We are the makers - IoT Learning Scenario
3d printed stress ball

1. Title of the Scenario	**Stress ball**
2. Target group	14 - 18 years
3. Duration	min. 3 hours
4. Learning needs which are covered through the exercise	- Understanding properties of materials - hardness, flexibility - Understanding there is a relationship between geometry and material behavior - Seeing some geometrical surfaces get 3d printed - connecting an abstract mathematical formula to a real object - Artistic exploration (of digital sculpting, improvement through iteration, design by playing with a digital block of clay) - There is no right solution, but also no 'better' solution. Discussing how quantifying the quality of a product is often 'fuzzy'. Imagine product design - Basic CAD modeling skills - Basic 3D printing skills
5. Expected learning outcomes	- Basic/Intermediate 3D modeling skills - Testing of developed solution - does it achieve the desired feel?, what is the correlation between the digital model and an object which can be 3d printed? what are the fabrication limits and how do they inform the design process? - Improving design through iteration loops - Lessons about strength of materials and geometry - Introduction to concepts of digital sculpting and advanced 3d modeling concepts - Understanding the work process of product design - from design to production and market

6. Methodologies	In this learning scenario the students will be 3d modeling and 3d printing a stress ball using flexible or elastic 3d printing filament. This will be tested on two parameters: a. correlation between 3d model and 3d printed product; b. at the end of each iteration, the 'sculptors' will have a vernisagge where each will present their product to their classmates and try to sell the stress ball they have made. The assessment is made on how many stress balls are sold by each student Students will improve their design over several iterations so that the digital model can be fabricated, the flexibility of the end product is close what the student had in mind, the designed shape can be fabricated with as much accuracy as possible. This learning scenario allows students to discover powerful and complicated ideas through playful and self driven learning towards the subject matter. As a teacher your role will be to provide questions to make the students reflect on their process (i.e. - why can't we print any shape that we 3d model? what is the relationship between geometry and material flexibility?), as well as getting them in a mindset of artistic exploration on one hand, and continous improvement on the other hand.
7. Place / Environment	Classroom with 3D printers, Makerspace, FabLab or similar
8. Tools / Materials / Resources	- projector; - 3D printers and equipment (spatulas, pliers, tweezers, bed adhesive etc.); different flexible or elastic 3d printing filaments; - computers with the following software: Sculptris, MeshLab, a slicing software (which has preferably a large list of infill types); - printed handouts; - printed Sculptris cheat sheet.

<table>
<tr><td>9. Step by step description of the activity / content</td><td>
1. Students will work individually and will take turns to use the 3d printer(s)
2. Give the students the design prompt, make sure to let them know that they are expected to experiment with digital clay and digital modeling in general, so they will not think they need to finish something as soon as possible. Also make sure to let them know that the final products will be assessed in two ways:
a. correlation between the digital 3d model and the final 3d printed object, and
b. after each design iteration, there will be a vernissage where all students present their work to the classmates and sell their stress ball
3. When the first print is done talk about the correlation between digital product and manufactured piece. Why is it that not all 3d models can be fabricated?
4. When the first round of stress balls have been printed, help your students group to assess the correlation between the digital product and the printed pieces. Also organize a vernissage with the sales pitch.
5. When both the a. correlation between the digital and the 3d print and b. the first round of sales are done, help your students plot the stress ball in the Oresmian Coordinate system.
6. When the stress ball is placed correctly, you can encourage your students to reflect on the outcome with questions such as:
a. What makes a 'good' quality 3d print (layer height, support or no support, number of contour lines, weight of object)?
b. What makes a 'good' design for 3d printing?
c. Where in the coordinate system do you want your stress ball to be placed?
7. Now have the students improve their design of the stress ball, and repeat the process as many times as possible within the time constraints of the day.
</td></tr>
<tr><td>10. Feedback</td><td>
a. The stress balls can be objectively assessed as per how close the digital model is to the printed product. A scale (i.e. from 1 to 10) will be made and a panel where other students help with grading accuracy for each stress ball.
b. The number of stress balls sold by each student during the vernissage is also quantifiable.

Plot these two values on an Oresmian coordinate system.
</td></tr>
<tr><td>11. Assessment & Evaluation</td><td>In the end, the best product/project is an average between a. and b., values are plotted on the Oresmian coordinate system and helps the students to self assess on the individual designs, but also on their process as a whole.</td></tr>
</table>