How will CAD help students design and make?

CAD software will allow the rapid modelling of ideas in 2D or 3D, in conjunction with other modelling methods such as sketching or soft construction methods with cardboard, plastics, Plasticine, kit materials etc. It's rapid in the sense that changes can easily be made and visualized. Without the limitations in drawing skills, products can easily be visualised in 3D. However, this does need some planning based on the knowledge of how a range of similar objects can be created. This will entail some discussion of the symmetry and similarity of solids, and the range of possible strategies for their construction. For example, cylindrical shapes can be created by extrusion of a set of circles or by revolving a profile. The best approach often depends on which dimension or part of the model needs to be changed when modifying the design.

Students will need some introduction to CAD as early as possible in their D&T work. This is often done using a series of step-by-step tutorials. The problem with following detailed tutorials is that the student doesn't really know why they are being asked to do certain actions. Another approach is to start with the essential minimum of shape generation strategies (extrude, revolve, sweep, etc.) using on-demand video, so that students know how to change things if they are not quite sure what they want? It's important to make sure that students experience the real benefits of CAD/CAM and that they don't spend their time doing too many tutorials just to master the software, but that their designing and making capability is supported and enhanced.

The outputs from CAD/CAM on-screen, printed or manufactured are of such quality that it's easy to become precious about them and forget that they are a development tool. Encourage your students to draw on, paint, carve and add to CAD/CAM outputs, so that the product can be improved.

3D solid modelling software is useful for visualising any product that is made or assembled from rigid materials and will enable easy and rapid changes to design ideas.

- These ideas could be parts that others have created and students are asked to modify them. The question to ask is "what if" the part was a different shape or

size, the part was assembled in a different way, or it was made from a different material, etc. The SCAMPER strategy is useful.

- Most CAD software has a ñkitò of ready-designed 2D or 3D shapes which can be modified. The students can use these rapidly and just add imagination.
- There is also designing to be done with mechanical assemblies which are amenable to CAD modelling. For example, a simple linkage or mechanism can be assembled with suitable constraints and animated with the mouse to check clearance and extent of movement. Very little capability is required if 'flat' components are being used, and these can be transferred to CNC to be cut, as profiles relatively quickly.
- CAD also allows testing of models through simulation and analysis of the effect of temperature and loading. In this way, the weaknesses of the model can be identified before manufacture.

How will CAM help students design and make?

With relatively inexpensive 3D printers it is now possible for students to make and handle the products of their own design in realistic materials. Some of the materials are sufficiently robust to use in the final prototype. Even with milling machines itôs possible to make fairly rapid models in Styrofoam for evaluation and further development although the fastest method is 2.5D manufacture or profile cutting.

Full 3D machining in schools takes time even using some of the modern high-speed routers. As an alternative, it is possible to take an STL file from any of the common 3D modelling software and use software to create ñthickò slices followed by profile cutting and assembly of the slices by gluing. This will of course result in a model with stepped edges, but may be sufficient as a 3D prototype, and anyway can be sanded down.

Many of the current CAD programs allow designing in sheet materials. A net of the unfolded design can be printed or laser cut and then folded by hand or on a line bender to create the finished product. Foam models made with CAM can also be used as vacuum forming patterns for complex shapes. With all CAM software itôs possible to simulate the manufacture before making with real materials. This allows the students to experiment with different cutting tools and speeds to evaluate the results before committing to real manufacture and therefore avoiding wastage.

The key benefits of CAM are accuracy, repeatability and quality of finish compared with other methods.

What is 3D Printing?

3D printing is a process of making a three-dimensional object of virtually any shape from a digital model. It is achieved using an additive process where successive layers of material are laid down. Each layer is a thinly sliced, horizontal cross-section of the eventual object.

Each object begins with a digital Computer Aided Design (CAD) file, created with a 3D modelling programme, or one which scanned into a 3D modelling programme with a 3D scanner.

Further information about 3D printing can be found on the 3D printing Industry wesbite, with an introductory video on TED explaining more.

For more information, read the associated file below.