INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
2 & 3 SEPTEMBER 2010, NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, TRONDHEIM, NORWAY

EXPERIENCES OF REVISING THE PROTOTYPING CULTURE FOR DESIGN, ENGINEERING AND ARCHITECTURE STUDENTS AT LONDON SOUTH BANK UNIVERSITY

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ABSTRACT
Additive and subtractive Rapid prototyping (RP) systems are becoming more the convention in industry and education; however, integrating RP systems fully into academic units needs careful consideration. There are distinct benefits from using these varied technologies, but are we in danger of losing analogue prototyping techniques that can be more appropriate for early stages of the design process because the students are mesmerised by the technology?
The genre of prototyping is becoming ambiguous, it deviated away from the dictionary definition years ago and rightly so, there is not one hard and fast rule for the development of a product per se. This needs to be reinforced in design education as not every design student arrives at the same career destination.
The analogue prototyping culture at London South Bank University (LSBU) has a tradition that has stimuli from engineering practice, product modelmaking and even sculpture. This has been used to speculate form and give ideas “shells” at the fuzzy front end of a project. Part of the problem with integrating RP systems is the reorientation of units, especially practical workshop units and Computer Aided Design (CAD) units. Without RP systems, it has been difficult to “test” data files for full integrity i.e. water tightness and that students can test their creations “actually” rather than just “virtually”.
The approach to this problem has been manifold; the first stage was looking at the practicalities of using the software, selecting materials pallets and designing process protocols to prototype on students. Another vital aspect has been investigating the cost of ownership for these systems, costing materials modules holds an interesting educational aspect for the students who, hopefully, will explicitly review the “worth” of the materials they are using.
The paper will place an emphasis on how product design students engage with this process as part of the product development aspect of their project work, but there is also insight on the relationship between the varied disciplines of engineering and architecture also.

Keywords: Rapid prototyping, digital design, analogue design, multimodality ,prototyping protocols

1 INTRODUCTION

The rational for this paper started under the auspices of a faculty research project intend to embed the use of rapid prototyping (RP) technologies into learning and teaching activities, run over 2 years the research aimed at rationalising the use of the varied RP equipment and embed taught elements within certain units. There was a request to cover the disciplines of architecture and engineering as well as the author’s core discipline of design,

1.1 The existing prototyping culture

The existing prototyping culture at LSBU varied between the disciplines, the design and architecture courses are predominately project based learning, (to reflect the industry practice) and a healthy percentage of the units require some form of prototyped deliverable to reinforce the tangible deliverable. As such design students are more likely to adopt a more proactive approach to the use of the current RP equipment, the dilemma occurs when student favour the use of RP over “traditional” forms of making, and lose the relationship between the product and the user in the process. The engineering courses are currently revising the practical content within their units to accommodate more project-based assignments, and the architecture students have adopted the use of the RP systems into their assignments with vigour.

1.2 Structure of academic units

The use of RP technologies cannot necessarily be embedded immediately onto students as they arrive into higher education, the existing programme of CAD units starts with 2D drafting content in semester 1 leading into 3D surface modelling in semester 2, current research via a questionnaire given to design and technology teachers suggests that use of a 2D element and then transferring to 3D solid modelling may be a more efficient route, it would also allow students to engage with 3D RP at an earlier level, and revisions are being made to blend in the use of RP into appropriate units.

1.3 Talking to the machines

At the earlier stage of the research a significant amount of time was spent learning the strengths and weakness's of the CNC equipment, and the idiosyncrasies of the machines themselves, there were serious restrictions in the ability to limit cutter paths, maintain datum's and run files that would run stably the software used was "introductory" and as such did not need a significant learning curve, apart from trying to understand the (counter intuitive) idiosyncrasies of the software interface.

1.4 Protocols

A conceptual protocol was created to map out all forms of the RP systems that we have "in house" but also show opportunities to use external suppliers for RP processes. Two versions were designed an email based one and a "foot-net" (in person) one to avoid extra complications of extra technicians training and infrastructure issues during the initial learning curve. This was designed after looking at the use patterns of all users of the system from Architecture, Design and Engineering. Figure 3

2 BODYSTORMING AND THE FUZZIER FRONT END

To try and further reinforce good design ideation and creativity via multimodal ways of working, [1] It was decided to implement a bodystorming session in LSBU's lighting studio for final year Engineering Product Design, Sports Product Design and CAD students, the cohort involved were working on projects as diverse as transportation systems to therapeutic medical "system" type products. The immediate feedback that bodystorming allowed dramatically changed the course of some projects that were previously (in some instances) generated purely in a digital form, existing placeholder illustrations were projected onto a wipe clean surface, and the projector and image were manipulated to arrive at a full scale image, lining tape was used to trace the imagery and then group participants were briefed to engage with the product, extra props such as chairs and flexible foam to extrude profiles into reality were used. Figures1 and 2 show students working on a transportation system and an inclusive exercise device. This form of low resolution "augmented reality" (AR) [2] has significant time compression benefits for large scale products that would require significant build time even if a crude rig was built.

Figure 1. Transportation system

Figure 2. Inclusive exercise machine

2.1 The quick and dirty- formative modelling

One benefit of the use of RP technologies is that they can enhance early stage formative rigs, this is not just centred on form development, but can also work well for "product architecture" placement for mechanisms, componentry or ergonomic verification. a favoured approach is to use a “digi-logue” approach, this approach blends both digital and analogue applications into the product development program to aid time compression and reveal human reactions to and engagement with the actual product experience at the same time. Considering design education projects are broken into unitised time, it is vitally important that students remain lucid to the task set and engage actively to reinforce rapid feedback loops, create evidence of iteration and are decisive and “test” ideas both physically and quickly, due to cost constraints of education and time constraints on the student. Evidence of the benefit of quick and dirty modelling can be seen during the LSBU “Dyson Day”, where First year students are set a day long project to brainstorm a vacuum powered product in the morning and are building rudimentary models using donor parts and card by the afternoon. This relatively short project allows the students to build a representation of a design that gives the idea equity. See Figures 3 and 4

Figure 3. Card modelling

Figure 4. Reviewing donor parts

2.2 Printing as prototyping

Using an inkjet printer can garner considerable feed back for a product during the early stages of developing from concept to reality, and arguably even engineering drawings have a prototyping phase when printed, proof read, marked up- discussed with the team and then updated before release. A significant leap in resolution can be gained if low-resolution foam models are clad or supplemented with printed imagery, Figure 5.This an easier step up in resolution for the time invested.

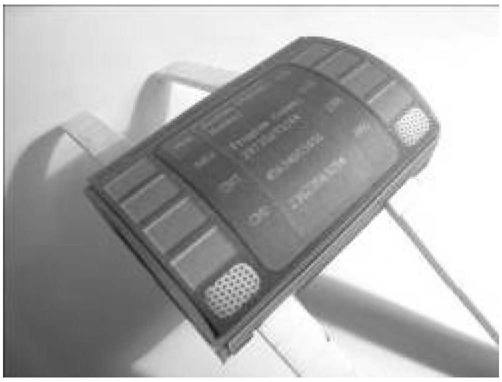


Figure 5. Mini Hal, first year project, blue foam and illustrator print model

3 I’M MESMERISED

There is a misassumption for some students that by using the most modern technology in their deliverables, that they will gain higher marks, this can sometimes be counter-productive, in some cases students queue to use the faculties’ laser cutter rather than use traditional skills to produce simple components and then use poor assembly or critical visual skills to identify weaknesses in their deliverable and reiterate prior to the final deadline.

4 MATERIALS COSTING-MATERIAL PALLETS

The implications of using RP systems can have serious implications on project costing at an academic level, most projects within industry have a blend of RP typologies attached, and arguably uses of analogue manufacturing tools such as circular saws, band-saws, mills and lathes are used in the preparation of the billet, and manual modifications are still used to give finishing touches.

Part of the initial research was based on a selection of materials that could be used for the production of design facsimiles, or used to create tooling, professional modelling foams and boards can be quite expensive, even if bought in bulk, if the cost is divided up to a particular volume per student these material can still inflict costs on to the unit materials. Although RP affords multiple iterations at a high resolution, and allows the focus to be on “design time” rather than “make time” the implications of material cost, per student or per unit could be a governing factor and negatively influence unit deliverables and in the worst case, creativity.

Currently we are monitoring material costs for all the systems we are using and a particular way of achieving this is to create a matrix of units throughout the levels and trying to rationalise the diverse routes to making from initial “sculpts” through to CNC’d aluminium prototypes.

4.1 “Design files” versus “model files”

Prior to the acquisition of subtractive RP equipment all CAD databases had only two destinations, either as 3d models transferred to 2D engineering drawings or as rendered images that can be “re-touched” in Adobe Photoshop, the issue came when a student had to use traditional pattern making skills to create a 3 dimensional representation, on occasion parity between data-file, drawing and artefact was lost. Wilgeroth [3] describes an elimination of design for model making as a positive, and by that the definition means compromising design or production intent due to restrictions of skill in traditional making processes, arguably this deficiency, without a stronger but softer front end to the processes of design development could shift the problem to the CAD tools, another issue would be that to propose a “design freeze” based on sound conceptualisation, design for manufacture and all of the components of the design recipe and then embark on a model design process where allowances for contraction, split line allowances and mating surfaces relevant to intended prototype finish may be more of a successful route.

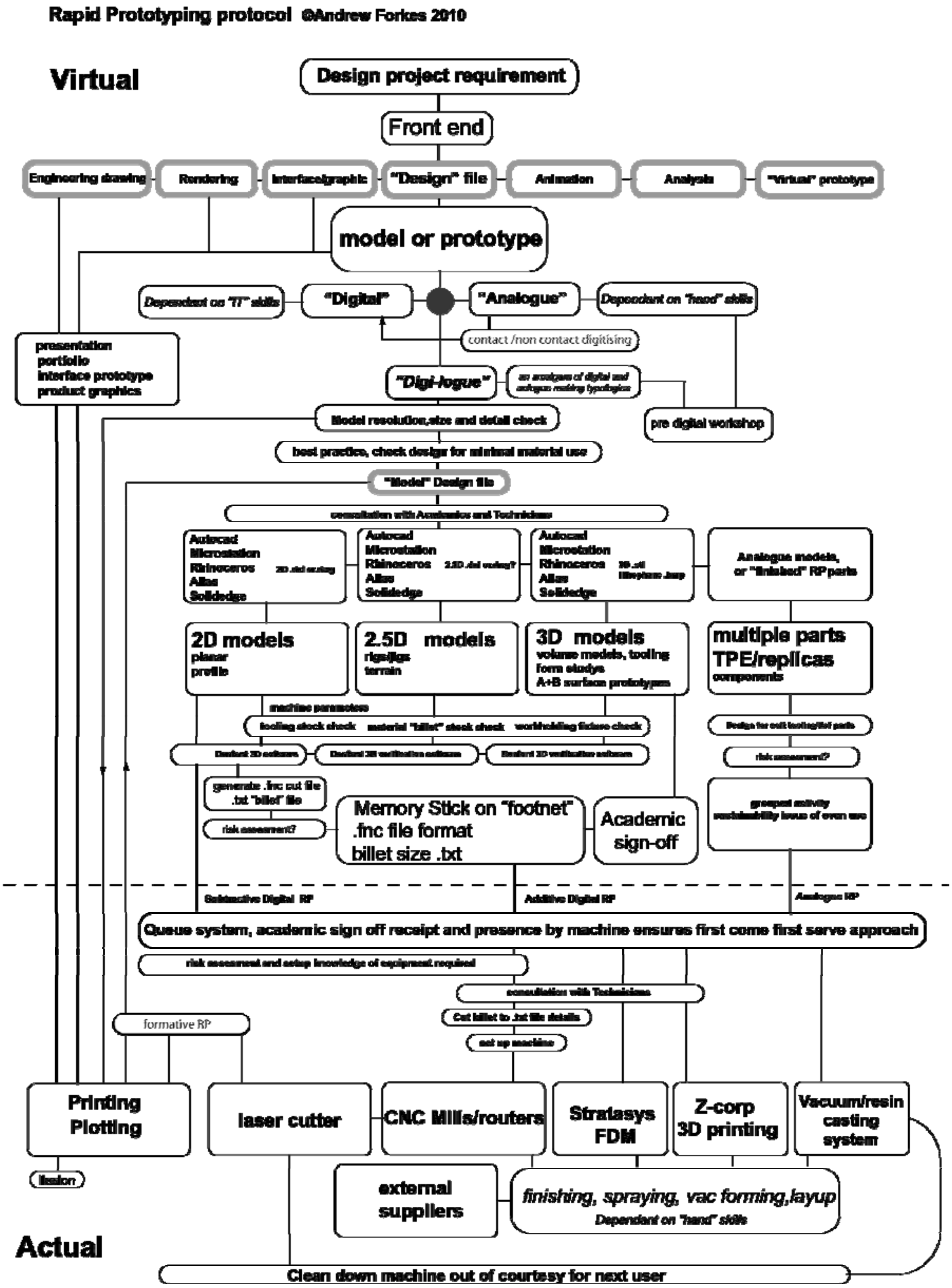
A “Design” file is the academic equivalent of a file that would be sent to a toolmaker for the production of tools, whereas a model design file has to incur other areas of design that relate to work holding, nesting and so on, an excerpt of the film “Objectified” verified this approach when Jonathan Ive [5] was seen discussing how the case parts for the new Unibody Macbook pro were developed, arguably the use of Subtractive technologies such as CNC machining and turning allows the students to step closer to the realities of production systems and inevitably more realistic product outcomes.

5 HEALTH AND SAFETY

Although the traditional approaches to form generation carry greater risk in terms of health and safety, the use of additive RP is relatively risk free, and subtractive RP has minimal risks associated with general tooling handling and general workshop practice, a concern that the riskier activities get replaced by less risky ones. The investment in a blended approach to making may reinforce student confidence and awareness in a workshop environment, and thus if coupled with risk assessment training reduce risks through negligence.

6 DIGI-LOGUE- DIGITAL AND ANALOGUE

The idea of the “digi-logue” process is to switch between “bits and atoms” [4] when designing products or services, however, with diverse concepts being generated in response to a single brief. The diversity of the students product outcomes cannot be always given a broad stroke in respect to the prototyping processes to be selected. If we consider that industrial design courses are reflecting the product design industry’s evolution of including service and experience design into their portfolio-the shift from designing “nouns” to a combination of nouns with verbs [6] giving students an opportunity to learn a blend of prototyping routes, may allow them to adapt their thinking when they reach a particular destination in the design industry.



7 FINISHING WITH FINISHING

Even with the most advanced subtractive RP systems the transition from made part to finished artefact requires hand finishing such as de-cusping, losing corner radii, spray finishing and assembly, the potential for an archive quality prototype is sometimes lost by the student who does not consider the

timings involved to gain the highest quality, the images below illustrate not only verification models in blue foam, but finished prototypes for the design degree show.
The images below figures 6,7 and 8 indicate high level final year major project models where surface finish gives the product equity and realism to a prototype, sometimes starting with a blue foam verification model to sign of form these finishes are intended to indicate a production reality.

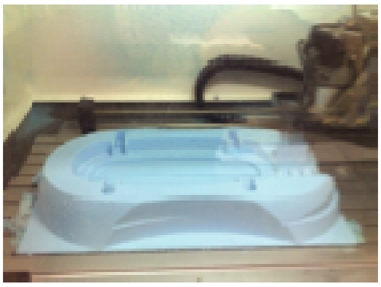


Figure 6. Verification model

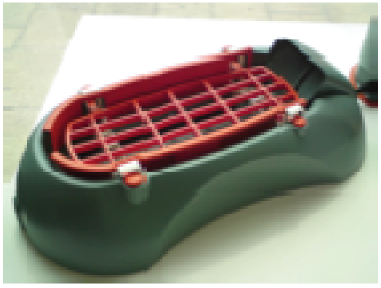


Figure 7. Sprayed prototype


Figure 8. Sprayed prototype grass ski

8 CONCLUSION

The conclusions that can be drawn from this research are the need for a blended approach towards the successful use of prototyping using both digital and analogue techniques, digital techniques can be used to supplement resolution on analogue models and vice versa. The reinforcement of "quick and dirty" techniques in the academic design process may save mistakes in time consuming processes and usability, would allow students to show evidence of iteration and resolution of design thinking and may even save faculty funds on wasted materials. If used appropriately, RP technology can still allow higher resolution of product ideas at an early stage, a quicker sign off to progress to the next phase of higher resolution prototyping. Further research would be needed to investigate the instances of transfer between digital and analogue making for a selection of defined product typologies, and highlight different needs for the disciplines of architecture and engineering. If students learn this multimodal way of working, they may be able to adapt more easily to the varying prototyping protocols that are employed within different aspects of the design industry.

REFERENCES

[1] Paterson G, Garner S & Earl C (2007) 'Multimodality through physical digital design', in proc. of Conference of International Association of Societies of Design Research (IASDR07), The Hong Kong Polytechnic University, 12-15 Nov 2007 [online] Available from: http://www.sd.polyu.edu.hk/iasdr/proceeding/html/sch_day4.htm [Accessed November 2009]

[2] Milgram et al. (1995) Merging Real and Virtual Worlds [online] Available from: http://vered.rose.utoronto.ca/people/spike/IMAGINA95/Imagina95.full.html [Accessed January 2010]

[3] Wilgeroth, P. and Gill, S. (2006). The unexpected benefits of an integrated CAD/CAM based model making strategy. e&pde06. The 4th Engineering & Product Design Education International Conference, September. Salzburg, Austria. (Paper)

[4] Gershenfeld Neil (2005) Fab: The Coming Revolution on Your Desktop--from Personal Computers to Personal Fabrication, Basic Books,

[5] Jonathan Ive talking about the design and development of the new Unibody Macbook pro, "objectified" [online] Available from: http://www.youtube.com/watch#!v=sxbiIpXZfG8&feature=related [Accessed February 2010]

[6] Brown Tim, (2009) Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation .Harper Collins