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'We are the makers - IOT' Learning Scenario:

Construction and printing of ancient astronomical instruments

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Figure 1: rendering of 'astrolabe', students work

1. Title of the Scenario	**Construction and printing of ancient astronomical instruments**
2. Target group	14 - 15 years
3. Duration	At minimum 4 weeks of 2*45min-lessons per week: in sum about 6-8 hours.
4. Learning needs which are covered through the exercise	▪ Basic Design Thinking inside a professional CAD-Package ▪ Relationship of CGI, CAD and CAM ▪ Using CGI to visualize before production ▪ Using a 3D-Printer to instantiate / implement models ▪ reverse engineering existing properties
5. Expected learning outcomes	Basic to intermediate: ▪ workflow inside the CAD-Software Autodesk Fusion ▪ knowledge in Rendering/Visualization ▪ workflow from CAD to CAM ▪ construction of several parts which have to fit together ▪ handling of a 3D-Printer ▪ post-processing different printed parts (glueing, screwing, adding)
6. Methodologies	In this scenario students will model, visualize and print ancient astronomical instruments; they will learn how to use them and make a presentation about it.
7. Place/ Environment	A Classroom with: ▪ more than one 3D printer, ▪ a set of notebooks/computers with CAD-packages ▪ and slicing software preinstalled ▪ word processor software preinstalled ▪ internet access for online research

8. Tools/ Materials/ Resources	▪ A projector for teaching tutorials and presenting students works; ▪ about five 3D printers per class of 20 students. Important: 3D printers have to be administered by the students not teachers! ▪ About 5-10 calipers ▪ worksheets computers with the following software preinstalled: ▪ Autodesk Fusion 360 (Education version), ▪ CURA slicing software, ▪ Meshlab ▪ An internet connection ▪ Word processor

9. Step by step description of the activity/ content	**List of astronomical devices:** 1. Armillarsphäre // **Armillary sphere** 2. Astrolabium // **Astrolabe** 3. Sextant // **Sextant** 4. Äquatoriale Sonnenuhr // **Equatorial Sundial** 5. Bauernring // **Astronomical rings** 6. Quadrant // **quadrant** 7. Nebra Scheibe // **Nebra sky disk** 8. Campbell–Stokes Aufzeichnungsgerät // **Campbell–Stokes recorder** **Background** Lessons are held in the school-subject "NWT", which stands for "natural sciences and technology". One major topic of these lessons is learning the basics of astronomy. Students will learn, how astronomical knowledge was used e.g by navigators twohundred years ago and how the underlying astronomical measurements were being made. **Lesson 1 & 2 (90min):** Students are presented a number of eight different designations of astronomical instruments and no further information is given. After that, the class is divided in 8 different groups of 2-3 students. Each group has to pick a certain designatet astronomical instrument they have to construct, 3d-print, assemble and post-process. They are starting immediately with their online research. **Lesson 3&4 (90 min)** Autodesk Fusion 360 is introduced like in the Learning Scenario "Intro to CAD". During this first lesson, the basic concepts of 3d-modeling are taught. Students can begin to experiment with easy parts of their astronomical instruments. Important: The concept of collaboration as a central part of the in-group-workflow must be taught: Each of the students has to model one certain part oft the whole astronomical instrument and after that the different parts will be put together. Autodesk Fusion 360 provides the necessary collaboration tools. **Lessons 5&6 (90 min)** Higher level modelling concepts are taught: constrained based modelling and timeline history. In a group of 3 students, one student should specialize in visualisation and preparation of the project-documentation, which will become a full-time job.

	Lessons 7-12 (270min): Teacher assists students in their work and eventually makes some ad-hoc-tutorials of some special topics in the CAD-workflow. Some examples: - Correct measurements inside the construction window - How to use the combine-tool correctly - How to use splines with tangent-constraints - How to model screws and holes correctly - How to use the split-body-tool in a smart way - Et cetera …

10. Results	***Example screenshots of astronomical instruments,*** constructed by the students:

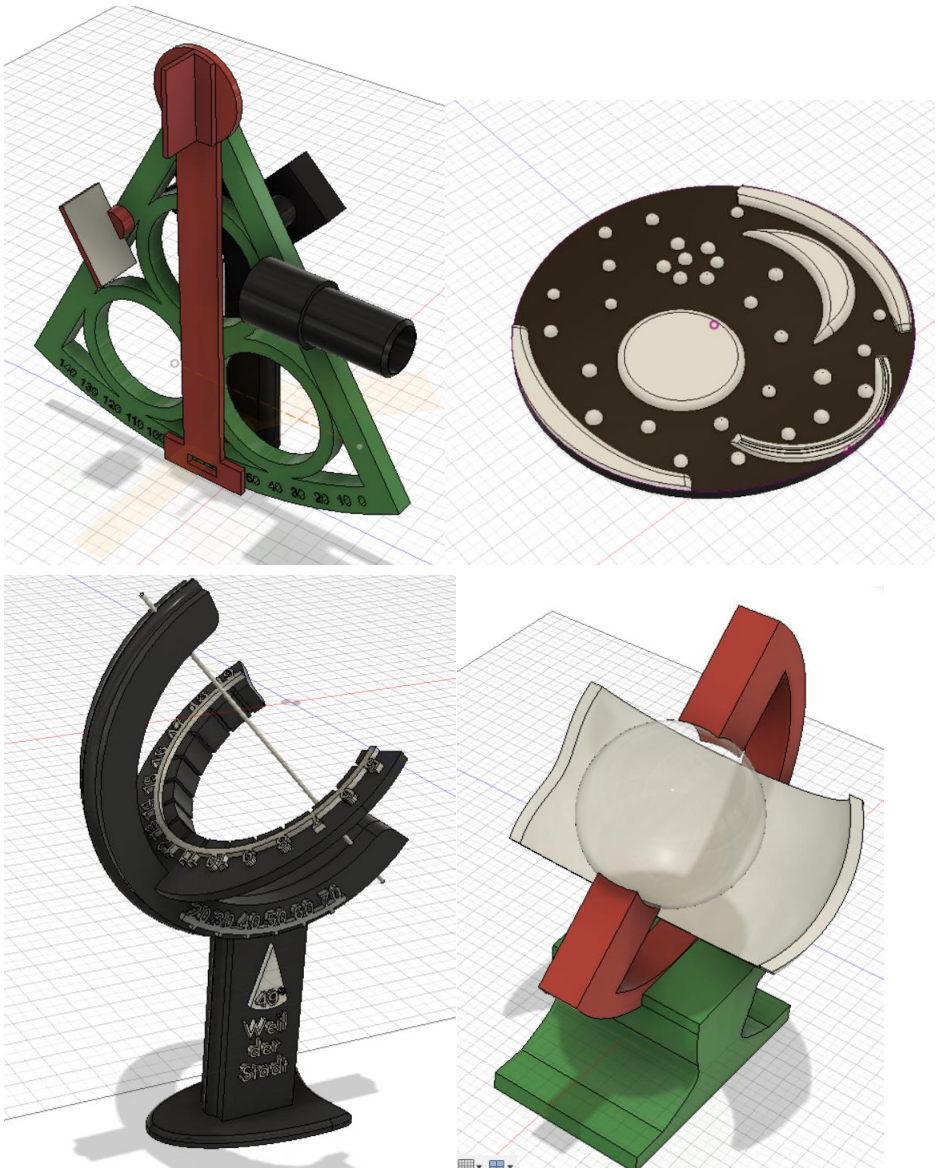

Figure 2: Some screenshots of students works

All completed astronomical instruments (3d-printed and assembled)

Figure 3: Objects 1 to 4 (of 8)

	 *Figure 4: Objects 5-8 (of 8)*
11. Assessment & Evaluation	At the end, all of the students groups should have 3d-printed their own individual astronomical instruments. Together with the printed documentation an exhibition can be made.