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'We are the makers - IOT' Learning Scenario: Intro to CAD/CAM/CGI-Workflows

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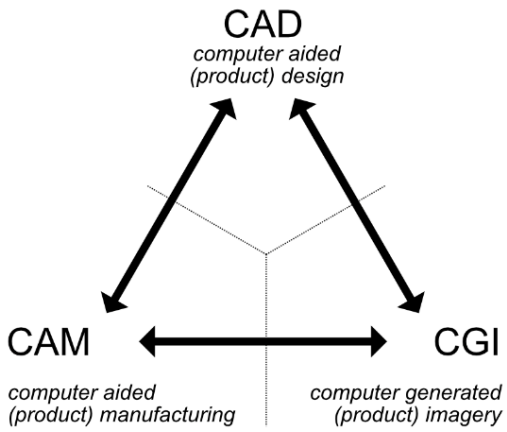
1. Title of the Scenario	**Design and build your own smartphone/tablet stand**
2. Target group	14 - 16 years
3. Duration	At minimum 4 weeks of 2*45min-lessons per week: in sum about 6-8 hours.
4. Learning needs which are covered through the exercise	▪ Basic Design Thinking inside a professional CAD-Package ▪ Relationship of CGI, CAD and CAM ▪ Using CGI to visualize before production ▪ Using a 3D-Printer to instantiate / implement own ideas ▪ Getting used to iterative workflows
5. Expected learning outcomes	▪ Basic workflow inside the CAD-Software Autodesk Fusion ▪ Basic knowledge in Rendering/Visualization ▪ Basic workflow of CAD – CAM – CGI (Design-Visualize-Realize) ▪ Basic workflow of the workflow from CAD to CAM ▪ Basic usage of the Slicing Software Cura ▪ Basic handling of a 3D-Printer
6. Methodologies	In this scenario students will model, visualize and print an individual stand for their own smartphone or tablet
7. Place/ Environment	A Classroom with: ▪ more than one 3D printer, ▪ a set of notebooks/computers with CAD-packages ▪ and slicing software preinstalled
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, made out of plastic, because metal calipers would cause scratches on the smartphones! ▪ worksheets computers with the following software preinstalled: ▪ Autodesk Fusion 360 (Education version), ▪ CURA slicing software, ▪ Meshlab ▪ An internet connection (Autodesk Fusion is Cloud-based)

9. Step by step description of the activity/ content	**Lesson 1 & 2 (90min):** "How would you build your ideas by yourself, e.g. some accessories for your smartphone? Is this possible or are we limited to prefabricated articles?" The Teacher encourages the students to discuss these topics. Then the teacher gives a basic overview of a standard industrial production workflows, starting from sketching an idea, implementing it in a CAD-package, visualising the idea via rendering (CGI) and realizing it using CAM-techniques. Relationship between CAD, CGI and CAM has to be elaborated:  Introduction of Autodesk Fusion 360: The teacher gives an overview of the necessary working steps inside Fusion: 1. Create Component 2. Create Sketch 3. Create Body 4. Refine Body Since Smartphones have simple shapes which are very easy to copy, students start with reverse engineering the shape of their own smartphone. The teacher has to assist the students while they are going their first steps inside a professional CAD-Package. **Lesson 3&4 (90 min)** Students will refine their smartphone models. Now everybody owns an individual unique smartphone-model, which can be printed, visualized and furthermore used to construct the smartphone stand. Now the students have to render the model before printing it, therefore the basic workflow of CGI hat to be tought: ▪ Using predefined shaders,

- Altering those shaders to fit individual needs of the model,
- Adding decals (e.g. display),
- Setting up the rendering environment with HDR-Imagery *(What are HDR-Images? This is necessary to explain)*
- Render with the Fusion-inbuilt local raytracer-engine.

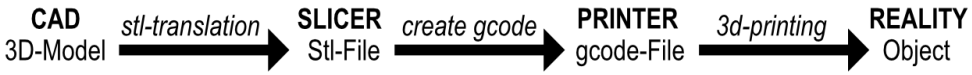
Lessons 5&6 (90 min)

How does a 3D printer work? What are the components of a 3D-printer? And: how is a 3D object encoded so that a 3D printer understands how to build it?

Students will see a FDM-3D printer in action and describe how it works:

- feeding the PLA-filament into the extruder,
- Melting of the filament inside the hot end
- Printing through the nozzle,
- Fabricating layers one after the other,
- Synchronizing this layer building with the automated positioning of the printing head in x, y- and z-directions.

The printer gets the information how to position the printing head and also how much filament has to be used out of a gcode-file, which was prepared inside a special middleware: The slicer
Using the projector, translation from stl-file-input to gcode is demonstrated, also the simulation of the printhead moving inside the cura-simulator. Students should cross-link what they had seen at the 3D-printer with the simulation on-screen. The following basic working pipeline is elaborated by the students:



After that, students prepare their own models for 3D-printing and try it out using the schools 3D-printing farm. Probably their first try-outs will fail because of bad printer calibrations or non-optimized slicing settings. Discuss those fails with the students so everybody can learn from the pitfalls.

Since 3D-printing an object takes a long time which can probably not be finished until the end of the lesson, students must be encouraged to have a look at their prints during their school day until the late afternoon (not overnight!). 3D-prints which cannot be finished until the evening need to be interrupted and to be continued the next school day.

	Lessons 7&8 (90min): Students build their own smartphone / tablet-stands based on the models they have already built. Now they should be familiar with the basic workflows and can concentrate on the modelling aspects of iterative design: ***Evolve the ability to adapt and to learn from failures.*** After visualizing a new "product generation", parts can be printed at a 1:1 or some smaller scale to test and discuss them. Modeling skills inside the CAD-package are furthermore developed.
10. Feedback	At the end, most of the students should have produced their own individual Objects, which can be discussed in the class. What impact does this workflow have in the near future? Will it be relevant? How difficult is it to invent objects? Will some of the students continue this kind of work at home?
11. Assessment & Evaluation	An exhibition can be organised using the 3D-printed parts: The 3D-printed smartphones inside their stands alltogether with the renderings.