

A LITTLE KNOWLEDGE IS A DANGEROUS THING? – DO BSC PRODUCT DESIGN COURSES DISCOURAGE COLLABORATION?

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ABSTRACT

BSc Product Design Courses aim to equip the Product Designer with a better understanding of the needs of professionals such as manufacturing engineers, material specialists, electrical engineers whilst also maintaining a focus on conventional design skills. One could debate that this greater understanding of these engineering disciplines should allow more productive collaboration with their respective practitioners. A key area looked at by this paper is, does this bias towards the technical, affect the designers predisposition towards collaborating with end users or those involved in the user experience in driving a new product design forward?

It will also consider the argument that the Product Designer is now in a position to collaborate less with other technical disciplines, with ever simpler tools such as FEA, CFD being part of CAD suites, allowing designers to carry out the kind of validation that would have once been exclusively the preserve of specialists.

The paper examines two completed design projects for SME clients, by a design research group based at De Montfort University. One project was undertaken by a BA graduate, the other a BSc graduate. It will look at how each graduate collaborated with end users and technical specialists and the effect this had on the project outcome. One of the projects will then be presented as a hypothetical live project to final year BSc and BA students and their approach to collaboration with end users and technical specialists examined.

Keywords: Collaboration, Design Engineering, Product Design

1 INTRODUCTION

The Design Unit is a multi disciplinary design research group based at De Montfort University, Leicester UK. The group is staffed by design academics and undertakes live projects with commercial clients from a wide range of industry sectors. The Design Unit team is made up of a mix of both BA and BSc Product Design Graduates who are also involved in teaching on both BA and BSc Product Design Courses at De Montfort University.

This paper will contrast two live projects recently completed by the Design Unit, one undertaken by a BA product design graduate, the other undertaken by a BSc product design graduate. Both designers graduated post 2000, but are experienced and are above junior level. The premise of the paper is to examine the approach of the two different graduates in terms of how they collaborated and how this affected the outcomes of the project. It is acknowledged that this sample range of two projects is too small to achieve a conclusion on BA and BSc design approaches; however the two projects show the consequences of different levels of collaboration and act as a basis for discussion.

In choosing two projects that could be objectively compared, the researchers opted for two simple medical/healthcare products with minimal technology. It is worth noting that both clients for these projects were SME's

The paper will also touch upon the approach taken by final year students of both BSc and BA courses by presenting one of the above projects to them and asking them a series of questions to predict how they would collaborate if they were to be given the project in their first post graduate professional designer roles

1.1 Types of Collaboration observed in this research

The two projects chosen for this study are intentionally simple to act as a potential foundation for further study of more complex design projects. The paper will pay particular attention to collaborative partnerships that were formed pro-actively by the designer for the overall benefit of the artifact, however the main areas of interest are the conventional types of collaboration that a designer would be expected to undertake, such as end user and technical specialists, with a particular focus on BSc graduates collaborating with end users.

1.2 A Brief Overview of the BSc Product Design Course

Norman states 'we need a new breed of designers. This new breed must know about science and technology, about people and society, about appropriate methods of validation of concepts. He goes on to say 'Design education has to move away from schools of art and architecture and move into the schools of science and engineering' – 'But beware: We must not lose the wonderful, delightful components of design. The artistic side of design is critical: to provide objects, interactions and services that delight as well as inform that are joyful.' [1] The BSc approach to product design attempts to address this dichotomy of core values with a view to producing graduates who, in addition to being creative and user centred designers are also adept in science and engineering..

1.3 Examples of collaboration being encouraged on the BSc programme

In order to create products that are viable and optimized for manufacture, students on BSc programs are more biased towards engineering disciplines than their BA counterparts, for example, the BSc course at De Montfort University is accredited for Incorporated Engineer (IEng) status by the Institution of Engineering Designers [6]. BSc students still undertake major design projects that should see them being encouraged to collaborate and carry out research with end users/specialists whilst at the same time collaborating with various engineering and technical disciplines. There have been various models that have been taught to BSc students that encourage early collaboration with different disciplines. One such model that was prevalent in the 1990s was Concurrent or Simultaneous Engineering (encompassing concurrent design). Prasad 1996 [3] states 'Here, everyone contributing to the final product from conceptual design to marketing teams is required to participate in the project from it's very inception' It could be argued that this approach would essentially force the designer/design engineer to collaborate at an early stage particularly in a larger company. However in an SME where the designer may also be project manager, the onus could be on the designer to encourage and embrace this culture. Baker et al 1996 [4] cite Parkinson and Short [5] when outlining the case for teaching Design students this approach, stating 'Because industry is increasingly making use of the concurrent approach and obtaining clearly recognised improvements in the design to manufacture process, Parkinson and Short outline the need to teach engineering students the principles and techniques associated with concurrent design.

In the 21st century another, strategy taught to BSc students is Product Lifecycle Management (PLM) Saaksvuori et al 2008 [7] state 'A PLM system is a collaborative backbone allowing people throughout extended enterprises to work together more effectively' PLM is a far reaching system that controls collaboration not only at the design inception, concept and development phases, it continues far beyond , encompassing ERP (enterprise resource planning), SCM (supply chain management), CRM (customer relationship management), and ALM (application lifecycle management) systems right through to a products end of life recycling strategy. A large subset of the PLM system and one that is very much applicable to the product Designer/design engineer is PDM (Product Data Management), this is an area very much concerned with collaborative engineering. Some mainstream CAD systems such as SolidWorks have the option of having PDM functionality built in to the software [8]. Rather than collaborating in a conventional face to face manor with other specialists on a design project, the PDM software allows the designer to oversee what other stakeholders are contributing and influencing on the project whilst adding their own contributions, without leaving their workstation. It is worth noting that a mainstream 3D CAD package such as SolidWorks can also be purchased with user friendly analysis tools for areas such as Structural Analysis Thermal Analysis, Structural Optimization, Fatigue Analysis, Electronics Cooling and Motion Analysis, all of which according to SolidWorks themselves 'Enable every designer and engineer to simulate and analyze design performance with fast, easy-to-use

SOLIDWORKS Simulation CAD-embedded analysis solutions'.[9]. This opens up disciplines to the designer that were once the preserve of specialist engineers.

The above examples are quite specific to BSc product design programs and whilst students of BA product design may be made aware of these concepts, they are very much on the periphery of the course, with more focus given to traditional product design skills and user centered research.

2 CASE STUDY 1: A 'BA' GRADUATE PROJECT – THE ERGOKNEELER



Figure 1: Two views of the Ergokneeler and a healthcare professional using the product (right)

The Design Unit was approached by company SH, who supply healthcare products, specifically moving/handling devices and mobility aids to healthcare professionals and healthcare organisations. Company SH had identified a market opportunity for a portable kneeling stool to be used predominately by healthcare professionals when attending to a patient's feet and lower limbs.

The brief stated that that the product had to have excellent ergonomics, be low cost, be easy to manufacture and address the issue of infection control.

The company does not have any design or in house manufacturing resources as their main focus is distribution and sales, however they do have at their disposal, the services of an eminent chartered physiotherapist and back care adviser, who could be called upon to evaluate the design.

2.1 BA Designer – Project Approach

The BA product Designer began background research, before calling the client in for an initial design meeting. The designer ensured that the consultant physiotherapist was present at this early stage, despite being proficient in the design of products with ergonomics at their core. The physiotherapist was invaluable in providing an ergonomic direction for the project. These three way meetings continued throughout the early stages of the project with a reciprocal collaborative relationship developing in which each stakeholder influenced the design process.

As the form of the product began to take shape, the project progressed to a stage where materials were to be specified. Again, the designer involved all three stakeholders.

Both the physiotherapist and the client were instrumental in specifying materials, the client from a viewpoint of, ensuring that materials and manufacturing process were commercially viable and the physiotherapist from a point of view of ensuring that materials were soft yet supportive, skin viable and light. . To meet UK healthcare standards, the materials must meet stringent guidelines to ensure that they will not harbor infection and that they can be repeatedly cleaned. 'One of the main problems is the wealth of legislation within the healthcare marketplace, which can create a barrier many companies cannot overcome' [2].

Both the Physiotherapist and the client had contacts within the healthcare industry that were able to collaborate on the project, assisting in the product being accepted by the UK healthcare sector.

The main constituent material for the product was polyurethane (PU). The PU had to possess certain properties to enable it to be fit for purpose. These factors made formulating the material quite challenging. The client had worked with a PU moulder on previous projects and was able to bring this company in to the project at the development phase. The fact that the client had a record of previous business with the company, gave the moulder confidence that the venture was worthwhile investing their own time on pre production material development.

Under guidance from the PU moulder, the Design Unit were able to use their own rapid prototyping facilities to produce prototype tooling for the moulder. This was then used to produce low cost but resolved prototype products for assessment and further development. The physiotherapist was able to use a network of end users/practitioners to gain early market feedback on the product

After several low cost prototypes a final iteration was produced, further field trials were undertaken by the physiotherapist's network of contacts. Once this was complete the client was able to take the step of investment in full tooling and launching the product to market, with confidence that the product was viable

3 CASE STUDY 2: A 'BSC' GRADUATE PROJECT – NEONATAL ENDOTRACHEAL TUBE CLAMP AND CLIP



Figure 2: The existing neonatal endotracheal tube clamp (left) and clip presented for re-design (Right)

Company CM is an SME who supply niche products in to the medical/healthcare sectors. The company approached the Design unit for a redesign of one of their products, a tube clamp and clip used in the treatment of premature babies. The clamp locates a tube in place, allowing a catheter to be inserted in to the patient's airway. The simple mechanical clip holds the tube at the correct level. There were some negative characteristics that were fed back from medical staff that made the product difficult to use and difficult to adjust. CM were keen to redesign this product, but had no in house design resource and little relevant in house manufacturing resource.

The brief for the product, stated all of the characteristics that the new product must have including excellent ergonomics for both patient and user, ease of manufacture, low cost whilst also setting out the environment that the product is used in and how the users interact with the product. At this time the input of two medical professions 'end users' was offered. i.e. two users would be available to review the new design at any given stage.

3.1 BSc Designer – Project Approach

The BSc designer was now versed in the design specification of the new product and being confident that this would be a straight forward design/ design engineering exercise, set out a timetable for the design project including regular meetings with the client. Initially several concepts were generated for review with very rudimentary test rigs being made for evaluation by company CM.

The client eventually settled on a concept that was based on their existing product but with several modifications that addressed the issues that previous users had reported back.

It was agreed by both designer and client that the same materials would be used for the new product these being a SEBs polymer for the clamp and an acetyl for the mechanical clip.

The Design Unit used additive manufacturing and vacuum casting to carry out pre-production trials, however due to the small ratchet mechanism on the clip itself the RP technologies available could not produce the detail required. The designer also used some of the basic analysis tools within SolidWorks to try and predict how the plastic would behave. The only way forward was to injection mould the product for evaluation. This is a large investment in comparison to conventional prototyping techniques and company CM was hopeful that the tooling could be used for initial production if the prototypes were successful. The client selected a toolmaker in China to manufacture the prototypes and all CAD data was sent to them.

The first samples sent back showed some unexpected problems, but they could be used for basic evaluation. These were presented to some of the end user groups. Some excellent feedback was given, but at this point it was difficult incorporate some of the suggested feedback without completely re-tooling the clip.

The CAD model for the clip was modified to allow basic tool modifications to be carried out by the tool maker in China. The second batch of prototypes showed some improvement, however further modifications were still required. Again, these were given to the end user groups. At this time, a fundamental weakness was fed back to the designer.

The clip was now at a stage where an effective re-design was required. The necessary work was carried out by the designer and the new CAD details sent to the tool maker in China. New tooling was manufactured and a new batch of pre-production samples sent.

4 COMPARING COLLABORATION ON BOTH PROJECTS

In the Ergo kneeler project, the designer involved the client and the physiotherapist in the project at an early stage resulting in them becoming instrumental in the design process.

The relationship they developed with the designer and the product itself led to them bringing further collaborators such as the PU moulder and end users/practitioners in to the design process. This greatly assisted in bringing the project to a timely positive conclusion with minimal re-working required. The collaborative nature of the project led to a continuous feedback loop which minimized unnecessary prototyping and ensured continuous product development, influenced by the right people at the right time, rather than the stakeholders providing a critique towards the later stages of the project where significant time and money would have already been invested.

The approach taken to the neonatal endotracheal tube clamp/clip project was one that focused on the engineering and functionality. The designer effectively followed the brief without questioning it or the client and the offer of input from medical staff was not taken until late in the project. As such, the user experience was not reviewed until the design direction had been decided and considerable amounts of time and money had been invested. The input of the end users led to significant design changes that could've been incorporated at the front end of the project.

The designer carried out his own FEA analysis, which proved to be inconclusive. A professional plastics engineer could've identified some of the weaknesses that were apparent in the first prototypes. The lack of input from the tool maker meant that the designer was cautious to ensure that the parts were easily moldable. Had a relationship with the toolmaker been established, the materials and the features of the parts could perhaps have been exploited more to improve functionality/aesthetics.

5 STUDENT APPROACH TO THE NEONATAL TUBE CLIP/CLAMP PROJECT

The neonatal endotracheal tube clamp/clip project was presented to both final year BSc and BA Product Design students at De Montfort University (each group was seen separately). The students were asked to imagine that they were in their first professional design role after graduating and to contemplate that they had been assigned this project. The scenario of end users/ medical staff being available to review the product was proffered and the fact that the tooling will be made by a small toolmaker in China was also made clear. The students were asked the following questions:

Question	BSc answers	BA answers
1. Do you feel that you have been given enough information in the brief to allow you to undertake the design of the clip and the clamp without further input from medical staff?	12% would collaborate with medical staff to gain more input in to the design	100% would collaborate with medical staff to gain more input in to the design
2. Would you feel confident in producing all the data required to manufacture tooling for the two products or would you expect another engineer to complete?	100% YES, I could produce all data autonomously	100% YES, I could produce all data autonomously
3. How would you go about specifying materials for these products? a) Use my own knowledge/experience b) Do my own research to find a solution c) Consult a materials specialist	90% combination of B and C 10% - C	100% combination of B and C
4. Would you use your FEA skills to test the strength and other properties of the clip or would you hand this over to an expert?	25% Would do their own FEA, 75% would do some basic validation before handing the analysis over to a dedicated engineer	100% would hand the analysis over to a dedicated engineer after doing some basic validation

It is interesting to note that the majority of BSc students would take a very similar approach to that taken by the practicing designer in that they view the project as a simple design engineering project and follow the brief without engaging the user early in the design process. There is a slight difference in the confidence of the students to use their own FEA analysis and not defer to a dedicated engineer (25% of BSc students would rely on their own judgements vs 0% of BA student

6 CONCLUSIONS

This initial research points to a greater tendency by BA graduates to collaborate with end users or those involved with the user experience, earlier and more prolifically than their BSc counterparts.

The research also suggests that the inclination to collaborate with other specialists such as material experts for example doesn't differ greatly across BA and BSc practitioners. It is acknowledged that a study of two projects is too small to verify these patterns, but it acts as a platform for further study in which a greater number of design projects undertaken by both BA and BSc graduates could be examined

Another point raised is how collaboration is encouraged on the two different design course programs. On both the BA and BSc courses, the importance of the end user in product design is instilled in to the students, however it could be suggested that with the weight of engineering disciplines also being applied to the BSc students, the user centered approach is clouded by other concerns such as how the product will be commercially manufactured. Perhaps a solution to this could be more cross discipline teaching between courses. Jedwab and Zivanovic 2010 [10] carried research in which both BSc and BA product design students were placed together to work on a series of commercially sponsored design projects, they state 'it worked synergistically, improving the levels of students in both disciplines, because it maintained high levels of interest and engagement from students and because it resulted in exciting new products that exceeded the learning outcomes'

A point for further discussion could be 'does the technical rigor prescribed by the BSc route create designers who are constrained by the brief, seeing it as a set of instructions, laying out the design project as a purely technical exercise without user input?' In both the projects featured in this paper, the brief was formulated by the clients (neither of whom were end users). The BA graduate was more inclined to use the brief as a guideline, basing much of their design input on feedback gained from user/specialist feedback, whilst the BSc graduate effectively used the brief as an instruction document which was followed closely.

Finally, the ever greater reliance on digital tools integrated in to CAD systems could have an effect on how both disciplines collaborate. From a BA perspective, the awareness and access to the analysis tools of more specialist disciplines, could lead to more production ready, viable products at the front end of the design process. In contrast the use of these tools by more engineering and technically conversant BSc graduates could lead to designs being verified and signed off by over confident designers who simply do not have enough in depth knowledge of specialist fields such as fatigue analysis or thermal analysis, posing the question is a little knowledge a dangerous thing?

REFERENCES

- [1] Norman D. *Why Design Education Must Change*, December 2010, www.jnd.org
- [2] Building Better Healthcare *Challenges regarding design and issues about adoption of innovative technologies* 11 August 2011. Available http://www.buildingbetterhealthcare.co.uk/news/article_page/Challenges_regarding_design_and_issues_about_adoption_of_innovative_technologies/71330
- [3] Prasad B *Concurrent Engineering Fundamentals, Volume 1:*, 1996 (Prentice Hall PTR) p2
- [4]. Baker R*, Short" C , Tranter I *, Meehaif A, Parkinson B *Modelling the concurrent engineering environment using artificial intelligence techniques*. Transactions on Information and Communications Technologies vol 8, © 1995 WIT Press, www.witpress.com, ISSN 1743-3517
- [5] Parkinson, B; Short, C. 1994 *The teaching of a concurrent engineering approach to design and manufacturing engineers'*. Proc. of the international conference on concurrent engineering and electronic design automation (CEEDA), Bournemouth, UK. 7-8 April, 1994. Society for computer simulation international.
- [6] De Montfort University website available at <http://www.dmu.ac.uk/study/courses/undergraduate-courses/product-design-degree/product-design-bsc.aspx> accessed 25/02/2016
- [7] Saaksvuori A, Immonen A, *Product Lifecycle Management*, Third Edition 2008 Springer
- [8] PDM vs PLM: It all starts with SolidWorks: Available at: https://www.solidworks.com/sw/.../PDMvsPLM_2010_ENG_FINAL.pdf accessed 20/02/2016
- [9] <https://www.solidworks.com/sw/products/simulation/solutions.htm> accessed 20/02/2016
- [10] Jedwab, Debora M. and Zivanovic, Aleksandar (2010) *Innovations in learning and teaching interactions between BA (Hons) Product Design and BSc (Hons) Product Design engineering students on design projects* 3rd International Conference of Education, Research and Innovation.