STUDENTS PRACTISING REALISTIC DESIGN PROCESS BY COLLABORATION OF DIFFERENT DISCIPLINES

Bernard HUGGINS[1], Sara LINDA[1], Sham RANE[1], Adam WALLEY[2] and Chris DOUGAN[2]
[1]City University London
[2]Glasgow Caledonian University

ABSTRACT
A pilot project was arranged between Product Design (PD) students at Glasgow Caledonian University and Engineering Design (ED) students at City University London. The assignment was to produce concepts for low cost solar thermal collectors, for a company based in Scotland. There was an underlying goal to produce an innovative sustainable product, with an identified target market.
The educational aim of the project was to teach students about working in collaboration with people from different disciplines. This included working in teams with a combination of the two disciplines from distantly located institutions, using modern means of distance communication.
An underlying synergy was observed in divergence and convergences throughout the design process. Regular meetings kept the lines of communication open and formed the integration point. This allowed ideas to flow between each group of students, and mutual benefit through the sharing of design process tools, whilst also ensuring all parties remained on track towards developing innovative solutions that would meet the researched requirements. Convergence occurred at the stage of creating a vision for the product. This was followed by a systematic process of developing concepts for further pursuit, and decision making. Productivity and innovation was enhanced by being open to all possible design tools that individual team members were comfortable with.
It is considered that through the collaboration of both disciplines for this project, students were able to come up with innovative, creative, and thorough solutions, with a clear place in a market of increasing green consciousness.

Keywords: Design process, product design, engineering design, solar thermal collectors

1 INTRODUCTION

Undergraduate students from two UK universities participated in a collaborative development project for a new product. Four groups of 6 to 7 students, each made up of half engineering design (ED) and half product design (PD) students, undertook to develop an innovative solution for solar water thermal collectors. This was to be completed via distance communication, with half of the students located in London and half in Glasgow.
The aim of the project was to provide students with the opportunity to collaborate with another discipline, and in turn learn about the other disciplines processes, co-operating effectively in a group, and communicating effectively over long distances. This paper is a summary of students observations on the learning outcomes of this the project.

2 THE DESIGN PROCESS

EGPR is a collaborative interdisciplinary project performed by use of virtual communication tools to provide holistic set of competences to undergraduate engineering and product design students [1]. The project described in this paper is aimed to prepare students for a successful international EGPR course.
The ED and then PD processes used by the two distinctive disciplines are discussed separately in this section in three stages: front end and vision creation, conceptualization, and final concept development and analysis, for each discipline. This is followed by an analysis of the two approaches, outlining their merits and demerits; then further discussed through application in section 3.

2.1 Engineering approach

The ED design process begins with categorizing requirements using three main tools. Firstly, an objective tree is used to identify overbearing criteria that must be met. These are then broken down into smaller, more specific, objectives. Each objective is given a relative weighting of importance versus the others at the same level, deduced from the project criteria and customer requirements. In this way the overall importance rating of the various identified goals is ascertained [2]. A functional model is used to identify processes that must be carried out by the product and in turn, engineering characteristics [3]. Both of these tools culminate in the third tool, the quality function deployment (QFD). Here, the qualities that the product should have are related to the engineering characteristics to clearly display and weight correlations. Specific targets that need to be met, such as weight limits and efficiency targets, are also recorded on the QFD, making it the combination of the first stages work and the quintessential problem definition. Utilizing this, a vision is created.

In the conceptual stage ED focus on specific engineering solutions to identified problems. A morphological chart is created to visually communicate ideas that could be used or had been used in concepts, for solving specific sub functions drawn from the functional model and QFD. Final concepts incorporating various solutions are then chosen.

In the final stage, the ED process makes use of performance costing analysis. Final concepts are developed to optimize this as well as to best meet all criteria set out in the problem definition, and the vision. A decision matrix, rating each of the final selected concepts against goals drawn from the objectives tree, then compares each design based on economic and technological merit, and the final concept is chosen. A flow chart clearly showing the process and tools is shown below in Figure 1.

Figure 1. The engineering design approach

2.2 Product design approach

The PD design process starts at the front end with rigorous market research, identifying already available products for the problem and potential target markets. This is done through both literature and brochure reviews, and economic report analysis respectively. This combined with conveyed customer requirements, results in a vision involving what type of products, specifically, should be pursued, and who it may appeal to [4].

With an identified direction, numerous sketches are made tackling various requirements. The best of these ideas can then be combined to produce comprehensive concepts that meet the various requirements. These concepts are then taken through to final development and decision making.

Final concepts are developed more thoroughly to fill in missing details, and modified to become as aesthetically pleasing as possible. From here, a final concept is chosen based on which one best meets the market requirements. The flow chart in Figure 2 shows this design process from start to finish.

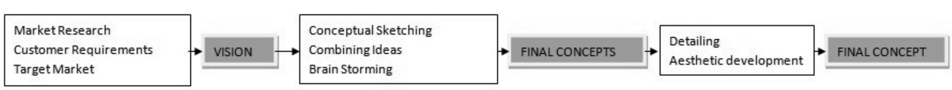


Figure 2. The product design approach

2.3 Analysis of approaches

By taking a quantitative approach, the ED design approach presents numerically and possibly scientifically justified decisions and final concepts. These can be easily and confidently be presented to stakeholders, using the tools as a basis for proof of the resultant concept being the best possible. This does have the downside of potentially missing a certain artistic and human feel to the concept, also of having a lack of knowledge of what a consumer desire might be.

Conversely, the PD design process seems to be blatantly more qualitative and consumer focused. Novel concepts are sought to break the mould in the market place, whilst producing something with a specific place in the market. Aesthetics are of the highest importance. The product is designed to appeal to the consumer on many levels. However, this can result in unrealistic designs that are fundamentally flawed in terms of functionality, or non manufacturability.

2.4 Synergy and collaboration

It is suggested that by combining a variety of approaches, a more successful product can be designed [1]. The result is a synergy in which the tools of each discipline culminate at the milestones in the design process. The flow chart in Figure 3 shows what may happen if the processes are used simultaneously.

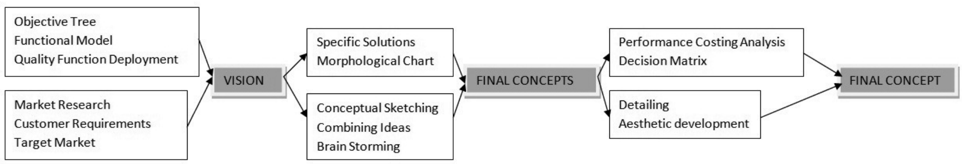


Figure 3. Combining the approaches

3 IMPLEMENTATION OF COLLABORATION ON CONCEPTUAL DEVELOPMENT OF SOLAR THERMAL COLLECTORS

This section details the project undertaken between Product Design (PD) and Engineering Design (ED) students, with the underlying theme of outlining the challenges faced, observed areas of effective collaboration, and what can be achieved through interdisciplinary co-operation. It is a study of one group out of four participating in the project.

3.1 Introduction to the project

PD and ED were given the task of developing a low cost solar thermal collector to be used for heating domestic water. The task was to be completed by groups which consisted of PD students from Glasgow Caledonian University and ED students from City University London, working together via modern means of distance communication such as video conferencing, email and internet chat.

The project consisted of two main phases: the research phase aimed at obtaining a vision, and a conceptual phase focused on achieving a suitable concept that met the goals which culminated in this vision.

Innovation, sustainability and cross discipline collaboration were all thoroughly encouraged, and remained the underlying goals of the project.

3.2 Research phase

ED students undertook to identify the customers ("company" requesting the product) requirements during this phase, as well as find out what applicable technologies were currently available. This allowed an objectives tree to be built and weightings to be given to various objectives. A functional model displaying the various functions a solar collector should perform was also built according to ED principles to help to identify areas of development.

Consumer research and market trend analysis were carried out by the PD students in order to identify sellable attributes that the product might have. This also allowed target markets to be identified, which would be useful in steering the development of any concepts.

Communication lines were kept open and regular team meetings held at this stage, to allow a big front end effort and a good level of group understanding. This lead to the creation of the Quality Function Deployment for the project, which combined the research completed by both disciplines phase into one interlinked graphical representation. Ties between various aspects of the products considerations could then be found, and a better understanding of what needed to be achieved gained.

All of this resulted in a vision – A clear, convincing statement of what is intended to be achieved with any final concept that may be presented. The vision was presented to a board of judges for comments and consideration, permitting a well informed progression into the next phase: "[The teams] vision revolves around creating innovative and sustainable solutions for future generations. Efficient, affordable collectors with reduced pay-back periods will attract the discerning and less informed alike.

They will be aesthetically pleasing, durable and long lasting; intent on inducing a trend that will last for decades to come

By making collectors light weight, modular and easy to install, set up costs will be kept to a minimum and future upgrades or extensions of the system easily provided for."

3.3 Conceptual phase

In this phase both disciplines utilized their respective tools. ED students sought to create a morphological chart, graphically representing solutions to various specific sub functions such as how to circulate fluid, absorb solar radiation, and fit the unit to a roof top. PD students promoted creativity by sketching solutions to particular problems such as how to create a modular product, and how to make it look aesthetically pleasing.

In this phase, the group started to place more emphasis on working within each other's fields, and discovering different ways to realize the product. The ED students began to produce innovative concept sketches, while PD students participated in the building of the morphological chart. Figure 4 shows a collection of sketches produced during this phase. As a result, a wide variety of possible solutions was created. The group convened to combine stand out ideas and create three concepts for further development. The concepts were developed in teams of two.

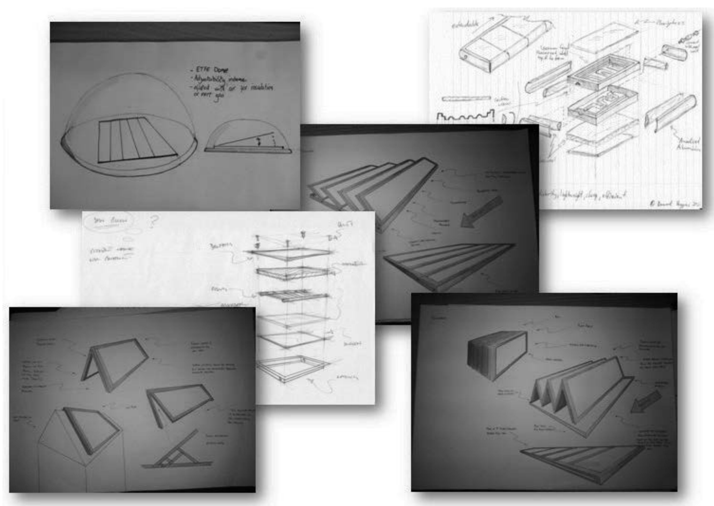


Figure 4. Concept sketches

3.4 The outcome

To decide on the final concept, the group completed a detailed analysis on each of the three fully developed concepts. This consisted of awarding points to each design based on the original requirements set out in the QFD, resulting in a decision matrix. Each requirement was given a weighting based on those established in the objectives tree at the start of the project. This provided scores for each of the concepts. These requirements were also split into technical and economical categories, which then allowed the graph shown in Figure 5 to be created. It shows that the Concept B was the highest scoring in terms of both categories and that it veered slightly toward a more technically developed product - this is not surprising, as both students in the team developing it were from ED.

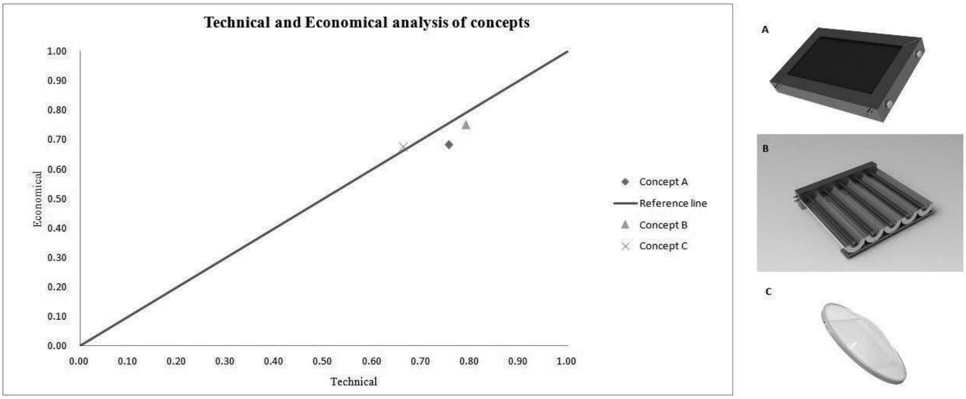


Figure 5. Comparative analysis of developed concepts

The final concept selected for presentation scored highly mostly due to its payback period – the time over which the initial expenditure to implement the unit would be made back in savings on electricity and government grants. This was approximately 9 years. Other benefits are its modularity and lightweight components. Figure 6 shows an assembled and exploded view of one purchasable 1x1m section, clearly depicting the division of parts for easy transport. The total unit weighs only 17.125kgs.

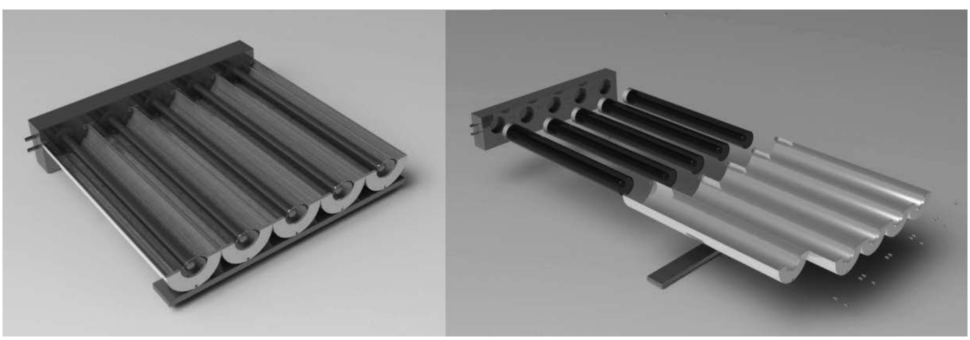
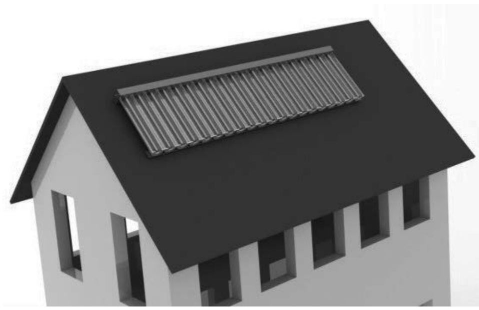


Figure 6. Final concept, assembled view right, exploded view left

Figure 7 shows a rendered image of four of the 1x1m units connected on a domestic rooftop, enough to achieve the proposed payback period stated above. This concept B was nurtured by two ED students working together on the design, with direct input from the PD students. It is observed that the aesthetics of this design are not especially pleasing. This is evident when observing concept A, developed by two PD students, pictured in Figure 8. It is considered to be a neat, unobtrusive installation; however, this concept had lower efficiency ratings when compared to concept B.



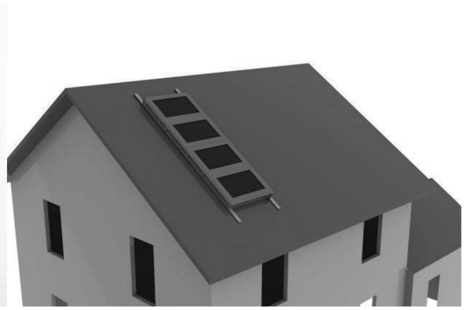


Figure 7. Final concept installation *Figure 8. Concept A Installation*

The two person team working on concept C from each discipline unfortunately experienced a communication breakdown in the final stages, meaning that the final concept was not quite up to standard. This may have been the result of trying to maintain distance communication within a smaller sub-team, without the structured meetings agreed to by the whole team of six, while losing out on productive time allocated to the project.

Overall, both groups of students gained a valuable insight into the various tools available for product realization, from disciplines outside of their own. The challenge of working together over long distances gave a good opportunity to develop team working skills, while encouraging individual work ethic so as not to waste precious time at team meetings.

4 CONCLUSION

Well thought out and innovative products can be developed through the collaboration of engineering design and product design practices. Each discipline can learn from the other with the outcome not only being the possibility of a good product, but also a better perception of the big picture of product design and its contributor's value.

Distance communication can be a valuable tool. However, discipline regarding meeting times and participation needs to be maintained for an effective result. Strong leadership and good self discipline are both important assets in this area.

Overall, the students gained valuable experience from the project, preparing them well for future long distance and interdisciplinary collaborations. Being able to work with new tools and in unfamiliar goal orientated environments, such as form over function, is an important skill gained. When colleagues' motivations for direction and decision making are understood, the operation can run much smoother. These skills will stand to serve the students well heading into employment.

REFERENCES

[1] Kovacevic, A., Competence Development in an International Product Design Course, *International Design Conference - Design 2008*, Dubrovnik - Croatia, May 19 - 22, 2008

[2] Pahl, G., Beitz, W., Feldhusen, J., & Grote K.H., *Engineering Design - A Systematic Approach,* Springer, 2007

[3] Van Boeijen, A., & Daalhuizen, J. Delft design guide. Available: http://wikid.eu/index.php/Delft_Design_Guide [Accessed on 2013, 20 February], (2011, 1 May)

[4] Koberg, J, & Bagnell, J. *The universal traveller: A soft systems guide to creativity, problem-solving and the process of reaching goals*. W. Kaufmann. (1981/1991)