INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2018, DYSON SCHOOL OF DESIGN ENGINEERING, IMPERIAL COLLEGE, LONDON, UNITED KINGDOM

A COMBINATION OF DESIGN- AND SCIENTIFIC- LED PROCESSES CAN BE A SUCCESSFUL APPROACH TOWARDS BUILDING INNOVATIVE PROJECTS

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ABSTRACT
Students like myself, the first author of this paper, with a science research background that have never been exposed to design methodologies initially struggle to deliver well-defined innovation led design proposals because they lack the flexibility to look into the future. They are used to structured procedures that are necessary for scientific experiments that do not provide space for imagination and improvisation. Within a design environment, speculating about future scenarios and how they will affect our behaviours are at the centre of innovative approaches. In some cases, design students, opposite to science research students, do not follow a linear process and then struggle to provide sufficient experimentation or hard evidence that backs up their visions. A combination of design and scientific tools provide an adequate framework for innovative projects: students that apply a scientific method to design experimentation are able to visualise, understand and express their progress. At the same time, exploring an innovative concept from both a practical and creative point of view increases the chances of creating a successful user-product interaction. It is equally important to base future concepts on current scientific research and to include creative design inputs to allow students to think ahead of what is happening today. This flexibility is needed to shape products and experiences for the nearby future. As a conclusion, a combination of both design and science tools can provide an effective route towards innovative design projects.

Keywords: Design process, scientific method, interdisciplinary collaboration

1 INTRODUCTION

The Innovation Design Engineering (IDE) masters was originally set up under the moniker Industrial Design Engineering in 1980. It arose from conversations between Professors Misha Black and Frank Height from the Royal College of Art and Professors Hugh Ford and John Alexander from Imperial College London and was conceived as a pathway for enabling engineers to acquire design skills and pivot into a new type of industrial designer [1]. As might be hoped for a degree associated with the terms innovation, design and engineering the degree has gone through regular phases of development and now no two years are the same [2]. The degree in its current inception is characterized by a series of intensive project activities in the first year, where students spend between 3 and 5 weeks working within a framework set by the course team. Currently approximately one third of the students admitted come from a design background, one third from engineering and one third from diverse backgrounds.

The students can generate their own brief within this framework and the majority of learning is achieved by peer to peer activities and tutorials enabled by a blend of permanent staff from both institutions and a significant number of visiting tutors, many of which are practitioners. A mix of solo and group project work is undertaken in the first year of the programme within modules such as Elastic Octopus and XY. In the second year students undertake a one term long student generated group project, followed by a two term solo project, again student generated. It is within this context that this paper presents the experiences of a particular student in navigating their journey through the programme and rationalizing their diverse backgrounds with the rules, frameworks and traditions as well as opportunities enabled by the innovation design engineering framework. A particular focus of this paper is the rationalization, or otherwise, of approaches associated with a scientific educational pathway with design and the innovation design engineering programme. Section 2 of this paper considers some classic design processes and a scientific method to provide context for describing these experience, prior to consideration of a series of project experiences for the student concerned which are described in Section 3, prior to a discussion in Section 4 and conclusions in Section 5.

2 STUDENT PROCESSES & METHODS

The Innovation Design Engineering programme is characterised by a series of experiences in the first year where students explore different options for design process through discovery. No single process is actually enforced although of course students will arrive with diverse experiences and knowledge of some of these. The rationale for not enforcing explicit methods is to give students freedom to explore an innovation landscape systematically, through a journey of serendipity, or some other means as they choose. Two genres of approaches that are often encountered in the programme are now described.

2.1 Design Processes

There are a wide range of design processes that have been documented as representative of practice. Examples include a systematic engineering design approach [3], the total design approach [4] and double diamond [5], as prominent exemplars. These typically involve phases of activity and iteration with information occurring at some later phase resulting in the need or opportunity to revisit a prior phase in order to address an issue or/and improve the outcome. In addition to these classic design models, some researchers have noted a non-linear or haphazard approach to design (Figure 1).

Figure 1. Newman Design Squiggle illustrating the design process [6]

2.2 Scientific Approach

"It is a systematised way of collecting, classifying and analysing data, making interpretations and formulating a logical conclusion." [7]

The scientific method allows its user to explore and explain phenomena by using logical steps (Figure 2). Through these steps, the user tests a hypothesis by manipulating experimental factors and looking at the results in responding to this variable. It is crucial to properly control experimental conditions so that others can repeat the results independently.

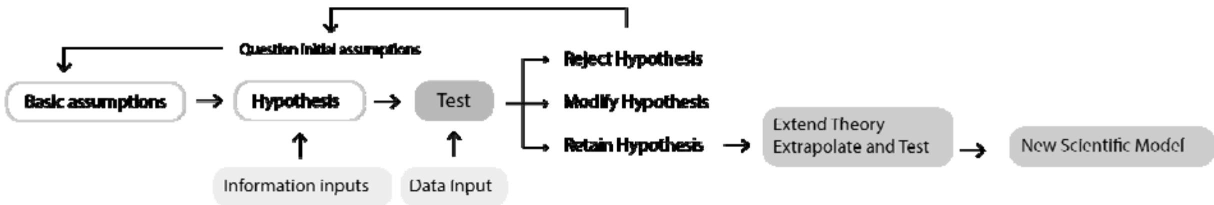

Figure 2. Lambert Dolphin's scientific method steps. Modified from CBE Life Sciences Education [8]

3 PROJECT CASE STUDIES

3.1 Elastic Octopus

Elastic Octopus was a disruptive module that prepared the students to confront challenging briefs that can be resolved after successive attempts and failures [9]. During this project, our team had to come up with a tele-transportation concept that we narrowed down to the creation of an engaging teleconference experience. We analysed different elements, such as eye contact, distance and position of the interlocutor, directional sound, physiological responses and body language.

During this stage we split into two teams to perform social experiments related with teleconferencing interactions. Testing included understanding the distance at which people wanted to interact. For this we created a screen prototype that framed our faces with two emerging ropes. The interviewed people were requested to decide at what distance they wanted to interact with us, considering it a teleconference call by pushing or pulling the screen further away (Figure 3).

Figure 3. Prototype to test users comfort distance for a teleconferencing experience

Once we gathered our results we realised that our outcomes from the same experiments were different and, hence, it was not possible to extract useful information. After further analysis on how the test was performed, I realised that we were not managing experimental variables in the same way, and how questions were conducted or how props were given to the users were different. We then conducted the experiments once again, but both teams did exactly the same. This time, we obtained similar results and could extract information that helped us build the next stage of the project. As a result of our exploration, we created a more natural experience when teleconferencing, that included a dynamic interface that can be modified, zoomed in and out and moved around in space, according to the user's needs (Figure 4).

Figure 4. A humanized teleconference experience was created. Real life conversations are dynamic, and this interface allows moving and scaling your interlocutor

3.2 XY

Singular, a mask for multiple appearances, exploits the colour changing properties of nanocrystals. It consists of an ultra thin, flexible skin made with responsive RGB molecules that enables people to have a dynamic face. Exposures to different light wavelengths activate the appearance of red, green and blue that overlap to create colours (Figure 5).

Figure 5. Nano mask changes colours through a reversible redox reaction allowing its users to change the aspect of their skin for medical or purely aesthetical purposes

This project came from the XY module that expects students to embrace current scientific advancements to create an innovative vision on how this technology could be applied in the nearby future. We partnered up with the nanotechnology department at Imperial and were introduced to their laboratory facilities and research. Our team spent many days researching in depth about nanotechnology. We had a general understanding, but struggled to connect this to any future vision. After days of frustration, we switched our approach and looked into topics that we were interested in, not necessarily related to any kind of technology. We ended up focusing on makeup and why/when we decide to use it. We were discussing that light has an effect on how we look and that was enough for one of our team members to decide it was time to improvise. We took some fabrics and lights with us, and we locked ourselves inside a dark room and flashed lights at a teammate's face (Figure 6) I was not familiar at all with this approach, and did not see any relations between makeup and our sudden idea of a lockup, and find it even harder to relate it with the goal of our science-led project.

Figure 6. Effect of light projected at different angles

This was the starting point of the development of a concept where different light colour projected into someone's face would take over the makeup and plastic surgery industry. We had previously read about the use of nanopigments for reusable paper and took that existent research to apply it in this context.

3.3 Group Project (Ripple)

Ripple is an accessory that encourages the experience of courtship in daily life, by scanning the surroundings and giving you tactile feedback when it detects that someone is interested in you. Ripple is the outcome of our second year group project that started from the broad statement that people have been moving away from communicating face to face.

Our increased uptake of digital technology has led us to be more immersed in a virtual world. We are less present in real life, making us feel vulnerable when we interact in the physical world. We wanted to investigate vulnerability in first interactions in as much ways as we could possibly think of, which lead to over 20 experiments that did not necessarily had a hypothesis or clear vision of what we wanted to achieve with it. We allowed ourselves this flexibility so that we would get the chance of getting insights from people rather than from our own pre-considerations. By the end of the initial exploratory phase we generated a visual map to cluster our experiments and have a look at a bigger picture that would allow us to find interesting connections between them. From there we picked the branches that we believed were most relevant and pursued further experimentation.

When narrowing down we decided to focus on romantic interest, and realised that a wearable device was the best way to move forward. From here we branched out again, but now with a clear focus on what it was that we wanted to create as our final outcome. This stage was about supporting initial experiments with proven scientific facts and adjusting the experience that we wanted to create by doing several user tests (Figure 7).

Figure 7. Different stages of prototyping the concept of a wearable device that provides tactile feedback that lets the user know who is romantically interested in them

4 DISCUSSION

In the three case studies described in Sections 3.1-3.3, creative tensions highlight the differences between scientific and design mindsets. These tensions and their results are discussed below.

4.1 A Science-led Approach: Experimental Variables

> *"We didn't understand that we understood experimentation in different ways" – IDE student (design background)*

Referring to the first case study (Section 3.1 - Elastic Octopus), the two team members executed identical social interaction experiments with users, only to generate inconsistent results, due to inconsistent treatment of experimental variables. The rigorous treatment of variables (varying only one parameter at a time) in the students' design experiments allowed validated discoveries and insights to be made, driving the project forward. In this case, the established view of variables from the IDE student with a scientific background prevailed.

4.2 A Design-led Approach: Suspending Disbelief

> *"It is the opposite from science! One would not typically start with improvisation." – IDE student (science background)*

Referring to the second case study (Section 3.2 - XY), the team members initially started with a science-led approach; conducting an extensive literature review to understand the technology they were working with. However, this led to a creative block, when tasked with envisioning the technology's contextualisation within society. In this case, a large amount of uncertainty was encountered, where an inspirational design-led approach helped. This required the scientific mind to 'suspend disbelief', to explore an innovation space through play. Once an opportunity was established through creative improvisation, then effective hypotheses could be formulated and tested rigorously.

4.3 Bringing it together: A Hybrid Scientific and Creative Approach

It is then important for hybrid creatively- and technically- minded students to be able to move through scientific and designerly modes of thought, or to operate in teams that respect these processes. This was demonstrated by the students from the first two case studies collaborating effectively on a larger, more complex project with a self-set brief. In this case (Section 3.3 – Group Project), the students reflected on how they had come to trust each other with different skills and developed their own unique approach to experimentation that blended the above approaches. Here, the group already had a good understanding of the importance of controlling the variables during experimentation learnt from previous projects; whilst simultaneously acknowledging that doing experiments without a precise hypothesis or variables is useful discover surprising or unexpected interactions.

The student group further identified an important skill of 'clustering' insights to transition between inspirational 'gut-feeling' exploration to rigorous science-led experimentation. This clustering activity brought together otherwise unhelpful, isolated insights generated from experiments, to identify important sub-topics, which in turn seeded more experiments, which begun to introduce scientific facts and research.

> *"The challenge in educating both designers and engineers concurrently is that of bringing to the designer the discipline of analysis and technological mastery, whilst for the engineer [or scientist] it is the move from analysis and theory to the handling of grey data". [2]*

A key opportunity in blending technical and creative cultures exists in the interplay positivist and constructivist approaches to problem solving and opportunity exploration, which Dorst and Dijkhuis describe as opposing paradigms of design activity [10]. By switching dynamically between convergent and divergent modes of thought and methodologies (as exemplified by the design and scientific methods described in this paper), students are empowered to conceive of and deliver imaginative and rigorous innovations. Students' hybrid approaches of working feel natural to each student, and often can go on to define students; professional identity and practice as seen on an IDE alumni design consultancy start-up for robotic interventions in ecosystem damage [11].

Through mediating conflicting approaches, each student in a hybrid team is forced to adapt their existing structures of knowledge to accommodate other ways of working, a key feature of social constructivism [12]. This informs the pedagogical approach of the programme – the emphasis on creating hybrid teams of students from different creative and technical cultures, and to encourage the formulation of design briefs that encourages students to encounter the limitations of a singular method, approach or way of thinking.

However, the collision and successful integration of two different working cultures and practices requires students with open minds, strong facilitation and conflict mediation, situated in a context that encourages self-definition of approaches.

5 CONCLUSIONS

Interdisciplinary working is of paramount importance for the modern designers working in an industry that often places them at the nexus of several disciplines. Whilst this has important implications for design education, Friedman argues that "interdisciplinary research is inherently ambiguous" [13], which makes interdisciplinary methodologies difficult to integrate into pedagogic practice. This paper illustrates the opportunities and challenges created when students' methodologies from two disciplines collide, compete and interact to create innovative concepts.

This collision of scientists and designers, when mediated well, often allows students to establish their own hybrid working methodology. In this case study, this approach merges both design and scientific tools: design instruments are essential to let creativity flow and discovering new connections, whilst scientific tools are needed for performing rigorous experimentation, clustering and building evidence to support creative starting points. Finding the right balance between design, creativity and scientific rigour can provide new routes for the development of innovation led projects.

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