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

INFORMAL MULTIDISCIPLINARY COLLABORATIONS: ADDING PERSPECTIVE AND VALUE

Kelly UMSTEAD and Preston MOELLER
North Carolina State University

ABSTRACT
It is well-accepted that multidisciplinary collaborations produce higher quality product development output than work from singular disciplines. Partnerships between industrial designers and engineers are desirable and ever-present in academic institutions. Though attractive, there are logistical challenges that make these formal relationships time-consuming and complicated. This paper describes an informal collaboration between industrial design students working in conjunction with biomedical engineering students running the Helping Hand Project (HHP), a student-run non-profit organisation that provides children with upper limb prosthetic devices. Industrial design students applied human-centred design methodologies that addressed the needs of children with reduced hand function. Biomedical engineering students acted as a non-profit client and knowledge experts on the topic and were heavily involved throughout the project, but not directly responsible for the final deliverables. A survey was conducted to collect industrial design student's self-reported assessments on interdisciplinary (interdisciplinary skills, reflective behaviour, and the ability to recognise interdisciplinary). This type of relationship, albeit informal in the current implementation, can be useful for students seeking insights into the working processes of other disciplines as well as understanding professional working relationships. The development of interdisciplinary skills within informal collaborations is the precursors to successful collaboration with outside disciplines.

Keywords: Multidisciplinary collaboration, interdisciplinary skills, design perspective, industrial design and engineering

1 INTRODUCTION

Within the product development industry, the allegiance between industrial designers and engineers is considered a necessary factor for successful innovation. The university setting is the ideal environment to foster these alliances, deliver valuable skill sets to students, and provides differentiation for programmes within the university. Research supports that collaborations enabling diverse perspectives yield quality products, entrepreneurial endeavours and educational success [1-4]. The challenges of multidisciplinary collaboration are also well-documented, particularly between industrial designers and engineers. Problem and project framing, design intent definition, industry lexicon, and values and drivers may be mismatched between disciplines and can hamper project progression. Conversely, the very same challenges are typically considered valuable learning experiences for students, both from the facilitator's point of view and in retrospect by the student.

Multidisciplinary and interdisciplinary collaborations are becoming more common and desirable within academic settings. There are a number of formal academic collaborations between industrial design and engineering disciplines (Marquette University and The Milwaukee Institute of Art and Design, the University of California at Berkeley's New Product Development course with the California College of Arts, MIT's joint programme with the Rhode Island School of Design, and Carnegie Mellon University's Integrated Product Development course, to name a few). Many of these partnerships began as informal collaborations. It is becoming increasingly desirable, and difficult, to formalise these interdisciplinary relationships while also satisfying multiple accreditation bodies, offering accessible courses and aligning disparate schedules. But yet, it is critical to expose industrial designers and engineers to multidisciplinary collaborations within the academic setting [5-7]. Formal collaborations are not always available and often require long periods of time to establish. This paper evaluates the roles and responsibilities of design and engineering students in an informal collaborative setting and discusses the skills and value attained, retrospectively, as beneficial to both parties.

2 INFORMAL COLLABORATION

2.1 Helping Hand Project

An informal collaboration was developed between industrial design students and biomedical engineering students (North Carolina State University and UNC/NC State Joint Department of Biomedical Engineering respectively) within an industrial design studio setting. The industrial design students worked in conjunction with the Helping Hand Project (HHP), which provides upper limb prosthetic devices to children. Each year, there are hundreds of cases of children born with missing fingers or hands which have not fully formed. Some of these children have reduced functionality of the hand that may be supplemented with the use of a prosthetic device. While beneficial, these prosthetics may quickly be outgrown by children and require significant financial investments from families. The Helping Hand Project (HHP) is a non-profit organisation, founded and run by biomedical engineering students, that provides upper limb devices to children, free of cost, using 3D printing technology. The HHP engineering students volunteer their time, expertise and skills to design, produce and deliver prosthetic solutions to children with limb differences. A mixed-level industrial design studio comprised of juniors and first-year graduate students (with non-industrial design backgrounds) partnered with HHP biomedical engineering students to design solutions which meet the needs of the children served by HHP.

2.2 Stakeholder analysis and role determination

A majority of interdisciplinary interactions occur relatively late in the educational progression, either during the senior year or within the final semesters of a graduate programme. This structural framework is based on a number of factors including, but not limited to, student technical competence within one's own field as well as the understanding and utilisation of design methodologies and skill sets. It is also likely that students do not receive formal training or guidance of how to work in team settings and are usually required to 'figure it out' along the way. While each student strives to provide meaningful contributions, they are simultaneously learning how to best communicate and work with the other disciplines. The necessary effort for team alignment may outweigh the time spent developing the actual project. From the facilitator's perspective, ample time should be focused on the collaborative process and the systematic management of the process as well as the management of collaboration. This can be effective, yet time-intensive [8].

In a typical multidisciplinary setting, both the designer and engineer would contribute to the development of the project. Referencing a simplified version of Brezing and Löwer's Integrated Product Model, the engineer would be responsible for practical functions and the industrial designer would contribute to the semantic functions (Figure 1) [9]. The practical functions are defined as the technical and operative aspects of the design while the semantic functions inform the sensory perceptions of the user which ultimately produce emotional and cognitive effects to the user. The Integrated Design Theory is used to express the essential relationship between designer and engineer in the product development process. Each profession possesses distinct knowledge that is required for a successful collaborative deliverable and fruitful partnership [9].

Within an equitable collaboration the active working area of the engineer-designer dyad resides near the central section of the Integrated Design Model Ramp Diagram (See Figure 1a). In the instance of the HHP current non-profit functioning structure, there are no industrial designers involved, so the active working area resides in the far-left region, indicating a majority practical functioning. The industrial design studio course was unable to impart a true collaboration, where the industrial design students and engineering students were equal partners in delivering the final product implementation. Alternatively, an informal collaborative structure was established, where the industrial design students adopted the non-profit HHP as a client, subsequently engaging the engineering students. This implementation shifted the active working area towards the right, outside of what a true collaboration would be in terms of responsibility for the final deliverable. However, integrating the various perspectives of the engineer into the product requirements throughout the process had an influence on where this working range ultimately resided (Figure 1c).

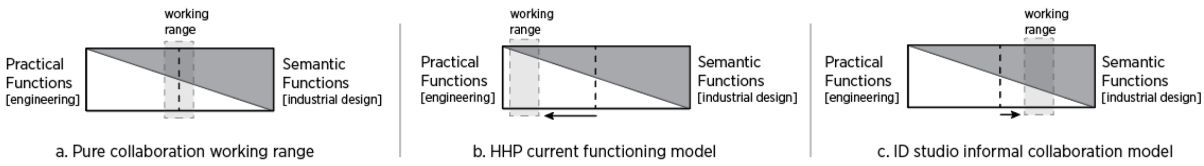

Figure 1. Integrated Product Model (adopted from Brezing and Löwer [9])

The industrial design students did not view the engineering students as team members, but as multifaceted stakeholders. In this permutation of an informal collaboration, the engineers filled the role of non-profit clients (being that HHP was providing feedback and critique throughout the design process and would be responsible for the final employment to the field), manufacturers in the design process (the student engineers are responsible to implement, modify, and produce 3D printed deliverables) and as knowledge experts (possessing technical knowledge unique to their field) (Figure 2). The engineering students wore many hats while involved with HHP and an understanding of the distinct nuances of the various roles proved critical to the success of the final product implementations.

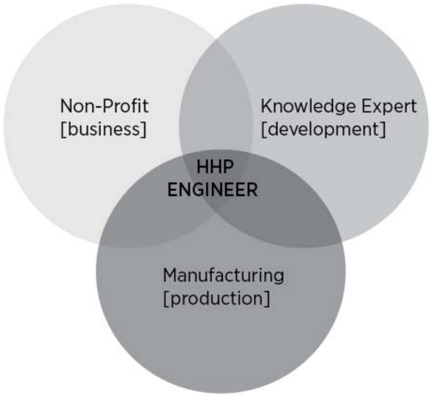

Figure 2. Stakeholder facets of engineering students

2.3 Project structure and collaborative touch points

The studio structure and general design methodology were established as follows:

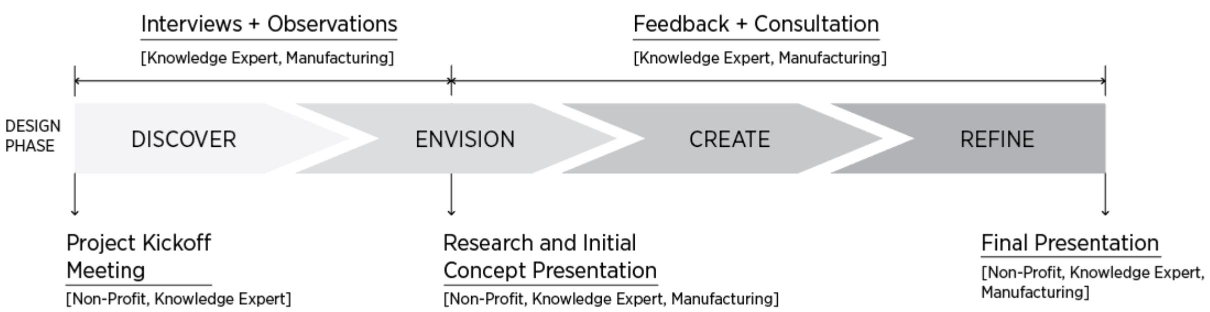

Figure 3. Design method and engineering roles at specific touch points

The industrial design students interacted with the engineering students multiple times over the course of the project. At project kickoff, several members of HHP attended the studio to provide an overview of HHP and the community services that they provide. HHP shared 3D printed parts of current models of upper limb devices. At the kickoff, the ID students viewed the role of the engineering students as non-profit business and engineering knowledge experts. Throughout the discovery portion of the project, industrial design students interviewed engineering students regarding these assumed roles at HHP, categorised as knowledge expert (design responsibilities) and manufacturing (production responsibilities). After the discovery phase and early-stage envision phase another milestone touch point for feedback occurred. Here the engineering students functioned as all three stakeholders: the non-profit, knowledge expert and manufacturer. During the creation phase, the engineering students were again consulted as engineering knowledge experts and manufacturers. During the last touch point, final presentations, the engineering students once again assumed the role of all three facets of the stakeholders. These facets of the engineering roles are important to understand because they influenced the designers' understanding of the perceived needs of the engineers and associated drivers, provided insights into their working methods, standards of success and expectations.

3 INTERDISCIPLINARY DISCOVERIES

Lattuca et al has identified a framework of interdisciplinary [10]. This was developed for large-scale university engineering programmes and has been adapted to the informal collaboration discussed here. In Lattuca et al's work, three factors of interdisciplinary were identified: appreciation and application of interdisciplinary skills, reflective behaviour and interdisciplinary recognition. After the conclusion of the studio course, students were surveyed to assess their self-reported measures of each of these three factors [10]. This paper does not claim validation of this tool for assessing the credibility of the data collected due to the small sample size of industrial design studio participants (n=10).

3.1 Interdisciplinary skills

One factor that Lattuca et al identifies within interdisciplinary is appreciation and application of varied perspectives. This includes the understanding of how specific disciplinary knowledge adds value to a project, as well as the integration of social co-operation across disciplines while expressing value for these diverse experiences. It requires an increased awareness of one's field of study and subsequent reflection on appropriateness of implementation. There must be successful application of skills to achieve a final deliverable that would unable to be achieved without the collaboration [10]. This informal collaboration realises the value that the engineering students bring. In addition to the practical functioning side of the product development equation, they also offered a personal perspective due to their involvement with HHP over time.

3.2 Reflective behaviour

Awareness and appreciation is followed by reflection, which is an understanding of how inherent biases affect project outcomes. This links closely to appreciation and application but is distinct because it is in regard to self-awareness [10]. The industrial design students needed to evaluate their knowledge limitations and gaps to determine where and when to seek external input from the engineers.

3.3 Interdisciplinary perspective recognition

The third factor identified by Lattuca et al is the recognition of interdisciplinary. This includes learning disciplinary boundaries, as well as achieving successful integration to move forward within the project [10]. In this studio setting, industrial design students were not provided any background information regarding their engineering collaborators. They had to discover these nuances through primary source data collection: observations and interviews with the engineers. Although the intent was to assess their needs regarding the Helping Hand Project, gaining a deep understanding of the multifaceted engineering needs required an understanding of the drivers and measures of success that the engineering students value. Although this was not seamless, it was relatively easy within the informal collaboration framework. While the engineers were not responsible for producing deliverables, they certainly maintained a voice within the process. This implementation of the professional relationship negates obstacles relating to contentious team work. The nature of the project also allowed for easy alignment between disciplines with the ultimate goal of providing design solutions for children with limb differences.

3.4 Survey results

The survey responses from the industrial design students were collected, averaged and are reported in Table 1.

Table 1. Interdisciplinary Factor Survey Results (n=10)

Factor	Survey Question	Mean (std dev)

Interdisciplinary skills	I value reading about topics outside of design.	4.5 (0.8)
	I enjoy thinking about how different fields approach the same problem in different ways.	4.8 (0.4)
	In solving problems, I often seek information from experts in other academic fields.	3.7 (0.9)
	Each academic field has its limitations when it comes to solving real-world problems.	4.5 (0.8)
	Not all engineering problems have purely technical solutions.	4.7 (0.5)
	Given knowledge and ideas from different fields, I can figure out what is appropriate for solving a problem.	4.2 (0.6)
	I see connections between ideas in engineering and ideas in design.	4.6 (0.7)
	I can take ideas from outside design and synthesize them in ways that help me better understand.	4.4 (0.5)
	I can take material from different fields and integrate it in ways that help me better understand.	4.4 (0.5)
	I can use what I have learned in one field in another setting.	4.7 (0.5)
Reflective Behaviour	I often step back and reflect on what I am thinking to determine whether I might be missing something.	4.0 (0.9)
	I frequently stop to think about where I might be going wrong or right with a problem solution.	3.9 (0.7)
Interdisciplinary Perspective Recognition	If asked, I could identify the kinds of knowledge and ideas that are distinctive to different fields of study.	4.4 (0.5)
	I recognize the kinds of evidence that different fields of study rely on.	4.2 (0.7)
	I'm good at figuring out what experts in different fields have missed in explaining a problem/solution.	3.6 (0.5)
	I usually know when my own biases are getting in the way of my understanding a problem or finding a solution.	3.7 (0.6)

Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree. [10]

4 DISCUSSION

The results of the survey indicate that the industrial design students express a degree of confidence regarding the self-reporting of interdisciplinary factors. They self-reported the highest numbers when averaged across the interdisciplinary skills factor (mean 4.5 across the factor). Reflection (mean 4.0) and recognising interdisciplinary perspectives (mean 4.0) follow behind reporting the average across factors. It was evident, anecdotally, within the studio that the industrial design students successfully cooperated across disciplines relatively unimpeded. The industrial design students did so willingly while recognising the unique perspectives and the added value that the engineers brought to the design projects. The very nature of the human-centred design process prepares the industrial design students for success in this regard.

The industrial design students emerged from this studio with numerous benefits from the informal collaboration. They were exposed to the unique perspectives and the subsequent needs of their engineering stakeholders. They gained knowledge of the needs of a non-profit entity, the perspective of engineering design methodologies and production requirements. The industrial design students gained empathic insights into how the engineers work to achieve their goals by understanding different perspectives and what the engineer's value as successful solutions. All of these factors provided the design students with interdisciplinary competencies.

Survey data was only collected from industrial design students enrolled in the course, which excluded the engineering students. However, it is believed that value was attained by the engineering students as well. For many of these engineering students, this studio project was their first introduction to the human-centred design process and its associated methodologies. It was also their first exposure to industrial design as a profession and subsequently, to the roles and capabilities of an industrial designer in the product development process.

Below are samples of unsolicited feedback from engineering students involved in the collaboration:

"It was refreshing to see new and creative ideas that tackled some of the main problems that we had at a different angle. Our club focused primarily with different hand designs but this helped me see that

not all prosthetics needs to look like a hand and can rather mimic a tool instead. It reminded me that sometimes the best designs are the simplest ones."

"Human centred design has been an aspect that we have been oblivious to, and the designs we have used in the past remained grounded on feasibility, rather than the personalisation needed when fashioning something unique to an individual."

5 CONCLUSION

As previously stated, interdisciplinary collaboration brings significant value to innovation. Informal collaborations may offer benefits to the collaborators that are expected, for they are easier to set up, manage and support. They also offer unexpected values; in this instance as a gateway to interdisciplinary training. Informal collaborations, as described here, may be an obvious first step to setting up more formal collaborations and also may be an appropriate way to introduce various disciplines to working with one other. There is an absence of tricky team dynamics or barriers regarding discrepancies of unfair work load because one segment of the collaborative group has ownership of work. These informal collaborations may begin taking place earlier in the academic careers of students so as to foster the development of interdisciplinary skills early in their coursework. This study indicates that there is great potential for more formal inquiries regarding alternative configurations of collaborations across disciplines, thus leading students to become successful stewards of interdisciplinary.

REFERENCES

[1] Dell'Era C., Verganti R. Collaborative strategies in design-intensive industries: Knowledge diversity and innovation. *Long Range Planning*, 2010, 43(1),123-141.

[2] Østergaard C.R., Timmermans B. and Kristinsson K. Does a different view create something new? the effect of employee diversity on innovation. *Research Policy*, 2011, 40(3), 500-509.

[3] Un C.A., Cuervo-Cazurra A. and Asakawa K. R&D collaborations and product innovation*. *J Prod Innovation Management*, 2010, 27(5), 673-689.

[4] Mayer R.C., Warr R.S. and Zhao J. Do pro-diversity policies improve corporate innovation? *Financial Management*, 2018, n/a.

[5] Norman D. and Klemmer S. State of Design: How Design Education Must Change. http://www.jnd.org/dn.mss/state_of_design_how.html, 2014, Accessed on 12 Feb 2018.

[6] Oehlberg, L., Leighton, I., and Agogino, A. Teaching human-centred design innovation across engineering, humanities and social sciences. *International Journal of Engineering Education*, 2012, 28(2), 484–491.

[7] Self, J.A. and Baek, J.S. Interdisciplinarity in design education: Understanding the undergraduate student experience. *International Journal of Technology and Design Education*, 2017, 27(3), 459-480.

[8] Lee J. The integrated design process from the facilitator's perspective. *International Journal of Art & Design Education*, 2014, 33(1), 141-156.

[9] Brezing A.N. and Löwer M. Engineering and Industrial Design: An Integrated Interdisciplinary Design Theory. ASME. International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, *Volume 5: 13th Design for Manufacturability and the Lifecycle Conference; 5th Symposium on International Design and Design Education; 10th International Conference on Advanced Vehicle and Tire Technologies*, 2008, 351-357.

[10] Lattuca, L.R., Knight, D. and Bergom, I. Developing a measure of interdisciplinary competence. *International Journal of Engineering Education*, 2013, 29(3), 726-739.