# How would you use a dodecahedron?

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| **Respective blueprint** | Roman dodecahedron |
| **Description** | Introduce the dodecahedron, its history, and some of its potential uses in different areas throughout history. Next, develop the design for the dodecahedron to be 3D printed. Then, put the dodecahedron into practice, inviting students to choose and display one of the potential uses and share their results at the end of class. |

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| **Learning Objectives** | 1. Learn about the history and varied potential uses of the dodecahedron.<br>2. Use creative and deductive thinking to develop hypotheses.<br>3. Improve students' capacities for designing a 3D element using mathematical terms, to be 3D printed afterwards.<br>4. Put the dodecahedron into practice.<br>5. Improve oral language skills by sharing results. It can be used for developing either native language or second-language skills. |
| **Related curricular subject(s)** | History<br>Language<br>Geometry |

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| **Prerequisites / preparatory actions for teachers** | Minimal research on the dodecahedron (links provided + additional research if desired).<br><br>Access to 3D printers.<br><br>Knowledge about 3D designing.<br><br>If not able to print on time, get some dodecahedra. |
| **Prerequisites / preparatory actions for students** | None. |
| **Age of students** | 12-14 years old |
| **Duration** | Approximately 3.5 hours over 3 sessions:<br><br>-1 h presentation<br>-Approximately 1.5h digital and 3D design<br>-1h putting into practice<br><br>(Consider 3D printing between the first and the last session) |
| **Level of difficulty** | Medium |

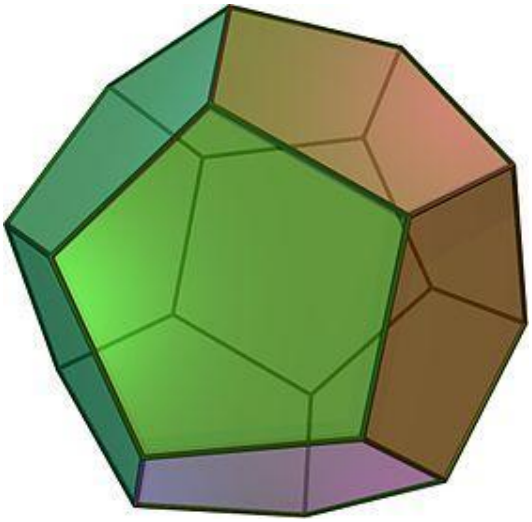
# Step by step description of the tasks

**Session 1 (30 min to 1h)**

**Presentation of the objects: the dodecahedron and the roman dodecahedron**

In geometry, a dodecahedron is any polyhedron with twelve flat faces. Its name comes from the Greek: δώδεκα dōdeka "twelve" + ἕδρα hédra "base", "seat" or "face").

A regular dodecahedron is composed of 12 regular pentagonal faces, three meeting at each vertex. It has 12 faces, 20 vertices, 30 edges, and 160 diagonals (60 face diagonals, 100 space diagonals), as shown in the drawing below:



Source: Wikipedia, 2021

When we refer to a **Roman Dodecahedron**, it is a particular object: a hollow metallic object, which has been cast into a regular dodecahedral shape with twelve flat pentagonal faces, each face having a circular hole of varying diameters in the middle, with the holes connecting to the hollow center. It has a peg on each vertex, as shown in the image below.

Source: Wikipedia, 2021

They have been found from Wales to Hungary and Spain and to the east of Italy, with most found in Germany and France, and the northern part of the empire.

## 2. The interpretation of findings in archeology

As there is no written register of what these objects were designed for, archeologists and researchers need to find out what they were using interpretation. This means that they use additional information to develop hypotheses of what they could have been used for. This additional information normally has to do with the context of the findings and/or some specific details of the object. For example, where

was it found? What else was found there? What are the climatic characteristics of the area? Is there any register of events happening nearby (battles, etc.)? Is it a specific site (cemetery, etc.)?

It is important to convey to pupils the importance of asking relevant questions in order to form possible hypotheses.

**3. Possible uses (theories):**

Many diverse interpretations have been put forward for the uses of the dodecahedron: glove knitting artifacts, surveying instruments, sprinklers, lamps, jewelers' jigs, measures, linings for pins, toys or cup-and-ball games, pommels for scepters, game dice, candlesticks with multiple gauges, masterpieces for teaching, or even elements illustrating Pythagorean theories (Saint-Venant 1907; Saint-Michel, 1951; Déonna, 1954; Nouwen, 1994).

There are thus two radically different types of conceptions: those that we can describe as purely utilitarian and those that are more charged with symbolism, which can be linked to Roman Pythagoreanism (Déonna, 1954, p. 67) and the mysticism of numbers (the 12 zodiacal signs: Thévenot, 1955). The latter find an application in acts of divination or consultation by fate, since these dodecahedrons would symbolise the universe or the sky. A discovery in Geneva, Switzerland of a solid dodecahedron, made of lead and coated with silver, with a sign of the

Zodiac engraved on each of its faces (Cervi-Brunier, 1985), reopens the debate.

Finally, it should be noted that in the sixteenth century, in the "Plaisant jeu du dodécaèdre de Fortune" this type of object was used as a dice for divination games (Déonna, 1954, p. 89).

**4. Practical exercise regarding interpretation**

- Separate the students into groups of 4-5.
- Give each group the same common object (a cup, a flute, a plate, etc.).
- Give each group a list of imaginary characteristics of where and when the object was found.
- Let them work for 30 minutes developing theories of what the object was designed for in that particular context.
- Let them present their hypotheses in front of the group, maximum 5 minutes per group.

**Session 2 (1.5 h + 3D printing time, this can be 2 separate sessions)**

**3D Printing a dodecahedron**

In this session, we will focus on allowing learners to use basic design principles to produce a 3D model of the dodecahedron, utilizing CAD (Tinkercad – free, web browser and easy to use) and CAM software (Cura to prepare for the 3D printer is free, download from Ultimaker website).

We will also focus on helping learners appropriately use manufacturing tools (the 3D printer) to produce a finished project. Afterward, learners can share the digital creation with members of the wider community, including children, adults, and the elderly.

The educator should use the corresponding blueprint for the Dodecahedron to carry out the following steps:

1- Start by getting familiar with CAD software. In this case you can use Tinkercad, which has a softer learning curve.
2- You can follow some of the tutorials built into the software itself to learn the most interesting tricks.
3- Import the 3D model of the dodecahedron and make the different sized holes. Build the balls at the vertices.
4- Once the basic piece has been designed, decorations like those found in museum photographs can be added.
5- With everything finished, we can define the printer parameters in the CAM software.
6- Wait for the printing time. Once it is finished, we can put it into practice.

**Session 3 (1h)**

**Putting the dodecahedron into practice**

Now that the students have learned the history, designed, and printed the dodecahedron, this session is dedicated to putting the object into practice.

Divide the students into groups of 4 or 5 students again (they can be the same as the previous class, or different configurations of students). If possible, give each group a dodecahedron for this exercise; if you only have one or a few on hand, they can be passed around the groups as they work.

Instruct students to think of one of the possible uses of the dodecahedron from the previous introduction/ history lesson or tell them they may invent their own interpretation for what they think the dodecahedron could have been used for. Make sure each group works on a different use of the object.

Students will have about 30-40 minutes to prepare a 5–10-minute presentation (depending on the number of groups) for the whole class that both verbally explains and visually shows how they would use the dodecahedron within their context. This requires them not only to use the object in a hands-on manner, but also to teach their fellow students how to use it for their chosen use. They may give a simple oral presentation, or they may choose to integrate other creative elements into the presentation (such as making posters, PowerPoint presentations, drawings of the steps for use, an interactive tutorial, etc.). Tell students they should be creative in explaining the steps for their use of the dodecahedron, and they should be able to have another classmate (from a different group) successfully carry out the chosen use afterward.

Students may consult with the educator regarding the organization of the steps, specific vocabulary needed, etc., but they should be

responsible for coming up with the structure and content of the presentation, as well as the user tutorial. This is an excellent opportunity to learn and practice both new vocabulary and oral presentation skills in a second language, though the activity is also great for developing these skills further in their native language/s.

## Assessment activities

This lesson does not need any set assessment activities per se, since it is largely based on the act of practicing communication skills and technical skills for 3D printing.

Still, educators may consider assessing the presentations given in Session 3 for the level of historical knowledge gained and/or the communication skills developed or displayed.

## References

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