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Using the continuum of design modelling techniques to aid the development of CAD modelling skills in first year Industrial Design students

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Introduction

Industrial Designers need to understand and command a number of modelling techniques to communicate their ideas to themselves and others. Verbal explanations, sketches, engineering drawings, computer aided design (CAD) models and physical prototypes are the most commonly used communication techniques. Within design, unlike some disciplines, visualisation tools, whether 2D or 3D, are an essential part of the communication process, particularly with clients. Many of these tools have modelling techniques at their heart. Students first encounter these techniques at school, typically as part of their Design and Technology education, where they tend to be delivered as part of a linear design process with project work progressing through the techniques one after the other. This rather artificial way of working is driven more by the need for assessment than a desire to reflect professional practise. As such, many students enter higher education with a limited view of how these techniques should be used in combination. In addition, the range of modelling techniques presents a steep learning curve for the students at the beginning of their studies. To continue to treat them as stand-alone tools with no integration between them merely adds to the difficulty. The authors report on efforts at Loughborough Design School (LDS) to provide an easier route to mastering these modelling techniques and using them to support each other.

Method

The key to this integration is recognising that within each modelling technique, similar behaviours are used, such as describing volumes, cross sections and proportions. The modelling media may change (e.g. sketching on paper, CAD, physical prototyping) but the fundamental process behind the shape description remains the same. Typically, these techniques are taught as separate activities, often by different educators in different sequential modules, and the students are then required to choose the most appropriate technique for design activity themselves. At LDS, the first year Design Practice 1 (DP1) module applies lessons learnt from design practice in industry (Storer, 2005) and teaches several modelling techniques in parallel. Its aims are to provide the students with an introduction to form analysis and creation through two “design and build” projects, with a focus on using modelling techniques as a continuum and not as a sequential process. Cross referencing between the techniques is encouraged and similarities in thinking and execution are highlighted. Sketching in DP1 is taught using similar form description methods to the way a CAD package creates surface geometry. Elevations, sketching planes, and critical cross-sections are used to describe product form when

sketching, directly relating to both engineering drawing conventions and CAD methodology. Existing products are analysed to determine how the surface geometry has been created (most likely in a CAD system) and how to describe it on a 2D sheet of paper. Following on from this, as part of their second semester assignment, all 130 students were asked to create an external product form around a given set of internal components. They were required to both sketch the form and translate it into a foam model. They were also given the option of using 3D CAD to complement their manual techniques. Iteration between the different media was encouraged.

Results

The expected outcome was that students would develop a competence in 3D shape analysis and the transformation into 2D profiles. This should enable them to create analogous 3D CAD and physical models more quickly, making use of the cross-sections they have identified. In order to assess the effectiveness of the approach, the authors inspected the drawing and modelling outcomes of all the students to identify how often the technique of key cross-section identification and creation had been used. It was found that the vast majority (> 90%) of the students had grasped the concept of key cross-sections and were able to identify these on images of existing products (see Figure 1 for an example image analysis). Again, virtually all of the students became very competent in iterating between 2D sketches and a 3D foam model, where they would derive the key sections from their model, re-sketch the shape they wanted and modify the foam accordingly (see Figure 2 for an example of sketch-foam iteration).

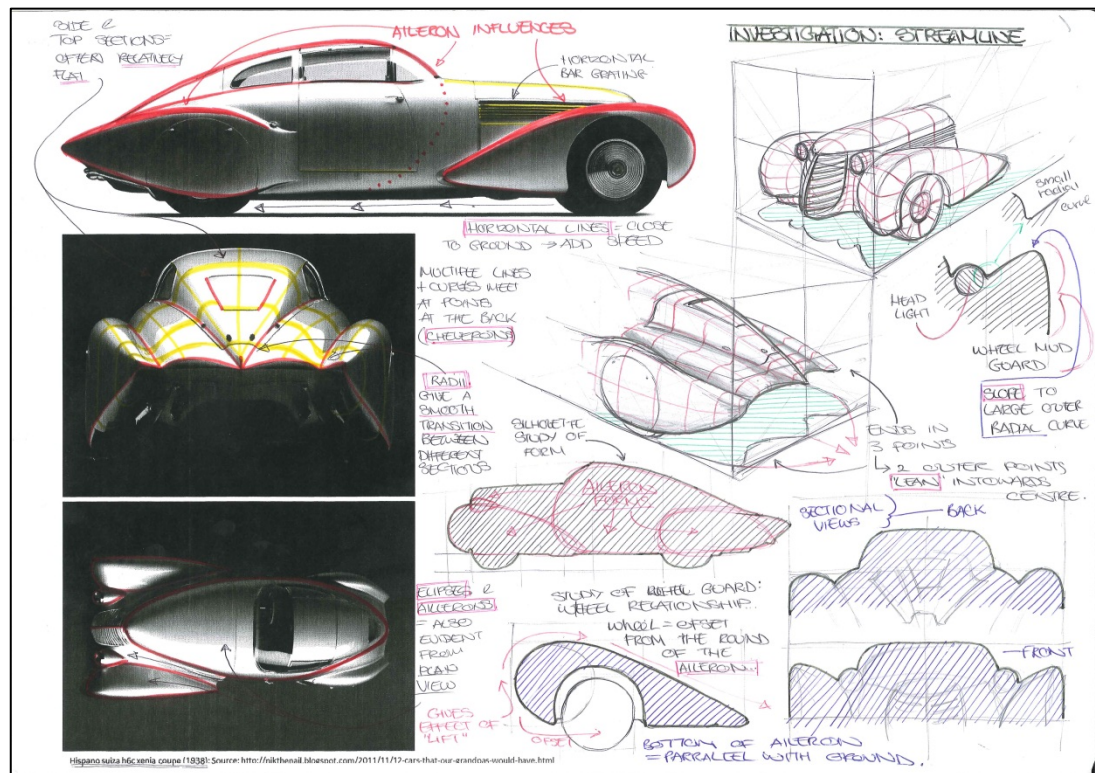


Figure 1: Example of student's identification of key cross-sections in an existing product

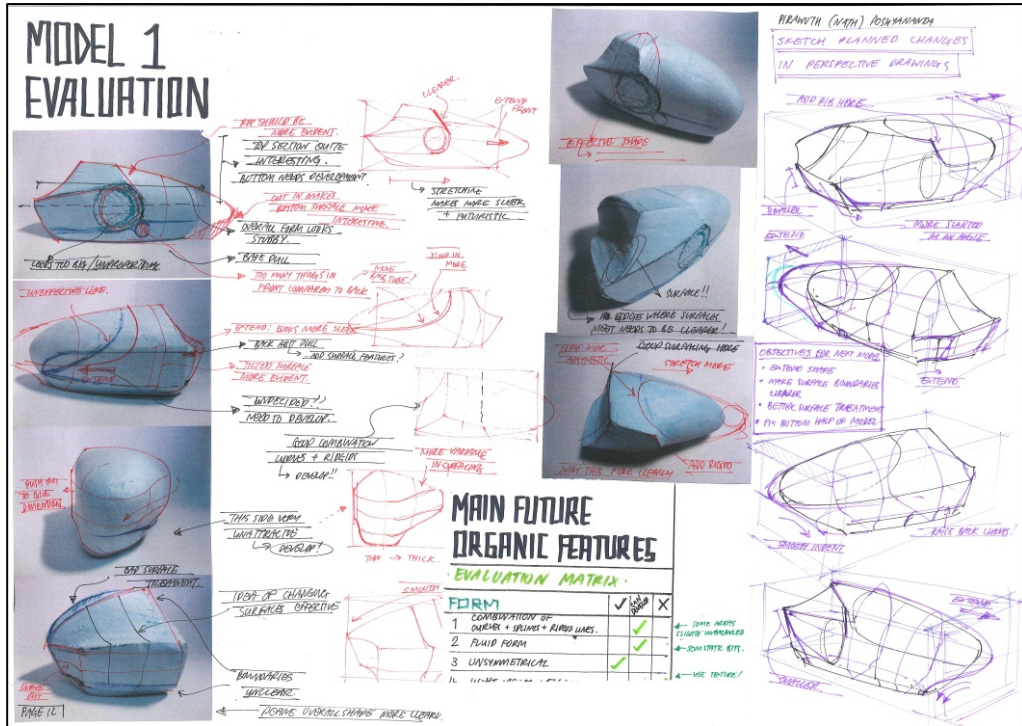


Figure 2: Example of student's iteration between sketches and foam model

When it came to 3D CAD modelling, only a small proportion of the students (less than 10%) took the opportunity of using this technique to support their manual activities. The main reasons given for this were time constraints and a lack of confidence in using CAD. Those students who did use CAD showed a clear ability at “importing” their 2D sketches into CAD but not necessarily the ability to convert these into the same organic form created in their foam model. For example, Figure 3 shows a rather “box-like” radio design created from a number of key sections taken from the original design. Even so, the geometric complexity of the design created is impressive, for a first year student.



Figure 3: Example of student's CAD model derived from key sections

Discussion and Conclusions

The literature offers many opinions on the importance and teaching of sketching and it remains a key visualisation technique, despite the increasing use of 3D modelling tools. There are numerous approaches to the teaching of sketching from freehand artistic through to prescriptive isometric. Many of these techniques will have originated before CAD modelling had even been invented, let alone entered common use in higher education. Therefore, they will typically give little consideration as to how the 2D sketch would offer an accelerated route to creating a 3D model. There are some exceptions to this, e.g. where the decomposition of the human body into 2D profiles as shown in the books of Andrew Loomis (Loomis, 1943), (Loomis, 1956). If the analogies between various modelling techniques are to be shown to students, it will be necessary to change the way some, or all, of these techniques are taught. The inherent flexibility of sketching means that it is easier to modify the way it is taught rather than recreate on-line CAD tutorials or change engineering drawing standards. This is the route that was followed at LDS and the results achieved to date are promising, particularly in relation to 2D images and 3D physical models. However, when it comes to CAD modelling, the ability to identify and even create key sections is not enough. As previously observed by Rynne et al (2010), placement of sketches must be done correctly and must be accompanied by adequate surface or solid modelling skills to achieve a complete model. Nevertheless, the ability to correctly identify the key sections does give students a good start to their CAD modelling process. This study will be followed-up through examination of the students' CAD skills in the second year of the course (when they learn surface modelling), to ascertain the continuing effect of the design modelling techniques they have learnt.

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