### 3D Printing- Design & Print Project (Sample Scheme of Learning for STEM)

<table>
<thead>
<tr>
<th>Module Outline /Description</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designing and Making/Prototyping with 3D printers.</td>
<td>This unit of work is aimed at students in Yr. 9 (12 -13 year olds) depending on skill levels it can be used with older/younger students</td>
</tr>
</tbody>
</table>

#### Prior Knowledge and skills
It is assumed that students have basic skills in using 3D CAD software (Creo Elements/Pro, Autodesk Inventor, Solidworks, Sketchup, etc.)

#### Resources
Project booklets for each student Download Project_Booklet (or provide them with PowerPoint “e-portfolio”); PCs with 3D CAD software; .stl to g-code conversion software (BfB Axon or skeinforge); RapMan or BfB3000 3D printer(s); ABS/PLA filament; SD card(s); Digital Camera; Teacher’s PC with digital projector and internet access, BfB 3D printer(s)

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Outcomes</th>
<th>Differentiation</th>
<th>Homework/extension tasks</th>
<th>Starter</th>
<th>Teaching Sequence</th>
<th>Plenary</th>
<th>Comments</th>
</tr>
</thead>
</table>
| 1 & 2  | - To introduce students to concept of 3D printing  
- To introduce students to basic functions of 3D printer  
- To introduce the design & make project | Group students together for peer support. | Students to think about possible “end users” of their products | “Thunk” – ask students to consider the following “Is plastic (which comes from oil, which comes from trees) man-made or natural?”  
1 minute individual thinking, 2 minutes discuss in pairs Students offer answers | - Introduce concept of 3D printing for prototyping and production.. show video if possible- BBC or Becta  
- Live demo of machine in action.. describe major working parts and functions see RapMan Basics pdf  
- Issue design project booklets – give students an opportunity to browse and fill in personal details on cover  
- Introduce the project brief and discuss possible outcomes | Discuss any concerns | A good starting point are the following projects  
MP3 Player  
Clip it and keep it safe |
| 2 & 3  | - Students formulate Design brief & spec  
- Students carry out research | Suggest ideas for brief to less able students | Start/continue research | “3 new words” - in turn students to suggest 3 new “technical” words from the previous lesson | - Discuss folder presentation and content  
- Introduce design brief and specification  
- Students write a draft brief and spec  
- In class discussion decide what research needs to be carried out | Review outcomes | Research to include  
- Details of “end user”  
- Printing parameters (size/shape of objects, overhangs etc)  
- Other constraints |
| 4 & 5 | Students produce mood board and “Splurge” initial design sketches  
Designing… development of 1 or 2 Ideas | Group students together for peer support | Continuation of initial designs and development  
Students to finalise design and consider details such as sizes, fixings etc. | Students to create a “To Do” list from a list of tasks on the board, to guide their activity in the lesson | Students to create “moodboard” of any thoughts, ideas, design influences etc.  
Students sketch/splurge initial ideas  
After comparison to specification students start to develop 1 or 2 ideas into workable solutions | Review outcomes  
Show good examples | Moodboard - a type of poster that may consist of images, text, and samples of objects. Designers and others use mood boards to develop their design concepts and to communicate to other. Online moodboard creation see Imagespark |
|---|---|---|---|---|---|---|---|
| 5 & 6 | Designing/CAD- students to start to produce 3D CAD designs | Provide less able students with pre prepared “templates”. Pair up less able students with more able.  
Students to compare design to specification – does the design still do what it is supposed to do.  
“Top tips for high quality design” – hot seating ie put a student “in the hot seat” other students to ask questions. | Explain to students any essential information necessary when designing using CAD – ie necessity to produce set working directories; produce the design on the “front” workplane in Creo (formerly Pro/ENGINEER)  
Show video of creating designs in Creo YouTube Video  
Students convert sketched design ideas into CAD designs | “Show and tell” – select some good designs and celebrate success | Check on suitability of student designs and ideas for 3D printing. Depending on availability of IT facilities it may be necessary for students to share computers/designs |
| 7 & 8 | Finalising of CAD designs and exporting designs as .stl files | Provide less able students with pre prepared “templates”. Pair up less able students with more able.  
If students have access to home versions of CAD software encourage them to continue the designing  
Quick reminders – orientation of design, avoid overhangs etc - discuss | Students to continue with CAD designing  
Students produce rendered image of final design (exported as .jpg)  
Students produce a quick orthographic drawing  
Demonstrate exporting as a .stl file (show video) YouTube video | Q&A – what problems have you had? – students to provide answers/solutions | Most 3D cad software will quickly produce orthographic drawings from the model… if it takes too long with your software skip this stage. |
| 9&10 | Continuation of CAD (if req).  
Introduction to Axon  
Converting .stl to g-code | Less able students given Axon profiles to use. More able students given opportunity to experiment with profiles | Provide students with a list of 10 abbreviations (.stl, .jpg, CAD/CAM, etc) – who can name them all?  
Explain what g-code is and what it does  
Introduce students to BIB Axon to convert .stl to g-code. (Show video) YouTube Video  
Students complete any CAD work  
Students convert .stl files to g-code with Axon | Collect design files and g-code from the students | Axon can be downloaded free from the BIB website downloads |

Note. The SoL is written for double lessons of about 1.5 - 2 hours duration. Modifications will need to be made to accommodate longer or shorter lessons and/or single lessons.
| 11 & 12 | Students become familiar with setting up machine.  
|         | Students to start 3D printing  
|         | Technician assistance for the 3D printing (especially for less able students)  
|         | Students produce a step-by-step flowchart of the setting up and printing process  
|         | Re show resource RapMan Basics  
|         | Demonstrate setting up the machine (loading material, homing, SD Card, Print)  
|         | Re-cap with students doing the setting up  
|         | Print a sample file (mini mug?)  
|         | Explain about support material show resource Printing with Support and Removing Support Material  
|         | Review outcomes  
|         | Give students a template for their homework  
|         | Pre prepare a “blank” flowchart template to add to the booklets  

| 13 & 14 | 3D Printing of designs.  
|         | Design modifications if required  
|         | Marketing and promotion  
|         | Group students together for peer support  
|         | Students to complete their marketing strategy  
|         | In 3 minutes students to think of a new name for “3D printer”... without using the words printer, 3D, RapMan etc  
|         | Students to set up machine(s) and start printing  
|         | If students need to wait for machines to become available they can finish any design work, fill in any missing work in booklets, modify/improve designs etc.  
|         | Ask students to prepare a marketing/promotion strategy for their new product... Leaflets, storyboard for an advert, posters etc  
|         | “Show and tell” – who has the best marketing strategy  
|         | As printing may take some considerable time select the best designs to print from the group, arrange extra-curricular time for other printing to take place  

| 15 & 16 | Students to do...  
|         | 3D Printing - continued  
|         | Post processing  
|         | Photograph products  
|         | Tidy up and finishing off  
|         | Group students together for peer support  
|         | Extension task for more able to produce Animoto slideshow  
|         | Students to take finished products home for testing / feedback by “end-users”  
|         | Students to create a “To Do” list from a list of tasks on the board, to guide their activity in this/next lesson  
|         | A tidy up and finishing off lesson ...  
|         | Continuation of 3D printing  
|         | Demonstrate and allow students to do “Post processing” (clean up “stringing”), remove support materials etc.  
|         | complete any work in portfolios/booklets  
|         | Photograph completed projects  
|         | Collect design files photographs and g-code from the students  
|         | Upload photos to Animoto to produce a video slideshow of students work  

| 17 & 18 | Students to do...  
|         | Evaluation of products/outcomes  
|         | Self and peer assessment  
|         | Prompt sheets for evaluating (for less able).  
|         | Finish testing /evaluations  
|         | View Animoto slideshow of students work to celebrate success  
|         | Q and A “how and why evaluate”  
|         | Students “test” their product by comparison to specification and or “Cafeque”. CAFEQUE-Posters  
|         | Lead students through self-assessment using PLTS and/or National Curriculum Levels  
|         | Students perform self/peer assessment.  
|         | “How could you have made a better product” – feedback from students on 2 improvements they could make.  

| spare | Show case  
|       | Allow less confident students to present in pairs  
|       | N/A  
|       | Prepare for presentations... remind students about timings, clear communication etc.  
|       | Students in turn do a 3 minute presentation to the rest of the group showing design work, products and marketing materials.  
|       | Collect work for marking  
|       | Don’t forget to provide feedback to students  

Note. The SoL is written for double lessons of about 1.5 - 2 hours duration. Modifications will need to be made to accommodate longer or shorter lessons and/or single lessons.