ECO-INNOVATION AND ADVANCED CAD WITHIN AN INDUSTRY+ACADEMIA+CONSULTANCY COLLABORATION: AN INTEGRATIVE ID STUDIO CASE STUDY IN THE AUSTRALIAN CONTEXT

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ABSTRACT
This paper discusses an "industry+academia+consultancy" collaboration between Australian electric appliance manufacturer Breville, the 3rd year industrial design studio of the University of Canberra (UC) and Eco-Innovators, an eco-design consultancy office.
Initially, the paper describes the thinking and planning process for this studio, planned with the aim of fulfilling the diverse needs of academia, industry and the consultancy within a collaboration which should be beneficial for all stakeholders. Main aspects of this initial stage are course curriculum change, the selection of the projects and diverse evaluation criteria within the different aims of the three institutions. Subsequently, the unit outline, design brief and projects are briefly described. Afterwards, some concrete examples developed by the students are used to illustrate tangible outcomes of the collaboration.
Finally, the paper evaluates the whole experience, highlighting aspects that worked as well as aspects that could be improved for the future, within the framework of action research in design education. Main conclusions of the paper describe the benefits for each of the stakeholders, which in summary were: 1) providing a broad array of innovative ideas for industry, 2) an integrated teaching of eco-innovation and advanced CAD within a real-life-project context for the design students, and 3) a trial test and evaluation of some of the educational material developed by the consultancy.
This paper is useful for design educators, industry, consultancies and many of the diverse stakeholders related to new product design and innovation as it provides concrete example of possible collaborations between multiple institutions.

Keywords: Collaboration, CAD, eco-innovation, industrial design, product design, education

1 INTRODUCTION

The term '*industrial design*' (ID) will be used within this paper for both terms; product design and industrial design, because Australian industrial design practice and education has had a tradition and reputation of an all-encompassing approach, including technical aspects of materials selection and manufacture. "*An Australian trained designer is one who comes with a robust practical approach that is engineering-like in its ability to think, design and almost simultaneously incorporate manufacturing considerations*". (Trathen and Varadarajan 2009 quoting Rob Curedal) [1].
In a period of change in design education internationally and in Australia (Trathen and Varadarajan 2009) this collaborative project maintained the core skills and knowledge around a traditional notion of industrial design, including aspects such as Design for Manufacture (DFM) and the application of advanced Computer Aided Design (CAD). It simultaneously attempted to incorporate relevant aspects of eco-innovation and design for sustainability thinking and their application into 'real life' design projects. This integrative ID 3rd year studio was also part of a transition within the new changes to course structure being reviewed and implemented including undergraduate course length reduced from a four year to three year bachelors degree and a new postgraduate two year coursework Masters. Internationally there is a strong history of industrial design education collaborating with industry for the mutual benefit of both parties, although many issues such as intellectual property, among others, must be negotiated (Liem 2009;)[2]. This has parallels in the Australian context where the UC-ID course has developed successful links with manufacturing and consultancy practices for more than 20

years to contribute to a *"Work Integrated Learning"* component of a student's design education. The approach by the companies working with the University of Canberra has often been more altruistic, with a 'wanting to give back' mentality of many graduates from the university who are now working in diverse industries. This has avoided some of the more difficult aspects of sponsored projects as outlined above.

Diverse papers report several experiences in teaching Ecodesign and Sustainability aspects to industrial designers (Belletire, St. Pierre and White 2004[3]; Montana-Hoyos 2008, 2009, 2010[4]) as well as the influence of CAD in the design thinking process (Dankwort et al. 2004)[5]. The main focus of this paper is the integration of all these aspects (transition from 4 year to 3+2 years, industry collaboration, ecodesign, CAD, and the support from a consultancy).

2 INDUSTRIAL DESIGN STUDIO, YEAR 3, SEMESTER 2, 2010

This unit sits within the final Industrial Design undergraduate studio for the new three-year Bachelor of Industrial Design course at the UC. As such its overall aim is to enable students to put into practice the knowledge and skills learnt throughout the course of their studies.

The syllabus for this unit places emphasis on the relationship between the industrial designer and the manufacturing industry. It uses and develops the way design responds to marketing theory and practice. Students engage in high complexity design projects with industry, as a means of developing design solutions that respond to marketing, ergonomics, production, engineering parameters and issues of sustainability and their effects on society. Professional ethics and responsibility are also integral to this unit and projects.

The unit, which represented 50% of the student's workload, consisted of two interrelated projects and an integrated CAD component. The two projects differed from previous collaborations negotiated with industries or design practices, in that there were more than two collaborators involved: 'Breville Pty Ltd' an Australian electric appliance design and manufacturer with local and international distribution, and 'Eco innovators', an eco design consultancy that provides a sustainability consultancy and education services mainly in Australia.

2.1 CAD integrated with studio

CAD is an integral component of the Industrial Design course at UC and by introducing it in the first year, ensures it is not only a visualization tool, but becomes an integral part of the students' design thinking process. From the start, CAD is taught from an industrial design perspective which places an emphasis on innovation and user-centered design thinking. CAD is seen as a tool for formal design exploration, development, validation and to facilitate the transference of a design concept into the real world. Typically it is taught with a design project as the driving force emulating how it is used in industry. This way it becomes an intrinsic part of the students design approach and students are able to decide when, in the design process, it is most appropriate to use.

CAD is introduced in the first year and continued in the second year with dedicated CAD units in each year. Later in the course CAD is integrated with design studios. In the collaboration discussed in this paper, studio projects and CAD were formally merged together after refined design concepts and blue foam form studies were approved for concept validation, approximately halfway through the project.

2.2 Project structure

The first project used DFM as the vehicle for applying and demonstrating knowledge, skills, and understanding of industrial design. The project involved the design of a hand held electrical appliance which entails a high level of design and manufacturing complexity. Other requirements included consideration for marketing, social responsibility, ergonomics and aesthetics, among others. Typically suitable products are those where at least 50% of the manufacturing process involves pressure die casting and or injection moulding as these typically entail a high level of design/manufacturing complexity.

The project submissions stages were: 1. Research to clarify the brief, 2. Concepts (hand generated or by basic digital means), 3. Final refined concept in 2-D accompanied by a blue foam form study to verify ergonomics, form, proportions and size of the design. 4. Approved design is developed on CAD to verify the design, produce presentation-quality rendered images, manufacturing drawings and to demonstrate understanding of manufacturing requirements. The development of a refined and fairly realistic CAD model provides students with a good foundation for entry into professional work (Dankwort et al. 2004)[5].

Industry was present at the original project handout and at two of the submissions. This was sufficient to give students adequate insight into what industry expected, while not imposing too high a demand on industry-staff time. The format also gave the students a sense of "real-world work achievement".

The second project was chosen in relation to the main project, but its focus was more on the sustainability aspects of design, rather than the manufacturing aspects. Although it is important to consider all relevant aspects in the design process as mentioned above (also summarized as syntactic: how it's made, pragmatic: how it's used and semantic: what it communicates), for educational purposes it is sometimes useful to give a specific focus to some of the projects, so students can concentrate and fully grasp the application and value of the aspect emphasized (such as basic composition, ergonomics, etc).

As such, the main task of the second project was to apply self-researched design for sustainability strategies in order to design an environmentally friendly package (taking in account aspects such as transportation, exhibition and storage, among others) for the product developed in project 1. The project had to be supported by concrete facts that explained positive social, economic and environmental impacts of the design through-out the complete life cycle of the product.

3 RELEVANCE OF PACKAGE DESIGN IN TEACHING D4S

Package design was chosen for three main reasons: 1) in terms of environmental impact, packages are some of the items that produce most waste material, 2) most products need a package and 3) package design is one of the possible fields of specialization of industrial designers.

Packaging's primary function is the protection of goods or products prior to consumer purchase and use. However, packaging serves several other purposes which are mainly "Storage" (the physical and pragmatic aspects), and "Sales" (the emotional and semantic aspects which have a direct impact on marketing and economic aspects). Although apparently simple, package design has to consider aspects such as stackability, palletization, distribution in containers, and exhibition in the point of purchase, among others and requires a thorough analysis within a systems approach.

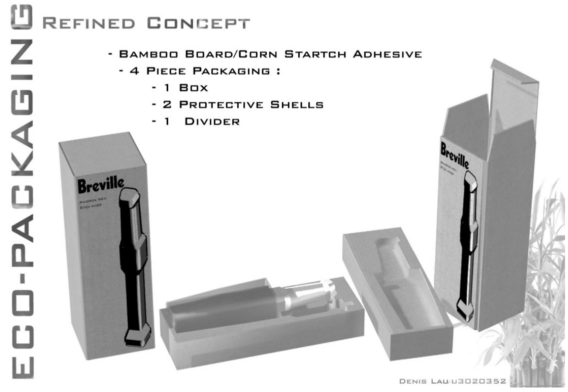
Life Cycle Analysis (LCA) and thinking was the main ecodesign tool chosen for the course, with diverse educational material which included the material developed by the consultancy Ecoinnovators, such as the document "Life Cycle Thinking" (http://www.thesecretlifeofthings.com/). Although different authors classify the diverse stages of the life cycle of a product in different ways for this project a general framework of 8 steps was provided (based on the Okala curriculum by IDSA 2008) as follows: Raw Material Extraction, Material Processing, Component Manufacturing, Assembly & Packaging, Distribution & Purchase, Installation & Use, Maintenance & Upgrading, Incineration, Land filling or Re-cycling, Re-using & Repurposing.

In relation to LCA understanding and application by the design students, packaging was a very relevant topic, as it is a "stage" of the product life cycle *per se*, and is closely related to other stages, such as "distribution & purchase", which also established a close relationship with the life cycle of project 1. Furthermore, the complete life cycle of diverse types of packages was studied in itself, exploring social, environmental and economic aspects relevant to each step of the lifecycle. This provided valuable knowledge of Design for Sustainability (D4S), while simultaneously expanding the student's knowledge on packaging materials and manufacturing processes, pertinent to DFM.

4 OUTCOMES IN TERMS OF STUDENT PROJECTS

The practical outcomes in terms of concrete student design proposals varied widely, from incremental to radical innovation. In general, more traditional proposals were mainly re-designs of current existing product packaging, with efforts in reduction of material and package volume and easy separation for recycling. More radical proposals ranged from exploring new materials (such as newly developed bioplastics made from mushrooms combined with biodegradable glues and inks), to other proposals which looked for an extended life of the package by turning it into accessories for the product (such as vegetable cutting mats, baking trays or other containers and racks that could be reutilized). It is interesting to note that no proposals were radical enough as to propose a complete dematerialization of the package or totally new ways of distribution, but this is understandable due to the nature of the product and the requirements of the project. However, future refinements of this sort of project could

include more radical approaches, maybe in collaboration with marketing students and with a stronger focus towards innovation and new ways of distribution, in line with current evolution of traditional industrial design in terms of service design or user experience design. This proposes a transition from sustainability as a component in design, to design as a component for sustainability.
Some of the most interesting examples of projects developed by the students, from incremental to more radical eco-innovations, are: Figure 1. Student Aaron Shaw focused on reducing the amount of elements and material in the package, whilst at the same time reducing volume of the package and increasing the amount of packages per pallet (which lowers the carbon footprint of the transportation step of the life cycle of the product). Figure 2. Although apparently fairly traditional, student Denis Lau focused on the use of renewable and biodegradable materials, such as bamboo pulp and mycobond. His proposal also included bio-degradable components such as corn starch adhesive and soy-based inks. Figure 3. Student Sam Cameron integrated a chopping board as the structural part of the package of the stick mixer, thus extending the life of the package components. Also, the handle might avoid the need to use plastic bags. Figure 4. Student Harry Lees opted to create a package that was rather a case and exhibitor for the product, thus extending the useful life of the package. Also, an integrals structural part of the package is the base, which is a baking tray, an accessory that blends well with the main use of the product.



Figures 1 and 2

Figures 3 and 4

5 DISCUSSION

In Australia, like other western economies, industrial design and product design have traditionally focused towards marketing goals and DFM, within the expected education of industrial designers prepared to work in traditional industry. Although many of these items were considered in this project in collaboration with industry, it is also an example of a successful engagement of the interrelated and ever increasingly co-dependent agendas of manufacturing, sustainability and industrial design

"*Design thinking"* has become a buzzword used by governments, companies and academia (similar to the case of the term *"sustainability")* there are many discussions in education on how to balance thinking skills with traditional design communication skills, such as sketching and CAD. Many designers and design managers currently recruiting recent graduates have criticized design schools for prioritising *'design thinking'* above basic design skills, such as sketching and modeling, which are inherent to the design process and communication. On the other hand, Mc Cullagh 2010 proposes that "*today, as business and governments start to take design thinking seriously, many designers and design experts are distancing themselves from the term"*[6]. We would argue that today a strategic design thinking focused on eco-innovation and D4S is fundamental in today's industrial design education, as seen in the evolution of ID and ID education, but nevertheless skills such as sketching and CAD are very important to communicate design projects and mandatory skills in professional work with industry. However, through this integration, the paradigm of DFM (design for manufacture) and D4S, the described collaboration could be understood as an evolution into a hybrid: D4SM (Design for Sustainable Manufacture).

Important benefits to industry included: opportunity to identify prospective graduates for employment; inspiration for fresh ideas; opportunity to be involved in having input to the development of future graduates; and giving 'something back' to their *"alma mater"*. Benefits to the course, staff and students included: benchmarking the ID course; ongoing course development to respond to current and future industry requirements; essential insights for students into how industry operates and its expectations; and establishing and maintaining valuable relationships with industry.

As stated by Acaroglu et. al (2010) the main objective of the participation of the consultancy (which was conducting a survey with diverse ID programs in Australian universities) was to *"evaluate the effectiveness of The Secret Life of Things (SLOT) project and the associated resources to test the assumption that new media and interactive educational resources are an effective method of engaging young people (often referred to as generation Y) with sustainability in the design and product development sectors"*[7]. As such, some of the benefits for them were: Divulgation of their educational materials as well as their consultancy services to future professionals and feedback from the users (design students) about the educational material, for evaluation and further improvement.

In relation to the link between the 2 projects (electric hand-held product design and the subsequent package for it) the package design project was an interesting vehicle for the students to explore a design for sustainability (D4S) focus within a real-life industrial project. Not only the project completed and enhanced the understanding of the main product design, which was useful for Industry as well, but also gave the students the possibility to understand a product, not in isolation but as part of a system, and to apply some basic Life Cycle Assessment (LCA) thinking tools to a concrete design project while becoming aware of social, environmental and economic considerations throughout the whole life cycle.

However, as noted by one of the authors in other similar courses in different contexts, it is evident that students concentrated mainly in the environmental and economic aspects, and less in the social aspects of sustainability. This is probably due to factors such as: the wide availability of ecodesign tools (which have an environmental focus), the direct link of design for manufacture with economic aspects of design and the economic constraints that the idea of "industrial feasibility" might pose in the mind of the students, and finally the lack of more specific guidelines and easy to use tools in terms of social metrics available to industrial designers (White 2008 as interviewed by Montana-Hoyos 2010)[4].

Although not conclusive, anonymous feedback from the students suggests that this sort of collaboration was very meaningful, providing an understanding of real-world situations. Some students did complain about the workload, but form anecdotal evidence from the authors' combined experience this seems to be a constant feedback in design-related courses.

Student feedback for the unit is derived from independent and anonymous Unit Satisfaction Survey (USS) data. The overall satisfaction was 78%,: Good Teaching Scale average score of 82%, Student experience Scale-positive contribution to student's overall experience at the University was 98%.

Further research in order to validate arguments above would include surveys with the participants in a later stage (maybe two years from now), in order to identify if the collaborative project had some long-term impact, on students as well as the industry and the consultancy. Possible indicators of this would be evidence of future implementation of some of the learned tools in the students' future professional practice, the implementation of some of the ideas by the company, or evidence of refinement to the educational material from the consultancy based on direct feedback from UC students

6 SUMMARY AND CONCLUSIONS

The main aspect to highlight from this project is the collaboration between the three institutions and the benefit for the diverse participants. Although the students benefited directly both from the input from industry and the input of the eco-innovation consultancy, both the consultancy and industry also benefitted. On one hand, the consultancy was able to test, evaluate and refine some of their newest educational material for design for sustainability. Simultaneously, while the industry received an interesting pool of different ideas about their product, they also received relevant information about possibilities to embed eco-design strategies to their products and packaging, offering a more complete and holistic solution.

The integration between both projects (the electric appliance and the package) through the product development process and with the support of advanced CAD and eco-design analysis tools provided the students with a broad understanding of the aspects involved in real–life product development. It also emphasized the importance of a systems and life-cycle thinking approach which considers not only the product in isolation, but also diverse issues related to different steps of the life cycle of the product and in relation to social, environmental and economic aspects.

In essence innovation is the implementation of creativity, and creativity implies the ability to find new connections in existing elements. Thus, we would argue that this type of collaboration offers a wider variety of elements than the standard industry+academia collaboration, thus enhancing the environment for creativity and especially for innovation.

Follow up studies with Alumni about the benefits or otherwise of these types of projects and their overall industrial design education are proposed. These include alumni, people who are employed in a DFM realm or others who have had to adapt their practice or perhaps have left design all together

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