**03.2 Lesson plan**

**Age group/grade: 10th grade**

**Lesson title: Bridge structure analysis and design**

**School Discipline: Engineering**

**Key concepts:**

**A beam** is a connecting element of walls and supports.

**Engineering** is a discipline and profession that practically applies knowledge of physics, chemistry, mathematics, materials science, mathematical modeling (and bioengineering biology), economics and practical activities in various technical fields - static and linear (roads, shipping and irrigation channels, communication lines, etc.), in the design, development, adjustment, repair and the like of equipment, machinery and other devices, technological systems and processes.

**A bridge** is a structure that connects a road above a river, canal, gorge, etc.

**Objectives:**

* To analyse bridge structures.
* To create a presentation of the chosen bridge construction type (scope and form depends on how long and how deeply we intend to analyze this information, whether we want students to get acquainted with bridge types, or learn to classify, describe, recognize, and construct them).

**Skills developed:** engineering thinking. Application of knowledge of mathematics and physics in civil engineering. Interest in innovative technologies and engineering solutions. During the production of prototypes, we will check the results of the design and construction and, after detailed testing, we will find out whether the component and the construction meet our expectations.

**Materials/Equipment needed:** computer class, VR headsets, cardboard sheets, drawing tools, scissors, spaghetti pasta, plasticine.

**Assumptions:** (Programs for students with special needs, other important information)

**Lesson plan**

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| **Stages** | **Description of activity** | **Time** |
| **Preparation before the lesson** | If this is a first VR experience for students – go through the safety rules:  -Students are to sit down whilst using the VR glasses and not hold anything in their hands, unless the experience is of such a nature that it requires you standing, in which case, ensure enough space is allowed around all students.  -Students will be told to expect a feeling of vertigo. If it gets worse, students must remove VR glasses.  -Students need to know how to adjust the viewing focus before using the headsets.  -Students must not use the headset when they are: tired, need sleep, under emotional stress or anxiety, when suffering from cold, flu, headaches, migraines as this can worsen their susceptibility to adverse reactions. | 2 min |
| **Introduction** | Students (with the assistance of a teacher if needed) suggest the representatives of professions that could help in building bridges. Here we find out that a good bridge builder benefits from knowledge of almost all subjects taught at school (mathematics, physics, foreign languages, chemistry, drawing, etc.). We integrate English into our activities: students discuss with the English teacher what does an engineer do; define meaning of words and concepts.  Main types of bridges by design:   * Suspension bridge      * Cable-stayed bridge      * Beam bridge      * Arch bridge      * Truss bridge     Teacher briefly presents the history of spaghetti bridges (students can be asked to do the research work independently and present it to the class or in groups). From slide 26 - steps and tasks, how to build a bridge from spaghetti pasta, what are the rules when loading it.    The idea of building spaghetti bridges was born back in 1983 at Okanagan College in Canada and soon became popular around the world.  The world record belongs to the team of Hungarian civil engineering students – in 2013, the less than one-kilogram bridge withstood a load of 570.3 kg.    The annual championship held in Hungary attracts more attention every year: students from all over the world gather to test their powers and demonstrate their ability in application of theoretical knowledge in practice.    To create a strong and good-looking structure is a serious engineering task. | 10 min |
| **Initial Immersive Experience** | Students are watching a video about bridge constructions.  <https://www.youtube.com/watch?v=KslRhJdtiS0> | 3 min |
| **Guided Immersive Experience** | After watching the video, it’s time to proceed with the task.  The teams (2 students each) are given a task: after analyzing the information, they have to create a presentation of the type of bridge structure assigned to each group (scope and shape depends on how long and how deeply we intend to analyze this information, whether we want student to get acquainted with bridge types, or learn to classify, describe, and recognize them). The bridges mentioned in the introduction are described by students themselves. | 1-5 min |
| **Follow up** | By involving the teachers of mathematics and physics into the practical work, we analyze the shapes, distinctive features and characteristics with students; forces acting on the bodies, and resistance.  Task: using the materials on the table make one triangle, one square, and one pentagon. Which of the shapes does withstand a maximum compression? Why? How could we stabilize other shapes?  Correct answer - TRIANGLE!      In the construction of various types of bridges, we find the dominant shape - a triangle.  What about a square and a pentagon?    We see how we can stabilize any shape - we just need to add diagonals thus dividing the shape into the triangles.  **Practical task (additional lesson)**  Spaghetti bridges.  The first task is to pre-determine the structural loads using minimum amounts of materials.  Materials:  - Bridges are constructed from ordinary pasta sold in supermarkets, in any shape.  - Hot glue is used to join the pasta.  Dimensions and mass:  The bridge must cover a span of 400 mm.  - The length of the bridge must not exceed 420 mm and the width must not exceed 100 mm.  - The maximum height of the bridge must not exceed 200 mm.  - The maximum weight of the bridge must not exceed 500g.  Load:  The bridges will be loaded with a concentrated force in the middle of the bridge span until the bridge collapses.  - The bridge is loaded by one member of the team.  - Bridges cannot be touched during loading.  - The winner is a team that has built the bridge with the maximum bearing capacity.  - If the bridges tested can withstand the same load, the lower weight bridge will be declared the winner.  **Supporting videos:**  Brief introduction to bridges https://www.youtube.com/watch?v=NE2VchWrtLM&index=8&list=PLRnZTaGt kHr3G\_rVN041M6MUF15QKTihR  What Makes Bridges So Strong?  https://www.youtube.com/watch?v=oVOnRPefcno&list=PLRnZTaGtkHr3G\_rVN 041M6MUF15QKTihR&index=1  Why are there so many different types of bridges? https://www.youtube.com/watch?v=5C3VG0RdNPo&list=PLRnZTaGtkHr3G\_rVN 041M6MUF15QKTihR&index=6  What forces act on bridges?  https://www.youtube.com/watch?v=EYRYtTMcYZM  Spagetti bridges https://www.youtube.com/watch?v=sQ2N5MB5lg0 https://www.youtube.com/watch?v=buhP8jcvGjA https://www.youtube.com/watch?v=0NXtgnVPZ4A https://www.youtube.com/watch?v=y1z66EC4n4o | 20 min  40 min |
| **Formative Assessment** | The analysis of bridges performed by students, justification of opinion, practical / engineering skills in construction, bridge design and rational use of materials are being assessed. | 5 min |