enhance their understanding through the assessment quiz and optional external 3D models from Sketchfab. The complete experience takes approximately 5 minutes, making it suitable for both classroom integration and individual homework assignments. By combining diagrams, text overlays, animations, and interactive elements in AR, the exercise makes invisible processes visible and connects abstract physics concepts (refraction, focusing) with concrete biological mechanisms (phototransduction, neural pathways), fostering interdisciplinary STEAM learning.

Participants:

The exercise is suitable for both individual students and small groups of 3–5 members. Working in groups is recommended to stimulate discussion, compare different observations at each stage of the visual pathway (light refraction, phototransduction, neural transmission), and develop collaborative problem-solving skills. In group settings, students can collectively analyze how the cornea focuses light, discuss the difference between rods and cones in scotopic versus photopic vision, and debate why we perceive the world right-side up despite the retinal image being inverted. This collaborative approach encourages peer learning and enhances engagement with the interdisciplinary content, making abstract concepts like signal transduction more accessible through shared exploration of the AR scenes.

Participants' age range:

- Minimum age: 17 years
- Maximum age: 19 years

To take part in the activity, students should have a basic understanding of biology and physics, in particular the anatomy of the eye (cornea, lens, retina, optic nerve), the concept of light refraction and focusing, and introductory elements of electrophysiology (electrical signals in neurons). These prerequisites ensure that students can connect the AR visualizations with their existing knowledge and appreciate the

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	interdisciplinary nature of the visual mechanism.
STEM subject and specific topic:	STEM Subject: Biology, Physics, Neuroscience, Technology Specific Topic: Human vision mechanism, optical focusing, phototransduction, visual pathways, and the relation between physical, biological, and neurological processes Main challenge of the topic: Students often struggle to connect abstract physics concepts (light refraction, focal points) with biological structures (cornea, lens, retina) and neural processes (signal transduction, pathway transmission). Vision is typically taught in separate disciplinary silos: optics in physics class, eye anatomy in biology, and perception in neuroscience, making it difficult for students to grasp the complete integrated mechanism. Furthermore, the invisible nature of phototransduction and neural signal transmission makes these processes abstract and hard to visualize How AR helps simplify the concept: Through Delightex Studio, students can interact with sequential AR scenes that show the complete visual pathway step-by-step. Each scene focuses on a specific stage (light refraction → phototransduction → neural transmission → cortical processing) with visual representations: diagrams showing light focusing on the retina, animated spark effects illustrating photoreceptor activation, and moving spheres simulating electrical signals traveling along the optic nerve. This sequential AR visualization bridges the gap between abstract concepts and tangible understanding, helping students see how physical light becomes biological signals and ultimately neural perception. The integrated quiz reinforces critical thinking about optical structures, and optional Sketchfab 3D models allow deeper anatomical exploration.
Gamification process:	The gamification strategy follows the recommendations of the BIOS4YOU WP2 guidelines, focusing on challenge-based learning and immediate feedback that can be realistically implemented with Delightex Studio – Spaces (Marker). - Challenge-based learning: students are given the task of

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following the complete journey of light from the external world to conscious perception in the brain. Each AR scene presents a specific stage of this pathway, and students must interact with buttons to progress sequentially, making the learning process active rather than passive.

- Immediate feedback: the integrated Delightex quiz at the end provides instant automatic feedback when students answer the question about which structure focuses light on the retina. Correct answers are confirmed immediately, while incorrect answers prompt reflection without revealing the solution directly, encouraging reasoning.

- Visual consequences: instead of points or badges, feedback is represented through the progression of AR scenes themselves. Successfully clicking NEXT advances the narrative from light refraction to phototransduction to neural transmission, creating a sense of exploration and discovery. Animated elements (spark effects for phototransduction, moving spheres for signal flow) provide visual rewards that reinforce understanding.

- Role-playing element: learners act as explorers of the visual system, navigating through the eye and brain to discover how perception is constructed. In group settings, they discuss and compare their understanding of each stage together.

This approach combines interactivity, sequential storytelling, visual feedback, and narrative framing to keep students motivated, aligning with the gamification principles defined in the BIOS4YOU WP2 methodology and adapted to the technical possibilities of Delightex Studio.

Written or graphic description of Augmented info:

The AR experience is developed in Delightex Studio – Spaces (Marker) and includes the following elements:

- Title and introductory scene: 3D text displaying "The Vision Mechanism: From Light to the Brain" with subtitle and background image, featuring a START button to begin exploration.

- Diagrams and images: high-quality anatomical images showing eye cross-section with light rays focusing on retina (scene 2), retina structure with rods and cones (scene 3), and complete visual pathway diagram from retina through optic nerve and optic chiasm to visual cortex (scene 4).

- Interactive buttons: rectangular clickable planes labeled

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	START, NEXT, and QUIZ that students tap to navigate between scenes. - Animated visual effects: small yellow spheres simulating spark effects in scene 3 (representing phototransduction when light activates photoreceptors) and sequentially lighting spheres in scene 4 (representing electrical signal flow along the visual pathway). - Integrated quiz module: native Delightex quiz presenting the question "Which structure focuses light on the retina?" with three answer options (Cornea, Retina, Iris) and automatic branching feedback. - Text overlays: short explanatory captions in each scene describing the process (e.g., "Light rays are refracted by the cornea and the crystalline lens to focus on the retina", "Photoreceptors (rods and cones) convert light into electrical signals", "Signals travel through the optic nerve and optic chiasm to the visual cortex"). All elements are positioned on a marker-detected surface, allowing students to view the complete visual mechanism pathway in AR overlaid on their physical classroom desk or table. The sequential scene structure guides students through the interdisciplinary content (physics → biology → neuroscience) in a logical, easy-to-follow progression.
External (or extra) tools required	- Devices: smartphones or tablets with the Delightex app installed (iOS or Android). - AR markers: required; Delightex Studio – Spaces (Marker) uses marker-based AR. Students scan the provided marker to launch the AR experience and view the visual mechanism scenes on their device. - Printed worksheets: to allow students or groups to record the sequence of events (light refraction, phototransduction, signal transmission to cortex), reflect on the outcomes of each stage, and prepare a short report connecting physics (optics), biology (retinal anatomy), and neuroscience (visual pathways).

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Links (video, images, text online and so on).

QUIZ

The quiz is integrated natively in Delightex Studio (scene 5) and does not require an external link. Students answer directly within the AR experience with automatic feedback.

COMPLEMENTARY 3D EDUCATIONAL RESOURCES

3D Eye Anatomy Visualizations:

Human Eye Anatomy: https://skfb.ly/ouEDB

Interactive 3D model showing complete eye anatomy with all major structures (cornea, lens, iris, retina, optic nerve). Students can rotate and explore the model to understand spatial relationships between optical and neural components.

Eye Cross Section:

https://skfb.ly/6E6x9

Detailed cross-sectional view showing the path of light rays through the eye's refractive media (cornea, aqueous humor, lens, vitreous body) to the retinal plane. Ideal for understanding light refraction and focusing mechanisms discussed in scene 2.

Eye Anatomy with Retina:

https://skfb.ly/o7G9M

Focused visualization of retinal structure showing the distribution of photoreceptors. Useful for exploring the biological basis of phototransduction covered in scene 3.

UNMC Eye Model:

https://skfb.ly/oWFJw

Educational anatomical model from University of Nebraska Medical Center showing labeled eye structures. Suitable for post-exercise review and anatomical reinforcement.

Educational Videos and Simulations:

How the Eyes Work - National Eye Institute (NEI):
https://www.nei.nih.gov/learn-about-eye-health/healthy-vision/how-eyes-work

Our Eyes - Our Vision - Science Learning Hub:

https://www.sciencelearn.org.nz/resources/3006-our-eyes-our-vision

PhET Geometric Optics:

https://phet.colorado.edu/sims/html/geometric-

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optics/latest/geometric-optics_all.html

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Pedagogical specifications

Here we will collect information on how to use the exercise in the learning session and the results and benefits of using it, from a pedagogical perspective.

How can this augmented information be used to address a STEAM topic in a more interesting way for students?

The AR experience transforms the abstract concept of vision into a tangible, interactive journey that students can physically explore on their classroom desk. Instead of reading about light refraction in a physics textbook or memorizing eye anatomy from a biology diagram, students navigate through 5 sequential scenes that show the complete mechanism step-by-step. The combination of visual diagrams, animated effects (spark particles for phototransduction, moving spheres for neural signals), and interactive progression creates an engaging narrative where physics (optics), biology (retinal structures), and neuroscience (visual pathways) are seamlessly integrated. Students see how light rays bend through the cornea and lens, watch photoreceptors convert this light into electrical signals, and follow these signals along the optic nerve to the brain. This multisensory AR approach makes the invisible visible and the abstract concrete, significantly increasing engagement and understanding compared to traditional lecture-based or static image-based instruction. The challenge-based quiz at the end reinforces critical thinking, and optional Sketchfab 3D models allow curious students to explore anatomical details beyond the core exercise.

Which pedagogical objectives are addressed through this scenario?

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The exercise addresses interdisciplinary understanding by connecting physical principles (light refraction, geometric optics) with biological structures (cornea, lens, retina, photoreceptors) and neurological processes (signal transduction, neural pathways, cortical processing). Students develop the ability to visualize invisible processes such as phototransduction and neural transmission. By navigating through scenes in logical order, students understand cause-and-effect relationships in the complete visual pathway. Students identify key anatomical structures including cornea, crystalline lens, retina, rods, cones, optic nerve, optic chiasm, and visual cortex, understanding their specific functions. The integrated quiz requires reasoning about which structure focuses light, moving beyond memorization to applied understanding. The AR placement on the desk helps students develop spatial mental models of how light travels through three-dimensional anatomical structures in the eye and brain.

Which results are expected to be reached with its use?

Students are expected to demonstrate improved comprehension of the complete visual mechanism compared to traditional instruction, as measured by quiz performance and assessments. The multisensory AR experience should improve retention of anatomical structures, their functions, and the sequential pathway from light to perception. Students should show higher engagement and motivation during the AR activity compared to passive learning methods. Students should articulate connections between physics (refraction), biology (photoreceptors), and neuroscience (pathways) rather than treating them as separate topics. Students should correctly identify the cornea as the primary refractive structure, understand differences between rods and cones, and explain perception of upright images despite retinal inversion. When working in groups, students should demonstrate improved peer discussion and collaborative problem-solving around visual mechanism concepts.

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Which benefits are expected to be reached with its use?

AR makes advanced interdisciplinary content accessible to 17-19 year old students by using visual representations and sequential storytelling to reduce cognitive load. By overlaying digital information on the physical classroom, AR connects theoretical knowledge with everyday visual experience. The integrated quiz provides instant feedback for self-correction during learning rather than on later exams. The 5-minute duration suits various contexts including classroom activities, homework, and flipped learning, working for individuals or groups. Students develop digital literacy with AR educational tools relevant for future learning environments. The AR experience requires only smartphones/tablets and a marker, making it cost-effective compared to physical anatomical models. The combination of visual diagrams, animations, text, and kinesthetic interactions supports diverse learning styles. AR visualization of three-dimensional structures develops spatial thinking skills valuable across STEM disciplines.

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Technical specifications

In this part it is necessary to specify whether the exercise was designed to be implemented with AR technology. This part is fundamental for the translation process. Please include text, audio text and all the necessary materials.

AR INFORMATION

Technology	https://edu.delightex.com/TAV-WRW The exercise is designed to be implemented entirely with Augmented Reality. It uses marker-based AR, since Delightex Studio – Spaces (Marker) requires students to scan a printed marker to launch the AR experience and view the visual mechanism scenes overlaid on their physical environment.
If it's needed a marker, description of the marker	A specific marker is required for Delightex Studio – Spaces (Marker). The marker is a printed image or pattern that students scan with their smartphone or tablet camera to launch the AR experience. The marker can be a custom-designed image related to the vision topic (such as an eye illustration) or a standard Delightex marker provided by the platform. Once the marker is detected by the device camera, the AR scenes appear anchored to the marker position, allowing students to view the visual mechanism pathway overlaid on their physical workspace. Teachers can print the marker on standard paper and distribute it to students or display it on a larger surface for group viewing.
Hardware and software needed:	- Hardware: smartphones or tablets with camera and internet connection. Gyroscope and accelerometer are required (standard in most modern devices). - Software: Delightex app (free, available on Android and iOS).

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	Teachers need a Delightex educational account to access and share the AR project. - Other: Printed marker for launching the AR experience. Internet connection is needed for initial download of the AR project and for accessing optional external Sketchfab links.
Type of Augmented data	The AR experience integrates different types of content: - 3D text (title "The Vision Mechanism: From Light to the Brain", scene labels) - Images (anatomical diagrams showing eye cross-section with light refraction, retina structure with rods and cones, visual pathway from retina through optic nerve and chiasm to cortex) - Interactive planes (rectangular buttons labeled START, NEXT, QUIZ) - Animated particles (small yellow spheres simulating spark effects for phototransduction and moving spheres representing electrical signal flow along the visual pathway) - Text overlays (short explanatory captions describing each stage of the visual mechanism) - Integrated quiz module (native Delightex quiz with question and multiple-choice answers)
Written description of the AR data	When students open the exercise with Delightex app and scan the marker, they begin with the introductory scene displaying the title "The Vision Mechanism: From Light to the Brain" as 3D text with a background image. By tapping the START button, they navigate to the second scene showing an eye diagram with light rays being refracted by the cornea and crystalline lens to focus on the retina, accompanied by explanatory text. Tapping NEXT advances to the third scene illustrating photoreceptors (rods and cones) converting light into electrical signals, with animated yellow spark effects representing phototransduction. The fourth scene displays the complete visual pathway diagram from retina through optic nerve and optic chiasm to the visual cortex, with sequentially lighting spheres simulating signal transmission. Tapping the QUIZ button launches the fifth scene presenting the question "Which structure focuses light on the retina?" with three answer options (Cornea, Retina, Iris). The integrated Delightex quiz provides automatic feedback: correct answers are confirmed immediately, while incorrect answers prompt reflection. The sequential progression through these 5 scenes takes approximately 5 minutes and guides students through the

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	complete interdisciplinary pathway from physics (light refraction) to biology (photoreceptor function) to neuroscience (cortical processing).
If Image	If the AR data are Images, the formats needed are .jpg and .png (better size < 2Mb). The exercise uses three main images: an eye cross-section diagram showing light refraction and focusing on the retina (scene 2), a retina structure illustration showing rods and cones distribution (scene 3), and a visual pathway diagram showing the complete route from retina through optic nerve, optic chiasm, lateral geniculate nucleus to the visual cortex (scene 4). A background image may also be used in the introductory scene. All images should be high-resolution educational diagrams clearly showing anatomical structures and light pathways, optimized for mobile display.
If Text	Short explanatory messages are displayed as text overlays inside Delightex Studio. Scene 1 displays the title "The Vision Mechanism: From Light to the Brain" with subtitle "Biology of vision and optics; signal transduction; from the eyeball to the visual cortex". Scene 2 shows "Light rays are refracted by the cornea and the crystalline lens to focus on the retina". Scene 3 displays "Photoreceptors (rods and cones) convert light into electrical signals". Scene 4 shows "Signals travel through the optic nerve and optic chiasm to the visual cortex". Scene 5 presents the quiz question "Which structure focuses light on the retina?" with answer options "Cornea", "Retina", and "Iris". All text is in English and should use clear, readable fonts suitable for mobile AR viewing. Button labels (START, NEXT, QUIZ) should be simple and immediately understandable. Text should be positioned to avoid obscuring important visual elements in the diagrams.
If video	-
If audio	-

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If 3D model	3D models in Delightex Studio can be used in formats compatible with the platform (.glb, .obj). The exercise primarily uses 3D text elements for titles and labels. Optional enhancement could include importing 3D anatomical models of the eye from external sources (such as Sketchfab models listed in the Links section) if Delightex supports direct 3D model import. However, the core implementation relies on 2D images (diagrams), text overlays, interactive planes (buttons), and particle effects (animated spheres) rather than complex 3D models, ensuring compatibility and smooth performance on standard mobile devices.

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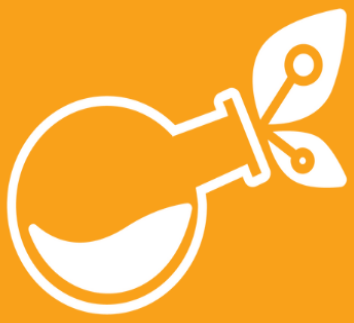

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