EDUCATIONAL HANDBOOK FOR USING AR/VR IN STEM EDUCATION IN SCHOOLS

A Guide for Educators on Integrating Augmented and Virtual Reality into Science, Technology, Engineering, and Mathematics Curricula

PROJECT INFORMATION

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PART I: PRACTICAL AR/VR FOR STEM TEACHING

Chapter 1: Understanding AR/VR Technologies and Tools for STEM Education

This handbook aims to provide you, STEM teachers in middle and high-schools with tools and tips to utilize in your classrooms in order to help you increase interactivity in your classrooms, and make your subjects more engaging and immersive for your students. In order to achieve these aims immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) can make experiences that were considered impossible, possible in today's classrooms. Imagine your students stepping inside a human cell, exploring a volcano, or creating molecules with their hands. With these technologies you can transform your teaching, making abstract concepts tangible and engaging students in ways that can be traditionally too dangerous, too invisible or too faraway to experience firsthand (Atlanta Technology Professionals, 2024).

This first part of this handbook introduces essential AR/VR technologies and also shows budget-friendly options for a start with STEM.

What You'll Learn

- Learn the difference between AR and VR
- Discover budget-friendly hardware and software options for your STEM subjects
- Recognize the benefits of these tools and prepare for common challenges.
- Differentiate different tools and tips to use in different STEM Courses

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1.1: Defining AR vs. VR: What is the Difference

Understanding the difference between AR and VR helps you choose the right tool for your teaching goals. Let's look at those in detail:

Augmented Reality (AR):

Augmented Reality (AR) is a tool where digital content such as images, videos, 3D models, or data can be projected onto the real world. In order to do that students can use a smartphone, tablet, or AR glasses to view both the real environment and virtual element.

Example in STEM: In a biology class, a student can point their tablet at a textbook page, and a beating in 3D heart can appear. Students can rotate the heart, zoom in to see its valves, and watch the animations of heart beats, all the while, their textbook stays in the classroom.

When to use AR? Consider using AR when your students work together in the same room with devices they already have, or you provide to them.

Virtual Reality (VR):

Virtual Reality (VR) are fully immersive digital environments that replace the student's view of the real world. You can utilize VR by using a VR headset, where students are transported into virtual spaces where they can look around 360 degrees and interact with virtual objects.

Example in STEM: In a chemistry class, with the help of a VR headset a student can transport himself inside a molecular structure, where they can manipulate molecules, and observe the results in a safe and controlled virtual laboratory.

When to use VR? Consider using VR for trips to places that are impossible to visit. These can be inside a cell, or outer space

1.2 Hardware for STEM Classrooms

Selecting the right hardware depends on your institute's budget, technical infrastructure, students age group, and specific learning objectives.

Here are options for every budget to consider:

Free Options: Use What You Have

• **Student Smartphones/Tablets:** Most AR apps work on devices students already own. Consider initiating BYOD (Bring Your Own Device) days to make accessible and free AR.
• **School Tablets:** iPads and Android tablets you already have in your institutes can have cameras, which support most educational AR apps without any additional purchase.

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Low Cost Options

- Google Cardboard offers the most economic option for using virtual reality. Students insert a smartphone into a cardboard or plastic viewer, which splits the screen into 3D views. While Google Cardboard has limited interactivity compared to VR headsets, it is a good start point for short field trips and 360°degree videos.
- Merge Cube: Merge cube is a commercial AR toy that is in mid-range cost. It works with smartphone/tablet AR apps to create 3D objects that students can hold and examine from all angles.

Moderate Investments:



Standalone VR Headsets: Devices like Meta Quest 3 offer full VR experiences with hand controllers.

Consider using standalone VR headsets, if your institution can afford it. One headset can be shared among classes using rotation schedules.

Photo: Students using VR headsets on charging station, by Stem.T4L on Unsplash

> 💡 **Getting Started Advice**
>
> Consider starting with free AR apps on your students' existing tablets or smartphones. Once you're comfortable with AR, depending on your availability, you might add 1-2 VR headsets for special activities, if your institution can provide.

1.3 Software for STEM Classrooms

There are many free and affordable solutions for using a software application for the AR/VR applications for STEM learning. Here are some that are organized by cost:

Free Platforms

- Google Expeditions has transitioned into Google Arts & Culture which is a free program where many of its 360-degree tours remain accessible. Students can visit the International Space Station, explore the reefs, or walk through the human circulatory system. They work on smartphones, tablets, and VR headsets.

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- **PhET Interactive Simulations:** PhET is a free educational project of the University of Colorado Boulder that creates interactive, research-based science and mathematics simulations designed to help students learn by exploring and discovering concepts themselves. Their simulations cover chemistry, physics, biology, earth science, and math.
- **SketchFab:** Thousands of 3D models (many with Creative Commons licenses) viewable in AR. Great for anatomy, geology, and cultural artifacts (University of Chicago Academic Technology Solutions, 2024).
- **YouTube VR:** Free 360° videos on every science topic imaginable. It is a good complementary for Google Cardboard or any VR headset

Free with Premium Options

- **DelightEx:** Previously CoSpaces Edu this platform offers opportunities to create AR/VR experiences and code interactions. There is a free basic version and a premium mode that adds extra features (Ramadhanya, F., 2025).
- **Labster:** Labster is an educational technology platform that offers interactive virtual science lab simulations used by schools, universities, and educators to teach STEM subjects like biology, chemistry, physics, and health sciences through browser-based simulations. Free access available for educators; premium includes full lab library.

Open-Source Tools

These tools are completely free and will always remain free. They're created by communities of developers and educators (Sathiyanarayanan, 2024):

- **ARToolKitX:** An open-source augmented reality software development kit (SDK) that lets developers build AR applications by overlaying virtual 3D content on the real world using camera tracking and marker detection. It's available on multiple platforms (desktop and mobile) and includes full source code so students and educators can explore and modify how AR works
- **Mixare:** Mixare is one of the first versions of a free, open-source augmented reality browser that runs on Android and iOS, displaying digital content over the real-world camera view. The project is currently archived but you can find an older version in the Android Store and App Store.
- **Blender**: While not an AR engine itself, Blender is widely used to build the 3D content (models and animations) that can be imported into AR projects and other immersive experiences.hh

Subject-Specific Quick Reference

Here are recommended tools for each STEM subject. Each tool will be analyzed in detail in the following chapters in this handbook. Here is a preview:

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STEM Subject	Example AR/VR Tools
Climate	Google Earth VR (free), Climate Explorer apps (free)
Geology	SketchFab geological models (free), Google Earth (free)
Physics	PhET simulations (free), Universe Sandbox (€30)
Chemistry	Labster (free for educators)
Biology	Complete Anatomy (free trial), AR anatomy apps (free)

1.4 Benefits and Challenges of AR/VR in STEM Education

Understanding both the advantages, and potential challenges of using these new technologies can help you make informed decisions.

Top Benefits of AR/VR in STEM Education

- **Make Abstract Concepts Visible:** With AR/VR, your students can see and interact with things which can be normally invisible. These things can be molecules, planets, or other elements which are too dangerous to have such as some chemical reactions.
- **Enables Impossible Experiences:** Related with the previous item, AR/VR technologies can take students places you could never go otherwise, such as inside of a volcano or an ocean floor, or back in time where dinosaurs roamed.
- **Dramatically Improves Retention:** Research shows AR can improve memory retention by up to 70% compared to traditional methods (OECD, 2025). This way, students remember experiences more than lectures.
- **Engages All Learning Styles:** AR/VR naturally works for visual, kinesthetic, and auditory learners simultaneously. Students who struggle with textbooks can find meaning and enjoyment with hands-on experiences.

Implementation Challenges (and Solutions)

Challenge 1: "I don't have the budget."

Mitigation Strategy: Start completely free with smartphones and free apps. The following chapters show how, in some cases, schools succeeded with minimal budgets.

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Challenge 2: "I'm not tech-savvy enough."

Mitigation Strategy: Most AR apps are as simple as downloading and opening them. In any case, in the following chapters of this handbook you will have a step-by-step guide on how to use the STEM-IT platform.

Challenge 3: "How do I manage devices and students?"

Mitigation Strategy: You can use station rotation. As in, while some students use AR/VR, others work on related activities. You don't need devices for every student simultaneously.

Challenge 4: "Won't students get motion sick?"

Mitigation Strategy: VR can cause motion sickness particularly during extended sessions or with poorly designed content. Most manufacturers recommend VR only for students 13 and older, though younger students may use AR without issues. As a mitigation strategy consider limiting the VR session length, allow students to remove devices at any sign of discomfort, and provide alternative activities for students who experience adverse effects.

Chapter Summary

AR/VR in education is growing rapidly. Understanding current trends helps you make wise decisions.

The convergence of declining costs, improving technology, and growing evidence of educational effectiveness creates a compelling case for using AR/VR in STEM education. While challenges remain, immersive technologies are becoming mainstream.

As you explore the specific STEM applications in the following chapters, remember that successful AR/VR integration isn't about having the newest equipment or the most expensive software but it's about thoughtfully selecting tools that align with your learning objectives, supporting teachers through the transition, and putting student learning at the center of every decision.

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Sathiyanarayanan, M.. (2024, February 16). *Free and open source augmented reality (AR) and virtual reality (VR) tools*. Medium. https://mitsquare.medium.com/free-and-open-source-augmented-reality-ar-and-virtual-reality-vr-tools-d59d19d32a64

Chapter 2: Pedagogical Strategies: Making AR/VR Work in Your Classroom

Choosing the software/hardware for the AR/VR technology is one thing, but using it effectively for your teaching needs is another. This chapter provides practical, research-based strategies for integrating AR/VR into your teaching, managing your classroom when students are using AR/VR tools.

What You'll Learn

- Apply evidence-based **pedagogical approaches** proven effective in STEM contexts
- Manage **cognitive load** and structure **immersive learning experiences**
- Implement **constructive alignment** to ensure teaching, learning, and assessment work together
- Design authentic, performance-based assessments using **evidence-centred design** principles

2.1 Pedagogical Approaches with AR/VR

Tene et al.'s (2024) systematic review of 22 peer-reviewed studies found that 72.73% of immersive technology interventions showed positive effects on student engagement and performance in STEM education. However, effectiveness depends critically on how these technologies are integrated pedagogically. The research identifies several key approaches that maximize learning outcomes as laid down below:

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Approach 1: Active Learning

Tene et al. (2024) emphasize that students learn best when actively exploring immersive environments with structured prompts rather than passive observation. The research shows that simply placing students in VR without clear objectives, leads to overload and surface-level engagement.

In order to apply this approach in your classroom consider encouraging students "Identify three organelles responsible for energy production. Describe their structure and location. Explain how they work together." instead of just indicating them to “explore a virtual cell” in a virtual reality environment.

Using the active learning approach prevents students from feeling lost while maintaining the exploratory benefits of immersive learning. Research participants using guided VR activities showed significantly higher comprehension of complex STEM concepts compared to unguided exploration (Tene et al., 2024).

Approach 2: Collaborative Learning

Tene et al.'s (2024) systematic review found that peer discussion and group exploration enhance reasoning and motivation in AR/VR contexts. Collaborative immersive tasks allow students to co-construct knowledge, with research showing improved comprehension when students work together (Tene et al., 2024). In order to apply this approach consider the following:

- **Partnered Observation:** Having a partner while observing the virtual environment can lead to more investigation, documenting findings and asking guiding questions. Add a second headset to the activity and pair your students for the activities.
- **Team-Based Challenges:** Assign different team members’ specific discovery goals in the same virtual environment.
- **Shared Problem-Solving:** Students use AR collaboratively to manipulate the same virtual objects, discussing approaches and testing hypotheses together with the observation of the instructor.

💡 Getting Started Advice

Immersive technologies prove most impactful when tied to authentic STEM problems. Consider the following framework to implement in your STEM classrooms:

- **Situate in Context:** Begin with a real problem ("How do engineers ensure bridge safety?") before entering VR
- **Explore in VR/AR:** Students investigate the problem using immersive tools (virtual structural testing, AR force visualization)

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- **Apply Learning:** Transfer virtual insights to real-world applications (design a model bridge, analyze local structures)

Approach 3: Constructive Alignment

Udeozor et al. (2023) ground their assessment framework in Constructive Alignment (CA), a principle stating that learning outcomes, teaching activities, and assessment tasks must **align** in order to **construct** knowledge and meaning-making. When applied to AR/VR, this ensures immersive experiences directly support learning rather than serving as engaging but disconnected activities.

Consider these questions while creating AR/VR activities in your classrooms:

- **Learning Outcomes:** What should students know and be able to do as a result of this activity? Are the outcomes connected to real-life contexts?
- **Learning Activities:** How will students practice these competencies? (AR simulation showing forces on structures)
- **Assessment Tasks:** How will students demonstrate mastery? What evidence do you require to evidence that they have met the criteria? (verbal, written, visual?)

2.2 Classroom Management with AR/VR

Effective integration of AR/VR technologies in the classroom requires balancing immersion with practical classroom realities. Consider these strategies that start small, provide time for adaptation before fully expanding your teaching according to research (Tene et al., 2024):

Phase 1 - Familiarization (Weeks 1-2): During this first phase introduce technology with simple 360° photos or videos, and some tutorials on how to use the technologies.

Phase 2 - Structured Exploration (Weeks 3-4): Start introducing guided VR/AR activities with clear learning objectives. At this stage you can also begin a station rotation model where immersive tasks can be alongside traditional activities (Udeozor, 2023). This model ensures every student accesses immersive technology while maintaining variety. Research shows that combining immersive and traditional activities yields better outcomes than immersive-only approaches (Tene et al., 2024). During this phase collect formative feedback on student experiences.

Phase 3 - Integration (Weeks 5+): In this phase AR/VR become a regular component of STEM lessons with more complex, longer activities with higher-order thinking. Students can even experiment with creating their own AR content.

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Safety and Supervision

Both studies highlight the need for controlled environments. Teachers must monitor student interactions and ensure immersive tasks remain aligned with learning goals rather than entertainment.

Essential Safety Protocols:

- **Physical Safety:** Clear 1.5m × 1.5m zones for standing VR; seated activities for 360° videos to prevent collisions.
- **Content Control:** Use special modes in your devices to restrict access to educational apps only; if possible monitor screens via teacher screen.
- **Pedagogical Focus:** Regularly check that activities align with learning outcomes; intervene if students drift toward entertainment.
- **Motion Discomfort:** Start with stationary VR; limit sessions to 15-20 minutes; provide immediate exit from activities if students show discomfort.

2.3 Assessment Strategies in AR/VR Learning

Tene et al. (2024) suggest using guided tasks and reflection prompts to check comprehension during immersive experiences. Formative assessment should be continuous and integrated into the activity itself.

Evidence-Based Formative Strategies:

- **Pause-and-Explain:** Periodically pause the immersive experience AR/VR and ask students to verbally explain what they observe.
- **Observation Checklists:** Teachers use screen mirroring to monitor student progress against specific criteria.
- **Immediate Reflection:** After 5-minute written reflection immediately post-VR: "What did you discover? What surprised you? What questions remain?"

Performance-Based Assessment

Udeozor et al. (2023) argue that immersive environments enable assessment of real-world competencies that traditional exams miss. Their case study assessed laboratory health and safety competencies through a VR game, measuring performance directly through student actions in the virtual environment. One thing was innovative was that they embed assessment tasks directly into VR/AR to ensure that the assessment is integrated with learning, not separated from it. According to their studies these are some tips for creating performance-based examples via VR/AR.

- **Problem-Solving Tasks:** Allow students to explore and solve authentic STEM problems in VR while engaging with the VR device itself. Observe how they approach

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problem-solving during the experience, as well as how they use and adapt to the technology.

- **Procedural Competencies:** Procedural Competency is a term borrowed from medical practitioners where the medical technicians correctly follow the steps and processes in a real-world environment such as looking at a dragonfly under a microscope. Check if the students follow the correct procedures step by step, apply proper safety protocols, and design and conduct experiments appropriately.
- **Decision-Making Scenarios:** Present students with branching scenarios requiring application of STEM knowledge.
- **Student-Created AR:** As students get more competent with AR devices, they can be assessed by their ability to design their own AR experience.

Rubrics and Constructive Alignment

A rubric is a structured scoring guide that is used to evaluate student performance. Both of the previously mentioned articles emphasize rubrics as valuable instruments to connect learning outcomes to immersive/virtual tasks. Udeozor et al. (2023) developed grading schemes for their VR game, categorizing performance as Novice, Competent, or Expert based on observable actions aligned with learning outcomes. A screenshot from the VR experience can be seen below:



Fig. 7. Scoreboard presented to students at the end of gameplay (Figure 7 in Udeozor et al., 2023)

What is important to consider is that in a rubric the learning outcome should be matching the cognitive level that the VR/AR activity is providing. For instance, if the goal is for students to analyze, the rubric should assess higher-order thinking (like comparing, reasoning, or evaluating) rather than simple memorization or recall.

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Chapter Summary

This chapter discussed research from two peer-reviewed journals which are Tene et al.'s (2024) systematic review of immersive technologies in STEM education and Udeozor et al.'s (2023) game-based assessment framework. Key findings establish that AR/VR effectiveness depends on pedagogical design: active learning with structured guidance, collaborative approaches, real-world contextualization, and constructive alignment between outcomes, activities, and assessment.

Classroom management requires incremental integration, station rotation for equitable access, and safety protocols. Assessment must be both formative (observation, reflection) and summative (authentic performance tasks), grounded in Evidence-Centred Design principles to ensure validity.

Chapter 3 to 6 will apply these pedagogical strategies to specific STEM topics, providing ready-to-use lessons incorporating research-based approaches from this chapter.

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Chapter 3: AR/VR for Environmental, Climate, and Earth Sciences

Climate change presents one of humanity's most complex educational challenges. Research demonstrates that immersive technologies effectively increase environmental awareness and foster pro-climate attitudes in ways traditional media cannot (Thoma et al., 2023). This section explores evidence-based approaches for teaching climate change through AR/VR, with particular attention to the STEM-IT's project context in terms of environmental, climate and earth sciences.

3.1: Climate Change and Migration

Traditional climate education faces a unique challenge: Students struggle to connect abstract data about carbon emissions with tangible impacts on their lives. VR and AR can help address this psychological distance problem through embodied experience.

Across four studies with over 270 participants, Markowitz et. al (2018) demonstrated that immersive VR experiences about ocean acidification produced consistent knowledge gains and more positive environmental attitudes compared to traditional learning methods. The same study also found that environmental awareness increased significantly after VR activities on glacier melting. As AR/VR became increasingly mainstream and an effective method to teach climate change and its effects, consider the following tips for integrating AR/VR into your teaching:

Tips for Teaching Climate Change (with AR/VR)

Tip 1: Inspire Hope not Despair

Ahn et al. (2023) found that overly broad doom-focused messaging overwhelms students. Try to focus on showing hope-based approaches while working with subjects like climate change.

Tip 2: Ground your examples in local contexts

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Design AR/VR experiences that reflect local ecosystems, weather patterns, or community impacts. In the study of Dhunnoo et al. (2023), when students see recognizable landmarks (like buildings and trams) in the VR experience, in familiar places in their local context, they found out that for them climate change becomes more concrete and relevant, therefore improving their comprehension and fostering personal responsibility for environmental response.

Tip 3: Make It Collaborative

Integrate AR/VR activities that require teamwork, discussion, and shared problem-solving. Collaborative exploration encourages peer learning, perspective-taking, and collective reasoning, reinforcing climate change as a shared societal challenge rather than an abstract or individual concern.

Tip 4: Include Reflection

In their study Markowitz et. al (2018) found that an increase in knowledge about ocean acidification was linked to increased engagement with and exploration of the virtual space and the cognitive processing time afterwards. Considering paired immersive experiences with reflection prompts or discussions. This will help them encourage actions related to climate change mitigation and adaptation.

Free and Affordable Climate Tools

• **Google Earth Timelapse:** Google Earth's Timelapse feature displays 40 years of planetary change, making long-term climate impacts visible. Use it in your classrooms to compare coastlines of Greek islands over decades to observe erosion, track agricultural land changes in Cyprus, or observe urban development in Malta.

• **NASA Climate Time Machine Platform:** NASA's Images of Change collection offers powerful before-and-after satellite photographs that document visible climate and environmental changes across the globe. Use it in your classrooms to help students observe dramatic transformations through simple image comparisons such as shrinking glaciers in the Alps, drought impacts on major rivers and lakes, or coastal erosion along Mediterranean shorelines.

• **360-Degree Science Documentaries:** Spiegel and Wang's (2024) research demonstrates stronger emotional connections to climate issues compared to traditional flat videos, as students feel physically present in affected locations.

YouTube offers freely accessible 360-degree immersive videos that allow students to experience climate change impacts from unique perspectives. Use these videos with VR

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headsets (like Google Cardboard or standalone devices) or simply on tablets and smartphones where students can move their devices to explore the full environment.

• **Virtual Museums for Climate Education:** Research on virtual museum design demonstrates that these platforms can effectively increase student motivation, support permanent learning, and help students understand abstract climate concepts by making them more concrete and visual (Ozdemir et. al, 2024).

Virtual museums are especially effective for elementary-level learners as they combine visual appeal with interactivity, making complex climate science more approachable. When using virtual museums in your classroom, consider platforms like Artsteps which allow educators to create customized exhibitions featuring climate-related images, videos, and information.

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3.2: Geology and Geography

Geology and geography pose unique teaching challenges that immersive technologies effectively address. AR and VR can provide spatial visualization skills that many students find difficult to develop through traditional textbooks and 2D diagrams. Reed et al. (2016) found that students remained engaged in the course for extended periods of time more than 20+ minutes as they explored how water flows across landscapes, how topography affects flooding, and how landforms change over time. Research demonstrates that immersive VR is highly useful for improving spatial understanding in geology education (Bonali et. al., 2021). Harknett et al. (2022) demonstrated that virtual field trips allow students to experience complex geological sites that would be impossible to visit due to cost, logistics, or physical barriers. All of these studies prove that Augmented and Virtual Reality technologies can provide valuable ways for STEM teachers.

Tips for Teaching Geology and Geography (with AR/VR)

Tip 1: Before you go for a field-trip use VR

Before taking your class for a field trip, let students explore the location in VR first. Research shows that when students see a place virtually before visiting in real life, they learn more during the actual trip (Harknett et al., 2022)

Tip 2: Combine Multiple Data Types

VR allows you to place different types of data such as temperature maps, or earthquake zones or historical photos on top of each other to see the connection between different types of information. Consider for instance layering mountain ranges of Greece with the recent earthquakes happening in the area. Students will be able to visually explore the correlation between seismic activity and geographical features, making it easier to understand how natural phenomena impact the environment.

Tip 3: No students left out

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Virtual Reality (VR) offers a powerful tool to ensure that all students, regardless of physical ability, can engage in immersive geographical experiences. Students with mobility issues can virtually explore the same cliffs, mountains, or volcanic sites as their classmates, allowing for shared learning experiences that would be difficult to replicate in traditional field trips.

Free and Affordable Geology and Geography Tools

Multiple free platforms enable effective geology and geography education and some of them also include through AR/VR:

• **Seterra:** Seterra offers interactive map-based quizzes that help students practise key geographical knowledge such as countries, capitals, rivers, mountains, and physical features. Use it in your classroom to reinforce map-reading skills, revise European geography, or assess students' understanding of tectonic plates and climate zones through immediate feedback and self-paced learning.

• **OpenSpace3D (Free VR/AR Creation Platform)**: Openspace3D allows teachers and students to create interactive 3D, VR, and AR environments without advanced programming skills. You can use it for geography lessons to build virtual landscapes, layer data such as elevation and seismic activity, or simulate natural hazards like earthquakes and volcanic eruptions, helping students visualise complex spatial relationships.

• **Google Arts & Culture Expeditions:** As we have discussed before, Google Arts & Culture Expeditions provides immersive virtual tours of natural and cultural sites around the world using 360° images and guided narratives. Use it in your classroom to take students on virtual field trips to volcanoes, deserts, glaciers, or UNESCO World Heritage sites, allowing them to observe landforms and human–environment interactions without leaving the classroom.

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3.3: Atmosphere and Greenhouse Effect

Like other climate and environmental sciences, using VR and AR for interactive visualizations greatly enhances student engagement and understanding of atmospheric processes (Cervenec et al. 2022).

Abstract concepts like greenhouse gas emissions, which are hard to grasp in terms of their real-world impact, become much more tangible through interactive visualizations. By making invisible processes visible and personally relevant, these tools help bridge the psychological gap between abstract theory and the tangible, real-world effects on our environment.

Tips for Atmosphere and Greenhouse Effect (with AR/VR)

Tip 1: Use Interactive Simulations to Visualize Invisible Concepts like Greenhouse Gases

Abstract concepts like greenhouse gas emissions, which are hard to grasp in terms of their real-world impact, become much more tangible through interactive visualizations. By making invisible processes visible and personally relevant, these tools help bridge the psychological gap between the theory and real-world tangible effects on our environment.

Tip 2: Show Long-Term Changes Through Time-Lapse Visualizations

Atmospheric changes happen slowly over decades, making them hard to notice. Time-lapse animations compress 140 years into 2 minutes, showing patterns that would otherwise be invisible. Students need to see the trend, not just hear about it.

Tip 3: Let Students Experiment with Different Scenarios

Interactive tools allow students to test what-if scenarios: What if we had more carbon dioxide? What about during the Ice Age? Research shows that students who can control and manipulate simulations develop deeper understanding than those who only watch (Cervenec et al. 2022).

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💡 **Exploration Questions using VR tools**

- What happens if we remove ALL greenhouse gases?
- What was temperature like in 1750 before factories?
- What if greenhouse gases double from today?

Free and Affordable Atmosphere and Greenhouse Tools

• **PhET Greenhouse Effect Simulation :** With this greenhouse gas simulator you can simulate the concentrations with a slider and watch Earth's temperature respond in real-time. They observe how sunlight passes through the atmosphere but infrared heat photons get trapped by greenhouse gases.

• **Copernicus Climate Change Service:** Copernicus Climate Data Store provides teachers with access to decades of European climate data in visual, easy-to-understand formats. You can use it to show students temperature trends across Mediterranean countries, compare rainfall patterns between different decades, or display how heatwaves have become more frequent in Cyprus, Greece, and Malta over the past 50 years.

• **European Environment Agency (EEA) Air Quality Index:** The EEA's Air Quality Index displays up-to-the-minute air pollution data for every European city on an interactive map. You can use it in your classroom to check today's air quality in your own city, or track how pollution changes hour-by-hour during the school day, helping students understand that invisible greenhouse gases and pollutants are real, measurable, and affect their daily lives.

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Chapter 4: AR/VR Tools for Safe Chemistry

Studying chemistry includes unique challenges that make immersive technologies especially valuable. Through AR/VR students can visualize atoms and molecules too small to see, understand three-dimensional molecular shapes from flat drawings, and connect invisible molecular changes to visible chemical reactions. Many important reactions are too dangerous, expensive, or time-consuming for school laboratories. Research found that VR laboratories can provide similar types of environments for students that satisfyingly provide the completion of learning outcomes as if they are in a real laboratory environment (Hu-Au and Okita, 2021). Consider these tips below to include AR/VR tools for safe chemistry classes.

Tips for Safe Chemistry (with AR/VR)

Tip 1: Embrace Accidents Risks in a Risk-Free Zone

Virtual laboratories allow students to go for the wrong options without the risk of getting hurt. VR/AR has an ability to transform mistakes that might have dire consequences in the real laboratories risk-free teaching moments. While exploring a virtual experiment that had an accident consider asking your students the following questions: “What just happened? Why? What would you do differently?”

A side benefit of accidents in the virtual laboratory is that students can repeatedly practice techniques such as proper pouring, eye-level measurement, and lighting a Bunsen burner, which helps build confidence and prevents repeated mistakes.

Tip 2: Make Experiments that Go Beyond School Budget

A meta analysis by Falah et al. (2024) found that 6.5% of reviewed articles reported that VR and AR reduce the cost of physical experiments in chemistry education. Virtual labs eliminate cost barriers, letting every student use rare elements or synthesize elements that can take hours or days to complete.

Tip 3: Show Students the Invisible World of Atoms and Molecules

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Virtual labs eliminate physical barriers, letting every student use rare elements or synthesize elements that can take hours or days to complete. They also give complete control over reaction timing to observe bond breaking, speed up rusting to see complete processes in minutes.

Free and Affordable Chemistry Tools

• **ChemCollective Virtual Lab (Free Online Laboratory):** Carnegie Mellon's ChemCollective provides a realistic laboratory with hundreds of standard reagents. You can use an in-class demonstration of successive dilutions using HCl, NaOH, a pH meter, and universal indicator solution. Students receive immediate feedback on incorrect procedures without wasting expensive chemicals.

• **MolView (Free Molecular Visualization):** MolView combines 2D structure drawing with 3D visualization. You can have students search molecules by name to examine structures, compare structural isomers with identical formulas but different arrangements, or investigate biomolecules like amino acids. It runs entirely in browsers with no installation.

• **MEL Chemistry VR (European Platform, Free Trial + Subscription):** This London-based platform delivers 3-7 minute VR lessons throughout Europe including Cyprus, Greece, and Malta. You can use it to let students build atoms, explore chemical bonding at molecular scale, investigate states of matter by controlling temperature, or examine reactions atom-by-atom. Complies with European safety standards (EN 71-4), certified by Education Alliance Finland. Works with affordable Google Cardboard or standalone VR headsets.

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Chapter 5: AR/VR Tools for Inclusive Biology

The dilemma of the biology teaching is that the most fascinating organisms live in places students cannot easily reach, and the smallest life forms remain invisible without specialized equipment. Salimi et al. (2024) found in their meta-analysis of 24 trials, VR demonstrates significant advantages for anatomy knowledge, with students rating virtual experiences as more beneficial than conventional instruction. A study with high school students demonstrated that mobile AR-based biology learning significantly enhanced students' motivation, self-efficacy, and attitudes toward online learning (Ciloglu & Özkan, 2023).This chapter explores available tools you can find online for making your biology courses more interactive and tips for using these and other similar tools.

Tips for Biology Courses (with AR/VR)

Tip 1: Build Three-Dimensional Understanding

AR places holographic organs on students' desks that they can walk around, rotate, zoom into, and manipulate with their hands. Hsu et al. (2023) found that VR teaching on human organs significantly improved high school students' comprehension and understanding compared to traditional textbook methods. One practical note though: in the same study researchers observed that some students experienced dizziness with extended VR use. Therefore it is recommended to limit VR sessions to 30 minutes to maintain student comfort and engagement.

Tip 2: Make the Invisible Visible by Shrinking Students to Cellular Size

Jiang et al. (2025) found that VR/AR facilitates visualization of invisible biological objects and concepts, helping students understand processes like photosynthesis, respiration, and gene expression that are impossible to observe in traditional classrooms.

Have students sketch cells before and after VR exploration to compare what details they missed in flat textbook versions. This visual comparison helps students recognize how much three-dimensional exploration enhances their understanding of cellular architecture and function.

Free and Affordable Biology Tools

• BioDigital Human (Free Basic Access): BioDigital Human includes 3D models of anatomy, diseases, and treatments accessible through browsers or VR. You can demonstrate disease progression, display surgical procedures through animations, explore anatomy by isolating individual systems, or construct custom presentations. Free accounts include thousands of pre-built models covering cardiovascular, respiratory, skeletal,

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muscular, and other systems. It is browser-based with no downloads required, making it ideal for schools with limited device storage or older computers.

• InCell: InCell is a gamified VR where students combat virus invasions inside cells while learning about organelles. You can introduce cell biology through engaging gameplay, reinforce organelle functions through repeated sessions, and offer struggling learners an enjoyable alternative to textbooks. The app is free for iOS and Android phones and compatible with Google Cardboard.

• Anatomy Learning - 3D Atlas: Anatomy Learning is a free 3D anatomy app for iOS and Android with no subscription required. You can rotate and zoom into detailed anatomical models, remove structures to reveal organs beneath, switch between different body systems, or quiz students on 3D locations. Includes bones, ligaments, joints, muscles, circulation, nervous system, respiratory, digestive, urinary, and reproductive systems. One advantage of it over BioDigital Human is that it supports multiple languages.

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Chapter 6: AR/VR Tools for Interactive Physics

Recent research found that VR and AR help students learn by turning abstract physics ideas into real experiences and letting them do virtual experiments that would be impossible or dangerous in real classrooms (Jiang et al. 2025). For teachers working with small budgets, limited equipment, and diverse students with different math backgrounds, AR and VR offer easier ways to teach physics.

Tips for Using AR/VR in Physics Courses

Tip 1: Speed Up or Slow Down Time to See What Actually Happens

Any physics events happen too quickly or too slowly for students to see. Car crashes happen in milliseconds, radioactive materials decay over hundreds of years, and light travels too fast to watch. VR lets you control time so students can slow down car crashes to see energy and motion step-by-step, speed up radioactive decay so students watch materials break down in minutes instead of centuries, pause light in mid-air to study how it behaves as both a wave and particle, or speed up planet movements to see orbit patterns in real time.

Tip 2: Let Students See Physics from Different Viewpoints to Understand Motion Better.

Students struggle with motion problems because textbooks show only one viewpoint, but physics requires understanding many viewpoints at once. Amri et al. (2020) found that 3D VR helped physics understanding, especially for space and viewpoint problems. This addresses a big challenge in which students can solve problems from one view but fail when asked to change viewpoints.

Consider creating activities where students must predict what they will see from a new viewpoint before switching views. For example, while watching a ball thrown upward from a moving train, students write predictions for both trackside observer and train passenger views, then experience both in VR. The instant visual feedback helps students see where their guesses conflict with physics rules.

Tip 3: Turn Physics into a Game

Instead of giving students physics rules as facts to memorize, VR turns students into scientists who discover relationships themselves. Design challenge activities where students must achieve specific goals by adjusting physics settings such as build a bridge that holds specific weights by adjusting material strength and shape, launch objects to hit distant targets by controlling angle and speed, or design electrical circuits to power devices.

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Free and Affordable Physics AR/VR Tools

• Newton's Playground VR: Newton's Playground is a Paid VR Physics game on Meta Quest where students change gravity, friction, air resistance, and material properties in real time. You can have students build structures and test them under different gravity, design vehicles and watch energy and motion, create chain reactions showing cause and effect, or experiment with over 60 physics settings. The multiplayer mode lets groups solve problems together by adjusting settings at the same time. One-time payment gives lifetime access. In order to explore it you need the Meta Quest 2 headset or newer headsets.

• Universe Sandbox: Universe Sandbox is a paid desktop and VR program that simulates gravity, planets, and space physics with accurate calculations. You can show planet orbit laws by moving planets, demonstrate gravity between multiple objects, simulate crashes between space objects, or adjust basic physics rules to show their effects. Especially valuable for astronomy and space units. It is available on Steam with school discounts. VR mode works with major headsets.

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PART II: GLOBAL BEST PRACTICES FOR AR/VR IN STEM COURSES

Chapter 7: European Case Studies

Across Europe, educators are innovating rapidly to solve a creative challenge: how to make STEM engaging for today's digital generation. While the challenges are similar, the solutions vary based on local resources and educational cultures. This chapter presents four real-world examples from Cyprus, Greece, Malta, and Italy. Each case offers a different starting point for you as a teacher: teacher training (Cyprus), gamification (Greece), local environmental connections (Malta), and technical skill building (Italy).

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7.1: Cyprus Case Study

Project Focus: Empowering Teachers as Creators through the EL-STEM Initiative

Context and Overview:

In Cyprus, many secondary teachers felt that Augmented Reality (AR) was too technical for daily classroom use. To address this, the **EL-STEM (Enlivened Laboratories within STEM Education)** project was launched. This Erasmus+ funded initiative involved partnerships across four countries, and was coordinated by the Open University of Cyprus. The program trained 25 lower secondary STEM teachers to design their own AR-enhanced learning materials for students aged 12-15 in chemistry, physics, and mathematics courses (Lasica et al., 2020).

This initiative focused on **Teacher Professional Development (TPD)**, operating on the belief that for technology to work in schools, teachers must be comfortable not just using it, but creating with it.

Implementation in the Classroom:

The project trained secondary STEM teachers to design "smart" learning materials. Instead of replacing textbooks, they enhanced them.

- **The Intervention:** Teachers used accessible AR tools to overlay digital information onto physical worksheets.
- **Subject Application:** In chemistry and physics classes (ages 12–15), concepts that are usually invisible, like atomic bonds or magnetic fields, were visualized through 3D models students could manipulate.
- **Inquiry-Based Learning:** The teachers did not just show animations but they built inquiry cycles. Students would scan a static diagram of a molecule, and a 3D model would pop up. They were then tasked with manipulating the model to answer specific questions, transforming passive viewing into active investigation.

Evidence of Success

Research published on this initiative provided clear evidence of its impact:

Teacher Transformation: Post-training data showed a significant rise in "Technology Acceptance." Teachers moved from being hesitant observers to active designers of digital curriculum. It was important as teachers didn't just learn to use the AR tools, but they gained confidence to create their own AR-enhanced lessons (Lasica et al., 2020).

Student Motivation: The "novelty effect" of AR successfully captured student attention, but the sustained engagement came from the interactivity. Students reported that manipulating the 3D objects made the abstract concepts feel "real" and

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understandable, and researchers observed students who typically paid little attention became actively engaged during AR-enhanced lessons (Meletiou-Mavrotheris et al., 2023).

Skill Development: The intervention helped students develop 21st-century skills, specifically digital literacy and spatial reasoning, which are crucial for advanced engineering studies (Lasica, 2021).

> 💡 **Takeaway for Teachers**
>
> Don't wait for a perfect, expensive software package. As the Cyprus case proves, just start small by finding one AR app that brings a single difficult concept in your textbook to life.

7.2: Greece Case Study

Project Focus: Gamifying Physics with Virtual Reality Escape Rooms

Context and Overview:

In Greece, researchers worked with the issue of student disengagement in "hard" sciences like Physics and Mathematics. They hypothesized that **Gamification,** which is using game design elements in non-game contexts, could reduce the anxiety students feel towards difficult calculations. This led to the development and testing of **Virtual Reality Escape Rooms (VRERs)** for secondary STEM education (Mystakidis & Christopoulos, 2022).

Implementation in the Classroom:

The intervention placed students inside a virtual scenario where "escaping" required applying scientific knowledge.

- **The Scenario:** Students might find themselves locked in a virtual laboratory. To unlock the door, they must solve a puzzle, for example, calculating the correct resistance for a circuit using Ohm's Law or physically placing the virtual resistor into a panel.
- **Immersion:** Using affordable headsets (like Google Cardboard) and desktop VR, researchers found that students experienced a sense of "presence." The urgency of the game made the math feel like a necessary tool for survival rather than a chore (Mystakidis et al., 2021).
- **Collaboration:** The competitive element of escape rooms drove students to work together and self-correct their mistakes, turning individual anxiety into team problem-solving.

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Evidence of Success

Teacher Perceptions: The follow-up survey involving 41 K-12 Greek teachers revealed that while they initially feared the technical setup, they found the 'playful learning' aspect highly effective. Teachers noted that the competitive element of the escape room drove students to collaborate and self-correct their mistakes. Another conference presentation involving 28 teachers showed similar positive results (Mystakidis & Christopoulos, 2022; Mystakidis et al., 2021)

Visualizing the Invisible: VR excelled at showing invisible forces (like electricity or gravity), which are otherwise impossible to see in a standard school lab. Students could manipulate virtual magnetic fields, watch electrons flow through circuits, and observe forces acting on objects in real time (Christopoulos et. al., 2022).

> 💡 **Takeaway for Teachers**
>
> Instead of a standard quiz, frame your questions as a "mission." If you can't use VR, even a paper-based escape room concept can boost engagement, but VR adds the critical element of "visualizing" the problem.

7.3: Malta Case Study

Project Focus: "STEMmersion" – Connecting Science to Local Environment and Careers

Context and Overview:

Connecting abstract scientific principles to the local context was the focal point of this case study. Students often struggle to see how STEM applies to their daily lives or future careers in Malta. Secretariat for Catholic Education and funded by Esplora Interactive Science Centre's National STEM Community Fund, **"STEMmersion"** project, addresses this gap between the classroom and the local environment (Secretariat for Catholic Education, 2025).

Implementation in the Classroom:

The project created a library of VR experiences specifically filmed in Maltese locations, focusing on environmental science and engineering.

- **Place-Based Learning:** Instead of generic stock footage, students visit local Maltese sites in VR: limestone quarries, marine biology reserves, and waste management plants. Students connect scientific concepts like erosion or biodiversity to places they recognize.
- **Career Guidance:** VR experiences include interviews with Maltese STEM professionals. Students exploring a virtual marine reserve hear from a Maltese marine biologist explaining their career path and daily work

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- **Curriculum Integration:** TContent was mapped to the national curriculum, allowing teachers to use these 'Virtual Field Trips' as direct replacements for logistically difficult real-world trips. Resources include 360-degree virtual tours, AR activities, robotics projects, and podcast production.
- **Free Accessibility:** All resources are freely available at www.csm.edu.mt/stemmersion, ensuring any Maltese school can access these materials without cost barriers.

Evidence of Success

The project successfully demonstrated how technology can localize education:

Relevance: By seeing their own country in VR, students connected scientific concepts (like erosion or biodiversity) to the world outside their window. This "place-based" approach is proven to increase student ownership of learning.

Teacher Support: The project provided ready-made digital resources. Research on Maltese teachers indicates that while willingness to use tech is high, time is a scarcity. Providing high-quality, localized content removed the barrier of content creation (Esplora, n.d.).

Environmental Awareness: The immersive nature of the content helped raise awareness about sustainable living on the islands, directly linking STEM education to active citizenship. Students could see the direct impact of human activity on local ecosystems (Żammit, 2023).

> 💡 **Takeaway for Teachers**
>
> Localize your content. Students care more about science when they see it in their "backyard." Look for resources that reflect your local ecosystem or industry. Even without VR, connecting lessons to local examples increases relevance and engagement.

7.4: Italy Case Study

Project Focus: Mixed Reality for Technical Skills and Distance Learning

Context and Overview:

Italy has a strong tradition of technical education. However, teaching Spatial Intelligence which is the ability to visualize 3D objects from 2D blueprints has turned out to be extremely difficult. Researchers from the Polytechnic Institute of Bari's Department of Mechanics, Mathematics, and Management developed Mixed Reality (MR) applications to solve this, particularly for mechanical engineering and distance learning scenarios. The research involved 84 students total across two studies (48 students in the first study, 36 in the

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second). While this case study focuses on higher education, the lessons apply directly to secondary technical schools (Gattullo et al., 2022)

Implementation in the Classroom:

Even though this specific case study has higher-education in their focus, there are still valuable lessons that can be derived from implementing mixed reality overlays holograms onto the real world.

- **The Tool:** Students view standard 2D technical drawings on paper. The MR app projects a 3D hologram of the machine part (gear, engine component) directly onto the paper, bridging the 2D-3D gap.
- **Interactive Disassembly:** Students could "explode" the hologram which means separating the parts in mid-air to understand how the internal mechanisms fit together.
- **Cognitive Load Management:** The study measured cognitive load to ensure the technology was helping, not overwhelming. The interface was designed to challenge students appropriately without causing frustration.

Evidence of Success

A study published in 2022 highlighted the effectiveness of this approach:

Spatial Understanding: Students using the MR tool showed marked improvement in their ability to translate 2D drawings into 3D mental models which is a critical skill for future engineers.

Usability: The application received an 'excellent' usability score of 84.7 out of 100. In addition to this, the 'cognitive load' was measured as medium, meaning the task was challenging enough to be educational but the interface didn't cause frustration.

Safety and Access: The tool proved invaluable for distance learning or for studying dangerous machinery that students could not safely handle in a physical lab.

> 💡 **Takeaway for Teachers**
>
> Use AR/MR to "look inside." If you are teaching complex structures, whether they are biological organs or mechanical engines, augmented reality is superior to static images for explaining how parts fit together.

Conclusion

These four case studies demonstrate that there is no "single way" to use immersive technologies, however they share a common thread: technology was not used to replace the teacher, but to solve a specific teaching problem. In Cyprus, the focus was on teacher empowerment; in Greece, it was gamification; in Malta, it was local relevance; and in Italy, it

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was technical visualization. Each approach succeeded because it addressed a real classroom challenge with appropriate technology.

As we consider who these future scientists and engineers will be, it is vital to ensure that these exciting tools reach all students. In the next chapter, we will look specifically at the contributions of underrepresented groups in science: the contributions of women in science.

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PART III: Celebrating Female Scientists in STEM

The representation of women in STEM fields remains a critical challenge for educators globally. Research suggests that "role model intervention" is one of the most effective ways to encourage girls to pursue science and engineering (Gladstone & Cimpian, 2021). When students see themselves reflected in the history of discovery, their sense of belonging increases.

This part of the handbook celebrates pioneering women who changed the world through their brilliance and persistence. By sharing these stories, you can help your students see that STEM is a space where every underrepresented group can lead, innovate, and succeed.

Chapter 8: Climate and Earth Scientists

• Dr. Marie Tharp

For a long time, people believed the ocean floor was flat and empty. Dr. Marie Tharp (1920-2006) proved them wrong. Working at Columbia University's at Columbia University's Lamont Geological Laboratory (now Lamont-Doherty Earth Observatory), she used data collected by sonar to create the first scientific map of the entire ocean floor. Her work was painstaking--translating thousands of sonar readings, longitude by longitude and latitude by latitude, into hand-drawn profiles of the seafloor (Lamont-Doherty Earth Observatory, n.d.).



• Her Discovery:

She discovered the Mid-Atlantic Ridge, a giant underwater mountain range stretching over 40,000 miles around the globe. More importantly, she identified a rift valley running along its center, a discovery that provided the "missing piece" of evidence for the theory of plate tectonics, the

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revolutionary idea that continents move across the Earth's surface (Felt, 2012). Her maps showed that the seafloor was not flat but covered in canyons, ridges, and mountains, revealing a dynamic, three-dimensional landscape beneath the waves (Smithsonian Ocean, 2023).

AIP Emilio Segrè Visual Archives, Gift of Bill Woodward, USNS Kane Collection - https://repository.aip.org/islandora/object/nbla%3A297089, CC0, https://commons.wikimedia.org/w/index.php?curid=123201510

- ## Her Success:

At the start of her career, women were not even allowed on research ships. She had to stay in the office and draw maps based on data others collected. When she showed her colleague the rift valley she had discovered, he dismissed it as "girl talk," saying it will be considered an outlandish theory (Library of Congress, 2021). It took nearly a year for the science community to accept her findings. Even after the significance of her work became clear, her name did not appear on the major scientific papers about plate tectonics published between 1959 and 1963.

> 💡 **Takeaway for Teachers**
>
> In order to commemorate Dr. Tharp's legacy use VR apps like *Google Earth VR* to fly over the Mid-Atlantic Ridge. Show students how Tharp's 2D drawings became the 3D maps we use today. Students can explore the ocean floor she mapped and see the rift valley she discovered.

- ## Wangari Maathai

Wangari Maathai (1940-2006) was a Kenyan environmental scientist, political activist, and the first African woman to receive the Nobel Peace Prize (2004). She founded the Green Belt Movement in 1977, a grassroots environmental organization focused on tree planting, environmental conservation, and women's empowerment. She was also the first woman in East and Central Africa to pursue a doctorate degree, receiving her Ph.D. in veterinary anatomy from the University of Nairobi in 1971 (Nobel Prize, 2004).



- ## Her Work:

Maathai recognized that environmental degradation and deforestation in Kenya were directly linked to poverty, especially for rural women. Starting with just seven seedlings on World Environment Day In 1977, the Green Belt Movement grew into a widespread tree-planting strategy. The organization has planted over 51 million

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trees and trained more than 30,000 women in forestry, beekeeping, food processing, and sustainable trades (Green Belt Movement, n.d.; Goldman Environmental Prize, 2023).

Wangarĩ Maathai at the Social Forum Note. Photograph by [Photographer's Name] (Year). Wikimedia Commons. URL

- **Her Impact:**

Maathai's work went beyond environmental conservation and became about social justice, democracy, and human rights. She stood up against the oppressive regime, leading successful campaigns against deforestation of public spaces like Uhuru Park. Her activism resulted in government persecution, yet she persevered and became a symbol of environmental and democratic activism worldwide (Learning to Give, n.d.).

> 💡 **Takeaway for Teachers**
>
> Use VR experiences or 360-degree videos of reforestation projects in Kenya. Have students calculate the carbon offset of planting 51 million trees using AR carbon footprint calculators. You can also have students design their own "Green Belt" projects for their local communities using AR design tools.

Chapter 9: Chemistry Scientists

- **Dr. Marie Curie**



Dr. Marie Curie (1867–1934) is perhaps the most famous scientist in history. She was the first person to win Nobel Prizes in two different scientific fields: Physics (1903, shared with her husband Pierre Curie and Henri Becquerel) and Chemistry (1911, awarded solely to her). She was also the first woman to win a Nobel Prize and remains the only person to win Nobel Prizes in two different sciences (Pasachoff, 1996).

- **Her Discoveries:**

She discovered two new chemical elements: Polonium (named after her native Poland) and Radium. She coined the term "radioactivity" to describe the phenomenon she was studying. During World War I, she developed mobile X-ray units called "petites Curies" to treat wounded soldiers on the battlefield, bringing radiological technology directly to field hospitals and saving countless lives (Pasachoff, 1996).

Nobel Foundation. (1903). Marie Skłodowska-Curie, 1903 Nobel Prize portrait [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Marie_Curie_1903.jpg

- **Her Legacy:**

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Despite facing extreme poverty and sexism throughout her career, she changed medical science forever. She was denied membership in the French Academy of Sciences because she was a woman, even after winning her first Nobel Prize. Yet she persevered, establishing the Curie Institutes in Paris and Warsaw, which remain leading cancer research centers today.

> 💡 **Takeaway for Teachers**
>
> Use AR simulations to show how Radium atoms decay over time. Apps like Elements 4D or chemistry AR platforms allow students to see atomic structure and radioactive decay in real-time. This makes the invisible process of radioactivity visible.

• Dr. Stephanie Kwolek

Stephanie Kwolek (1923–2014) was a chemist who initially wanted to attend medical school to do polymer research while working at DuPont. Her unexpected career change led to one of the most important material science discoveries of the 20th century.



• Her Discovery:

In 1965, while searching for a lightweight fiber to reinforce tires, Kwolek synthesized a liquid crystal solution that was cloudy and thin- which was unlike anything she had seen before. Most researchers would have thrown it away, assuming it was contaminated. But Kwolek trusted her instincts and asked a colleague to test it. The result was extraordinary: the fiber was five times stronger than steel but as light as plastic. This became Kevlar, a revolutionary material that has saved countless lives (Time for Kids, 2020).

Kalish, H. (n.d.). Stephanie Kwolek [Photograph]. Science History Institute. https://commons.wikimedia.org/wiki/File:Stephanie_Kwolek

• Her Impact:

Today, Kevlar is used in bulletproof vests, protecting law enforcement officers and military personnel worldwide. It's also used in spacecraft to shield against micrometeoroids, in suspension bridges to provide strength with reduced weight, and in countless other applications.

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💡 **Takeaway for Teachers**

Use AR to show the molecular structure of Kevlar compared to steel. Students can manipulate 3D molecular models to see how the para-aramid polymer chains align to create exceptional strength. You can also show VR demonstrations of materials testing--comparing how Kevlar performs versus traditional materials.

Chapter 10: Biology Scientists

• Dr. Rita Levi-Montalcini

Dr. Rita Levi-Montalcini was an Italian neurobiologist who conducted her most famous experiments in a secret bedroom laboratory during World War II because she was banned from universities (Nobel Prize Outreach, 2025).



Her Discovery:

Working with makeshift equipment in her bedroom, Levi-Montalcini studied nerve cell growth in chicken embryos. She discovered the Nerve Growth Factor (NGF), a protein that tells cells how to grow and stay healthy. This discovery was revolutionary for showing that chemical signals control how our nervous system develops and functions. Her work was vital for understanding neurodegenerative diseases like Alzheimer's and cancer (Nobel Prize Outreach, 2025). For this discovery, she was awarded the Nobel Prize in Physiology or Medicine in 1986.

Hagblom, K. (1986). Rita Levi-Montalcini during a visit to Lund, Sweden [Photograph]. University Library, Lund University.

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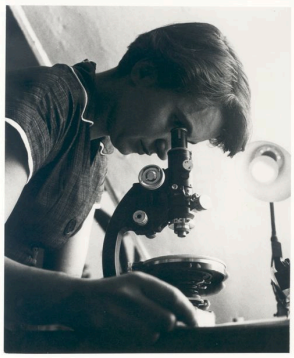
💡 **Takeaway for Teachers**

Use VR biology apps to show students how nerve cells grow and connect. Apps like InMind VR allow students to journey through the human brain and see neurons in action. Show AR overlays of the nervous system to demonstrate how NGF guides nerve growth during development.

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Dr. Rosalind Franklin

Dr. Rosalind Franklin was a British chemist (1920-1958) and X-ray crystallographer whose work was essential to understanding the structure of DNA, yet she received little recognition during her lifetime.



Her Discovery:

She took "Photo 51," an X-ray image that clearly showed the double-helix structure of DNA. Her photograph was the crucial piece of evidence that James Watson and Francis Crick used to build their famous DNA model. However, the photo was shown to Watson without Franklin's knowledge or permission by her laboratory colleague Maurice Wilkins. Watson and Crick published their model in 1953, and they, along with Wilkins, received the Nobel Prize in 1962. (Rosenfeld, 2003).

Figure 1 Rosalind Franklin with microscope Note. Photograph by MRC Laboratory of Molecular Biology (1955), from the personal collection of Jenifer Glynn. Licensed under CC BY-SA 4.0.

Her Impact:

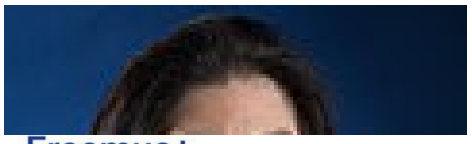
Without her high-quality X-ray crystallography images, the discovery of DNA's structure would have been delayed by years. Beyond DNA, she also made significant contributions to understanding the molecular structures of viruses (Johnson, 2017).

> 💡 **Takeaway for Teachers**
>
> Use AR to show students the double helix structure of DNA. Apps like DNA Play allow students to manipulate and explore 3D DNA models, understanding how the structure relates to function. Show students Photo 51 alongside modern DNA models in AR, helping them see how Franklin's X-ray image revealed the helical structure.

Chapter 11: Physics and Energy Scientists

Dr. Fabiola Gianotti

Dr. Fabiola Gianotti is an Italian particle physicist who made history as the first woman to be Director-General of CERN, the world's largest particle physics laboratory. She has served in this role since 2016 and was reappointed for a second term--the first time in CERN's history that a Director-General has served two full terms.



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ΙΔΡΥΜΑ ΚΡΑΤΙΚΩΝ ΥΠΟΤΡΟΦΙΩΝ ΙΚΥ

The Discovery

From 2009 to 2013, Gianotti was the elected spokesperson for the ATLAS experiment at CERN's Large Hadron Collider. On July 4, 2012, she had the honor of announcing to the world one of the most significant discoveries in physics: the Higgs boson, often called the "God Particle." The Higgs boson explains why objects in the universe have mass- which is a fundamental question in physics. The discovery confirmed a theory proposed almost 50 years earlier and was so important that Peter Higgs and Francois Englert received the Nobel Prize in Physics the following year (CERN, 2024).

Brice, M. (2015). Portrait of Dr. Fabiola Gianotti [Photograph]. CERN Document Server. https://cds.cern.ch/record/2116825

Inspiration

Gianotti studied piano at the Milan Conservatory before turning to physics. She often speaks about the harmony between her love for music and the humanities and her passion for physics, showing students that scientists can have diverse interests and talents.

> 💡 **Takeaway for Teachers**
>
> Use VR experiences like CERN VR or Google Arts & Culture: Inside CERN to take students on a virtual tour of the Large Hadron Collider. They can see the massive scale of the particle accelerator and understand the technology behind the Higgs boson discovery. Use AR to show students particle physics simulations--visualizing subatomic particles and their collisions.

Dr. Fotini Markopoulou-Kalamara

Dr. Fotini Markopoulou-Kalamara is a Greek theoretical physicist known for her groundbreaking work in quantum gravity, particularly her development of the theory known as "Quantum Graphity." She represents the modern, interdisciplinary scientist--moving fluidly between theoretical physics, design engineering, and technology innovation.



Her Work:

Markopoulou challenges our most basic ideas about time and space. In 2008, she and her colleagues introduced Quantum Graphity, a revolutionary model suggesting that spacetime itself might emerge from a network of connections, like nodes on a graph that can be "on" or "off."

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According to her theory, at extremely high temperatures (like those just after the Big Bang), all points in space are randomly connected and spacetime as we know it doesn't exist. As the universe cools, this network undergoes a phase transition, and spacetime "condenses" into the four-dimensional reality we experience (Konopka, Markopoulou, & Smolin, 2006).

- **Modern STEM:**

Beyond physics, Markopoulou co-founded Empathic Technologies, a company that uses psychophysiology research to create wearable technology. She represents how STEM careers can evolve--from pure theoretical research to applied technology that impacts daily life (Markopoulou, 2015)

Dr. Androulla Vassiliou

While not a laboratory scientist, Dr. Androulla Vassiliou is a Cypriot lawyer and politician who served as European Commissioner for Education, Culture, Multilingualism and Youth from 2010 to 2014. Her work demonstrates that STEM leadership extends beyond the laboratory into policy-making and educational reform.



- **Impact:**

Vassiliou was a key figure in promoting STEM education across Europe during a critical period of educational reform. She focused specifically on digital literacy and encouraging girls to enter technical fields. Her work addressed the systemic barriers that prevent women from pursuing STEM careers, advocating for policy changes at the highest levels of European governance (European Commission, 2008).

Androulla Vassiliou, European Commissioner for Education and Culture Note. Photograph by Marina Ofugi (2011). Wikimedia Commons.

- **Policy Power:**

Her work shows students that STEM careers include leadership, policy-making, and educational reform. Before her role as Commissioner, Vassiliou was active in Cypriot politics, serving in the House of Representatives and promoting legislation on women's rights, children's rights, and patient rights (WISE, 2019).

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Conclusion

The women featured in these chapters shared a common trait: they looked at the world differently. They overcame social barriers and technical limitations to expand the boundaries of human knowledge. By introducing your students to these role models, you provide them with a map for their own future.

Having explored the "why" and "who" of STEM education through AR, VR, and inspiring biographies, we will now move to the "how." In Part IV, we provide step-by-step tutorials on how to use the tools of **STEM-IT.**

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PART IV: Practical Implementation

In Part IV of the handbook we focus on the practical use of the tools developed within the STEM-IT project. The following chapter presents each tool through a brief introduction, an explanation of its educational use, and a step-by-step guide. At the same time, it highlights how AR and VR technologies can be leveraged to make STEM instruction more interactive and immersive. The goal is to help educators understand how these tools work and how they can be applied in the classroom in a simple and practical way.

Chapter 12: Quick-Start Guide to STEM-IT Interactive Tools

This chapter presents the interactive tools developed as part of the STEM-IT project and shows how they can be used in actual STEM classes. Each section focuses on one tool, explains its basic use, and provides practical guidance for teachers and students. Through examples from various academic disciplines, such as chemistry, climate change, geography, biology, physics, and thermodynamics, the handbook demonstrates how AR, VR, and 3D environments can make teaching more interactive and engaging.

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12.1 AR Tutor

AR Tutor is an augmented reality educational platform that connects printed or digital learning materials with interactive content. Students can use a smartphone or tablet to scan specific pages or images of a printed or digital book and view the digital elements linked to them.

The platform was developed by the Advanced Educational Technologies and Mobile Applications (AETMA) Research Lab at the Democritus University of Thrace, Greece, and has been continuously developed since 2016. It is available free of charge to educators and students worldwide, following its vision of “Immersive Education for All”.

AR Tutor - Educational Tool for STEM

In STEM lessons, augmented reality can help make difficult concepts easier to see and discuss. Instead of only reading explanations or looking at diagrams, students can scan the material, observe the digital content and interact with it more directly.

AR Tutor is also useful for teachers. It allows educators, even those with limited technical skills, to create augmented reality books and prepare more engaging classroom activities without needing programming knowledge. To do this, teachers first choose the resources that fit the subject and the unit they want to teach, such as images, videos, audio files, links or 3D models, and then connect them to the relevant pages of the book through the platform. The platform also includes accessibility-oriented features that may support students with movement disabilities.

Acids, Bases and Salts with AR Tutor

The following example shows how AR Tutor can be applied in a real STEM lesson, using chemistry as the subject. The STEM-IT project has developed two ready-to-use AR Tutor courses focused on the unit "**Acids, Bases and Salts**".

The course is available in the following versions:

- **High School Course**: designed for high school students and focused on the basic concepts of acids, bases and salts.
- **Middle School Course**: designed for middle school students and adapted to the relevant learning level.

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“**Acids, bases and salts - High School Course**” is a micromodule/ unit aimed at High School students. E-book’s QR code can be sent to all students via email.

“Acids, bases and salts - Middle School Course” is a micromodule/unit aimed at Middle School students. E-book’s QR code can be sent to all students via email.

The access process is the same for both versions.

Students need to download ARTutor app (for Android: https://play.google.com/store/apps/details?id=com.aetma.artutor3Chl=en) and (for ios: https://apps.apple.com/gr/app/artutor4/id1573116812) to their smartphones or school’s tablets in order to see the augmentations by scanning the e-book. Their smartphones need to be ARCore supported devices. Devices supported are Android 8.1 (API 27) or later and ios ARKit-compatible devices running iOS 11.0 or later. More information about available devices can be found on the link below: https://developers.google.com/ar/devices#google_play_devices

1. Open the ARTutor application and select the QR code scanning option.
2. Scan the QR code shown in [Figure 1] using the ARTutor scanner [Figure 2].
3. Once the QR code is recognized, the book will be automatically uploaded to the application.
4. The camera will then be activated and ready for use.
5. Place the printed book or open its PDF version in front of you.
6. Scan the pages of the book using the device's camera to view the available augmentations

After the book has been loaded, students can freely explore its augmented elements by scanning the corresponding pages.
There is an arrow with a text “scan image” above each image on the e-book to help students understand what they need to scan.

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Figure 1: E-books QR codes

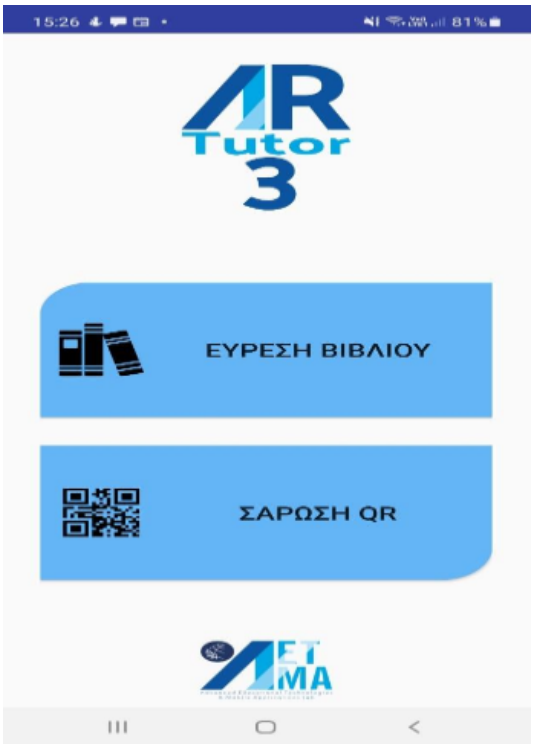


Figure 2: ARTutor QR scanning functionality

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Alternatively, through ARTutor application students can search for “Acids, bases and salts - High School Course” book.

Other books are also available by clicking the first option on the app’s home screen. By selecting a category all the books in this category are retrieved and listed. For each book,the title, description, author, and language of the book are displayed [Figure 3]. When a book is selected, the server retrieves all the augmentation assigned to the various areas of the book. Following that, a new screen appears, displaying the camera preview, and the device is ready to scan the various pages of the selected book and recognize the trigger images.

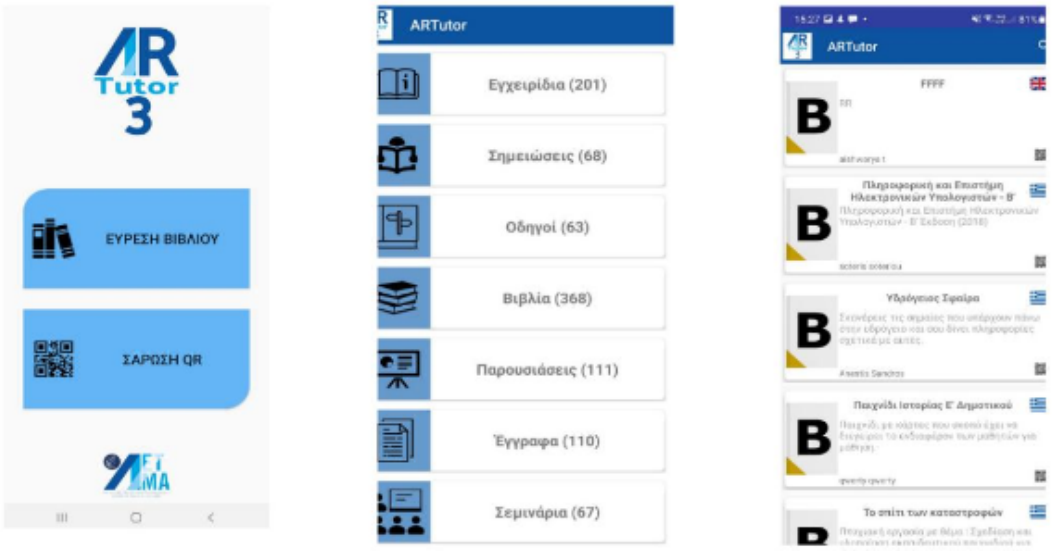


Figure 3: Searching for books in ARTutor application

Creating Books with AR Tutor

Apart from using ready-made AR Tutor courses, teachers can also create their own interactive learning materials through the ARTutor platform. This allows them to upload a document, select specific areas of the pages, and connect them with digital resources such as videos, 3D models, images or external links. The following steps provide a simple overview of how a teacher can create a new interactive document in ARTutor.

Step 1: Register and log in to ARTutor

Teachers first go to the **ARTutor platform** https://artutor.cs.duth.gr/home/ , create an account and confirm their registration through email. After logging in, they are transferred to the “My Books” area, where they can manage or create their books.

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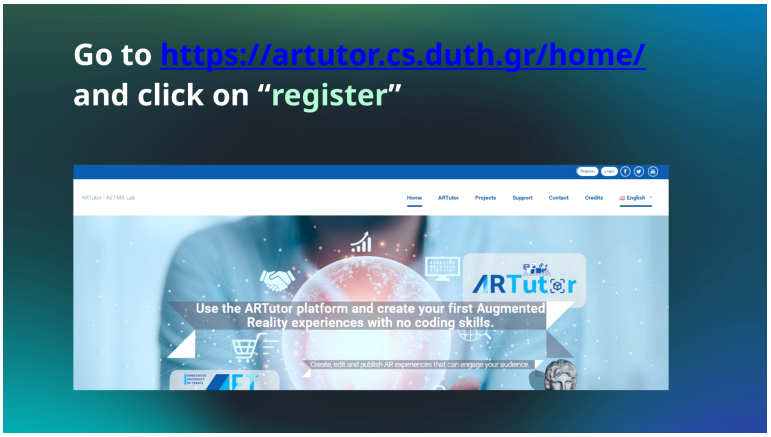


Figure 4: Creation of account in the ARTutor platform

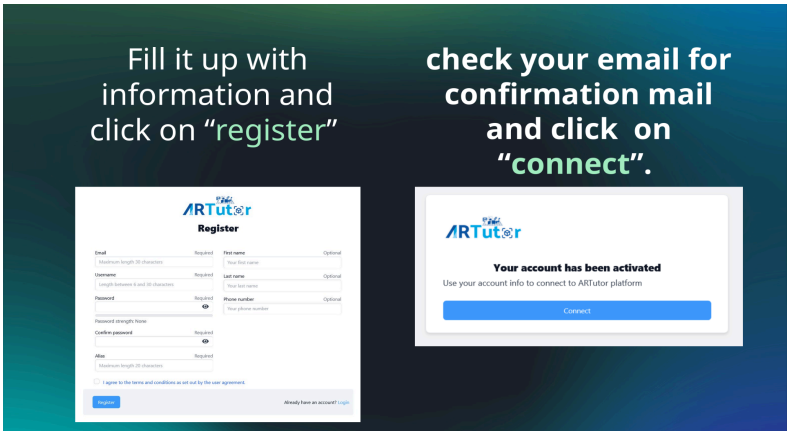


Figure 5: Email confirmation of the registration

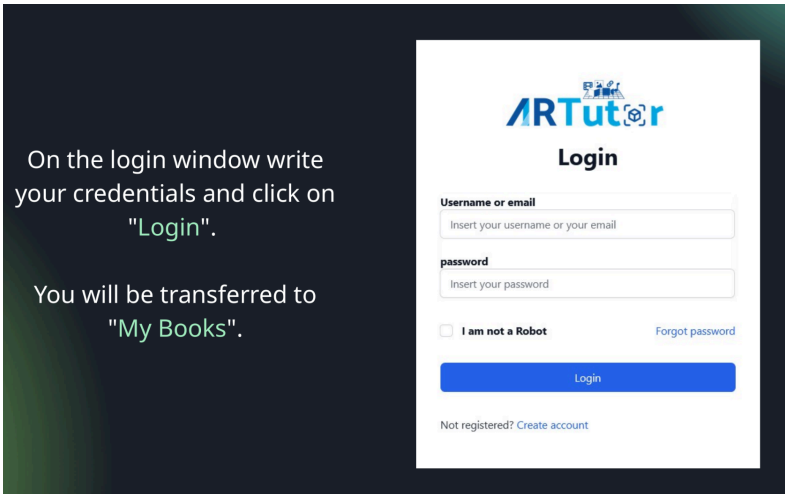


Figure 6: Login with credentials

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Step 2: Create a new book

From the right side menu of the editor, teachers click on the “Create” button and fill in the required book information, such as title, description, labels, category, language, knowledge field, educational level, cover image and PDF file. Once the information is completed, they go to “**Create Book**”.

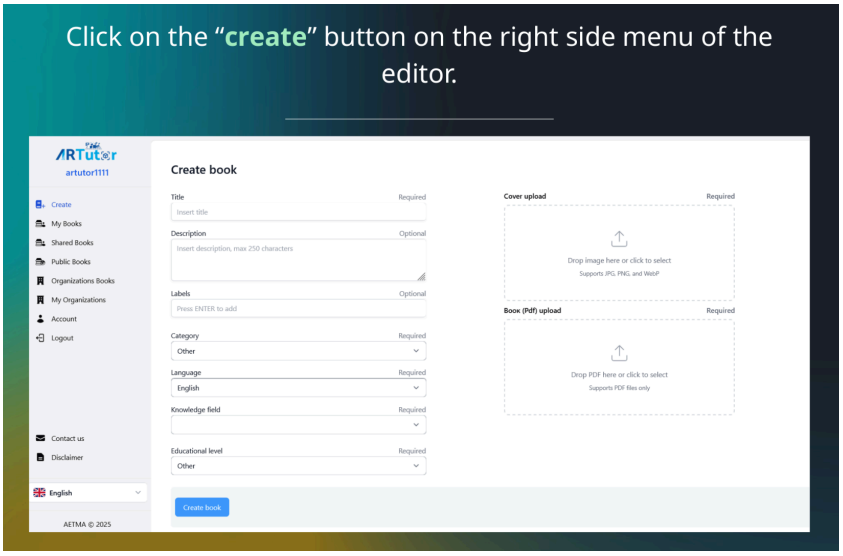


Figure 7: Creation of a book

Step 3: Add augmentations

After creating the book, teachers can add augmentations by selecting the relevant page area through the crop tool. The crop area should be large and clear enough for the camera to recognise it.

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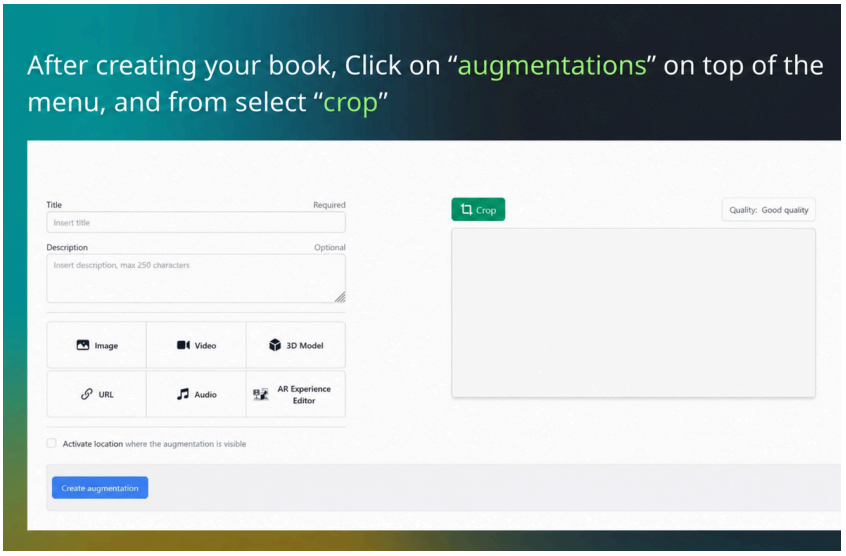


Figure 8: Crop tool

> 💡 **Tip!**
>
> When creating new AR Tutor material, make sure that the selected crop area is clear and that the platform shows “**Good Quality**” or “**Excellent Quality**” before saving.

Step 4: Add digital resources

Teachers can connect different types of resources to the selected areas of the document, these may include videos, 3D models, URLs and images. Each resource is added by filling in a title, description, selecting the source type and uploading or linking the relevant file.

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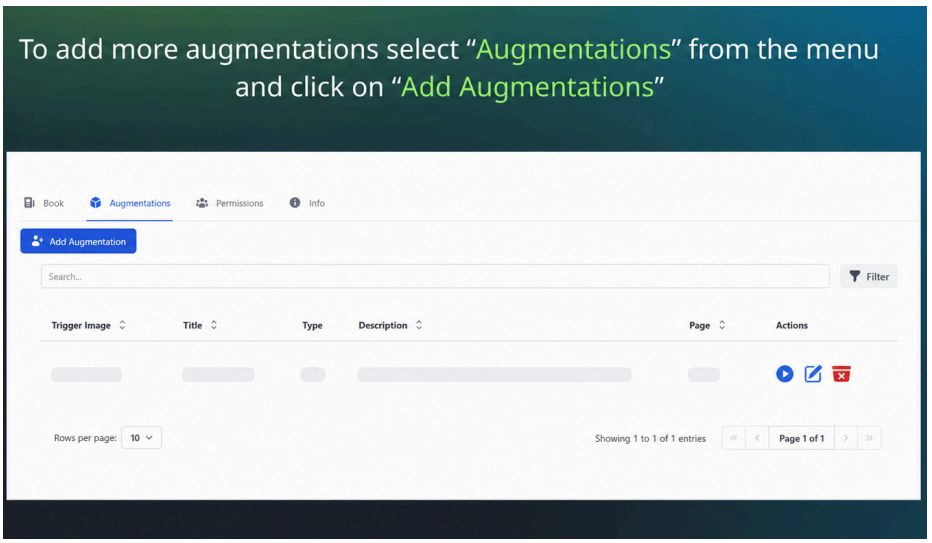


Figure 9: Adding augmentations in the book

Step 5: Publish and scan the material

Once the augmentations are added, teachers should set the book status to “Completed” and the visibility to “Public”. Students can then open the ARTutor4 app, scan the QR code and use their mobile device to scan either the PDF on a screen or a printed copy of the document.

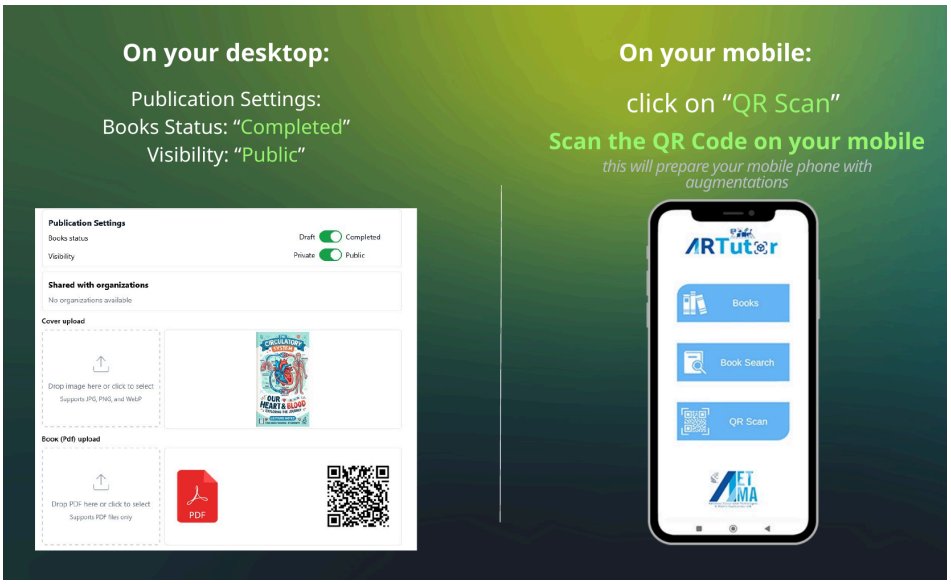


Figure 10: Publication Settings & Scanning

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12.2 VR Museum

In the STEM-IT Project, the **Metasteps platform** was used to create the "STEM-IT VR Museum - Climate Change Exhibition". Metasteps is a platform that helps teachers turn learning content, projects and classroom activities into 3D virtual experiences. Metasteps can be used to create virtual exhibitions, 3D galleries and virtual classrooms where students explore resources in a more visual and engaging way.

In STEM teaching, virtual learning can make complex topics easier for students to follow. Instead of reading all the information in one place, students move through a virtual museum, visit different rooms and explore the material step by step.

For teachers, the VR Museum is a practical way to bring different learning resources together in one space. Through Metasteps platform, they can add images, videos, 3D elements, audio, text and links, and then create paths that guide students through the exhibition. Before building the museum, teachers need to choose resources that match the subject, the lesson unit and the learning goals. The material should be clear, reliable and suitable for the age of the students.

STEM-IT VR Museum - Climate Change Exhibition

"STEM-IT VR Museum - Climate Change Exhibition" is an interactive virtual museum where users can explore the science behind climate change, its environmental and social impacts, and the solutions that can help protect our planet. As the users move through the exhibition, they will discover how human activities influence Earth's climate system and how individuals, communities, and societies can contribute to a more sustainable future.

The museum consists of **6 Rooms** where different periods and cases are analyzed. Users have the opportunity to explore the process of climate change through images, videos, 3D models, games and at the end they complete a quiz to evaluate the knowledge they have acquired.

The **1st room** introduces visitors to the fundamental concept of climate change and humanity's evolving relationship with the Earth.
The **2nd room** explores the historical development of climate change and how scientific observations have revealed long-term changes in Earth's climate.
The **3rd room** focuses on the scientific mechanisms that regulate Earth's climate. The **4th room** presents the environmental consequences of climate change around the world.
The **5th room** explores how environmental changes such as rising sea levels, floods, droughts, and extreme weather events are forcing communities to relocate.
Finally, the **6th room** focuses on solutions and collective action. Visitors explore renewable energy technologies, ecosystem restoration, and community-driven initiatives that help address climate change.
In the final room (6th) exists the Quiz.

When users open the museum's link (Link to VR Museum) they are in front of the museum in **Path 1**. By clicking the arrow on the bottom left side of the screen *[Figure 1]* they can see **8 Paths** that have been created which help them navigate properly in the VR Museum and

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simultaneously been informed via audio C text about the concept of each room. By clicking each Path users will automatically navigate in each different room of the museum.



Figure 1: Paths

Above the arrow button, on the left side of the screen, users will see another map-like button that shows them the exact place they are in the museum *[Figure 2]*.

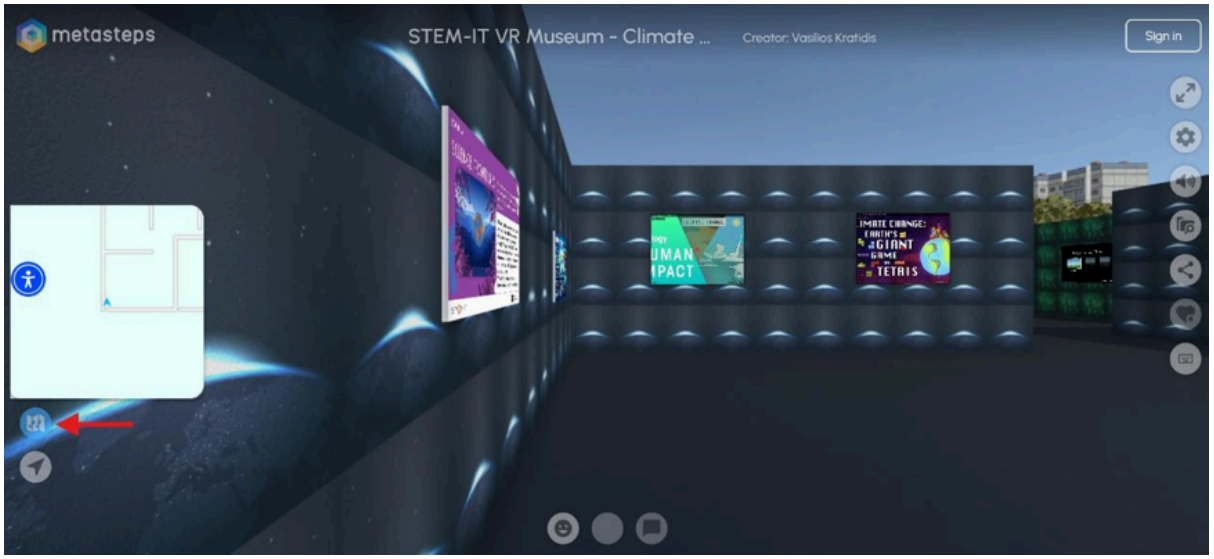


Figure 2: VR Museum Map

In the middle of the left side of the screen there is a button for people with special needs *[Figure 3a]*, which allows them to adapt their experience accordingly in the museum *[Figure 3b]*.

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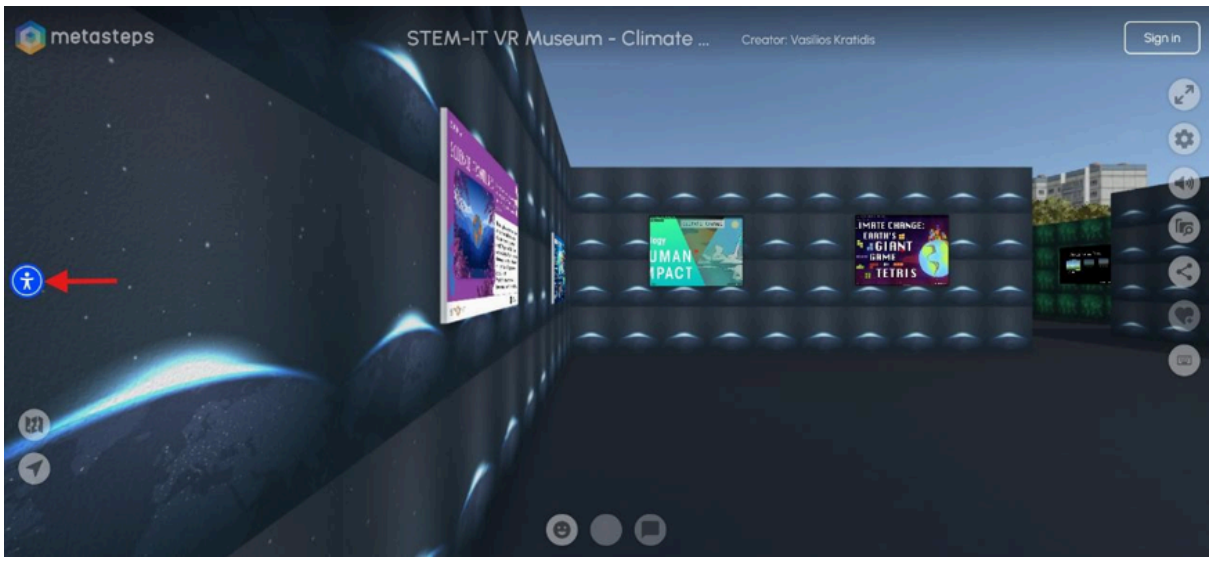


Figure 3a: Special Needs Button



Figure 3b: Special Needs Features

On the right side of the screen [Figure 4] there are various buttons such as:

- **Settings**,
- **Sound**,
- **Other VR Spaces** that users can navigate,
- **Share** button to share the VR Museum with other users,
- **Like** button and finally the
- **Navigation control button** which explains how someone can navigate the museum using the buttons on their computer keyboard.

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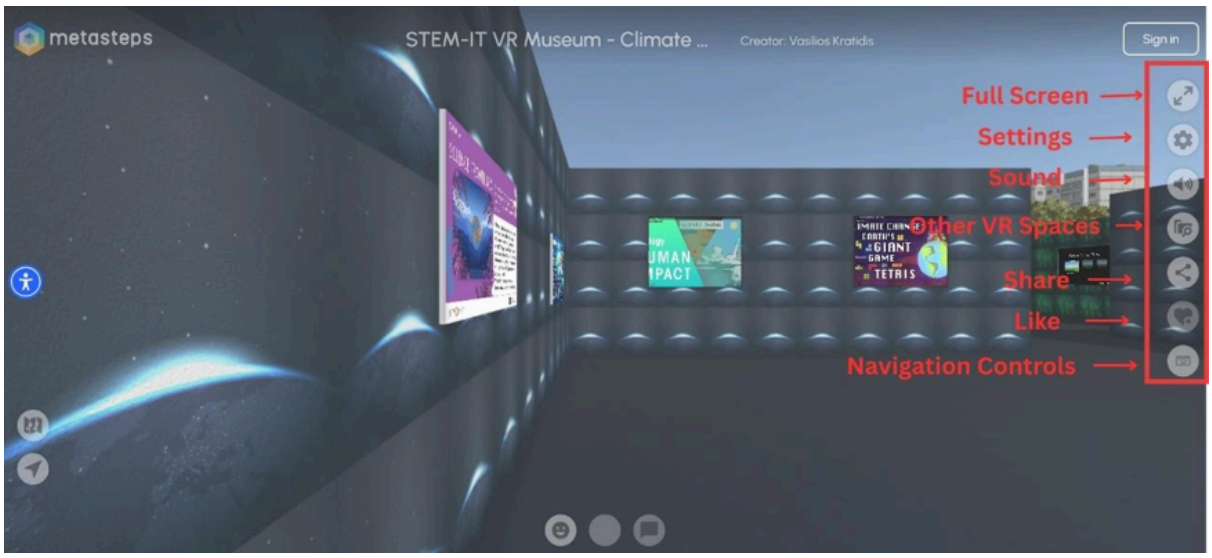


Figure 4: Other Available Buttons

Inside the museum there are many different resources such as images, videos, 3D elements etc. *[Figure 5].* In order to view them, users click on each object on the wall, and they automatically come in front of the object. There they have the option of choosing to zoom in, reading relevant information as well as making the object full screen *[Figure c]*.

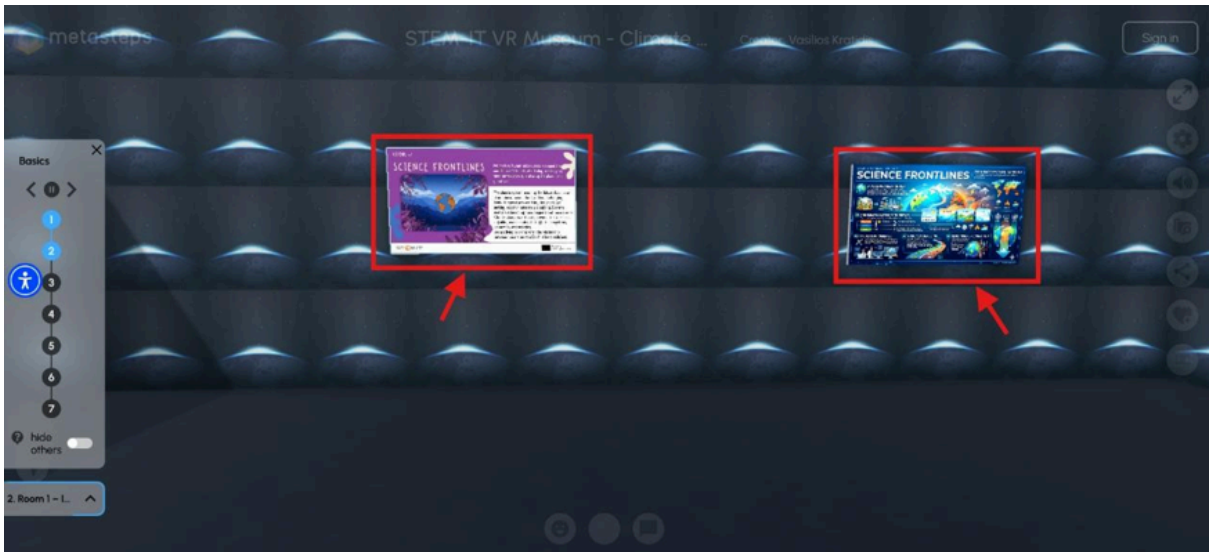


Figure 5: Available Resources

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Figure c: Buttons for each Resource

12.3 EnergyLab VR

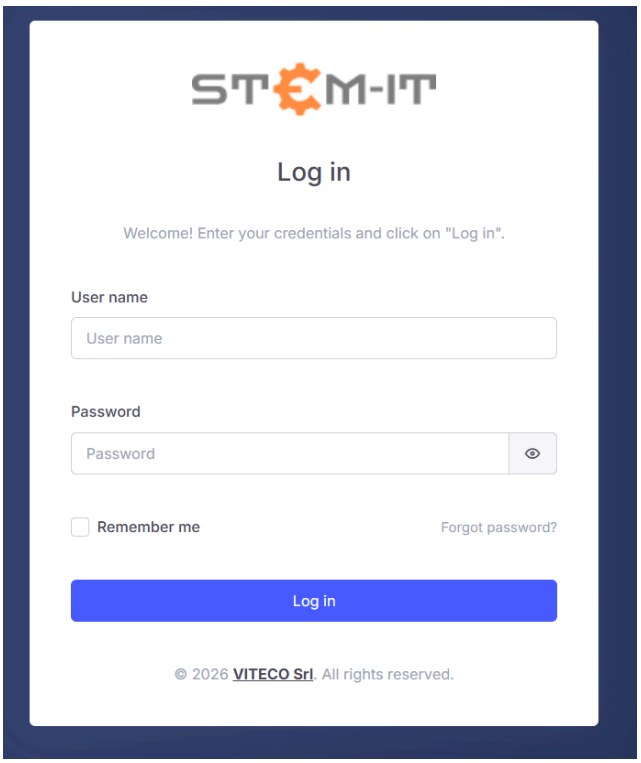
EnergyLab VR is an interactive virtual science laboratory developed by VITECO, in which students explore the First and Second Laws of Thermodynamics through six hands-on experiments. This guide walks teachers through setting up a course on the STEM-IT platform, enrolling students, and using EnergyLab VR in the classroom, step by step.

Teacher Access

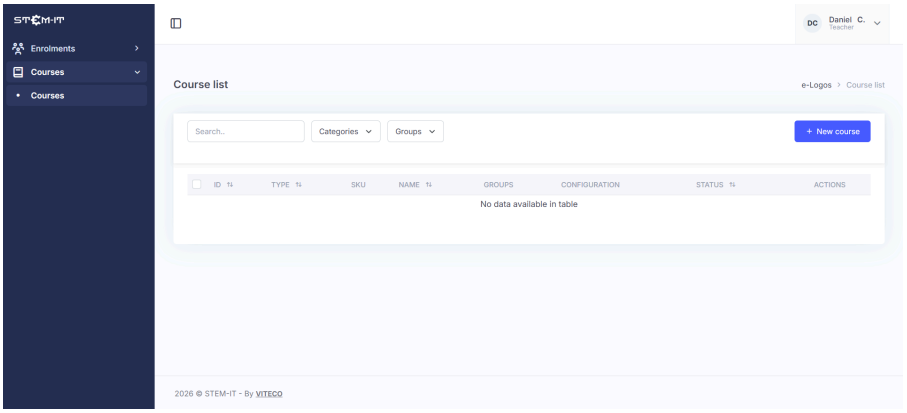
Teachers access the platform through a dedicated link: **platform.stem-it.eu/gest**

1. Go to the STEM-IT **platform**.
2. Enter your **User name** and **Password**.
3. Click **Log in**.

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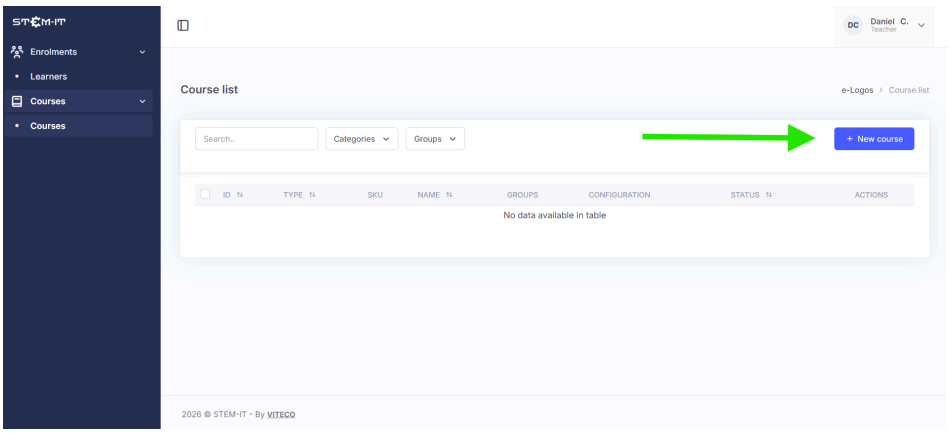
After logging in, you land on the **course list** page. The left sidebar gives access to **Enrolments** (manage students) and **Courses**. Your name and role appear in the top-right corner.



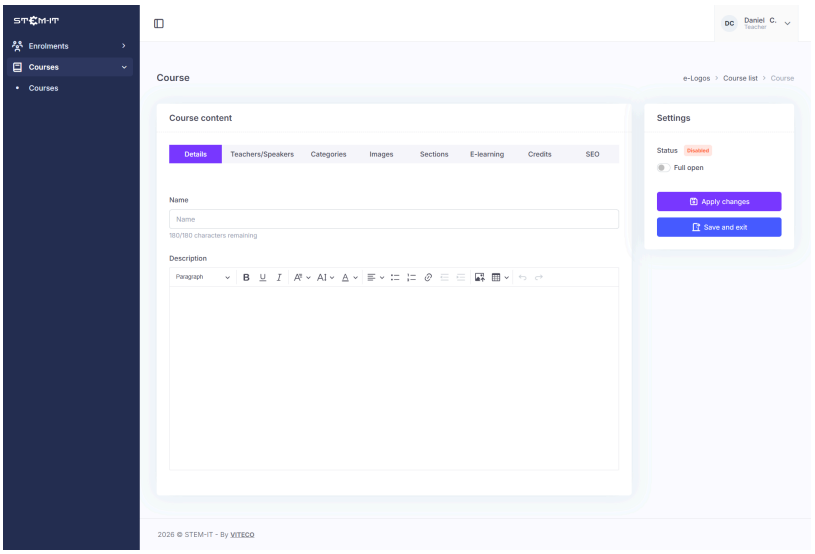
Creating a Course

1. In the left sidebar, go to **Courses > Courses**.
2. Click **+ New course**.

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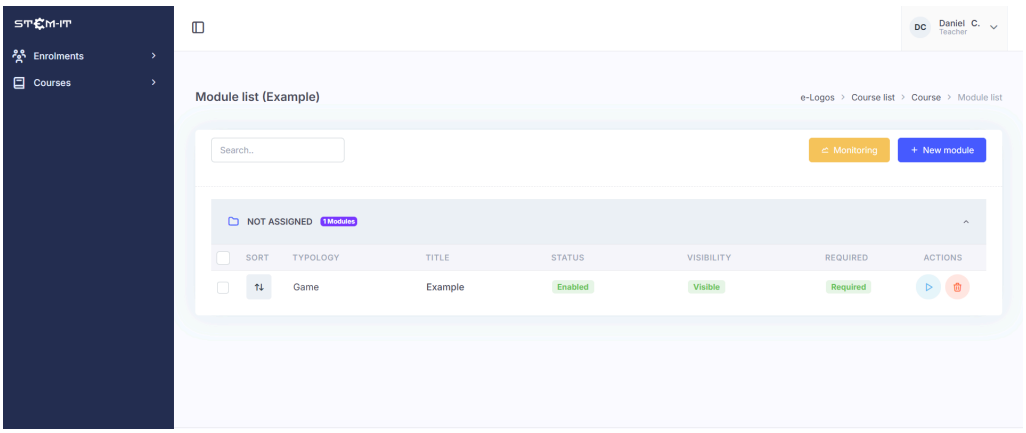


1. In the **Details** tab, enter the course **Name**.
2. Click **Save and exit** (or **Apply changes** to keep editing).



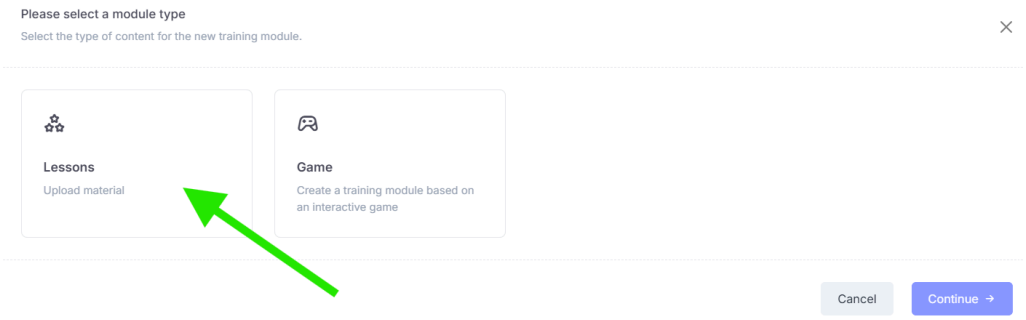
Creating Lessons and Uploading Materials

After saving the course, you land on the **Module list** page. Existing modules are grouped by folder. Click **+ New module** to create a new lesson, or use **Monitoring** to track student progress on existing modules.

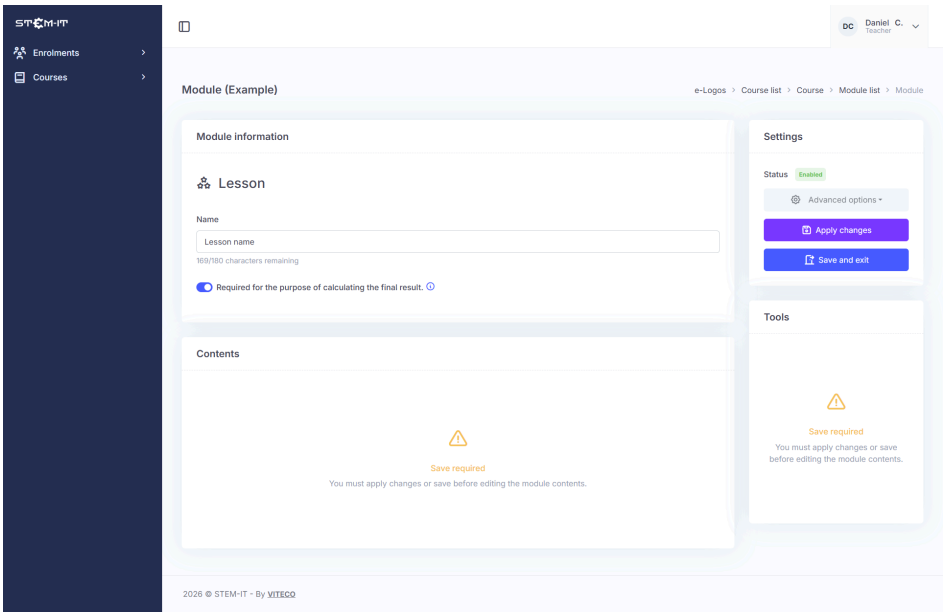


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1. Click **+ New module**.
2. In the "Please select a module type" window, choose **Lessons**.
3. Click **Continue**.

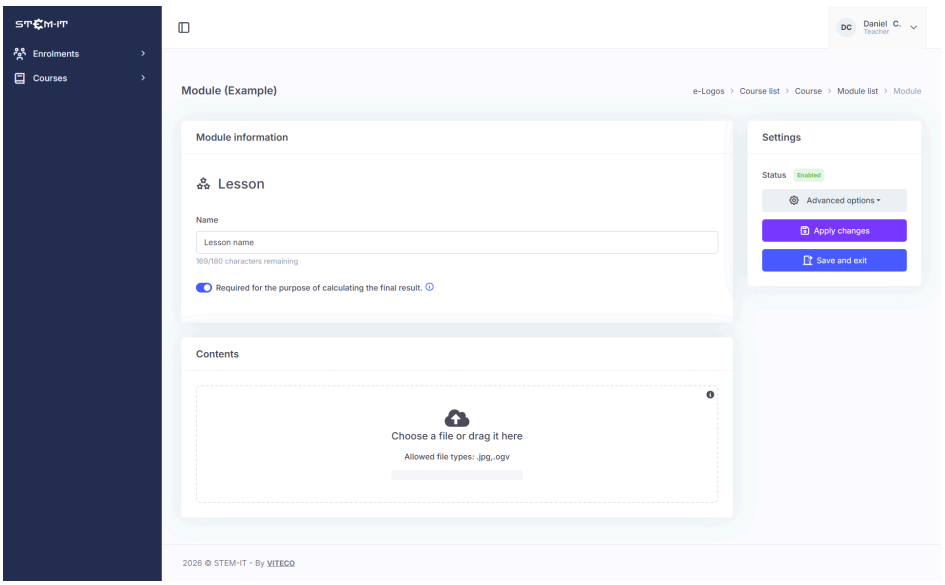


1. In the **Module information** panel, enter the **Lesson name**.
2. Click **Apply changes**.

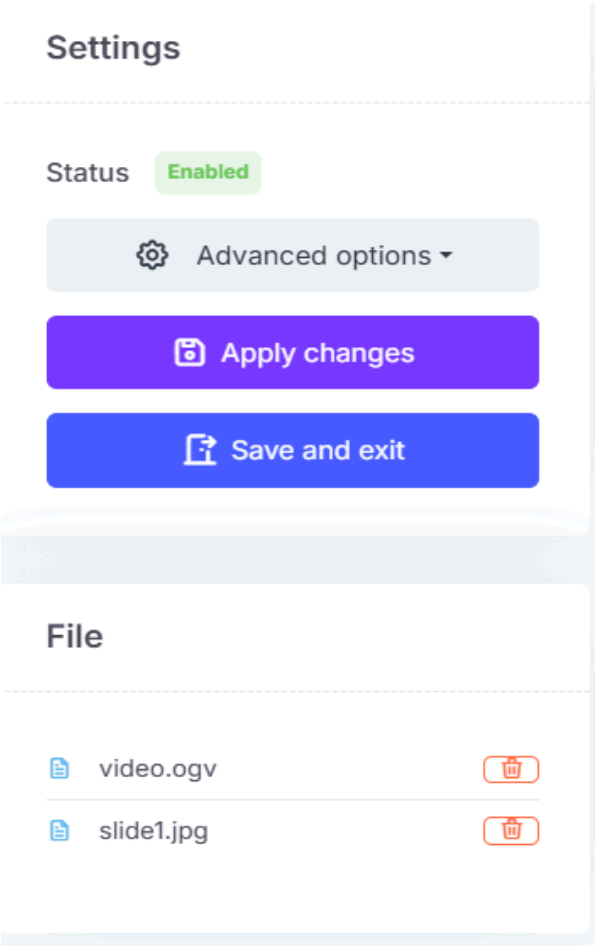


Once the module is saved, the **Contents** section unlocks. You can now upload your teaching material by dragging files into the box or clicking to browse your computer. Allowed file types are **.jpg** (images/slides) and **.ogv** (videos).

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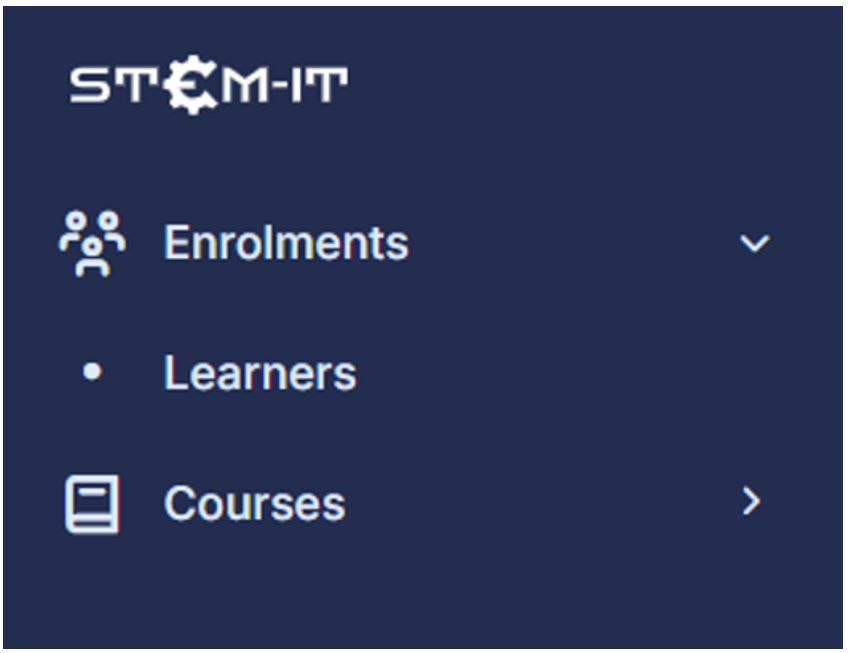
After uploading, check the **File** list on the right-hand side to confirm your materials were added correctly (each file can be removed using the trash icon if needed).



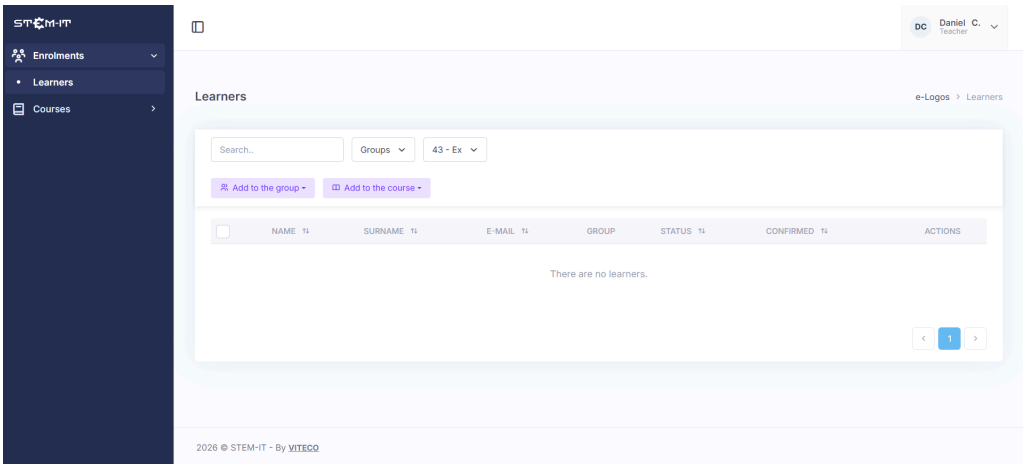
Enrolling Students

1. In the left sidebar, expand **Enrolments** and click **Learners**.

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If the list is empty, like in the image below, your students first need to create their own account.

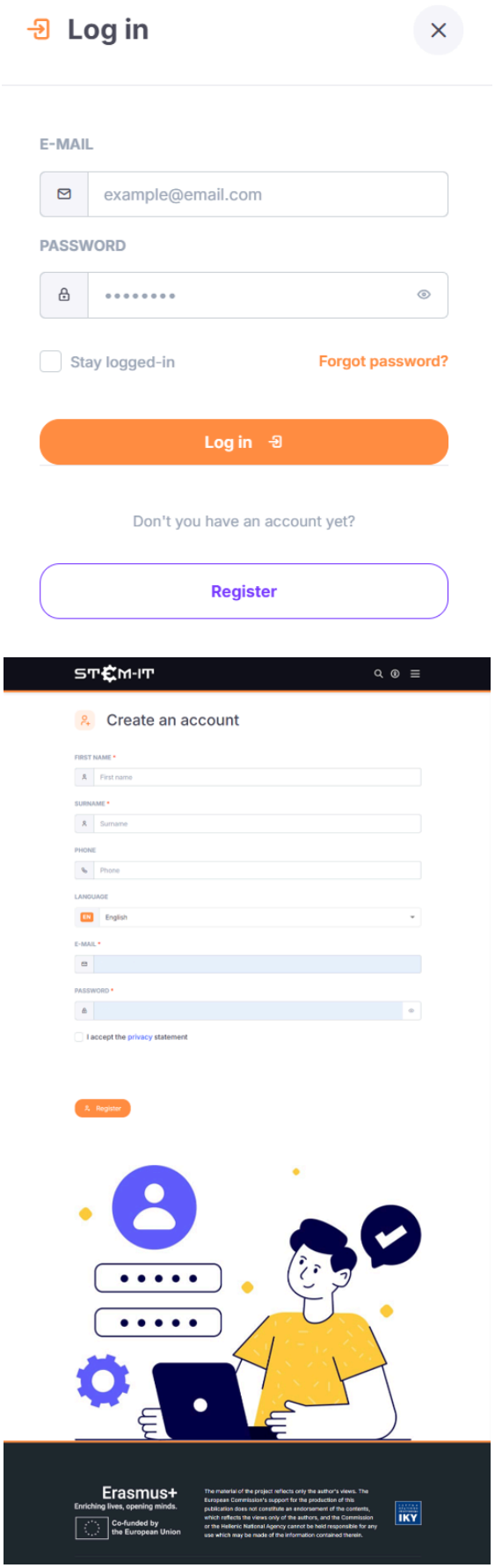


Student Registration

Tell your students to go to **platform.stem-it.eu** and register:

1. Go to **platform.stem-it.eu** and click **Log in**.
2. In the login window, click **Register** (for users who don't have an account yet).
3. Fill in the registration form: First name, Surname, Phone (optional), Language, E-mail and Password.
4. Accept the privacy statement and click **Register**.

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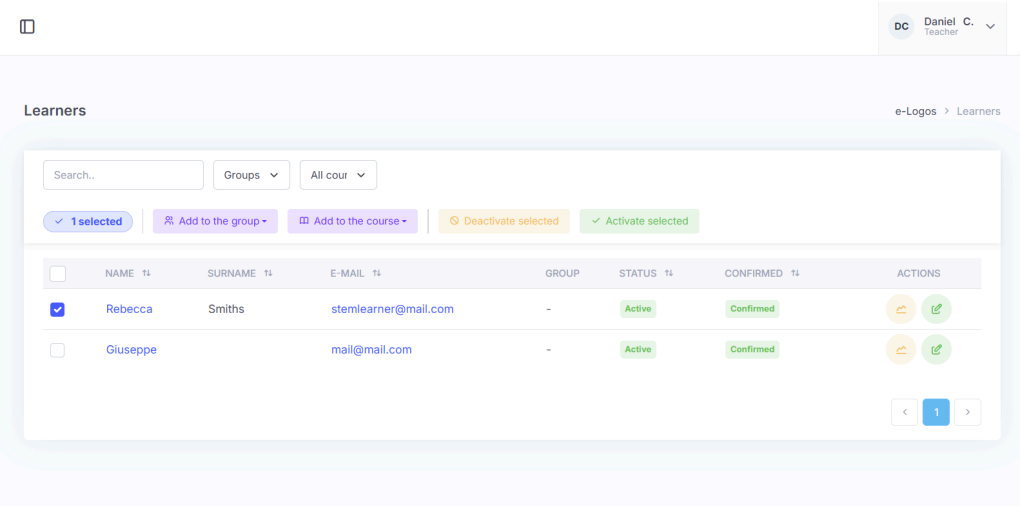


Screenshot 14 — Student registration form.

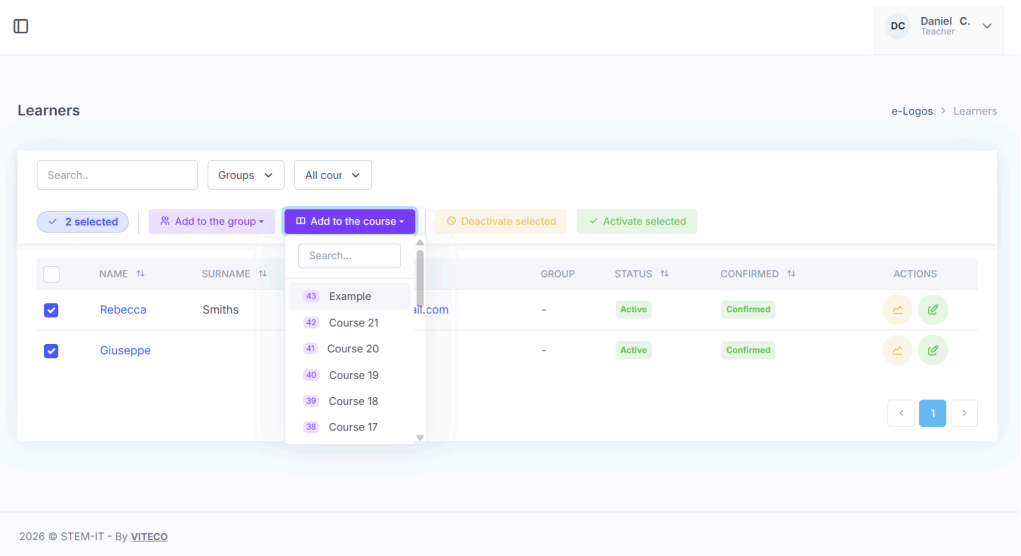
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Assigning Students to Your Course

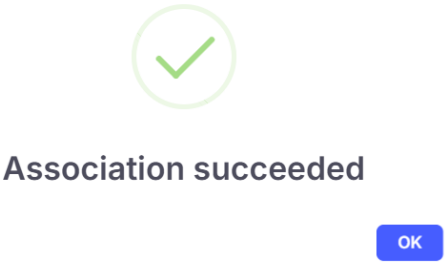
Once students have registered, they appear in the Learners list.



1. Select the learner(s) you want to enroll using the checkboxes.
2. Click **Add to the course** — a dropdown appears listing all available courses (use the search field to find yours quickly).
3. Click on the desired course to assign the selected learner(s) to it.



A confirmation message appears. Click **OK**.



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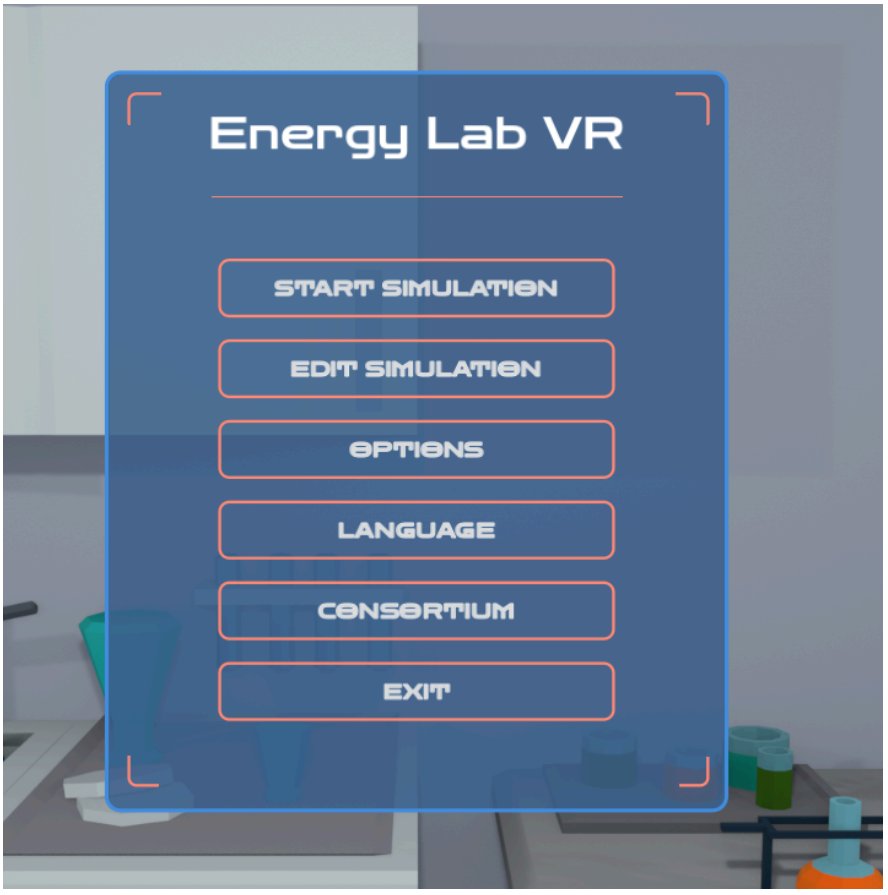
Using EnergyLab VR — The Main Menu

1. Click **Start Activity** next to EnergyLab. The laboratory will open in a new browser tab.
2. Wait for the loading screen to finish.



The main menu appears, with the following options:

- **Start Simulation** — enter the lab as a student would.
- **Edit Simulation** — configure the six experiments (see section 6).
- **Options** — adjust Music Volume and Sound Volume.
- **Language** — choose your preferred language.
- **Exit** — close the application.



Screenshot 19 — Main menu.

Optionally, click **Options** to adjust Music Volume and Sound Volume, then click **Back**.

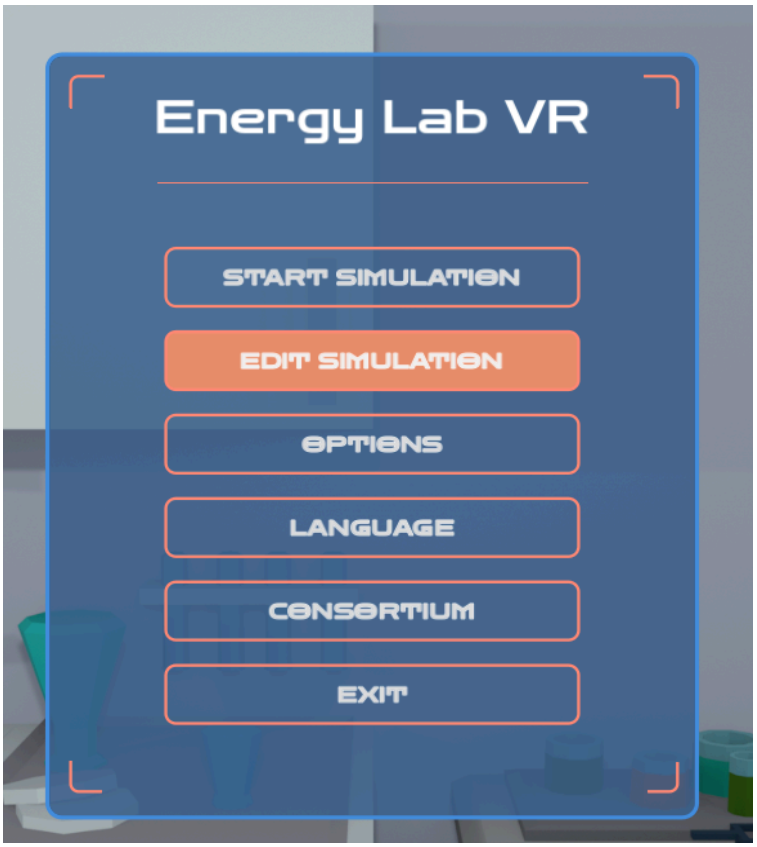
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Configuring Experiments (Editor)

Before students play, teachers can customize the six experiments through the editor.

1. From the main menu, click **Edit Simulation**.



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2. On the Edit Simulation screen, click **New Level**.



3. Enter a name for the level (e.g. "Level 1") and click **Confirm**.

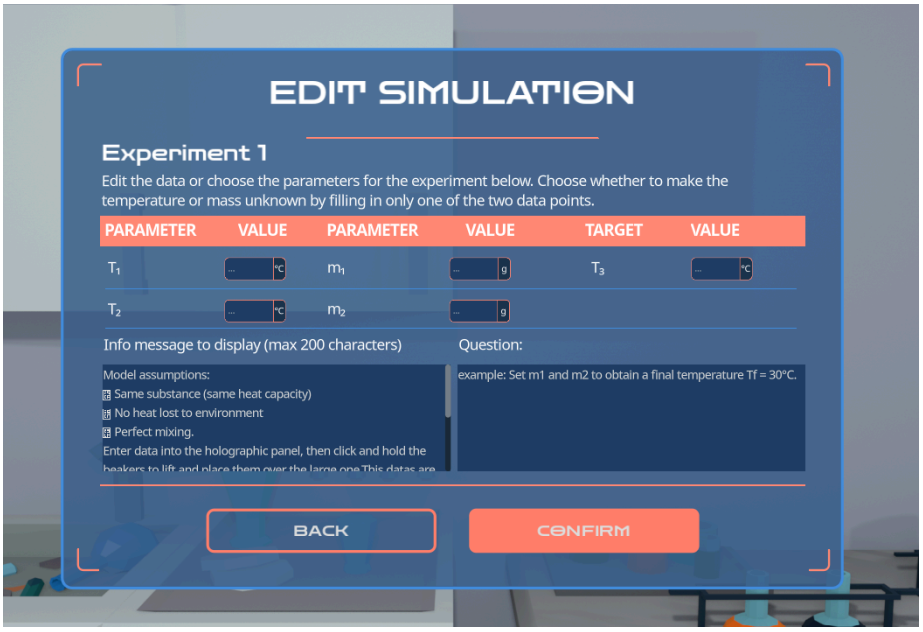


The editor lets you configure all six experiments, based on the First and Second Laws of Thermodynamics. Experiments 1–3 are guided (with a specific target to reach); Experiments 4–6 are open-ended and exploratory.

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Experiment 1 – Heat Transfer & Liquid Mixing

Enter the following parameters: T_1, T_2 (temperature) and m_1, m_2 (mass) for each liquid — you only need to fill in the unknown you want students to solve for. Set the target final temperature (T_3). Add an info message (max 200 characters, e.g. model assumptions) and a question for students (e.g. "Set m1 and m2 to obtain a final temperature Tf = 30°C"). Click **Confirm**.



Experiment 2 – Work into Heat (Friction)

Enter the following parameters: F (force, in N) and s (displacement, in m). Set the target temperature variation (dT). Add an info message (max 200 characters, e.g. model assumptions and the relevant formula — here: Q = W = F·s) and a question for students (e.g. "Calculate the displacement (s) needed to increase temperature by 30°C"). Click **Confirm**.

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Experiment 3 – Electric Motor & Formulas

Enter the following parameters: V (voltage) and W (energy input, in J). Set the target time (t, in seconds) needed to lift the weight. Add an info message (max 200 characters, e.g. model assumptions and the relevant formulas — here: $P = V^2/R$, $Ein = P \cdot t$) and a question for students (e.g. "Adjust Voltage (V) to lift the weight in exactly 5 seconds"). Click **Confirm**.

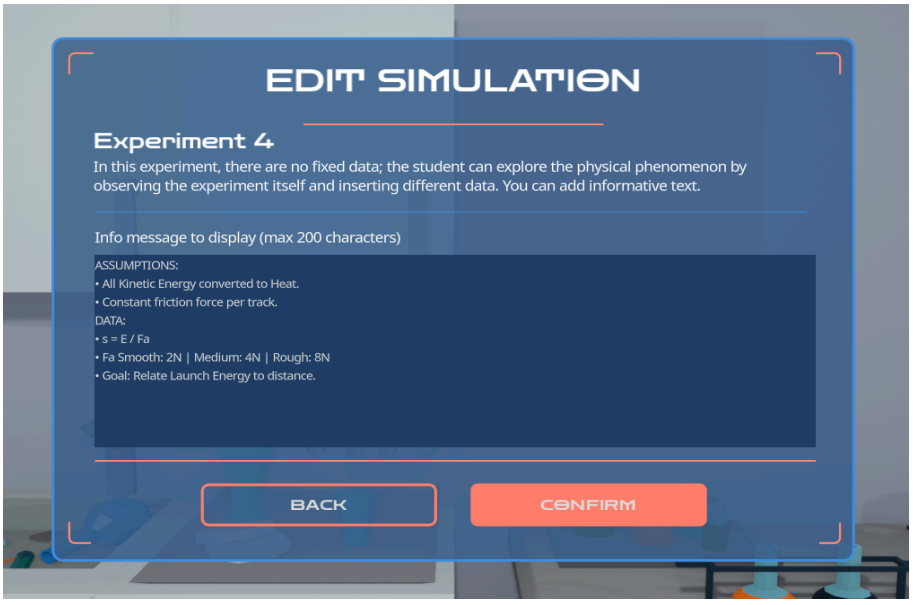


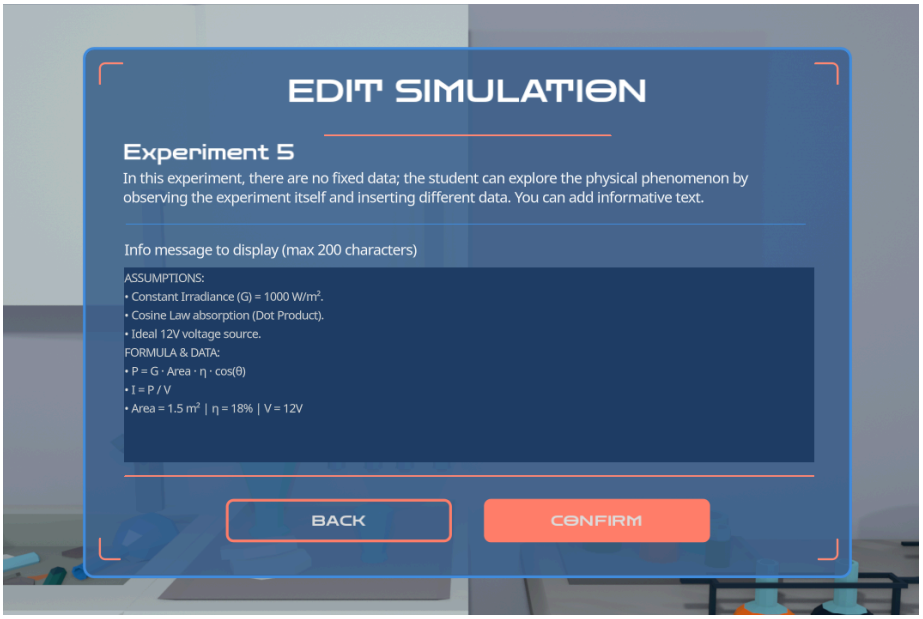
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Experiments 4–6 — Exploratory

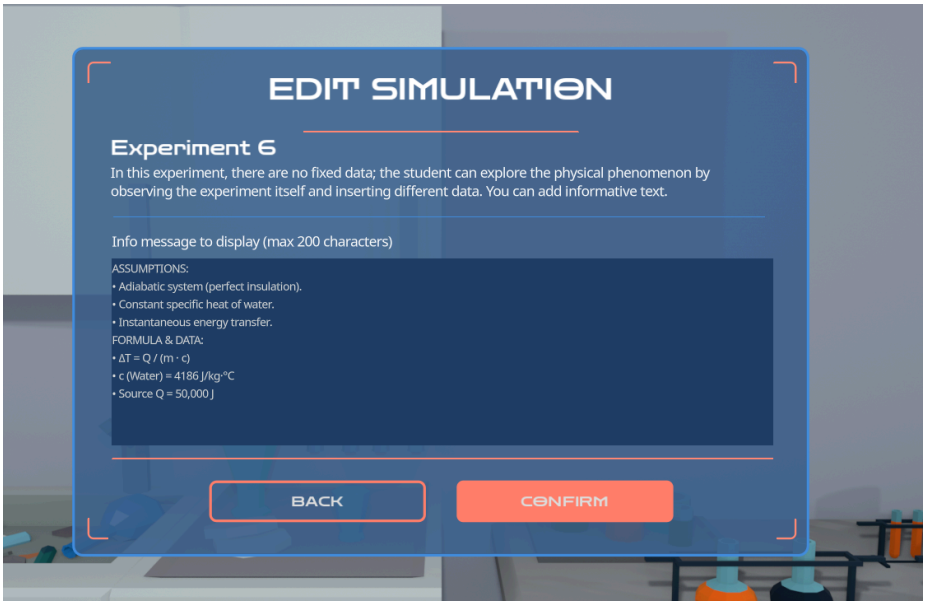
The final three experiments are open-ended: there is no fixed data to configure and no target to reach. Students explore the phenomenon freely by entering their own values. For these experiments you can only edit the info message (max 200 characters) — e.g. model assumptions and reference data (relevant formulas and constants). Click **Confirm**.

- **Experiment 4** — friction tracks: relates launch energy to distance travelled (formula s = E / Fa, with friction values per track type).
- **Experiment 5** — solar panel: relates panel angle to efficiency (formula P = G·Area·η·cos(θ), I = P/V).
- **Experiment 6** — heat transfer to liquid: relates energy input to temperature change (formula ΔT = Q / (m·c)).





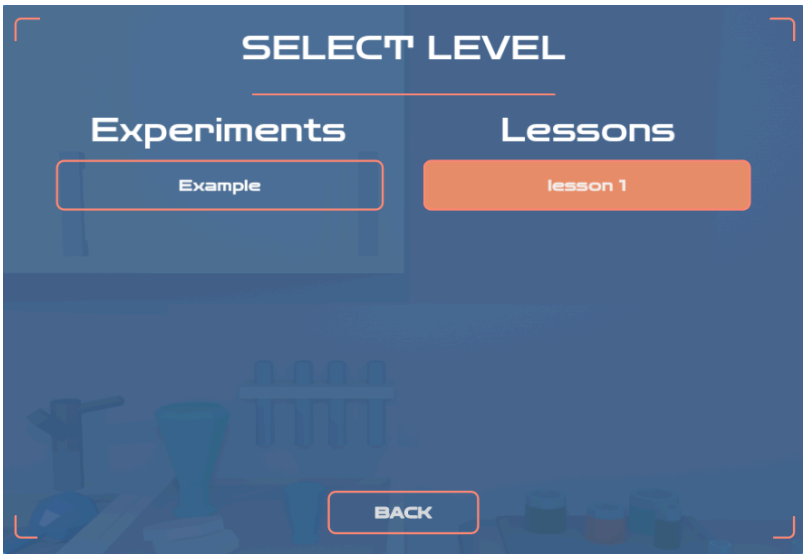
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Entering the Lab

1. From the main menu, click **Start Simulation**.

The **Select Level** screen appears, with two columns: **Experiments** (pre-built demo levels) on the left, and **Lessons** (levels created by the teacher) on the right.



1. Click **Lessons**, then select the lesson you want to use.

A short two-screen tutorial appears before you enter the lab itself:

- **Screen 1** explains basic controls (WASD to move, mouse to look and click, touch/select to interact, clipboards for theory, buttons to toggle holographic interfaces) and shows an example of a holographic data panel. Click **Next**.
- **Screen 2** explains the two experiment types — some let you freely test data to observe real-time reactions, others require solving a puzzle to reach an exact result. Click **Start Simulation** to enter the lab.

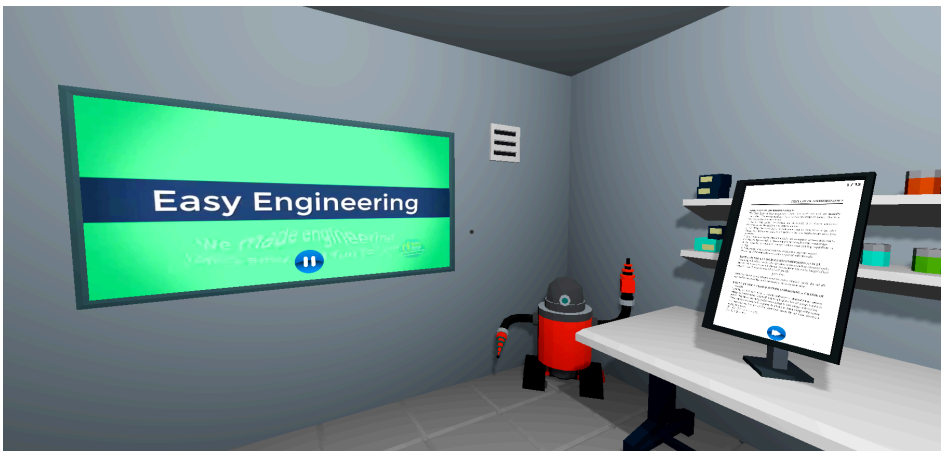
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Screenshot 31 — In-game tutorial, controls.



Inside the lab, students find a dedicated area for lesson content: the **blackboard/screen** plays any video (.ogv) uploaded when creating the module, while the **monitor/tablet** on the desk displays any images or slides (.jpg) uploaded in the same step (see section 3).



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Playing the Experiments (Student View)

- **Move**: use the **W, A, S, D** keys.
- **Look around**: move the mouse. A small dot in the center of the screen is your crosshair/pointer, showing exactly what you're aiming at.

Note: *this is a web-based game, so browser security requires a double click to start any multimedia content (e.g. pressing Play on a video). The same rule applies when pausing: press ESC twice to open the exit menu, then click Exit to return to the main menu.*
Note: *experiments are sequential — students must successfully complete one experiment before the next one unlocks.*

Experiment 1 — Beakers & Mixing

1. Walk to the table with the beakers.
2. Point the crosshair at the clipboard to read the experiment's instructions.
3. Close the clipboard, then click the **red button** to open the data-entry (holographic) panel.
4. Enter the required values and click **Confirm**.
5. Click and hold the left mouse button on a beaker, then drag it over the larger one to pour the liquid. Repeat with the second beaker.
6. Read the final temperature on the thermometer.



If the values entered are correct, the panel shows **Next Experiment** — click it to unlock and move to the next experiment. If the values are incorrect, the panel shows **Retry** instead.

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Experiments 2–6

The second experiment (friction) appears on the same table. As with Experiment 1, read the clipboard, click the red button, enter the required data, and click **Confirm**.



The same process applies to Experiments 3 through 6: read the instructions, enter or explore the data through the holographic panel, click **Confirm**, and observe the result before moving on to the next experiment.

12.4 SCP 3D Model Viewer

For the STEM-IT Project, **SCP** has undergone the task of creating an interactive application that allows teachers and students to inspect **3D Models** by rotating around and zooming in on them, while also providing pins with relevant information about the specific pinned spot or object. This helps students to get a visual, sometimes animated perspective on topics they are learning about.

The game engine **Godot** was used to develop this application. It is an open source engine which can be used to develop fully featured **games or simulations**, however it can also be useful when creating smaller scope, targeted **tools** allowing developers complete freedom to

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build the application. The **SCP 3D Model Viewer** is one such tool. It is also useful that **internet access is not required** beyond downloading the application files initially, which can help schools that do not have a stable internet connection.

The application contains two pre-packaged scenarios as **examples** and to demonstrate its capabilities: *"Heart"* and *"Earthquakes"*, guiding a user through various heart and blood related organs and showing how earthquakes can affect different parts of the Earth, respectively. In this guide, we will first walk through how to use the application and look at the example scenarios, as well as guide a teacher to create their own scenario in the application.

Downloading the Application

In order to view the sample scenarios or to create new scenarios, first the application must be downloaded. Please follow the link below to download the package:

https://stem-it.eu/scp-stem-it-3d-model-viewer

We will use the files in this package through the guides, so please save it in an organized location on your computer such as ***"Documents"***. It is a **.zip** file which means it needs to be extracted first, which can be done by right clicking on the .zip file and then choosing to extract/unzip, though this may vary depending on your operating system. After unzipping, the original .zip file can be safely deleted, as now there should be the extracted files in a new folder.

This package includes:

- Applications for **Windows, Android Smartphones, VR Headset** in the **"APPLICATIONS"** folder, each in their respective folder.
- The project source code along with the game engine **Godot** inside the **"PROJECT SOURCE"** folder. These are used when creating new scenarios.
- **Example documents** as **samples** for coming up with new teaching plan scenarios in the **"PLAN SAMPLES"** folder. The plans used when creating the default sample scenarios are included.
- A text file containing credits for the assets used in the sample scenarios or the application.

Installing/Running the Application

Windows

No installation is needed, the executable files are included. Simply navigate to the **APPLICATIONS -> WINDOWS** folder and double click on the application file to run it. Note that there may be a warning regarding the trust of the application, it is recommended to click any option such as **"Allow"** or **"I trust this source"** to proceed. An anti-virus may also flag it as potentially harmful, in this case it must be allowed in the anti-virus, which may vary depending on the anti-virus software.

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Android Smartphone

NOTE: The Windows version is recommended over Android Smartphone.
The application is not available on an official store like **Google Play Store**. In order to install applications **not from the official Google Play Store**, the smartphone must be set to *"Developer Mode"*. In most cases, this involves going to the phone's **Settings -> About Phone** and then tap on **Build Number** 7 times, then a popup will appear saying that developer mode is enabled. With Developer Mode enabled, the file in **APPLICATIONS -> ANDROID -> SCPSTEMIT.apk** must be moved to the phone's storage via connecting it with a **USB**. On the phone, find the file using a file explorer application like **Files** and select the file, allowing the install. After installing, you may disable developer mode by going to the Phone's **Settings -> Developer Mode** and toggling Developer Mode OFF, but this is optional.

After installing successfully, the application can be started by tapping on the SCPSTEMIT icon in the library of apps.

VR Headset (Standalone)

Installing unofficial applications on VR headsets, especially **Meta Quest**, can be a bit complicated and must be done through a 3rd party app called **SideQuest**.

SideQuest: https://sidequestvr.com/setup-howto

In the above link, there are good videos guiding users on the setup. Keep in mind you must follow the tutorial on the **right**, which is about installing SideQuest on your desktop PC, which must then be used to install the **SCPSTEMITVR.apk** file in **APPLICATIONS -> VR**

VR Headset (Connected to Desktop)

Alternatively, **VR Mode** can be enabled within the Windows application by clicking on the **VR button** on the bottom right while in the application. This requires a relatively strong graphics card in the computer, and for the necessary drivers to be installed.

- Go to the Meta Quest Setup page: https://www.meta.com/quest/setup/
- Download and install the **Meta Quest Link App** for Windows/Mac.
- Open the app, log in, and click ***"Add Headset"***.
- Connect your Quest to your PC using a high-quality USB 3.0 cable.
- Put on your headset and enable **Quest Link** in your **Quick Settings** menu.

Using the Application

Selecting a Scenario

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By following the instructions above for the device of your choice, you should now be met with a screen like this:

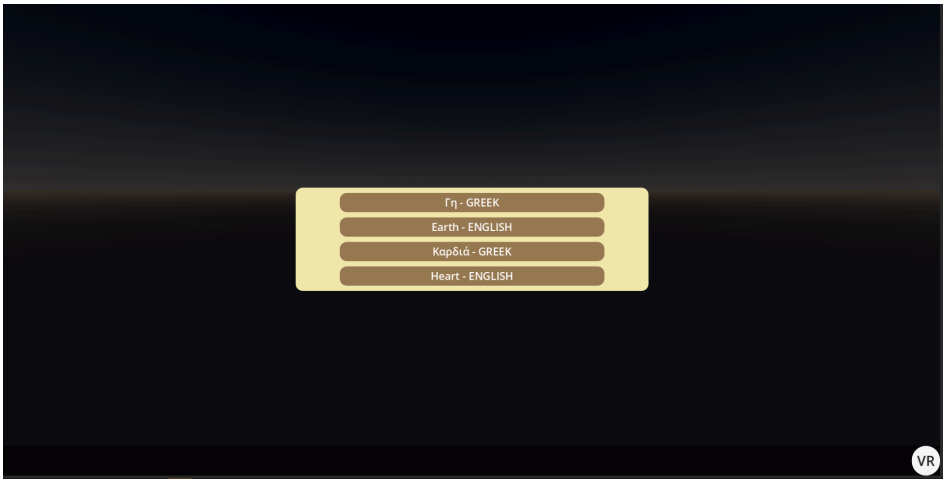


Figure 1: Scenario Selection Menu

This is the **Scenario Selection Menu**. As its name suggests, a scenario can be selected here.
To select a Scenario, the controls for each device are listed below.

Desktop	Android	VR
Click on Scenario title	**Tap** on Scenario title	Point to Scenario title with either controller and press the "***Trigger" (back) button***

For the sake of this start-up guide, the ***"EARTH - ENGLISH"*** scenario should be selected.
The screen should show the following:

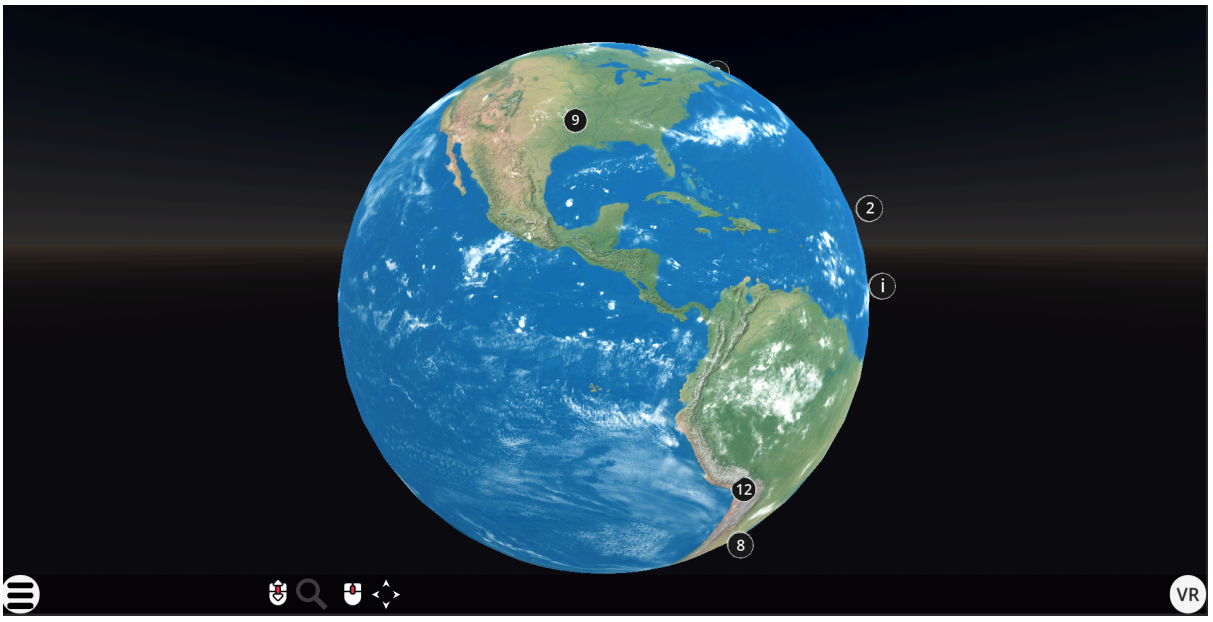


Figure 2. Earth Scenario Starting Scene

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Basic Controls

Control	Desktop	Smartphone	VR
Rotate Camera	Hold Right Click + Move Mouse	Touch and Drag	Hold “Grip” button (on the side) of RIGHT Controller and rotate controller
Zoom In/Out	Mouse Wheel Up/Down	Pinch Gesture In/Out	Left Controller Control Stick Up/Down
Pan Camera	Hold Middle Mouse Wheel + Move Mouse	N/A	Hold ‘Grip” Button (on the side) of LEFT Controller and rotate controller
Select/Deselect Pin	Left Click on Pin	Tap on Pin	Point to Pin with either controller and press “Trigger” button (on the back)
Return to Scenario Select	Click on the thee-bar button on the bottom left.	Tap on the thee-bar button on the bottom left.	Press “Y” Button (Left Controller)
Return to Previous Scene	Click on the Bottom Left Arrow button (when available)	Click on the Bottom Left Arrow button (when available)	Press “X” Button (Left Controller) (when available)

OPTIONAL NOTE: As mentioned before, VR Mode can be entered from the Desktop Application by clicking on the bottom right “VR” Button, if a supported headset and link program is installed on the desktop.

In *Figure 2*, we can see a **model** of the Earth and various **numbered** or **“i” labeled Pins**. Use the controls guide to rotate, zoom or pan the model and look around. Pins can be clicked on to either **display information** or to **move to another model scene.** Start by clicking on the **“i”** pin to see an information popup.

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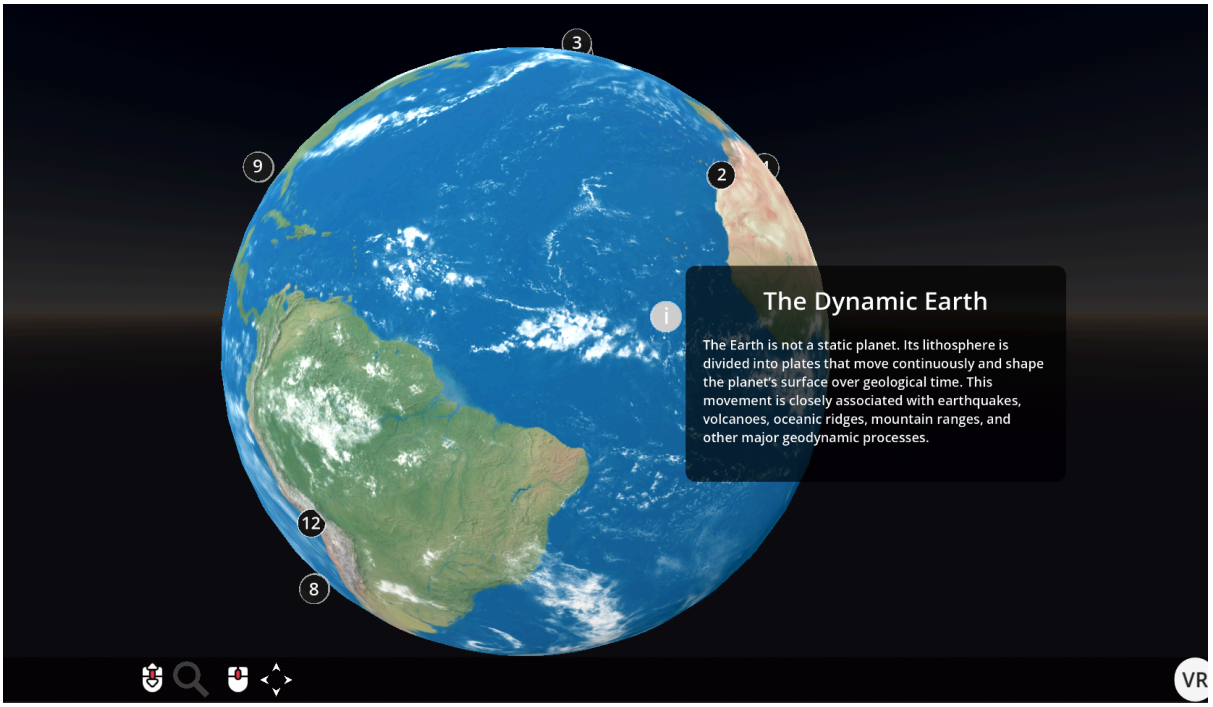


Figure 3. Information Pin

A selected pin can be clicked on again to **close** the information popup.
Next, we can click on any of the numbered pins. In this lesson plan, each pin takes us to different parts of the planet demonstrating different effects of earthquakes and volcanoes. Let's click on **Pin 10**, which is located in *Japan*.

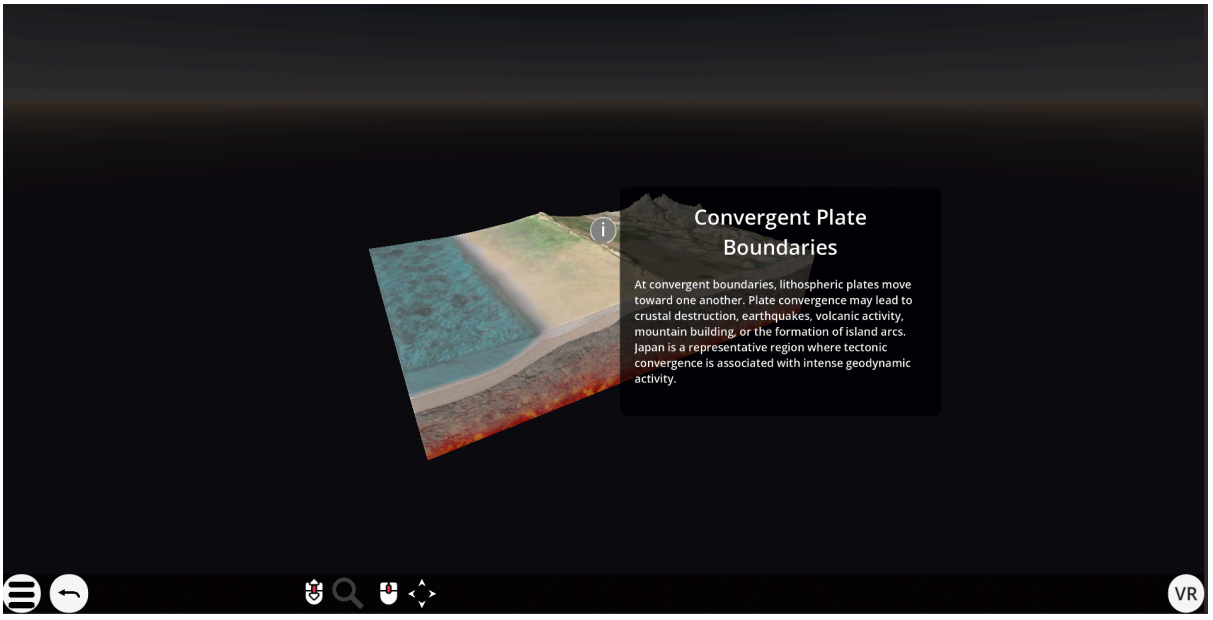


Figure 4. Pin 10

We can see a model showing what earthquakes might look like in Japan beneath the surface, as well as an information pin. The pin can be selected to view information. To return

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to the Earth scene, we can **Return to the Previous Scene**(refer to the *Basic Controls* above).

The same process can be repeated for all the pins. Once finished looking at the models, return to the **Scenario Select Screen**(refer to the *Basic Controls* above).

The same process can be repeated for the *"HEART - ENGLISH"* scenario, as the controls are the same, and will be the same for any newly created scenarios. In the Heart Scenario, we can follow a tour from outwards to inwards towards the microscopic level of the Heart.

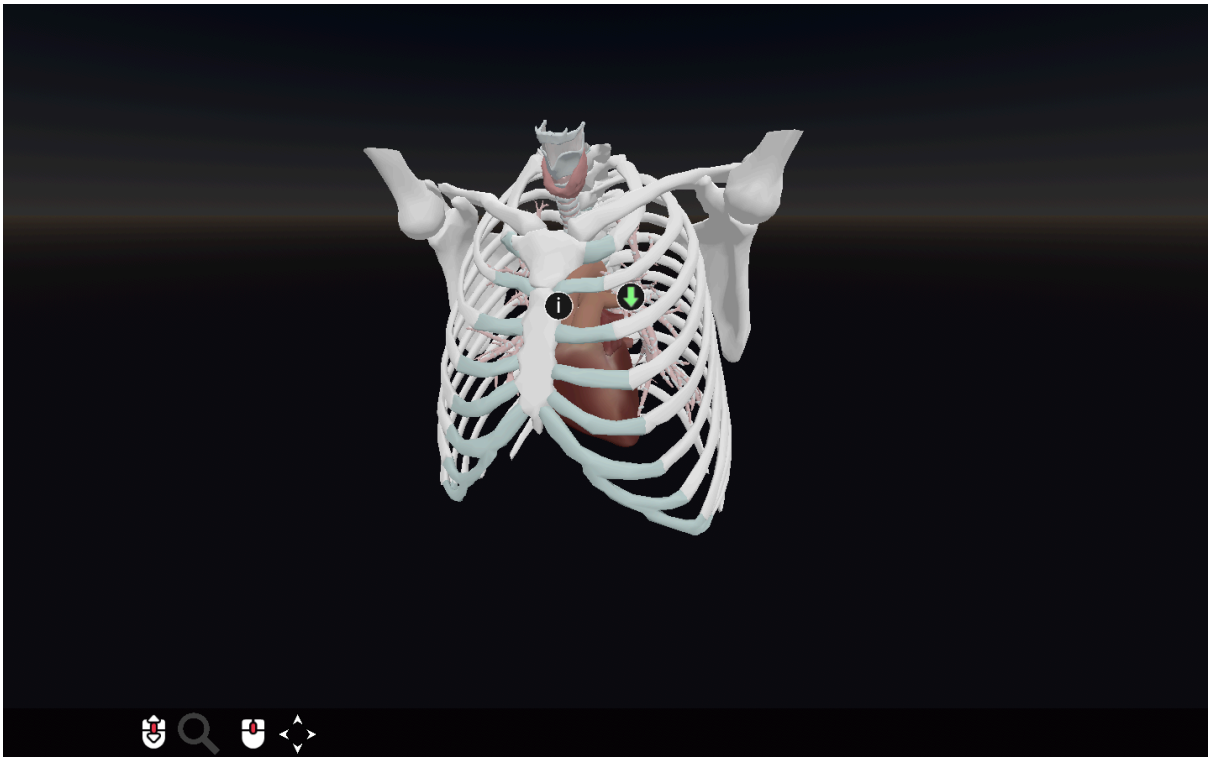


Figure 4b. Heart Scenario beginning

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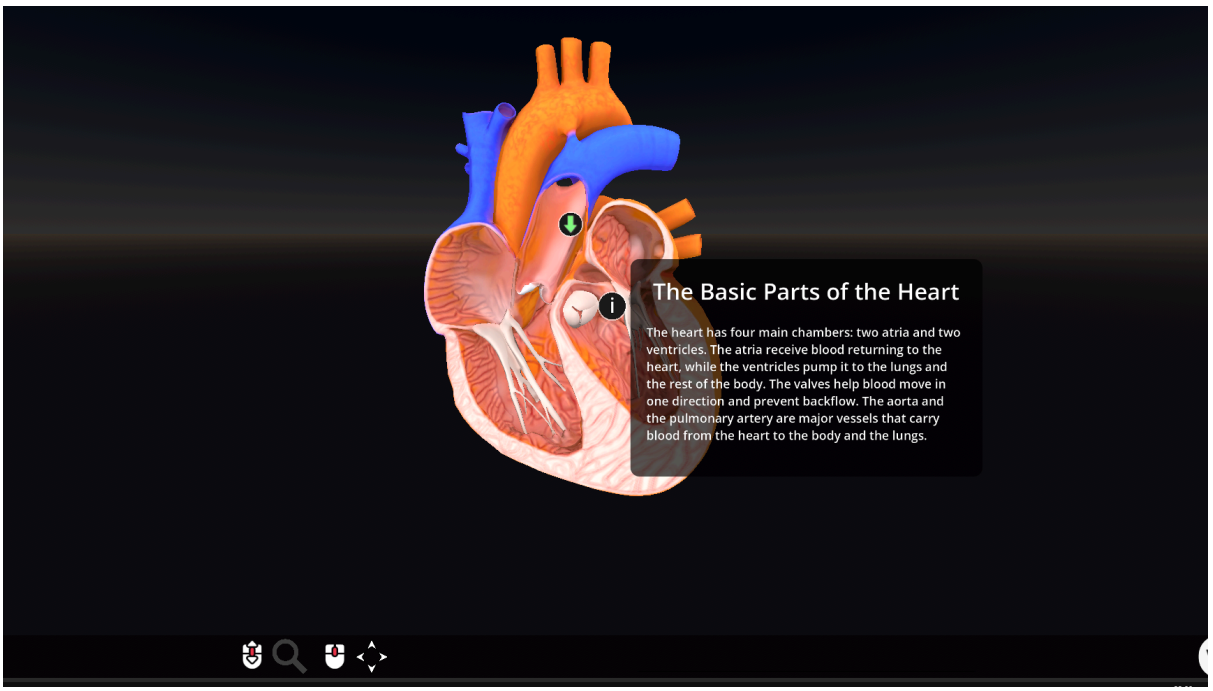


Figure 4c. The Basic Parts of the Heart

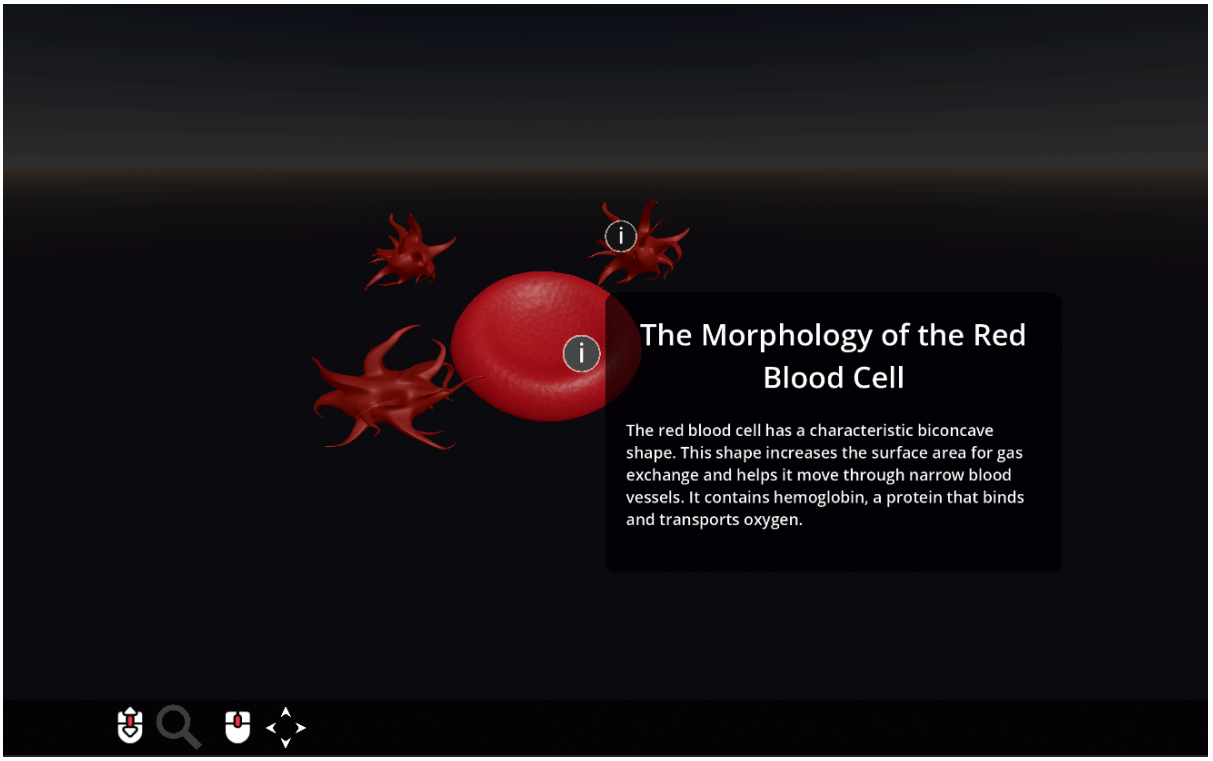


Figure 5c. Red Blood Cell & Platelets

This concludes the *Application Usage Guide*.

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Creating New Scenarios for SCP 3D Model Viewer

The scenarios viewed in the tutorial are examples of what can be made. They were created using the same method that this guide will go through.

Summary of the process:

- Choose a subject and write down a **lesson plan** as a document
- Look for and **download relevant models** on sketchfab.com
- **Import** the models into the project in **Godot**
- Setup scenes with the models and add pins to them
- **Export** the application with the new content

Lesson Plan

The first step is to write down a plan for the scenario. Knowing beforehand what will be made should make the process *much* easier. Write on a document details about the subject you'd like to create a scenario about, find relevant models on *sketchfab.com (explained in next step)*, the information on pins or if they would lead to another model, and this document is to be followed when creating the scenario.

This document can be written in any way you like; such as *Google Docs, Microsoft Word, or a plain text file.* It will only be used as a **reference** when creating the scenario and is **not part of the actual application**.

You can find the lesson plan documents used for the sample scenarios to use as a reference in the downloaded files in the **"PLAN SAMPLES"** folder.

Downloading Models from Sketchfab

Creating 3D Models is a complicated task which can be done by professional 3D Artists. As such, it is not realistic to expect to create your own models for these lesson plans. Many 3D Artists share their work on websites such as sketchfab.com to show them as their portfolio, however, some are kind enough to allow downloading the models and allow free use of them - usually for educational purposes.

First, go to https://sketchfab.com and *create an account(required for downloading models)*. Then search for keywords for the objects you'd like models of, *e.g. "volcano"*. Now, in order to view **only** downloadable models, the *"Downloadable"* filter must be enabled.

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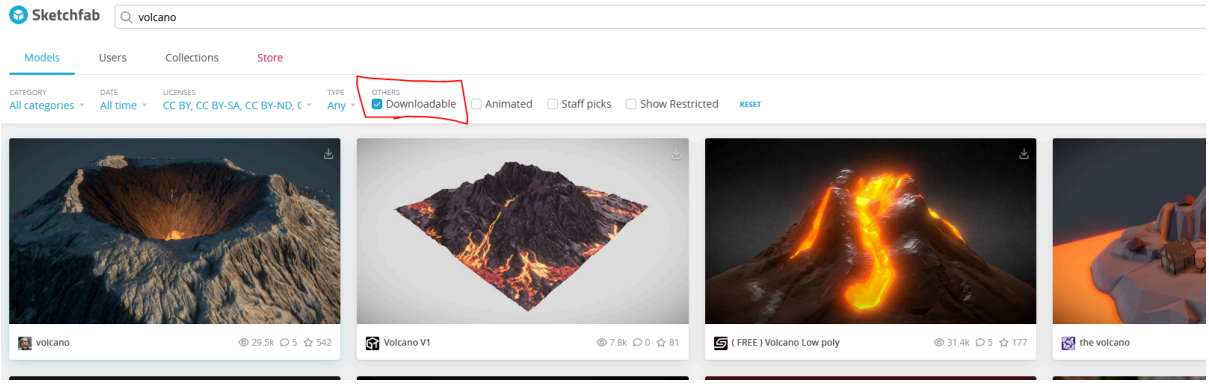


Figure 5. Enabling "Downloadable" on Sketchfab search

Additionally, a filter on the *"License Type"* must be set as well. When clicking it and the choices appear, hovering over them summarizes in what situations you would be allowed to use the **3D Model**. Generally, as long as you don't **sell** or **redistribute (put up for public download)** the application you export with the new content, ***all*** license types *(except for the last 2 red ones)* can be **enabled**.

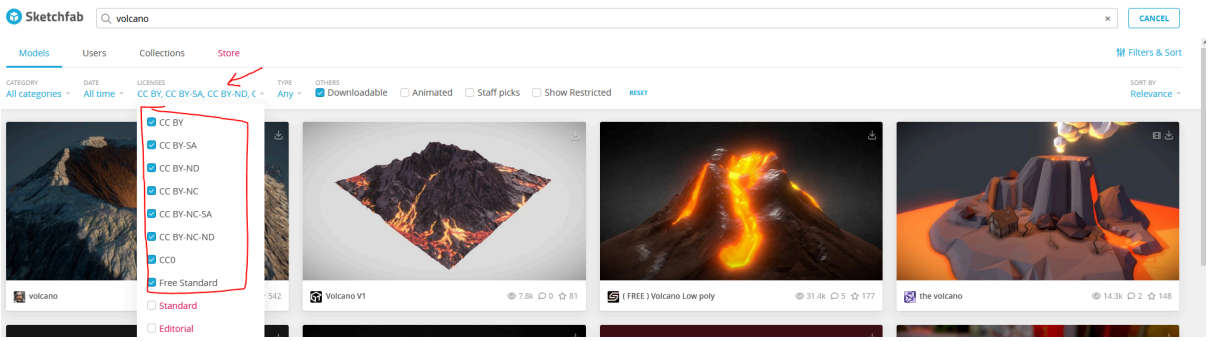


Figure 6. Sketchfab Search license types filter

Clicking on a 3D Model opens up sketchfab's model viewer, along with details about the model.

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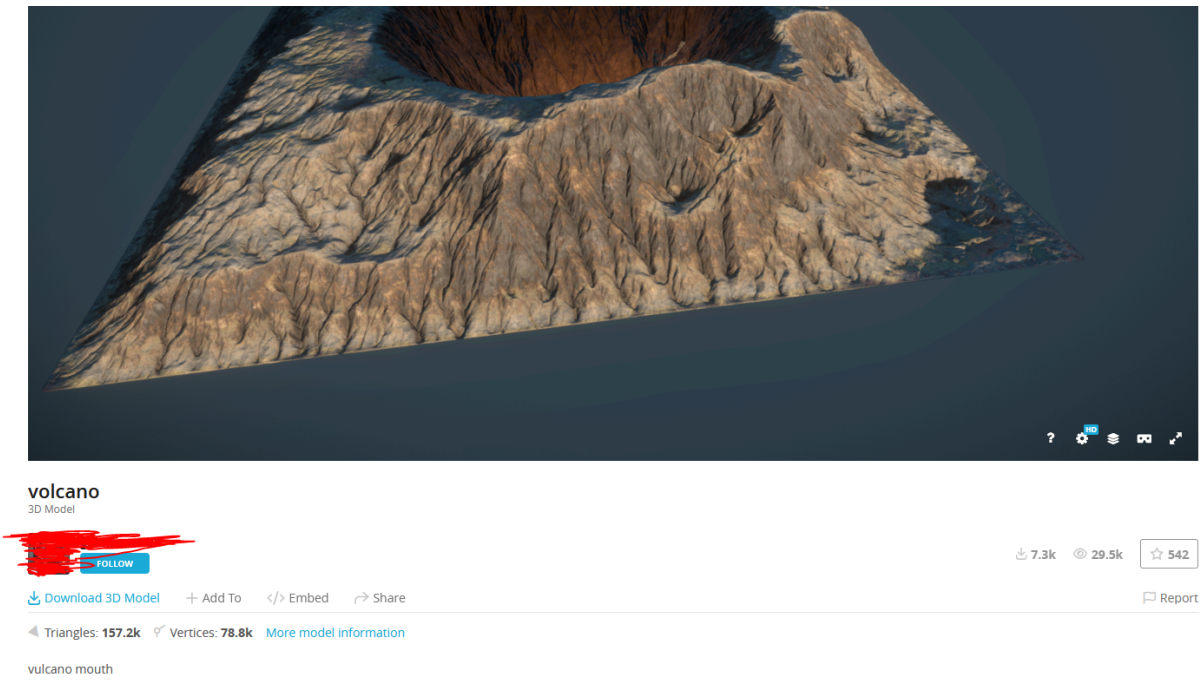


Figure 7. Sketchfab Model Details

In *Figure 7*, we can see the **"Download 3D Model"** button under the model name and author. We also below it have the amount of triangles the model is comprised of, **which is slightly relevant to us.** The more triangles there are, the higher the processing load will be on devices. Even up to a **million** triangles should be fine, however be wary of any higher fidelity models with much higher triangle count than a million, as they cannot effectively be used in the game engine without slowing down the application.

Now, if the download button is pressed, we will see a new dialog.

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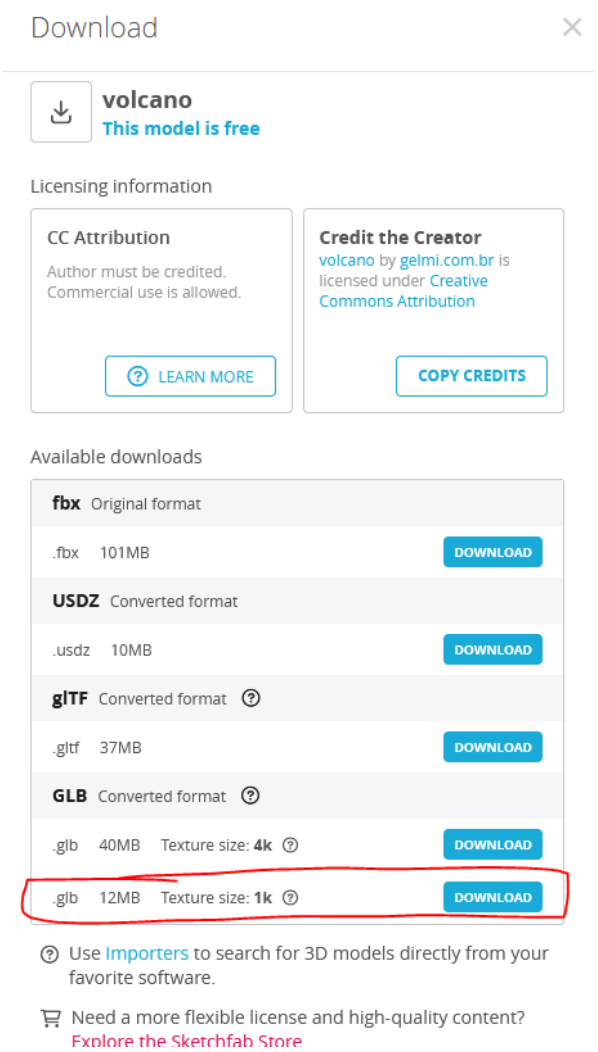


Figure 8. Sketchfab Model Download Dialog

Make sure to **always** download the **GLB** converted format, and with the **lowest** texture resolution available. The format is most compatible with the game engine, and low texture size saves disk space.

You may create a folder named after the subject in your **'Downloads"** folder to download these files into.

Now that downloading models is explained, the *lesson plan* document can finish.

Creating New Scenarios in the Engine

With the lesson plan in hand, the scenario can now smoothly be prepared in the engine by building on top of the source project. While it is the actual game engine itself we will delve into, we will only look at very surface-level controls and buttons, mostly drag and dropping objects the developers have pre-made. **No code knowledge is required.**

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In short, the sample scenarios we've seen consist of **scenes** that contain **one model** and some **pins** are placed around it. The goal is for us to create a few scenes, place pins in them, and place pins that take us to another scene to create a full scenario based on the previously constructed **lesson plan**.

Opening the Project

Find ***"Godot 4.6"*** in the **PROJECT SOURCE** folder and double-click it to open it. The project selection screen will appear. Click on the **"Import"** button at the top to begin locating the project.

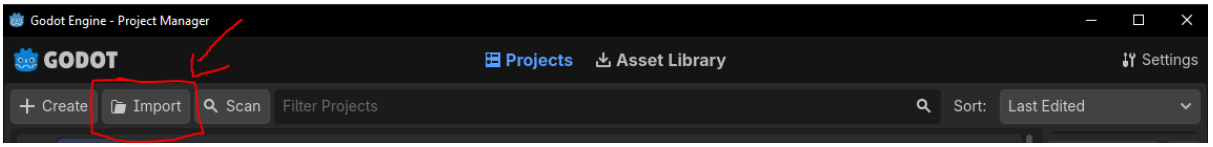


Figure 9. Godot Project Selection

A window will popup that asks you to locate the project. By pressing on the ***"up arrow"*** button, you can move up a directory. If the project files were placed in *"Documents"* as previously instructed, the *"Documents"* folder should be easily accessible by pressing the *"up arrow"* button a few times.

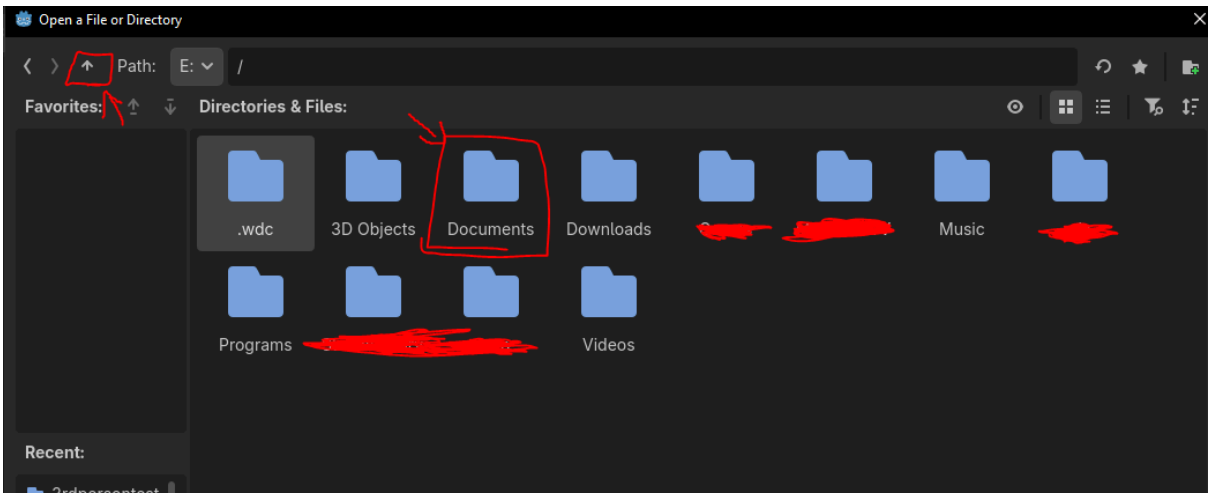
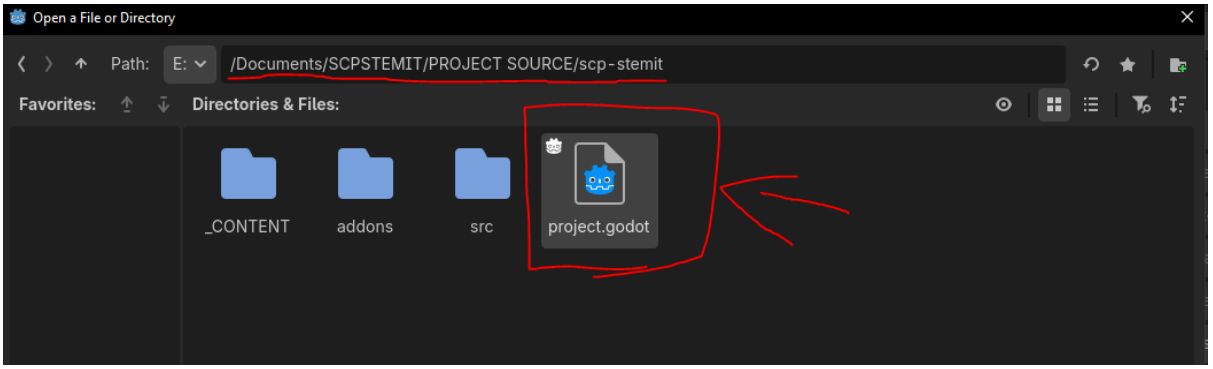


Figure 10. Project Finder Window

Navigate to the folder **SCPSTEMIT -> PROJECT SOURCE-> scp-stemit** and double-click **"project.godot"**.



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Figure 11. Project location

On the next window that pops up, click “Import”. Since “Edit Now” is ticked, this will open the project as well.

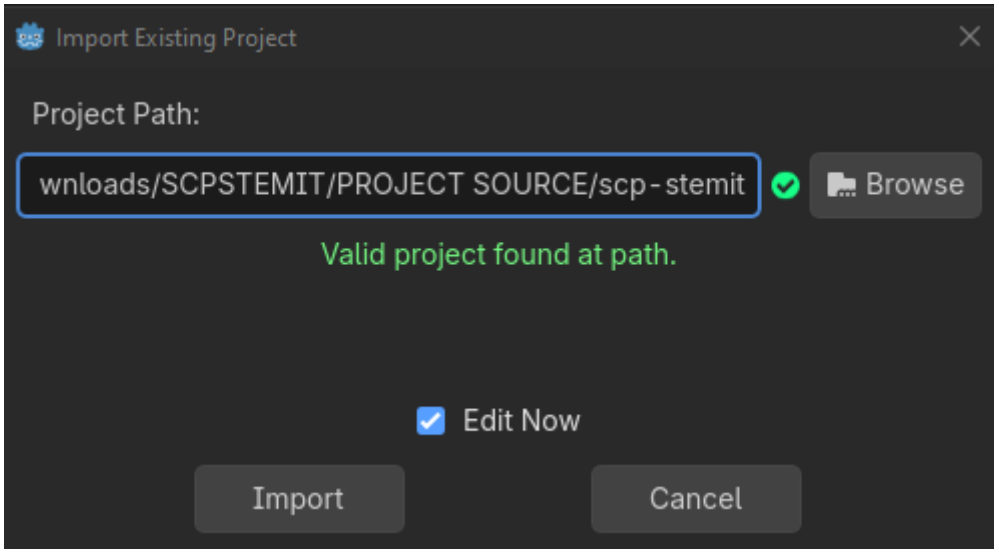


Figure 12. Project Import Confirmation

NOTE: The import process is done only for the first time. In the future, the *“SCP Stemit”* project will appear in the project list and can be double-clicked there to open the project.

Note that opening the project for the first time may take a few minutes.

Basic Interface Controls

Once the project is opened, we should see a screen like below.

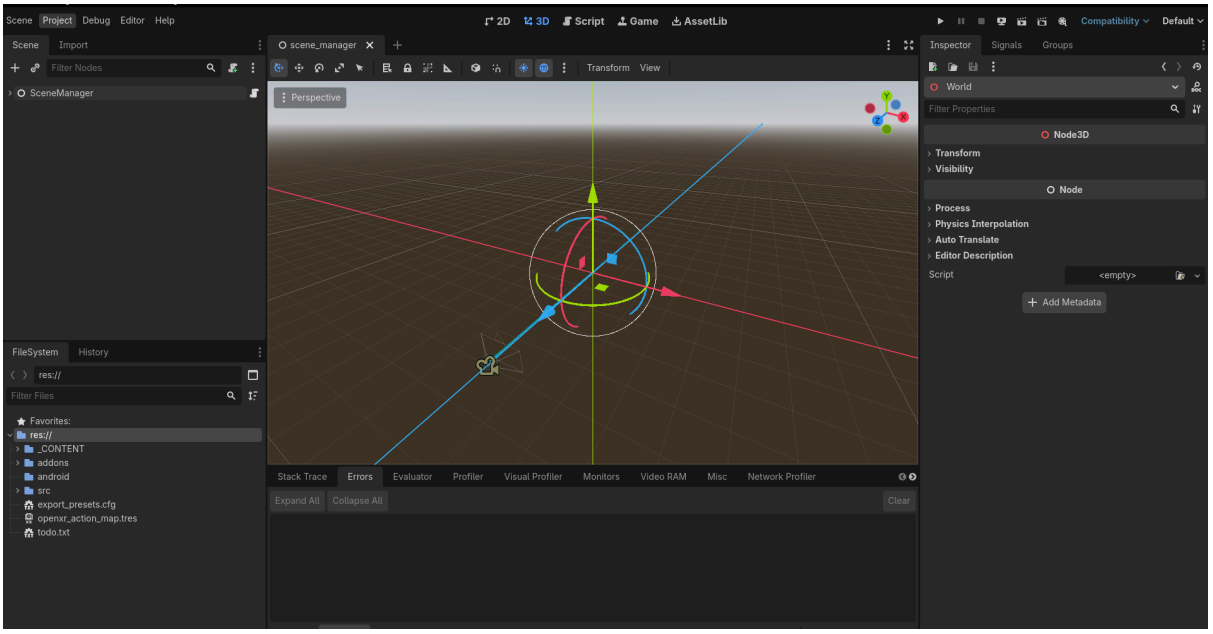


Figure 13. SCP Stemit Project Main

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To briefly explain, on the **left** we have the **"Scene Tree"** which lists the objects in the scene. When we add a model and pins, they can be found here. There are also objects that the developers have placed before as well, so they can be ignored.
On the **bottom left** we have the project files, which we will use when importing the downloaded 3D Models into the project.

On the **right**, we have the **Inspector**, which allows setting **properties** of a selected object. We will use this to set the text for the **pins**.

In the **middle**, we have the **Viewport**, which displays the current scene in 3D. Objects can be selected by clicking on them here or in the Scene Tree list. However, there are no visible objects yet in the scene we are on, so this cannot be tested yet. **It is important** to take a few minutes to learn to navigate the camera in this middle viewport right now:

- The camera can be reset to the **center of the scene** by pressing **"O" on your keyboard** after clicking anywhere on the viewport.
- **Zoom in/out** with **scroll wheel up/down**, while scrolling the zoom level appears on the left. A good zoom level we are using is **"4.5m"**.
- **Hold Right Click and drag the mouse** to rotate the camera view.
- **Hold Middle Mouse Click and drag the mouse** to orbit around the center.
- **Hold Right Click and press W, A, S, or D** on your keyboard to **pilot** the camera. This is the most useful feature.
- Remember again that the **"O"** key can be pressed to reset to the center, which is where our focus is on.

We will look at these slowly in the guide. It is time to import the models.

Import Models into the Engine

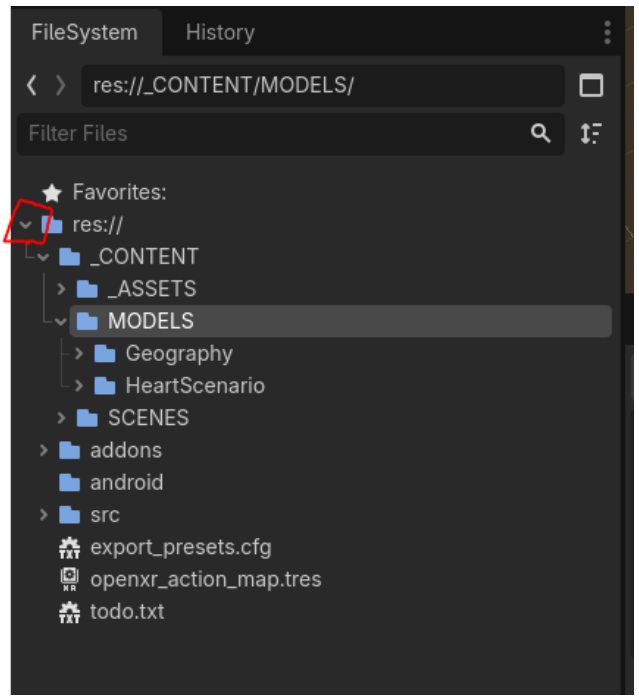


Figure 14. Project Files

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Before importing the models, let's create a new folder to put them in. This helps keep things organized. In the **bottom left**, the project file section, the folders can be expanded by clicking on the arrow to the left of the folder. Locate the **_CONTENT -> MODELS** folder. **Right click on the MODELS** folder, hover over **"Create New"** (The first choice) and then click on **"Folder…"** to create a new folder under MODELS. The new folder dialog will appear, so enter a name such as the theme of your subject.

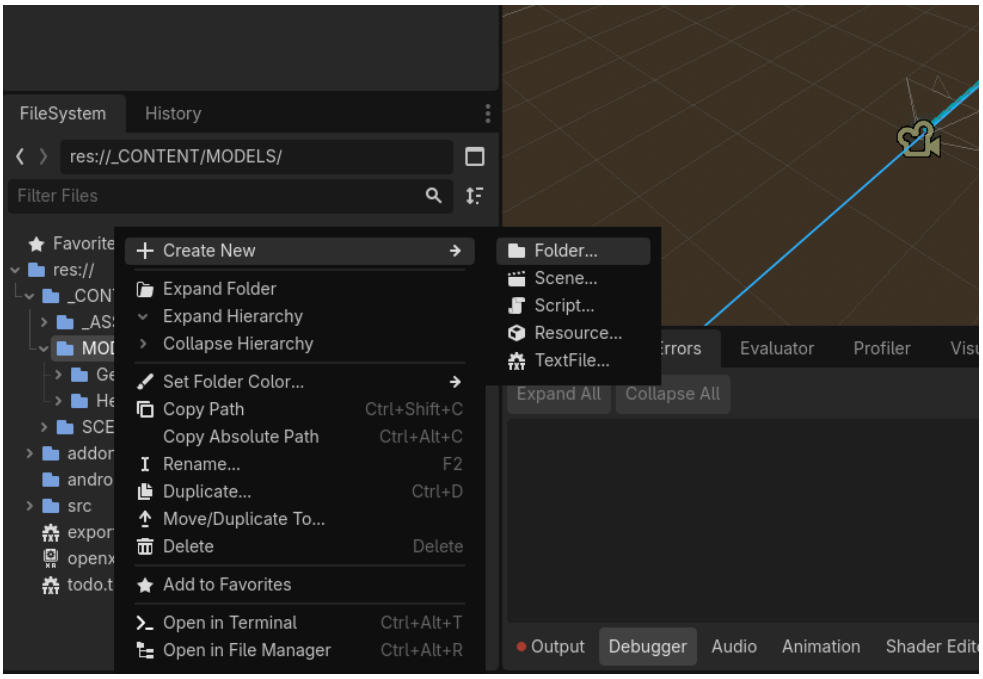


Figure 15. Create New Folder

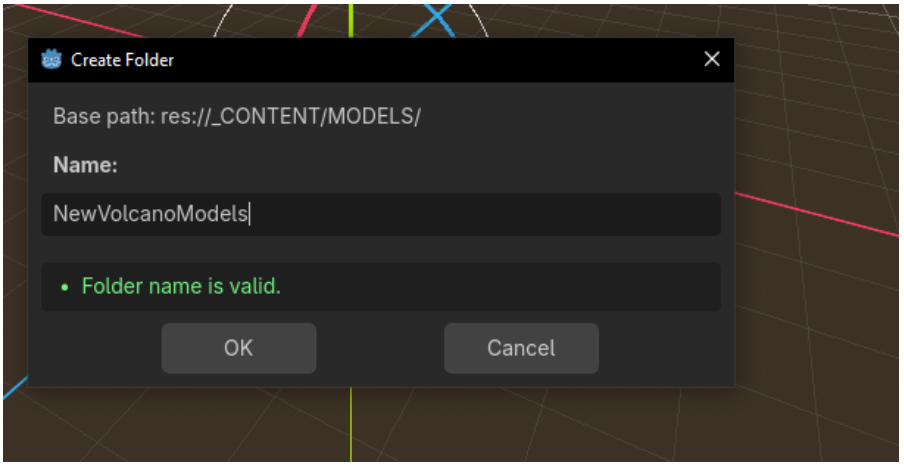


Figure 16. Create Folder Window

Now we can drag & drop the downloaded model files into the folder. To do so, open or return to your operating system's File Explorer and navigate to the folder where you previously **downloaded** the 3D Models. Unmaximize the file explorer window so that the project can be seen in the back and drag & dropping is possible, then simply select all the models and drag & drop them onto the folder in the project.

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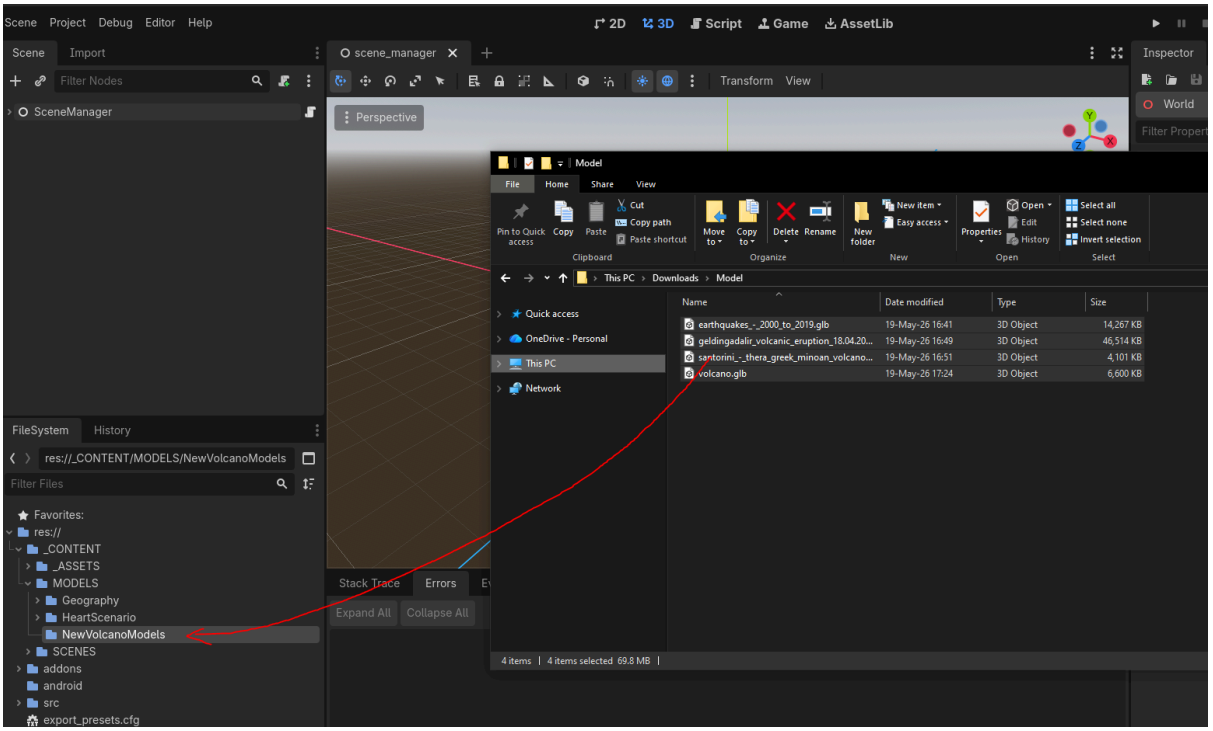


Figure 17. Drag & Drop Models

These may take some time to import. It is also a good idea to not select ALL of the models if there are many and instead import them slowly in chunks. We should have this result in the folder now:

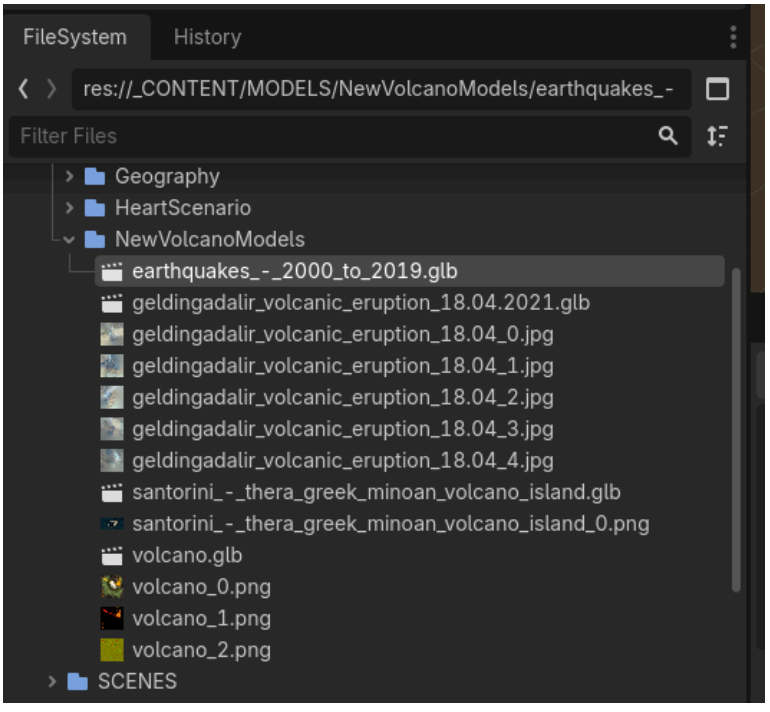


Figure 18. Imported Models in the File System

The files that end in **.glb** are the model files. Some **texture image files** have also been extracted from the model in order to be used by the engine, but we can ignore them completely. We will focus on **.glb** files only.

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Scenes Setup

It is finally time to start working on the 3D Scenes. This is the **most important part** and needs the **most attention**. In the sample scenarios, each screen we saw that contains a model and pins is **one scene each**.

Creating a New Scene

On the **bottom left** File menu, navigate to the **_CONTENT -> _ASSETS** folder. **Right Click** on **_SCENE.tscn** and select **"New Inherited Scene…"**

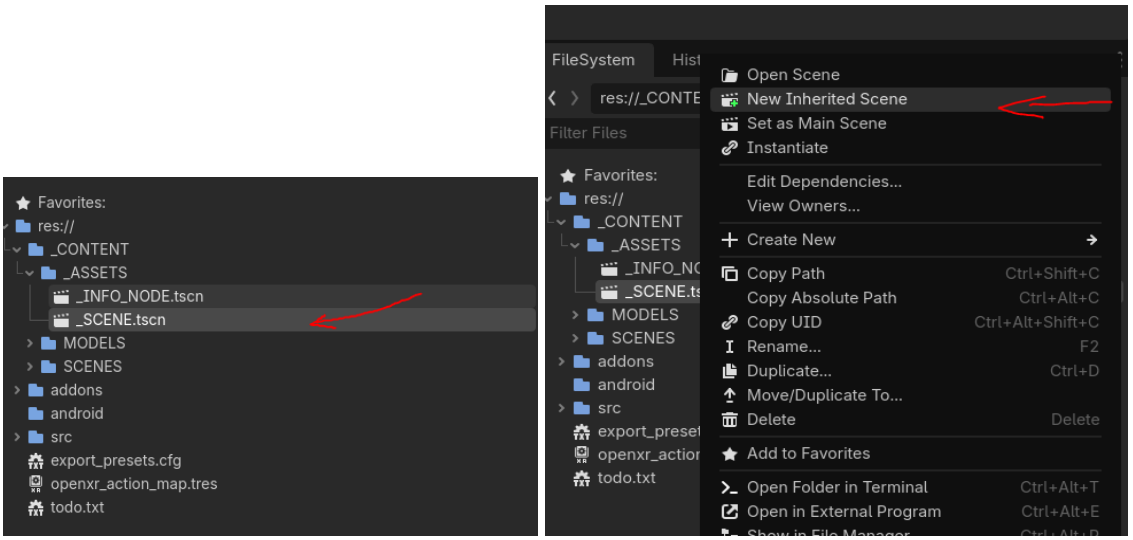


Figure 19. Creating new inherited scene

This will now create a new scene that inherits the functionalities given by the developer.

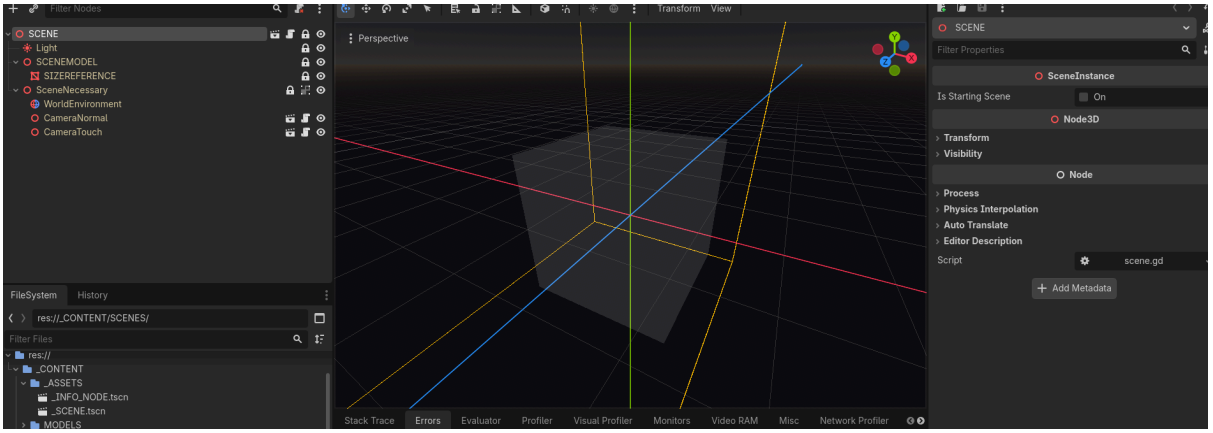


Figure 20. New SCP STEMIT Scene

While we can save this new scene at any point, we should take care of it now. In the same fashion that we created a new folder for the **models** under **_CONTENT -> MODELS -> (New Folder)** we should do the same for the scenes. Navigate to **_CONTENT -> SCENES**, right click on SCENES and create a new folder with the name of your subject.

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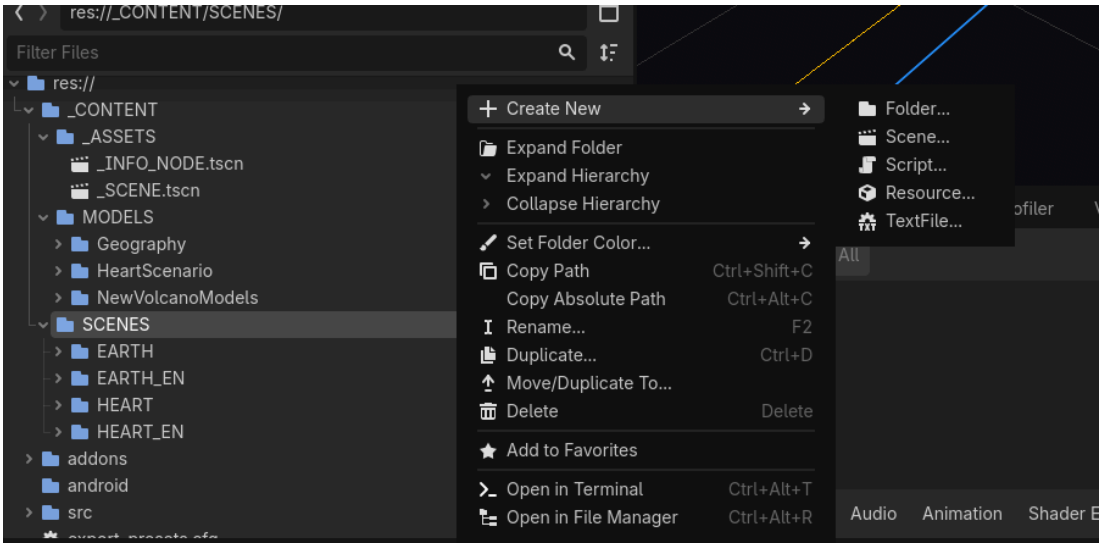


Figure 21. Creating new folder for Scenes

Now we can save the scene into this folder. Click on **"Scene"** on the top left and select **"Save Scene As…".** A window will popup where the save location must be specified. Navigate to **_CONTENT -> SCENES** and into the new folder you have created for the subject. The scene should be named according to what model is to be displayed in this scene, which should be the first one in your previously constructed **lesson plan**.

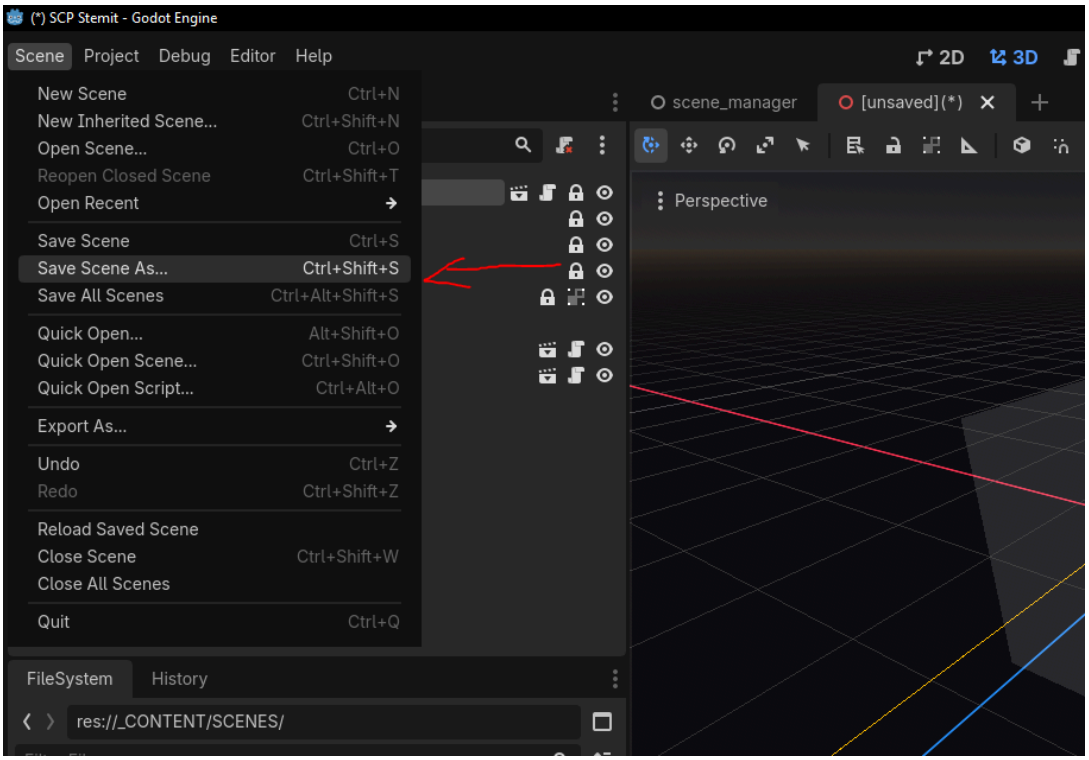


Figure 22. Save Scene As…

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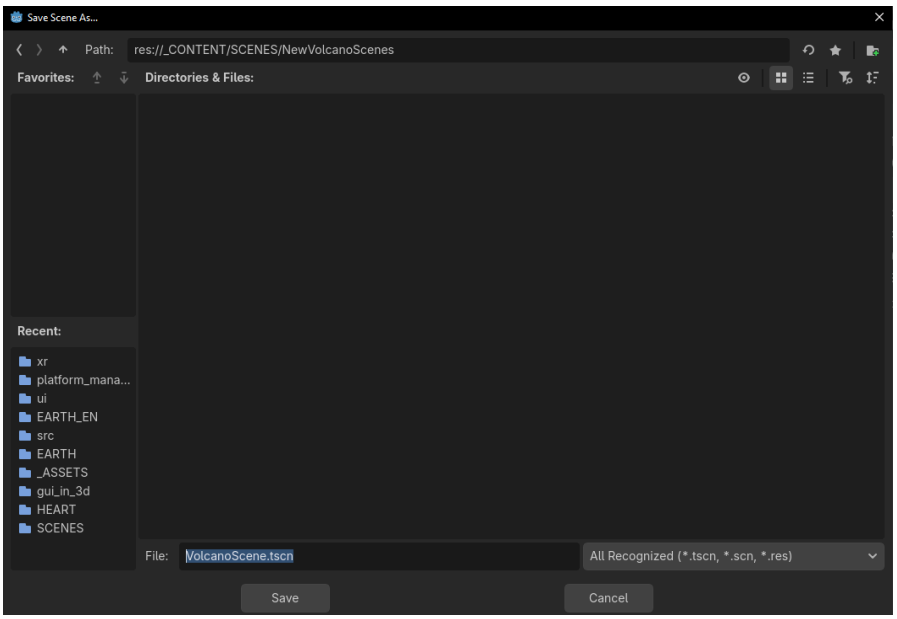


Figure 23. Saving the new scene with a name.

Adding Model to the Scene

To add a model to the scene, it can be directly drag & dropped into the center of scene from the folder in MODELS that was created earlier. As a reminder from the interface controls, “O” can be pressed after clicking on the viewport to reset the camera to the center, and you can zoom in/out (to a recommended value of 4.5m) with mouse wheel up/down.

With the camera properly pointing to the center of the screen, **drag & drop the .glb file to the center.**

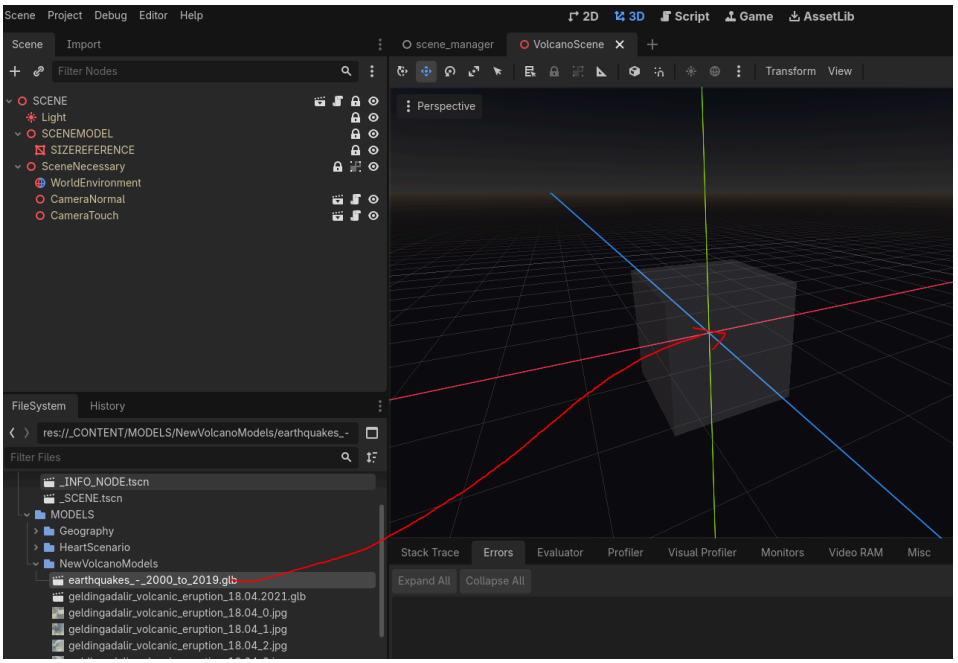


Figure 24. Drag & Drop the .glb into the scene

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Resizing the Model, Size Reference

The model should now be visible in the scene. However, 3D Artists may work on different size scales when creating the models. As such, the model that is now placed may be **too big** or **too small** in relation to what our program is working with.

This is why there is a faint cube in the middle of the screen. The developers have placed it there as a reference for what a good size is for the application. Fortunately, we can resize the model within the engine by **scaling** it. The model can be selected either from the **Scene Tree** on the left (it is likely called *"Sketchfab_scene"*) or by clicking on it in the **Viewport** (the middle screen). With it selected, we can now edit its properties. In this case, we want to edit its position and the scale. Click on the arrow next to **"Transform"** in the **"Inspector"** on the right of the screen to expand some positional properties.

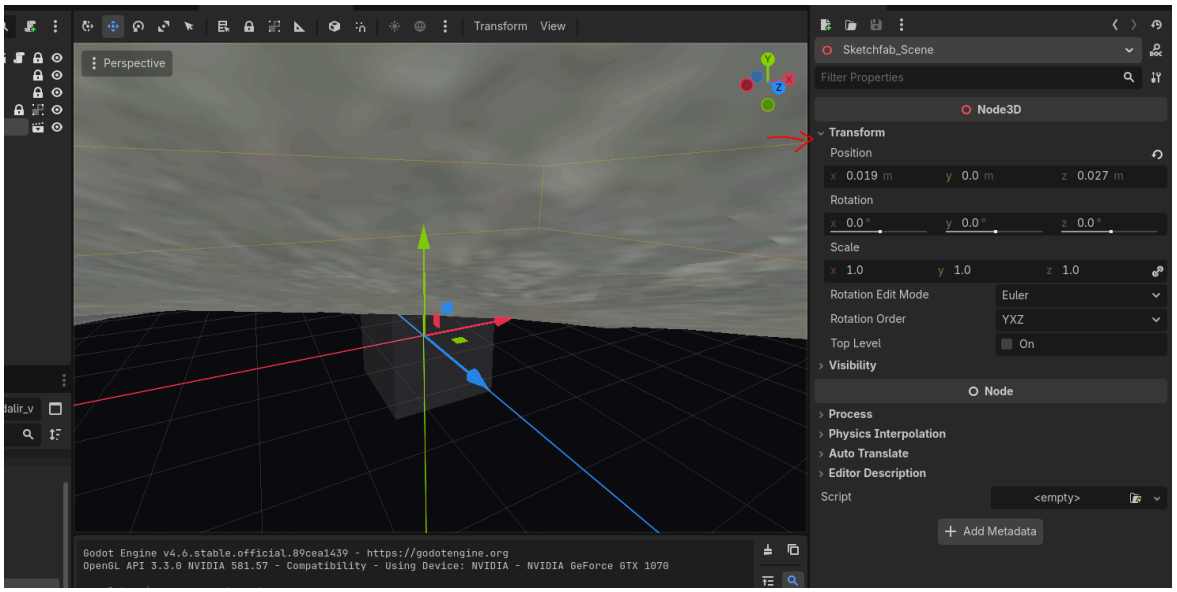


Figure 25. Expanding Transform

It is highly recommended to **edit values by inputting numbers here directly**, though it is possible to move objects also with the green, red and blue arrows in the viewport.

It is recommended to set the **x, y and z** Position values to **0**. Click on the **number, input 0** then press **Enter** for each. This makes sure our model is located in the center.

The **scale** is what is important here. Currently it is at 1.0 (default scale), however in the screenshot's case the model is very big compared to the **size reference** cube. To scale it down, manually input a value of for example **0.1** on any of the x, y or z axis for Scale and press Enter, and we can observe a change in size. By default, changing one scale axis also uniformly changes the rest. If we see that a scale of 0.1 is still too small or too big, we can further adjust the scale.

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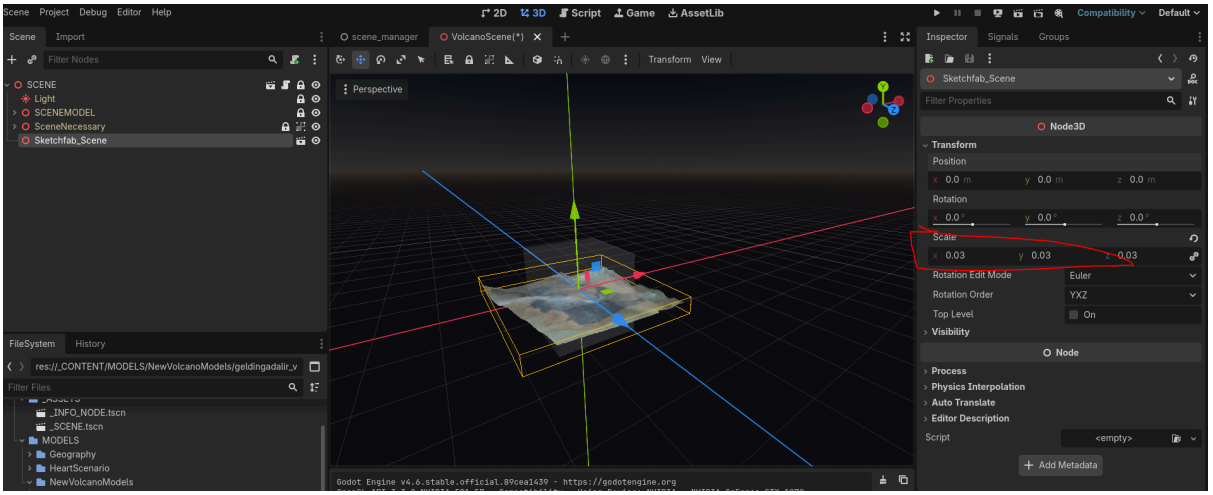


Figure 26. Setting the scale. A scale of 0.03 for this particular model was needed to fit into the size reference cube.

The scene can be saved again by pressing Scene on the top left -> Save Scene.

Adding Pins to the Scene

Pins can be added to the scene by drag & dropping a pin object into the scene. Navigate to **_CONTENT -> _ASSETS** in the **File** menu and drag & drop an **INFO_NODE.tscn** into the scene, similarly to the model.

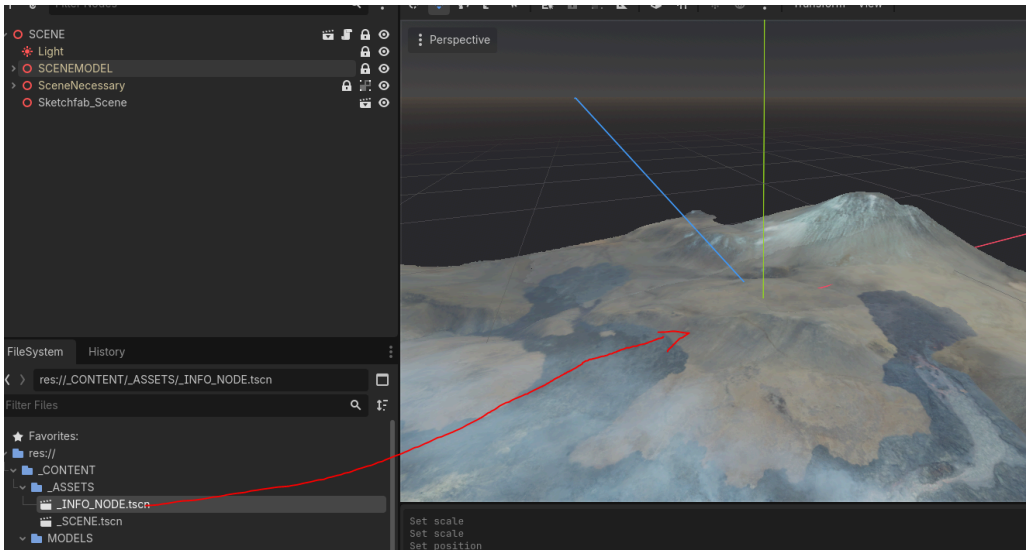


Figure 27. Adding a Pin to the Scene

Keep in mind, the pin object can be quite small so in order to locate it you may need to navigate the camera as described in *"Basic Interface Controls"* earlier. When the application is actually running, the size is auto-adjusted for the screen and zoom size, so there is no need to worry about scaling it up/down like we do with the model.

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Once the pin is in the scene, it can be **positioned wherever we want**. **Select it** by either **clicking on it after finding it in the scene**, or by **clicking on it in the Scene Tree** on the left.

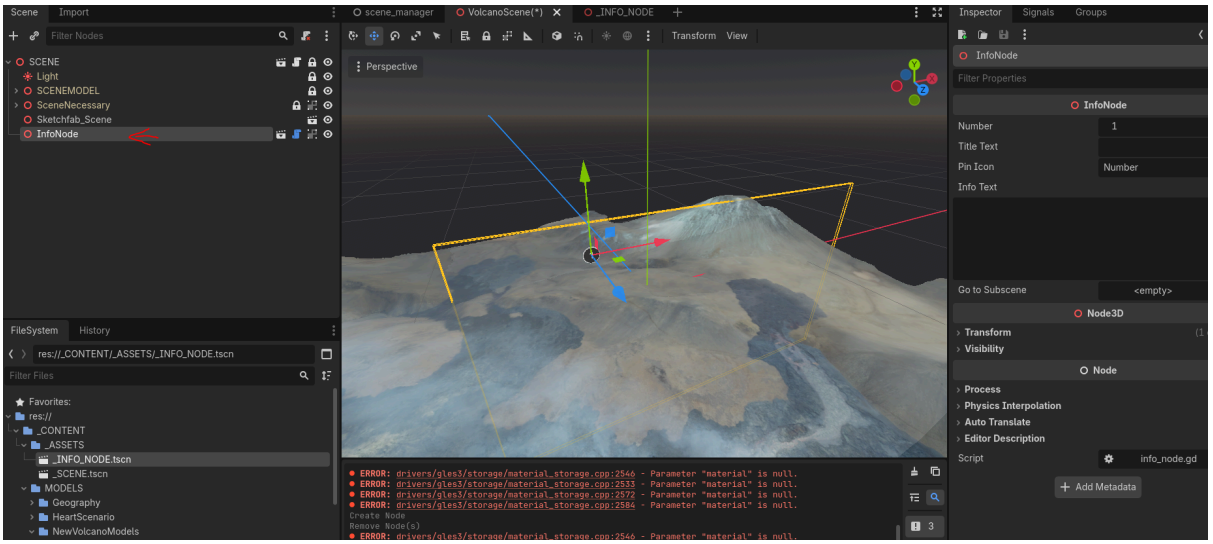


Figure 28. Selecting the added Pin

If you cannot find it in the **Viewport**, but can see it in the **Scene Tree** *(it will be named InfoNode, or InfoNode and some number if multiple are in),* please continue adjusting the camera and zoom to find it. Similarly to the model, we can set its **Transform's Position** to 0, 0, 0 to make sure it is at the center, and press **"O"** key to reset our camera view and it should be there.

To position the pin where we want, use the green, red and blue arrows to move it into the position you'd like. The arrows will appear only while the Pin object is selected. Make sure also that **"Move Mode"** is selected in the toolbar.

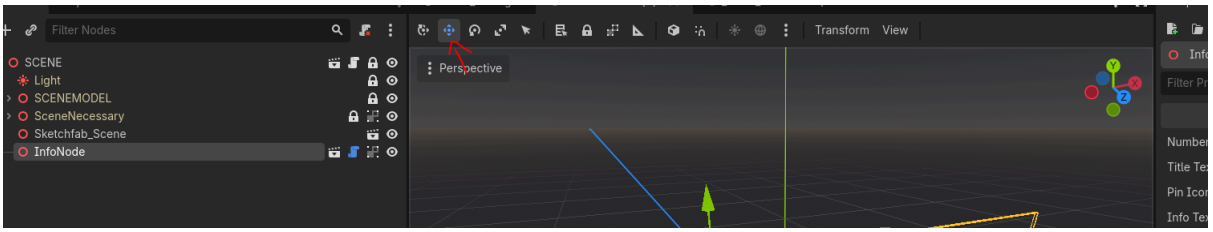


Figure 29. Making sure "Move Mode" is enabled

With a pin selected, we can now also **edit its properties** in the **Inspector on the right** by clicking on the field next to each property. If the property is changed, clicking on the circular arrow to the left of the property field **reverts it to default** which might be needed sometimes.

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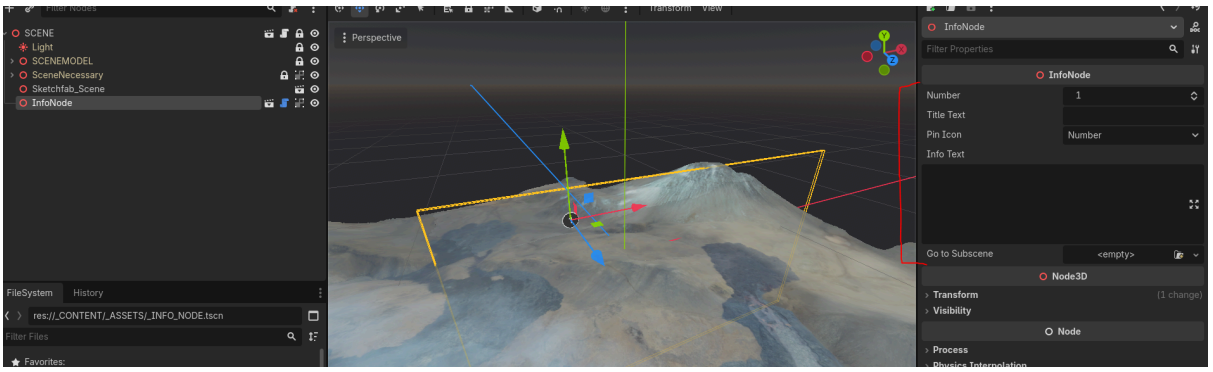


Figure 30. Pin properties

Property	Function
Number	Changes the number displayed on the pin.
Title Text	Set the Title of the information popup that appears.
Pin Icon	Change the icon that appears on the Pin. “Number” displays the set number, “Info” displays an “i” icon, and “Arrow” displays an arrow icon that indicates this pin moves us to another scene.
Info Text	Set the text that appears on the information popup.
Go to Subscene	Drag & Drop another scene to create a transition from this scene to the specified scene when clicking on this pin. If this is set, the information popup will not appear.

The process can be repeated for as many pins as we’d like in a scene. It is also possible to duplicate a pin and change its properties to slightly speed up the process by **selecting it in the Scene Tree** on the left and pressing **Ctrl + D**. Once finished, save the scene again by clicking on **Scene** on the top left and then **Save Scene**.

Transitioning Between Scenes

Transitions between scenes are done entirely using the Pin’s **“Go to Subscene”** property. Repeat the **“Scenes Setup”** process for the scenes/models that you’d like, and then drag & drop the scene into a pin’s **“Go to Subscene”** property. For example, I’ve created a scene with a Volcano and another one with Earth and saved them to my subject’s folder in **_CONTENT -> SCENES -> Volcanoes.** Now after adding a pin to the Volcano scene, I can drag & drop the Earth scene into “Go to Subscene”.

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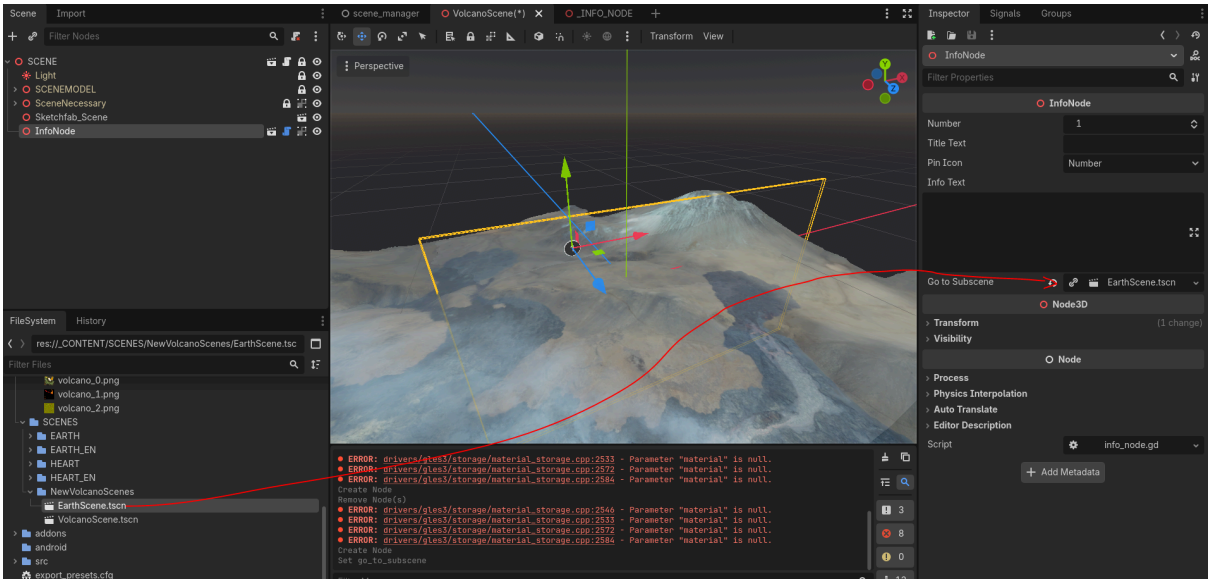


Figure 31. Drag & Dropping another Scene to the pin

Now when that pin is clicked during the application runtime, the scene will change to the specified Earth scene.

NOTE: Since we have a models folder and a scenes folder, make sure to not confuse the two of them! Models are different from the scenes we create, but the scenes contain the models.

Closing/Reopening Scenes

Godot can keep multiple scenes open so that you can switch between them easily. Remember to close them when not needed anymore, as if they add up then the computer can slow down. This is done by clicking on the **X button** next to the **Scene Tabs** above the Viewport.

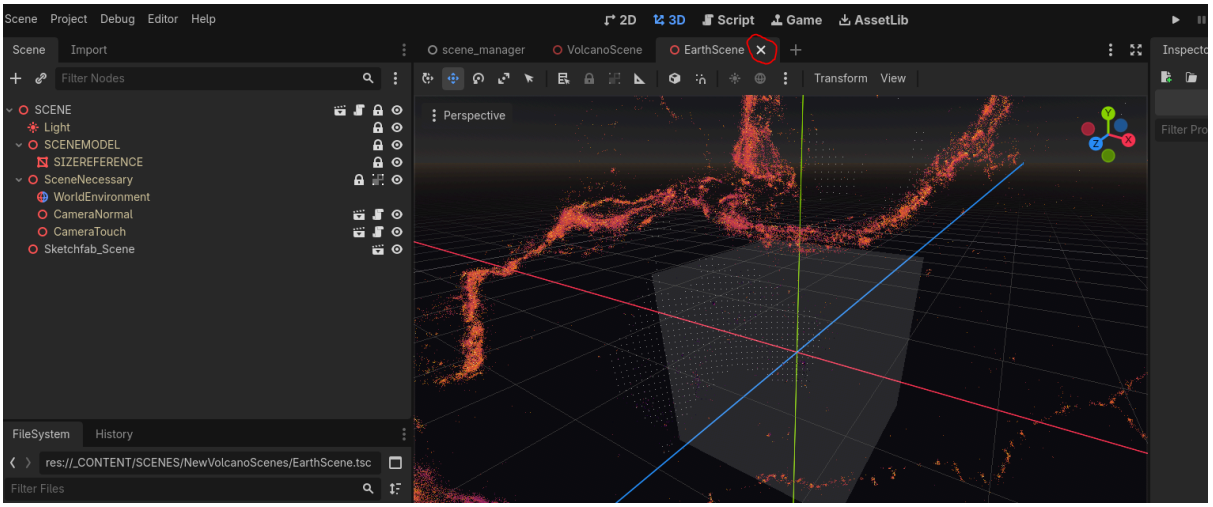


Figure 32. Closing Scene Tabs

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Of course, any previously created Scenes can be re-opened by finding them in **_CONTENT -> SCENES** and the folder you have created and double clicking them, and any changes to the model position/scale and pins can be done here.

Setting a Scene as a "Starting Scene"

In order for the scenario to appear in the **Scenario Select** menu, its first scene must be marked as a "starting scene". To do this, open the scene you'd like to be the first scene and click on the root object called ***"SCENE"*** on the left-side Scene Tree to select it. Its properties appear on the right side, the Inspector, and **"Is Starting Scene"** is the only exposed property. It can be ticked on/off. Put it **ON** for the starting scene. This should **only be done** for the scene that we want to start on when selecting this scenario.

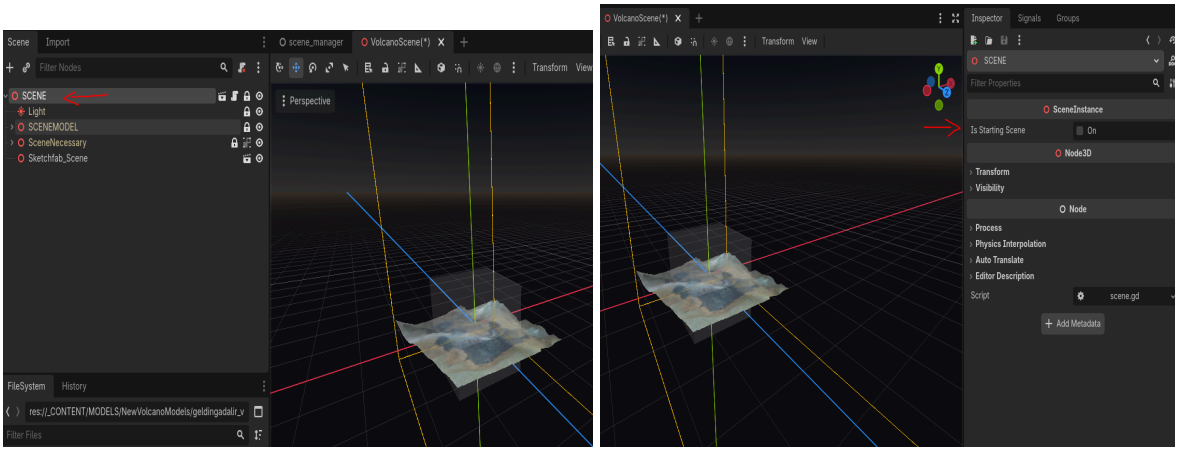


Figure 33. Setting Scene as Starting Scene

Summarize The Scenario Development Process

- Create new scenes by creating a new Inherited Scene from **_CONTENT -> _ASSETS -> _SCENE.tscn**
- **Drag & drop** a model(.glb) from the FileSystem to the center. Adjust its **scale and position** to fit into the **size reference cube**.
- **Add Pins** by drag & dropping **_CONTENT -> _ASSETS -> _INFONODE.tscn** into the scene much like the model, and reposition them with the Transform arrows. Set also their text properties on the right when selecting it.
- **Repeat for** all the scenes/models in your lesson plan.
- **Revisit** the scenes you have saved to now add transitions from one to the other by drag & dropping scene to any pin's "Go to Subscene" property. This is **done later when revisiting because** when creating the scenes, you likely **do not yet have the next scenes ready**.
- **Revisit** the scene you'd like to be the first scene that appears when selecting the scenario and set its "Is Starting Scene" property to ON.

Now the scenario can be tested!

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Testing

The scenario can be tested within the engine. On the top right bar, we can find the **“Play”** button that runs the game. Likewise, the **“Stop”** button close to it ends the test when needed.

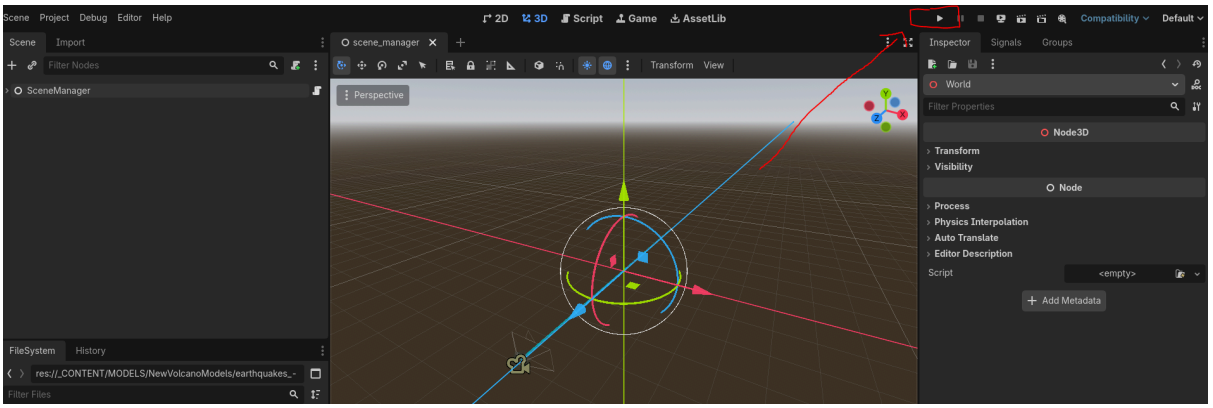


Figure 34. Play Test Button location

It is recommended to test often when building the scenario.

If the new scenario is not visible in the test, something must have gone wrong during the process, but please double check that the scene that should load first has ***“Is Starting Scene”*** selected, as mentioned previously.

Exporting the Application

Upon reaching this point, we have a scenario that can be played on the desktop PC through just the testing method. If the goal of the lesson is to simply show these models from the Desktop PC and the testing method is enough, **it is possible to end here**! However, if you’d like to have an exported **.exe** version that you can save to a **USB** or other device, then an **export** of the application is needed.

Windows

Exporting the application for Windows is the easiest of the platforms. On the top toolbar of Godot, click **“Project”** and then **“Export”**.

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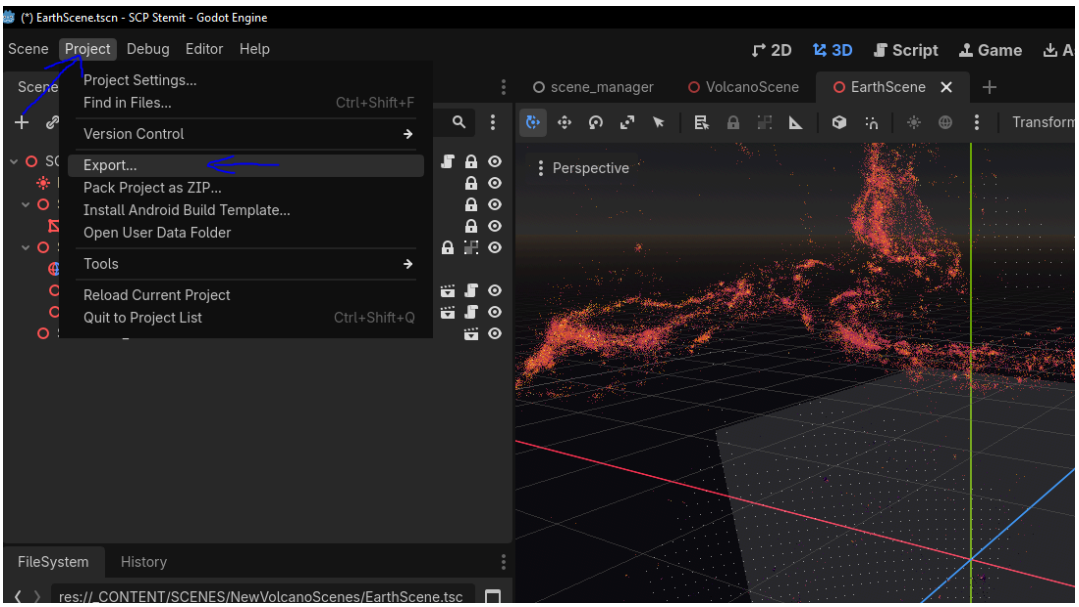


Figure 35. Location of "Export" option

The Export window should popup. On the left are three export presets that can be used to export the application to Windows, Android, or Android VR.

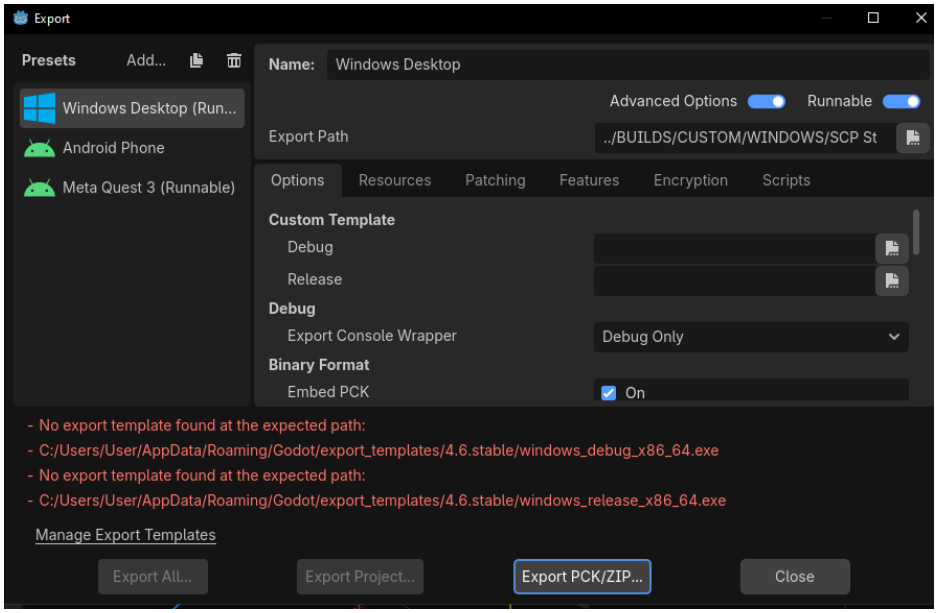


Figure 36. Export Window

In order to export to Windows, an export template must be downloaded, as the warnings in red text say. It is a process done automatically, with a few clicks. On this screen, click **"Manage Export Templates"**.

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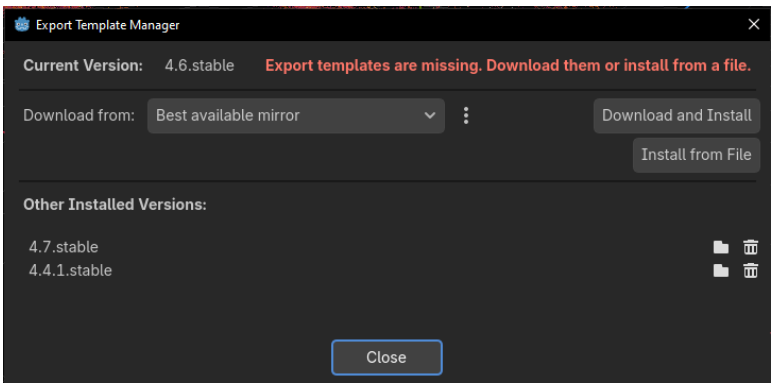


Figure 37. Export Template Manager

The Export Template Manager will open. From here, simply press **"Download and Install"** and wait for the download to complete. Keep in mind, the download size is around **1.16GB**. This needs to be done **only once.** Any subsequent exports will not require you to download the export template again.
When completed, click **"Close"** and then go to the **Export Window** again by pressing **"Project" -> "Export…"** on the top toolbar as done previously.

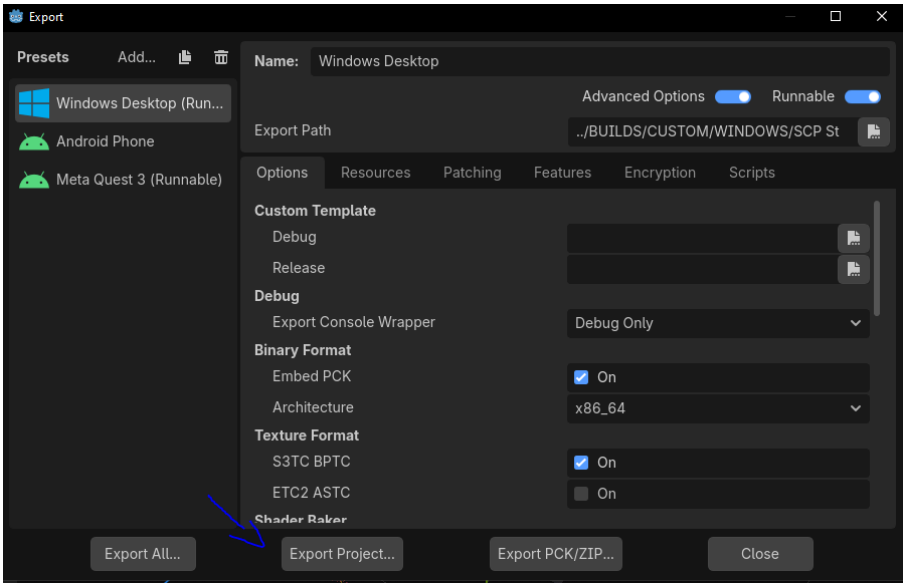


Figure 38. Export Window with no Warnings

The warnings in red text should be gone now. Simply click on **"Export Project"** now.

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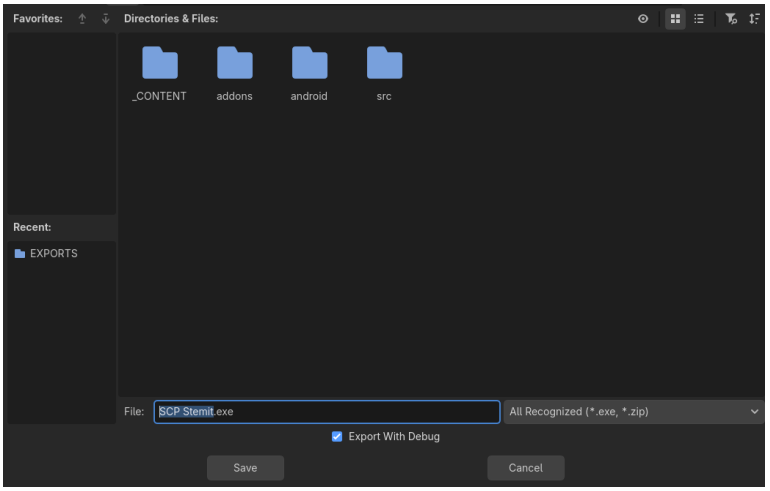


Figure 39. Export location

You are now given the choice to export the application to a location of your choice. We have pre-configured the export location to be in the project folder **"APPLICATIONS -> CUSTOM"**, so it is recommended to simply press **"Save"** to begin the export process, unless you know where else you would want to export. Since it is a simple **.exe** file, it can also just be moved anywhere else later.

Wait for the export to finish, then go to the specified folder. The application should be there, and can be ran!

Android Smartphone

Exporting for Android has a bit more technicalities, and as such it is **not recommended.**
It requires installing **OpenJDK** and temporarily installing **Android Studio** to get some necessary components for exporting to Android and then setting up the paths to those components in Godot. This official guide in the Godot documentation explains the process:

https://docs.godotengine.org/en/stable/tutorials/export/exporting_for_android.html

After those are set up, the exporting method is the same as for **Windows**, except that the **"Android Phone"** template must be selected.

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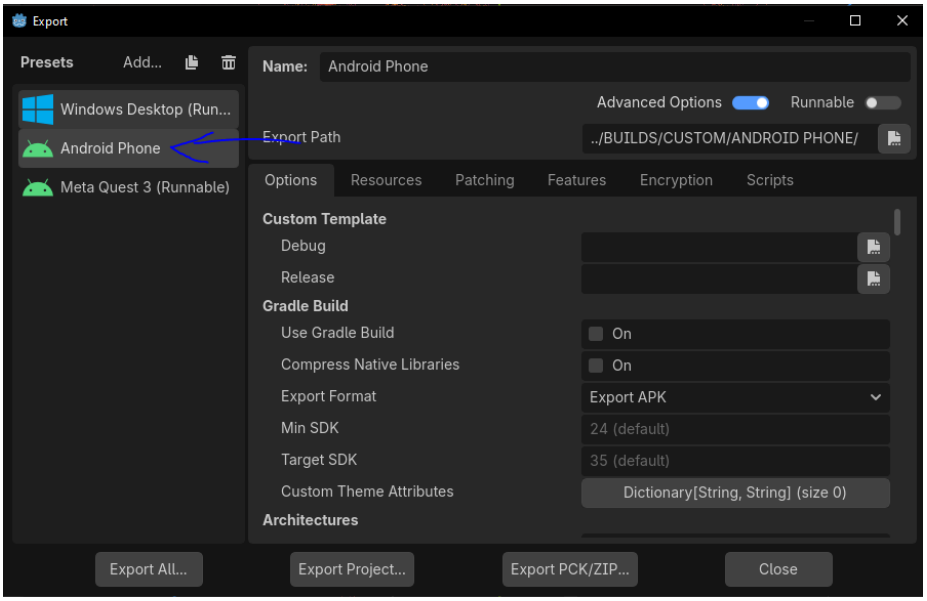


Figure 40. Selecting the Android Phone Template.

As in Windows, the export path is pre-configured to be in the project folder **"APPLICATIONS -> CUSTOM".** The resulting export is a single **.apk** file, which in order to be installed to a device, the guide for installing to Android that was in this guide before must be followed again: Geography.docx

VR

VR Headsets use Android OS, and as such requires the same process for set up as the Android Phone export. If the guide for the Android Phone export was already followed, it is also possible to export for VR already by just selecting the "Meta Quest 3" export template in the Export Window. Upon export, the guide to install to VR must be followed again: Geography.docx

Due to the technical requirements of exporting to VR and Android Phones, it is recommended to stick to Windows, as that can also run VR if your desktop is capable of it.

12.5 Delightex Edu

Delightex Edu, (formerly *CoSpaces Edu*), is an online platform where teachers and students can create their own interactive 3D environments. They can build a scene by choosing objects and placing them in a virtual space. Each object can be moved, resized or rotated. They can also add text, images, audio, videos and external 3D models. Simple actions and animations can be created with CoBlocks, the platform's visual coding tool. Once the project is ready, students can explore it on a computer, tablet or mobile phone. With a VR headset, the same scene can also become an immersive learning experience.

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Teachers can use the free Delightex Edu Basic plan. At the time of writing, a Basic account can invite up to 29 students, create up to two projects, one class and one assignment, upload up to ten external files,and use basic CoBlocks. These limits are sufficient for a small guided STEM activity when the project is planned carefully and built mainly with reusable objects and simple shapes.

Delightex Edu in STEM lessons

In **STEM teaching**, Delightex Edu is useful for lessons that involve space, movement or scale. A virtual scene can become a laboratory, an ecosystem, a machine or even a base on another planet. The tool works well when students are asked to explore a problem, investigate how something works, design a solution or explain their ideas.

Before creating the scene, the teacher should first decide what students are expected to learn and prepare one main question for them to answer after the tour. A short route with three or four stops is usually enough to keep the activity focused. It is also helpful to decide which information will be provided during the experience and which points students will need to investigate themselves. A simple worksheet can be used to record notes, evidence and group decisions.

Mission Mars: Can We Survive?

Link: https://edu.delightex.com/MJB-PBK

As part of the **STEM-IT project**, an astronomy learning activity called “Mission Mars: Can We Survive?” was created with the *Delightex Edu* tool. It presents a small human base on Mars with four main areas, which are an arrival zone, an energy station, sleeping quarters and a food station. At first, the base appears ready for the crew. However, a closer look reveals that several essential systems are missing. Students enter the base and follow Sara, a student researcher, as she visits each area. At every stop, she shares a clue and asks them to observe their surroundings and think about what the crew may still need. At the end of the tour, Sara meets her professor, who asks the class to work in groups and discuss whether people could live safely on the base for a long time.



Figure 1. The Mission Mars scene in Delightex Edu.

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Build the activity step by step

The screenshots below show how Mission Mars was built. A teacher can follow the same steps for another STEM topic.

Step 1: Create an account and open the dashboard

Open the Delightex Edu website https://edu.delightex.com and create a free teacher account. There are also sign in options via Google, Microsoft, or with a login code. Then open *My Projects*. This is where you create, edit and organise your scenes.

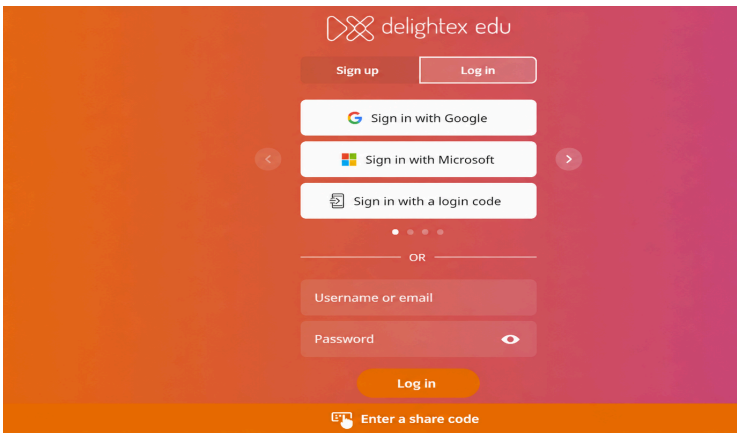


Figure 2. Creating a teacher account.

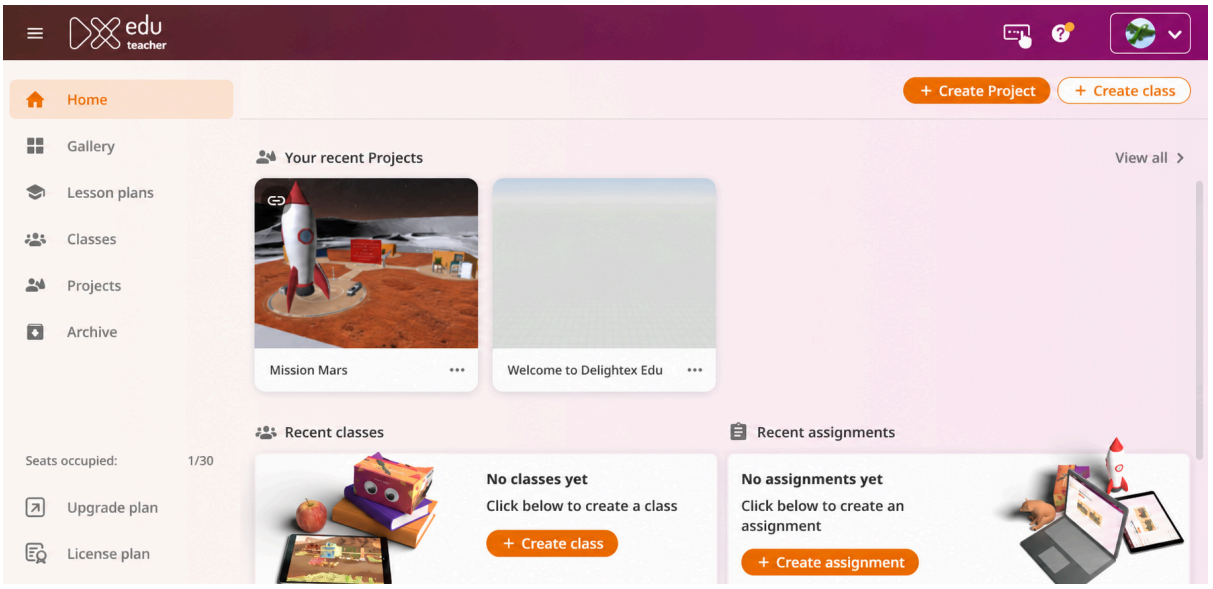


Figure 3. The teacher dashboard and My Projects

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Step 2: Create a new 3D project

Select ***Create Project*** to open the available scene types. Delightex Edu allows teachers to create different activities, including a 3D environment, a 360° image, a quiz or a virtual tour. For this activity, select the 3D environment and then choose the Project to begin with an empty scene. This gives you the freedom to build your own learning environment and add the objects, characters and information needed for the lesson.

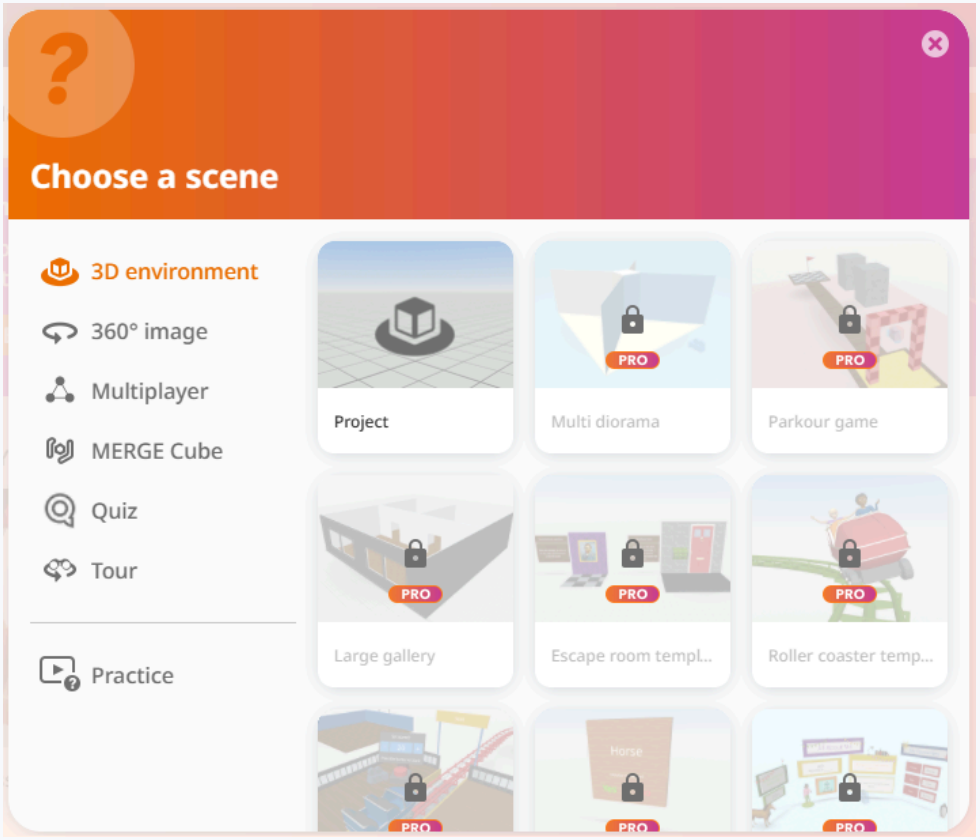


Figure 4. Choosing a new 3D scene.

Step 3: Sketch the layout

Build the main layout before adding small details. Mark a starting point and decide where each investigation area will be. Leave enough space for students to move without hitting objects. Mission Mars has one central point and four short routes, so learners can always see where they are.

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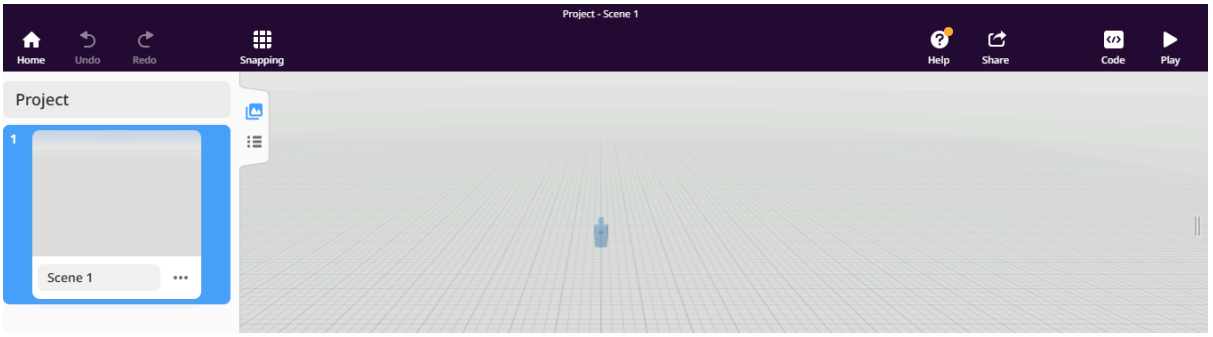


Figure 5. Planning the main areas of the scene

> 💡 **Tip!**
>
> **Build in this order:** floor and main areas, large objects, paths, labels and interactions. Test each stage before adding more detail.

Step 4: Choose the setting

Open the scene settings and choose a background that matches the topic. You can use a ready-made setting or upload a 360-degree image. Mission Mars uses a dark sky and a Martian landscape. The background gives context, but it should not distract students from the task.

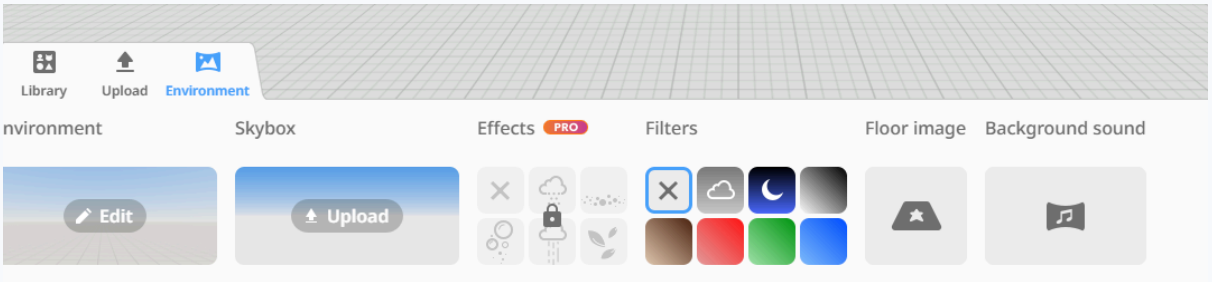


Figure 6. Choosing the scene background.

Step 5: Add objects from the Library

Open the Library and drag an object into the scene. Use the controls to move, turn and resize it. The Library has different types of objects that are suitable for simple shapes and work well for floors, platforms, labels and barriers.

- Drag an object from the Library into the scene.
- Move it to the correct area and place it on the floor.
- Turn and resize it with the object controls.
- Change its colour or material if the option is available.

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- Duplicate it when the same object is needed elsewhere.

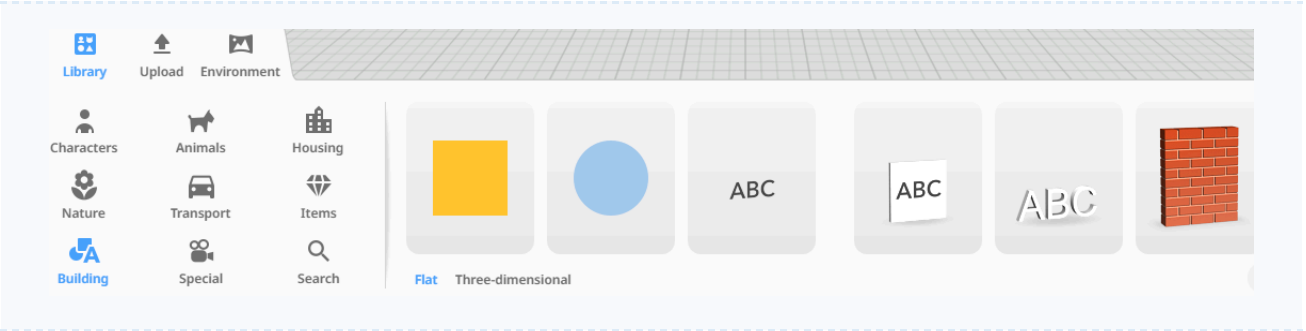


Figure 7. Adding and editing a Library object.

Step 6: Add an external 3D model

If the Library does not have the object you need or if you want to include extra objects, open *Upload Tab* and import a 3D model, preferably in GLB format. Sketchfab is one possible source for searching 3D models (https://sketchfab.com). Download a model only when its licence permits reuse. Keep the file small, because a model with too many details may load slowly on student devices.

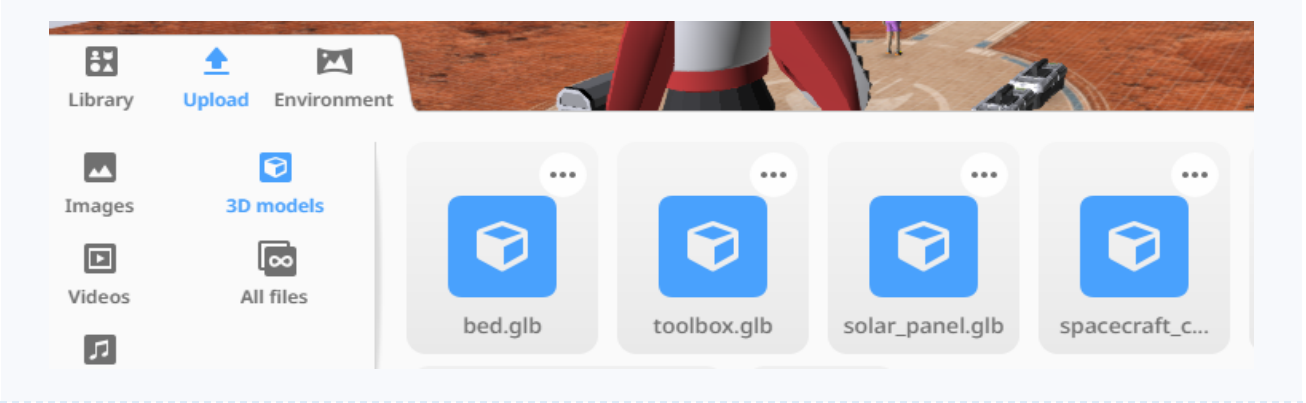


Figure 8. Uploading an external 3D model.

Step 7: Add images, video or sound

Another resource option can also be an image or a short video, explaining a process. Moreover, sound can set the scene or give an instruction. Delightex accepts common image files, GIFs, MP4 video and MP3 or WAV audio. Use media only when it helps students understand the lesson. Free-stock sites such as Pexels, Pixabay, Unsplash and Wikimedia Commons may be useful. Check the licence of each file before using it. Keep a note of the author, title, link and licence for the project records.

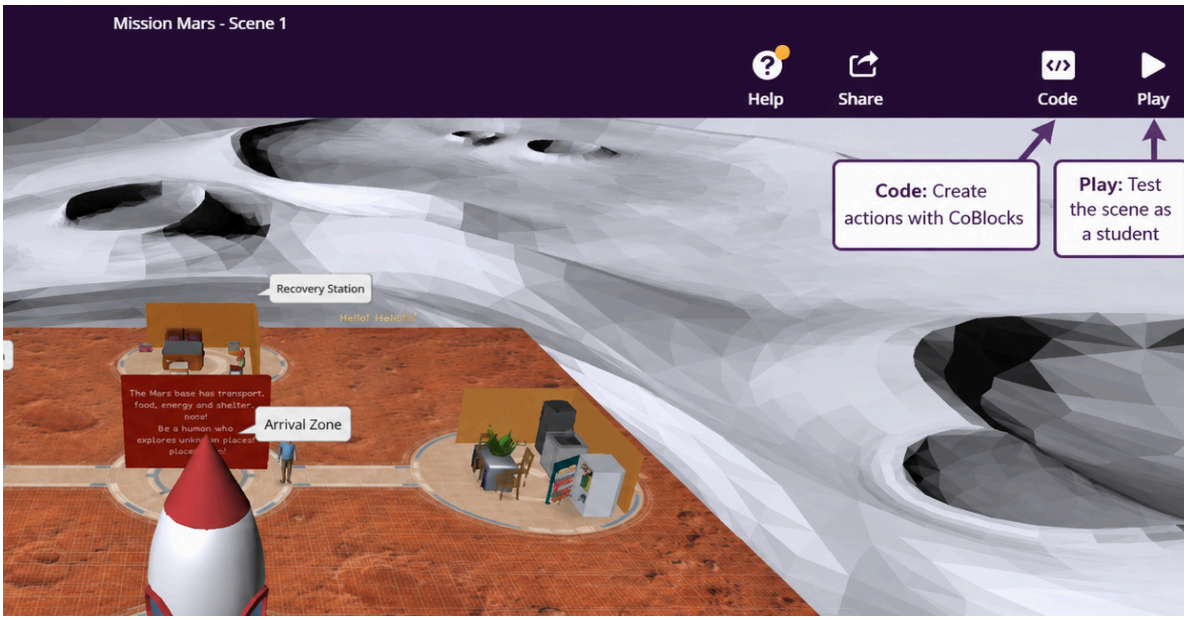
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> 💡 **Tip!**
>
> **Keep files light:** Compress images and keep video short. Delightex currently allows MP4 files up to 50 MB. Smaller files open more reliably on school devices

Step 8: Create the learning sequence with CoBlocks

Once the scene is ready, open *CoBlocks* by clicking the **Code icon** on the right side of the screen. Then select the character or object you want to program. *CoBlocks* uses visual blocks that can be dragged and dropped into the order in which each action should happen, so no previous coding experience is needed. CoBlocks turns a 3D scene into a guided learning activity, allowing you to present information gradually, direct students' attention and include questions for observation and discussion. Use these blocks to decide when a character speaks, when an information panel appears and how the character moves from one point to another.

The complete sequence should always be tested in *Play mode* before it is shared with the class, by clicking the **Play icon** on the right side of the screen.



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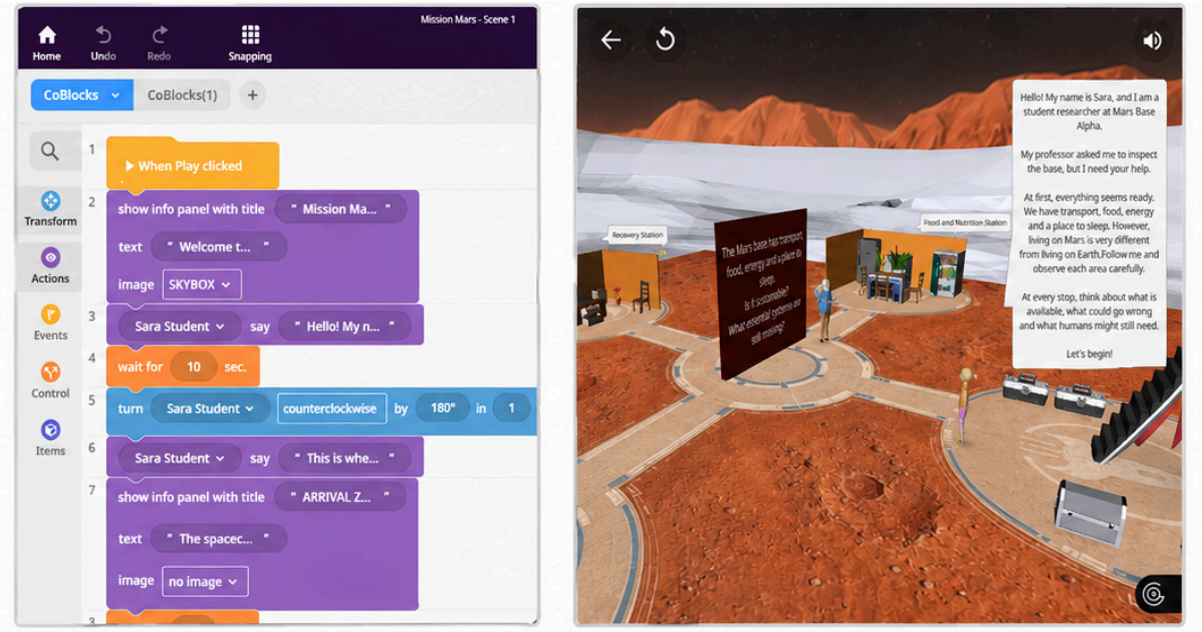


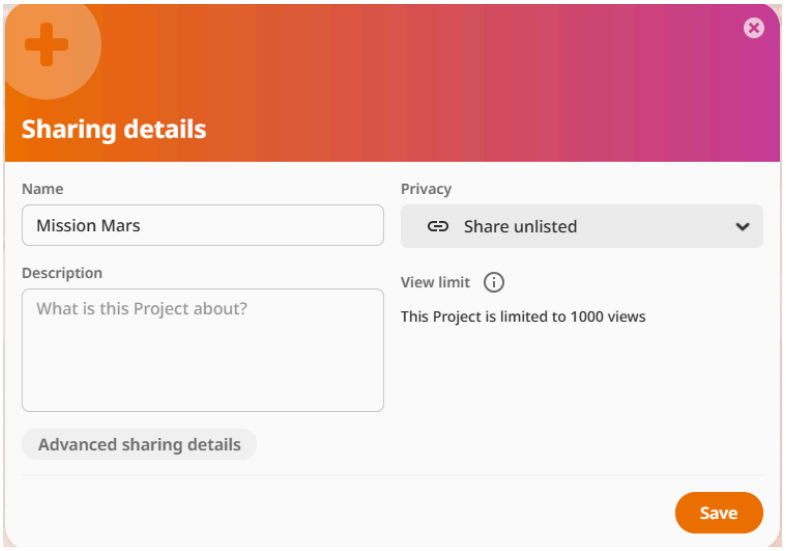
Figure 10. Building paths with CoBlocks and test the 3D scene

Step 9: Share the project with students

As a final step, click the Share icon in the upper-right side of the screen. The options shown will depend on whether the project is being shared for the first time or has already been published.

First time sharing

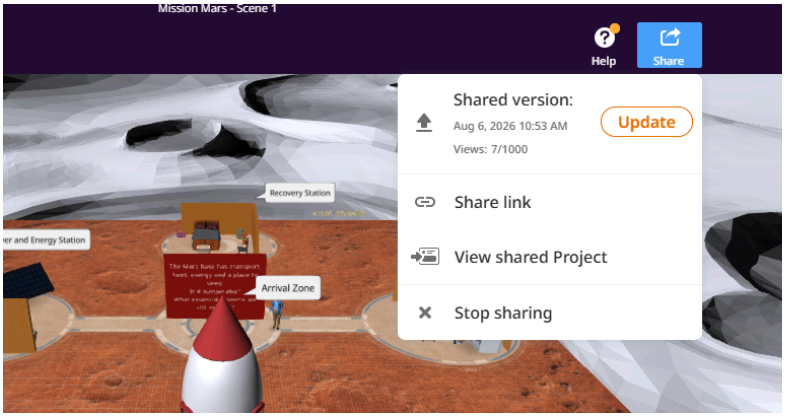
Add a clear title and a short description. Choose the appropriate privacy setting, then click Save.



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After making changes

Open Share again and click Update. This makes sure that students receive the latest version of the scene.



After saving or updating the project, open Share link and use the viewing link, QR code or class assignment option available in your account. Do not copy the private editor address from the browser. Share the lesson question and the student note sheet together with the link. Students can explore the activity alone or in pairs, depending on the devices available.

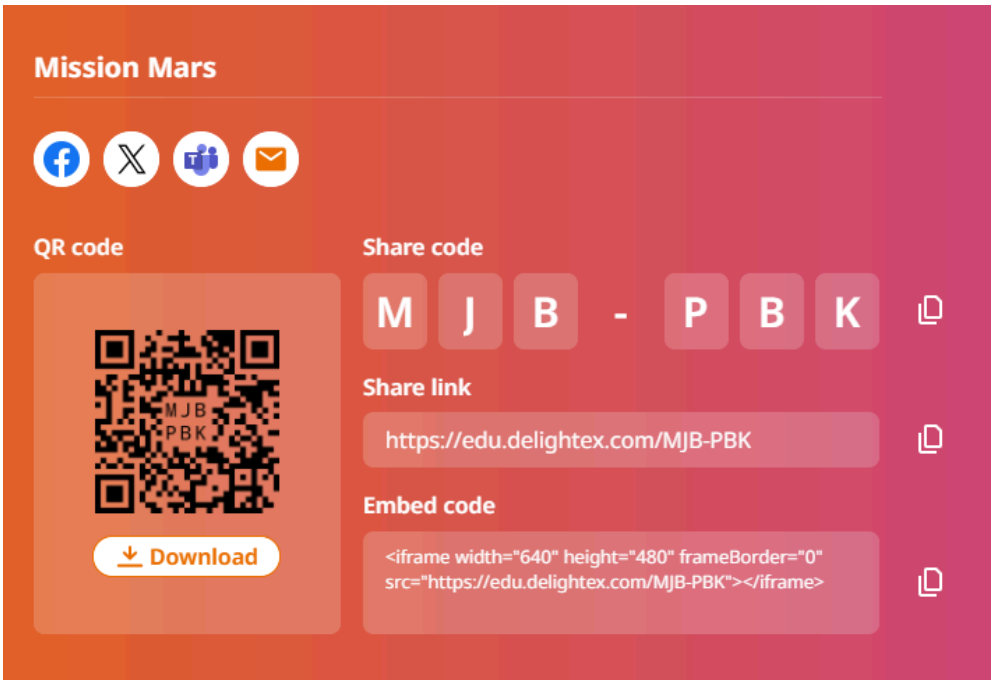


Figure 11. Sharing the finished project.

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12.6 STEM -IT Tools & Resources

Educational Tool	Technology	Classroom Use	Access
AR Tutor	Augmented Reality	Students scan learning materials and explore digital content	https://play.google.com/store/apps/details?id=com.aetma.artutor3Chl=en/ https://apps.apple.com/g/app/artutor4/id1573116812
VR Museum	VR / 3D environment	Students explore a virtual exhibition through guided rooms	https://metasteps.com/viewer/6a1ac46b-5e45-426f-a54a-4886bba730fa
EnergyLab VR	Virtual lab simulation	Students complete virtual experiments on heat and energy	http://platform.stem-it.eu/gest
SCP 3D Model Viewer	3D / VR model viewer	Students explore 3D models and information pins	https://stem-it.eu/scp-stem-it-3d-model-viewer
Delightex Edu	Interactive 3D / VR environment	Students explore a Mars base, identify missing systems and propose sustainable solutions.	https://edu.delightex.com/MJB-PBK

12.7 Conclusion

This chapter presented the interactive tools developed as part of the STEM-IT project and the ways in which they can be utilized in teaching STEM subjects. By utilizing these tools, teachers can explore different applications of augmented reality, virtual reality, and 3D environments in the classroom.

Each tool offers a different learning experience. Students can scan augmented educational materials, tour virtual exhibits, participate in virtual experiments, and explore 3D models. In this way, the tools help make STEM lessons more visual, engaging, and interesting.

In addition, the chapter includes a step-by-step guide for first-time use of the tools, with the goal of enabling them to be gradually integrated into teaching, depending on the needs of each course.

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