The Use of Computer Systems and Software Tools for Modelling Products

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With a recent major enhancement of the facilities for computer aided engineering on the Loughborough campus all undergraduate students in the Department of Design and Technology have access to a powerful range of software tools running on sophisticated hardware. As designers, dealing with a variety of technological projects it is essential that students in Design and Technology are introduced to these facilities and are made aware of the advantages and limitations of this type of resource. Through learning about how to use these design tools during project work, students have the opportunity to assess the capabilities of the software and to exercise discrimination when it comes to selecting which resource to use for a particular application.

In order to develop this type of activity and to give staff the opportunity to assess the problems involved in teaching in this area, we chose to take a group of third year students working on a project with Lotus Cars Ltd., and Sheller Clifford Ltd., and introduce them to a three dimensional solid modeller. Five students were involved in this project and this article seeks to explain the nature of the software tools to which they were introduced, the results which they obtained and the observations which staff and students made in connection with this exercise.

On the Loughborough campus, individual Departments generally have their own computing facilities, micro, PC and mini type machines. More sophisticated computing resources are provided centrally by the Computer Centre in the form of a number of teaching rooms.

The Department of Design and Technology is currently expanding its local computing facilities within the Bridgeman Centre. We have a well established teaching room of BBC microcomputers which are essentially used for word processing, programming in BASIC and control. These machines work well in these roles and have provided a very successful and intensively used resource. The new facilities are being based around current computer technology, IBM AT compatible machines, offering greater speed and power of processing, a wider set of applications software and a standard which is common in many industrial and commercial environments. The developing and anticipated uses for these machines are in the area of graphics work using colour drawing and sketching packages, two dimensional draughting using tools such as AUTOCAD and PC DOGS, desk top publishing systems, wordprocessing, and computer aided design tools for surface modelling, printed circuit board design, etc.

Once this local Departmental facility is complete it will provide students with easy access to a range of medium level software tools which, as designers, they can select and use as appropriate. It will also support a variety of research work both in the field of computer aided design, expert systems and computer based training.

The more sophisticated software tools which are available in the Compuer Centre provide further support for staff and students. The cost of the hardware and the software dictate that it is not possible to provide these facilities locally within individual Departments, the solution being two CAE teaching rooms which can be booked by Departments and which are available to staff and students during non-timetabled time.

The hardware in each of these rooms consists of eight Apollo DN3000 colour workstations which are linked to a high speed domain network. Each workstation consists of a high resolution colour graphics screen, its own powerful local processor and 4 Mbytes of main memory. Software is provided by PAFEC in the form of the applications packages, including DOGS 2D, DOGS 3D, BOXER, PAFEC FE, DOGS NC, SWANS and DUCT.

The project for which students used the system was the design of a car steering wheel for the two companies mentioned earlier. The project was prompted by a proposed change in the test regulations relating to this piece of equipment which is to be introduced in 1990. These new regulations will require all steering wheels to be exposed to a test which will simulate the impact of a human head on the wheel using a honeycombe matrix material. The ability of the wheel not to damage this material is essential and requires a wheel which will absorb energy effectively. Students were involved in the investigation of a variety of possible alternative solutions to this problem which would satisfy both the aesthetic and technical requirements of Lotus Cars, the manufacturing and testing demands of Sheller Clifford, the technical specification detailed by a variety of current regulations pertaining to steering wheels in different countries and the proposed new section dealing with testing facial impact.

In this design situation, students had a requirement to model their proposed designs in three dimensions to evaluate visual and technical aspects. Further, dimensioned drawings of the design were required for evaluation of the proposed method of manufacture.

The software tool chosen to help with this task was BOXER, a three dimensional solid modeller which has full colour shading capability along with a variety of different viewing options. Students were introduced to the software by means of a six hour course covering use of the Apollo computer system, logging in and out, filestore management, the shell and display manager etc., using the basic features of BOXER to create and manipulate solid objects, colouring objects, changing viewing position etc..

Having received this basic introduction the students were asked to develop a model of one of their proposed designs. The initial design work had been completed on paper to a level where visualisation using a three dimensional image was required. The students were therefore encouraged to use traditional means of design development and modification until a model was required for evaluation.

An alternative method of producing this model was by traditional clay moulding techniques. The students also used this method and a useful comparison was therefore available.

It was envisaged that using the computer as a tool to model the steering wheel would provide the following benefits:

- The wheel could be built up quickly, viewed and visualised without need to use expensive and difficult to manipulate materials.
- Modifications could be carried out and the change in the nature of the wheel observed immediately.

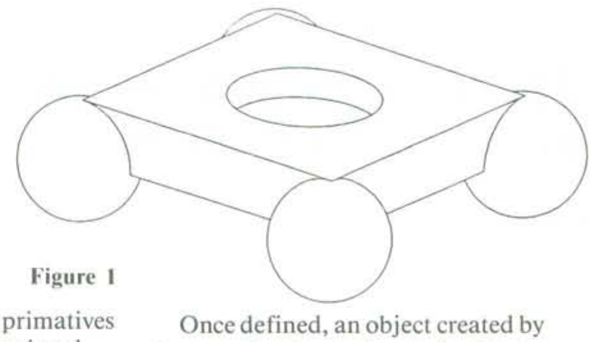


Figure 1

- Different lighting effects could be set via the computer to allow the wheel to be set in a situation similar to that which is evident in the intended vehicle.
- Different viewing angles could be set to show the appearance of the wheel from a variety of positions within the car, giving the opportunity to represent what the driver, passenger or a person outside the car may see.
- A working drawing could be produced on the same computer system from the information generated during construction of the solid model.

In order to consider the results which students obtained and their observations concerning the use of this type of tool, it is necessary to briefly describe the basic facilities which BOXER offers.

Boxer, is a software package for use in the design and visualisation of three dimensional solid objects. The interface with the user is menu driven and is accessed via a mouse. Some keyboard entries are required, for co-ordinate values or details within menu options. The screen consists of a drawing area and a menu from which options are selected using the mouse.

All objects are specified in terms of three dimensional data. Information about objects can be input in a variety of different ways, the essential requirement on the part of the user being the ability to visualise objects in space on a three dimensional system.

Within this geometric frame of reference, cartesian co-ordinates can be used to specify locations. Objects can be constructed from either a basic set of primatives which are contained within a library, or user defined boundaries which are either spun or extruded to generate a solid. The five basic primatives are block, cylinder, cone, sphere and torus. A selection of further primatives generated from these are available from a library within the software.

The combining of primatives to create objects is effected by the use of boolean operators, union, difference and intersection. For example, to define the object shown below in figure 1 the following stages would be needed:

- Define the primatives cylinder, block and sphere, taking care to size, orientate and locate these primatives correctly in the three dimensional system by defining correctly the variables associated with each.
- Copy the sphere three times to the locations at the corners of the block.
- Join the block and spheres via the union operator.
- Subtract the cylinder via the difference operator.

These operators provide the mechanism for integrating different primatives, unions, differences and intersections into composite objects which represent either a product or component. The more complex the article which requires modelling, the more time that needs to be spent planning the construction of the basic objects which go together to form representation.

The skill of the user in being able to visualise what is being created and understand the stages required to achieve this result is essential if a coherent and realistic model is to be created. This requires advance planning in order to ensure that dimensional data is correct. This planning is not wasted as information associated with the picture created can be passed to DOGS 2D for dimensioning and development into an engineering drawing of the component.

The other alternative is to define a two dimensional boundary and to extrude this or to spin it around an axis to form a solid object. Construction tools are available to help the user to draw the two dimensional boundary. An example of each method of generation is shown below in figure 2 and figure 3.

Figure 2

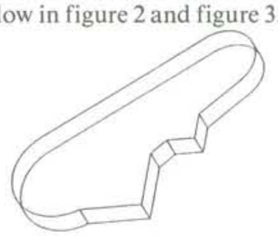
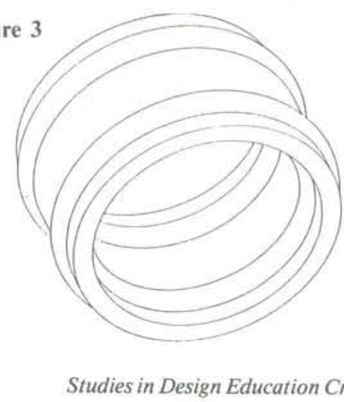


Figure 3



Once defined, an object created by these methods may be manipulated using the three dimensional tools described earlier.

In the case of the steering wheel models which students developed, considerable effort was required to ensure that the primatives and other solids were placed correctly in the co-ordinate system. On completion of this process, the student was left with a solid model of the proposed design of steering wheel, represented on screen in the form of a wire frame. In order to visualise this, Boxer provides a variety of different viewing options, orthogonal, perspective and isometric. Objects can also be sectioned to reveal internal detail.

Colour pictures can be generated from the solid model, the useer choosing the number of light sources required and the position, intensity and concentration factor of each source. This is a powerful tool for assisting students in assessing the aesthetic qualities of a design and allows them to modify a design and then test the modifications made by re-drawing and colouring the object.

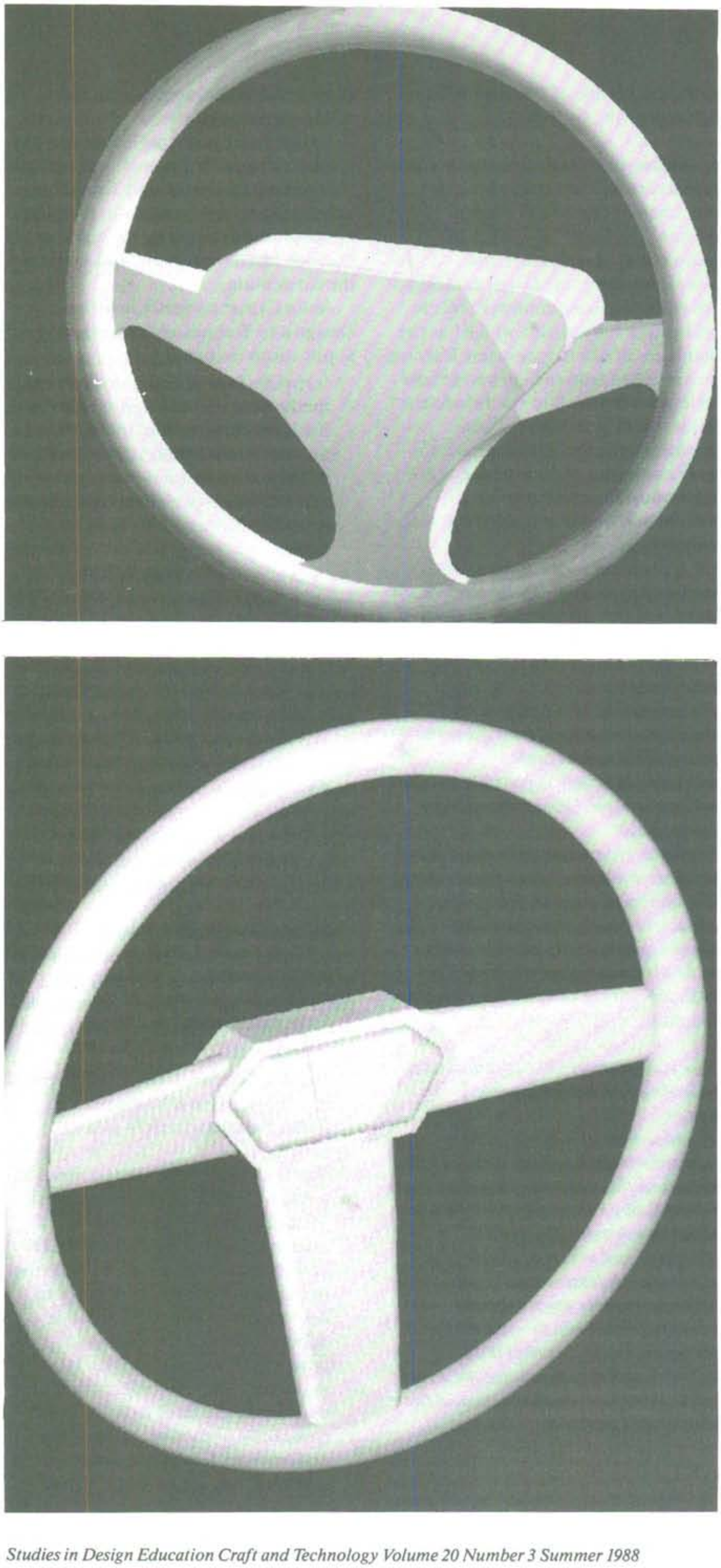
The five students who worked on this project all attempted to develop models of their proposed steering wheel design using this system. Two of the images which have so far been generated are illustrated below in figure 4.

Conclusions

The exercise has allowed the students and staff concerned to use and evaluate in the context of a 'live' project a computer based solid modelling system and to assess the type of support and teaching which will be required for future groups of students in Design and Technology.

It is clear that the computer based solid modelling systems have a significant role to play in supporting the work of the technological product designer. They provide a powerful tool for visualisation and allow a product to be modified, redrawn, colour shaded and viewed in three dimensional form accurately and yet sensitively. If data entry is considered carefully then this system can also be used for the production of engineering drawings.

The quality and realism of the pictures of steering wheels which



students produced was very high. Flexibility in viewing the objects drawn allowed the investigation of a variety of situations which would be difficult and very much more time consuming by other means.

It was evident whilst using this tool that there is a level of complexity for the object being modelled beyond which this tool becomes inefficient. The time spent by the student constructing the model and the computing speed required to colour shade the picture combine together to restrict the efficiency of the tool and make other methods of modelling more appropriate.

Giving students the ability to select and use software tools where appropriate is an extremely important aspect of their education. The power of software tools available on computer systems to which they have access is increasing steadily. As designers they will need to discriminate between situations where a software tool would support their work and enable them to make better, more informed decisions about aspects of a design, and the situations where using a computer would provide only a limited enhancement of their ability to develop a design with a major overhead in terms of the time spent using the computer system.

The facilities provided by the solid modeller BOXER enabled a number of the students involved in this project to develop complex models of their products and to visualise these objects in a variety of different orientations and lighting. As a result of an introduction to this software tool and subsequent experience in developing both simple and complex objects the students have a broad understanding of the capabilities of sophisticated computer based modelling systems and the opportunities which they present to the designer. Through the active use of BOXER in the context of this project, they have also acquired experience of selecting an appropriate tool for a task and are now in a position to make a decision as to the usefulness of other, similar software tools.

Figure 4