Design and Technology Education: An International Journal

26.3

A blended approach to design education through clinical immersions and industry partnerships in design for healthcare

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Abstract

Contemporary design education seeks to prepare students for the workplace through studio-based learning that replicates real world practice. Design problems in the workplace have become increasingly complex and one example of this is within the area of design for healthcare, which requires multidisciplinary collaboration between various stakeholders to build knowledge in order to create new products, services systems and spaces. The complexity of these roles creates challenges for design educators in preparing students for the workplace. This paper presents a hybrid approach to address this challenge by presenting a real-world approach to design education. This entails a bottom-up approach to facilitate design research in a clinical setting to gather rich insights and needs of the clinical setting along with a top-down industry collaboration with sponsored briefs to guide students through the requirements of developing solutions in a heavily regulated field. The paper outlines examples of this process and how it was achieved in a blended model that was predominantly online in response to the changed environment caused by the COVID-19 pandemic.

The advantages of this model are threefold, students gain deep knowledge and skills through collaborating with a variety of stakeholders within health care, they gain the opportunity to validate their designs through testing and feedback with these partners and lastly students develop the connections to create opportunities for further partnerships and employment.

Keywords

Real world practice, Design education, Design for healthcare, Clinical immersion, Industry collaboration.

Introduction

Design and healthcare

Due to the many challenges faced by healthcare such as ageing populations, chronic diseases and pandemics, providers are looking to the services of designers to help with reimagining healthcare. These services range from designing medical devices and medical charts, to designing medical services for tackling pandemics, and the layout of operating theatres (Fairs, 2020).

A study conducted by Kiernan and Ledwith (2014) showed that product design graduates believe that design education needs be more aligned to the demands of industry and facilitate them with flexible and transferable skill sets to take advantage of the evolving role of the designer. Further criticisms labelled at design education is that few schools are adopting the trend towards interdisciplinary teamwork that takes place in industry and that design students are not well prepared with the knowledge and skills required for employment when they graduate (Medola et al., 2021; Yang et al., 2005). It has also been shown that there is no great link between design practice and design education (Gajendar, 2003; Roald, 2006).

Bhavnani et al. (2017) argue that the transformation of Healthcare requires collaboration and a shared vision between various stakeholders to create models that are primarily patient-centered. Fry (2019) argues that co-creation and multidisciplinary teams are necessary in the design of healthcare products and services and advise an iterative, user-centered and holistic approach that considers the patient experience. They state co-creation with all stakeholders can challenge the hierarchy and silo-mentality that is ingrained in many healthcare organisations.

The role of the designers has changed and this in turn poses further challenges for Design education. Park (2020) proposes five skills that designers can bring to developing solutions in healthcare:

1. Problem solving and the ability to deal with ambiguity;
2. Communicate skills to understand the needs of others and to communicate solutions;
3. Empathy for those who may be anxious or suffering from chronic illness;
4. Ability to co-create with users and multiple stakeholders; and
5. Creativity in challenging conventional solutions with blue-sky ideas.

Traditionally design education has focused on studio-based learning that follows the master apprentice role. It is clear that student designers must be afforded the opportunity to leave the studio and collaborate with the stakeholders and experts within the subject field to fully understand the complexities of the problem before they can develop solution. In turn, they need to be able to validate proposed solutions with the same stakeholders and experts.

This paper describes a blended studio-based and online design curriculum, which uses both clinical immersion and industry collaboration to facilitate real-world-based design skills acquisition and experience. Two case studies are then presented which describe the bottom-up learning approach of clinical immersion and the top-down approach of industry collaboration. Clinical immersion is a bottom-up approach as it involved the application of design research by student designers to uncover a range of unmet needs to provide opportunities for innovation, while the top-down approach of the industry collaboration requires students to design solutions for specific, already identified needs, and then validate those solutions. These approaches were used in conjunction with in-house design challenges to triangulate different experiences, ultimately enhancing industry-relevant skill acquisition, expectations, and experiences.

Studio based and online learning

Studio based learning has many advantages mainly due to face-to-face interactions between students and teachers in a master apprentice type model (Yorgancıoglu & Tunalı, 2020). There are concerns with regard to this model of education as Product design pedagogical approaches require different competences knowledge and perspectives, that demands the input of expertise from fields outside of design (Medola et al., 2021). However, in the traditional model of design education there are concerns that the acquisition of knowledge is limited and based on the personal experiences of one discipline which may be disconnected from real design problems which has been reported to hinder students motivation and engagement (Rodriguez et al., 2018). It has also been shown that an overly teacher-centred studio environment may hinder the ability to carry out group work, research activities and the development of critical thinking skills (Yorgancıoglu & Tunalı, 2020). Medola et al. (2021) argue that immersive experiences that provide human interaction and engagement with immediate real-life feedback are the key elements of constructivist learning to facilitate real world problem solving. The involvement of multidisciplinary specialists and end users, can facilitate collaborative and active learning in the solving of today's complex design problems (Seidel & Godfrey, 2005). There have been calls for design educators to create the environment to teaching designers to function in multidisciplinary teams emphasising the complex process of inquiry, learning and decision making (Dym et al., 2006). These real world experiences can be created by building links with industry to partner on design briefs (Breitenberg, 2006; Harriss & Widder, 2014) as industry problems are very different from the types of problems normally used in education (Jonassen et al., 2006).

Due to the recent pandemic the teaching environment has shifted to online. While there are advantages to a virtual design studio, to create a forum for collaboration there are also disadvantages. The virtual studio has some advantages and can provide a forum for highly interactive engagements in a timeless and flexible manner (Niculae, 2011). The virtual environment can facilitate flexibility in learning styles to allow students to work at their own pace (Fleischmann, 2020). It can foster knowledge building, independence and efficiency in file sharing and project management (Rodriguez et al., 2018).

However there are drawback to relying solely on online learning, and many researcher point to restrictions in peer learning amongst other factors (Iranmanesh & Onur, 2021). There are potential issues for students to be able to meaningfully interact sufficiently to receive feedback, critique and support (Alnusairat et al., 2020; Tuckman, 2007). Students can also feel unsupported and become disengaged from the online studio experience (Alnusairat et al., 2020)

A number of researchers propose a blended design studio that combines the traditional physical studio with a virtual model (Iranmanesh & Onur, 2021; Saghafi et al., 2012). Further to this Rodriguez et al. (2018) advocate that a blended approach which combines, the conventional studio, a virtual studio and live projects, in order to promote effective collaborative learning at different levels and via diverse means.

Methodology

The paper presents a reflective analysis of data gathered through an MSc in Design for Health and Wellbeing around two projects carried out. The first project entailed a clinical immersion in several hospital to observe maternity and gynaecological clinics. The second project involved a collaboration with a medical device company to develop solutions for a Laser Lithotripsy device. The sources of data are listed and described in Table 1.

Table 1: Description of data sources

Data source	Description	Number/ duration
Process books	Students' documentation of their research and/or design process, comprising text and visuals (sketching, CAD, or prototyping as appropriate) – ranging from 30-100 pages (submitted as a PDF), created over one 8-week period and one 4-week period, and collected at the end	25 (11 clinical; 14 industry)
Reflections	Students' written reflections and feedback, submitted at various stages of the projects	12
Recorded and transcribed feedback of presentations to clinical and industry partners	Students frequently met with both clinical and industry partners during each project, and in several cases fed their project findings back to them via video meetings in order to receive feedback; these were recorded and transcribed	4 hours

In analysing the above data, a process of inductive analysis informed by reflective thematic analysis approaches was applied (Braun & Clarke, 2020), as it has been used as a method to organise and explore both students' coursework (Semb, Kaiser, Andersson & Sundborn, 2014), as well as to analyse varied data corpora (Deighton-Smith & Bell, 2018). To do this, each author read the data sources thoroughly, with two authors then assigned to each student project to improve inter-coder reliability. Both pairs of authors used a procedure of coding with close reference back to original data. A final round of categorisation sorted our second-round codes into themes. We finalised our themes during a final meeting among all co-authors. Not all themes emerged in each project and Table 2 shows, which themes corresponded to each of the projects:

Table 2: Description of data sources

Themes	Clinical immersion	Industry partnership
Understanding how to conduct design research	x	
Empathy and user understanding	x	
Understanding Dignity and ethics	x	
Understanding ergonomic and human factor requirements	x	x
Student clinician/ industry partner engagement	x	x
Expert critique	x	x
Designing for real world constraints and requirements		x
Student reflections on the immersion experience	x	x

Findings

Findings from clinical immersion

The aim of an immersive experience is to identify design opportunities within a clinical setting. The students were immersed in a number of maternity and gynaecological clinics across five different hospitals in the South west of Ireland. The purpose of the immersion was to identify problems and needs associated with various aspects of the health care environment with the purpose of developing solutions in response to those needs. The students acquired hundreds of observations which were rigorously distilled to key needs. These were then progressed through ideation and concept development, and then validated by the maternity staff. Figure 1 outlines the immersion process.

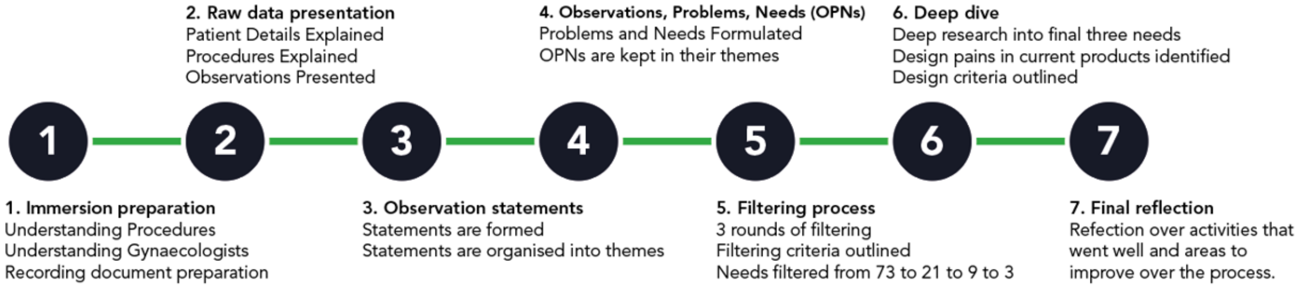

Figure 1 The Immersion project process

Understanding how to conduct design research

Students attending the clinical immersion sites engaged in note-taking, which they later took home to scaffold their anonymised observational data. All names of the students were anonymised with pseudonyms. For many students, this was their first time carrying out field research in this manner, and they approached the process of documentation in slightly different ways, see Figure 2. Ian took the advice of the lecturing staff and created his own template printouts, which he used to structure his observations. He also took time to research the context and the different roles he might encounter. In writing up his background preparation, he reflected that certain things worked well - 'analysing potential stakeholders and sub-environments helped me focus on all aspects of the hospital environment' – but he would change some things based on the fast-paced nature of the clinics he attended:

> *"I would try reduce the amount of pages as it was difficult to turn through pages quick enough [and] I would change the overall layout of the observations document sheet as there is not enough time to document everything … I would put a bigger emphasis on sketching as it would again save time but also give a better visual understanding."*

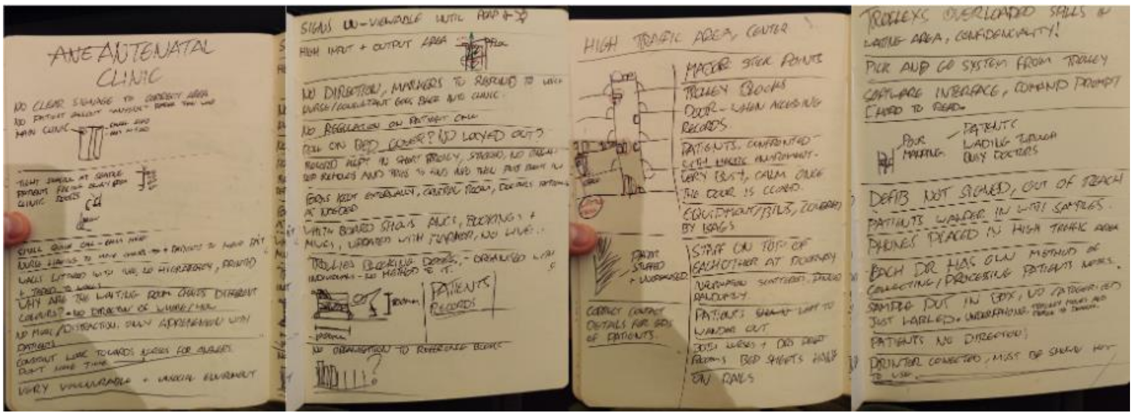

Figure 2: field notes examples

Following the immersion clinics, the student continued to collaborate with tutors peers and clinicians online. Miro and Teams were used to facilitate online collaboration. Students collaborated in real-time with one another. The online platforms allowed:

- The uploading of physical sketches & prototypes and sketching
- Students and tutors to annotate and comment on work
- A repository of work
- A forum for presentation to the external partners

Figure 3 is an example of a Miro board:

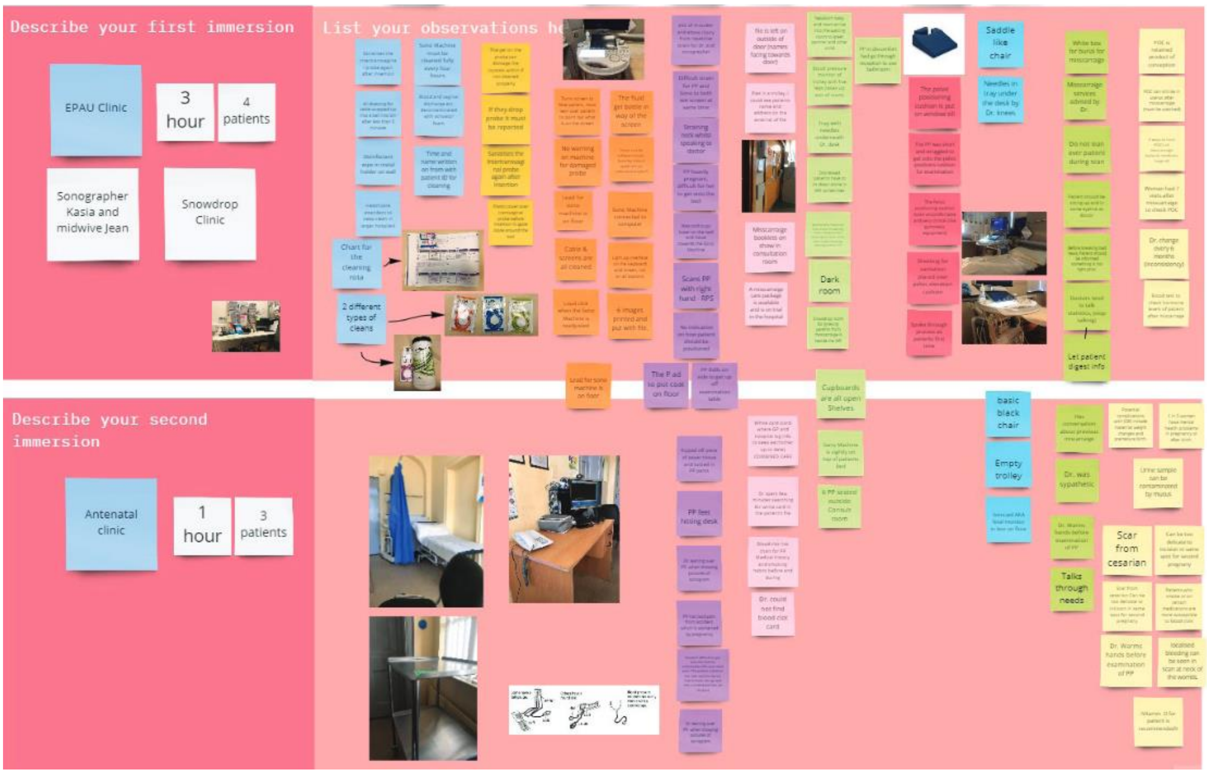

Figure 3: Miro board example

Empathy and user understanding

Designers are required to empathise and design for the needs of their users and all stakeholders. The immersion experience gave the students the opportunity to put themselves into the shoes of others (Kouprie & Visser, 2009). During their clinical immersion, many of the students were cognisant that they were witnessing procedures and other clinical experiences that may be uncomfortable or even distressing/traumatic for some patients. This is evident in Rachel's field notes, who reflects on the insufficiency of the designed space for patients dealing with trauma:

> *"The space in the EPU [early pregnancy unit] is not patient focused. Many patients that come in are suffering miss carriage [sic] and the space used doesn't give them privacy or a place to come to terms with the news."*

Similarly, Dana's field notes, pay particular attention to the need for patients undergoing difficult procedures to also be comforted by staff:

> *"Patient wanted to be comforted but nurse was busy – the patient was nervous and squeamish making the procedure harder. Nurse couldn't hold the patient's hand due to electric shock – the patient was upset that her hand wasn't held at the point she needed it most."*

Understanding Dignity and ethics

Some students noted issues surrounding dignity, fairness and overall ethics at their immersion sites.

One student observed a clinician who had to order her PPE at her own expense – as a hijab wearer; the PPE provided by the healthcare system did not meet her needs regarding head coverings.

Many students were struck by the compromising of patients' dignity during often-difficult times:

> *"Patients were uncomfortable removing clothing in scan room, as anyone, including the public could enter the room."*

Understanding ergonomic and human factor requirements

Many of the students noted an ill fit between the environment and equipment provided in the clinical immersion sites. This extended to both cognitive and physical aspects of the environment. One student observed issues around placing patients in the correct position for clinical examinations and developed solutions accordingly, see Figure 4.

Figure 4: Examples of solutions around ergonomics in positioning of patients

These observations around the 'fit' of the user to the equipment continued into the operating theatre, where students noted that such discrepancies might have dangerous consequences.

One student identified issues in the operating theatre:

> *"surgeon could not find the tray to change his gloves initially so he had to be shown by the nurse' and 'surgeon was unable to tie his apron so he had to get a nurse to pass him the ties to secure it."*

He notes several issues with shorter staff members who have to use 'steps' or assistance from a colleague to reach a patient's body in order to complete stitching.

During his immersion, Ian notes several constraints that arose, perhaps due to an interaction between anatomical difficulties and insufficiently well-designed equipment:

"The surgeon was finding it difficult to extract the fluid using the suction equipment as organs were in the way and it kept suctioning on to them… the surgeon had difficulty inserting the surgical tool through the port as both his hands were occupied and the port was moving around."

Similarly, Jake identified concerns arising from difficult manoeuvres he witnesses during laparoscopy, and cites:

"a need for a method of cutting tissue and stemming blood-flow within a patient that causes minimal damage to surrounding tissue and is easily carried out from any position at the operating table by a single user."

Student clinician engagement

Students' engagements with healthcare staff during the immersion led to their creating new ideas for products, services and systems that, had they not had the same interaction, they would not have noted as possible or relevant. Students also felt that it was important to maintain the links with the clinicians during the development phase of the project to validate ideas:

"I would also collaborate with a clinician to review the problems that I have developed to ensure that they are actually issues that need addressing and to confirm that they are accurate."

Describing his engagement with Dr Ng during his time in the hospital, Dave noted that Dr Ng was 'happy to take any questions' during times when patients were not in the room – in particular, Dr Ng provided Dara with 'some medical brochures on the Harmony Prenatal Test [and] links to websites' This information provided to Dara later becomes the basis for his design proposal around sex disclosures in prenatal testing.

Describing his own experiences in the clinical setting, Wayne similarly credits the interaction with clinicians as 'essential':

"Discussing with them allowed two essential things, to understand precisely their work methodology, but also to ask them what they saw as the problem with their work. That is how I became aware of the obvious problem of the positioning of the oxygen balloon, which on the new machine does not have a telescopic arm to give the nurse the possibility of working in a pleasant position. All these may seem to be just details, but together they create a field of possible improvements."

Expert critique

Finally, clinicians' engagements with students on an ongoing basis through the MSc was important not just because, as mentioned above, it fleshed out their anatomical knowledge, but because, together, interaction with the clinicians helped the students to incrementally scope out the burgeoning design spaces emerging through their work. This was achieved in a dialogical manner, with students presenting their design work to clinicians and then engaging in a process of questioning and answering. The following is an example from a later presentation to clinicians where the student, Phillip, is presenting a mechanism that would operate inside the uterus:

Dr Shone: “So basically you're saying there's a sheet in which the silicone goes in and it takes the shape of the hole inside of the cavity. So at the end of the - you know, the balloon - will it not come out, will the gel will not fall out?”

Paul: “You can set that the shape of the balloon by whatever [way] you choose so you'd have a pre-set shape that would be cured to that shape.”

Clinician’s participation was not just isolated to asking and answering questions, they suggested new possibilities for design ideas around which students had only just begun to ideate. For instance, in reviewing Dara’s design work, Dr G. levies some potential shortcomings of the idea, before suggesting refinements to the form:

“You could do it like an M shape but a little bit at the top instead of bringing it down - so that you can look at the size of the, you know, uterus and put it up there rather than it going in the middle. Therefore, in the middle - it can be at the top, that way it might be good. I like that - when you put it in and you just retracted out. That was really good. Yeah. Excellent.”

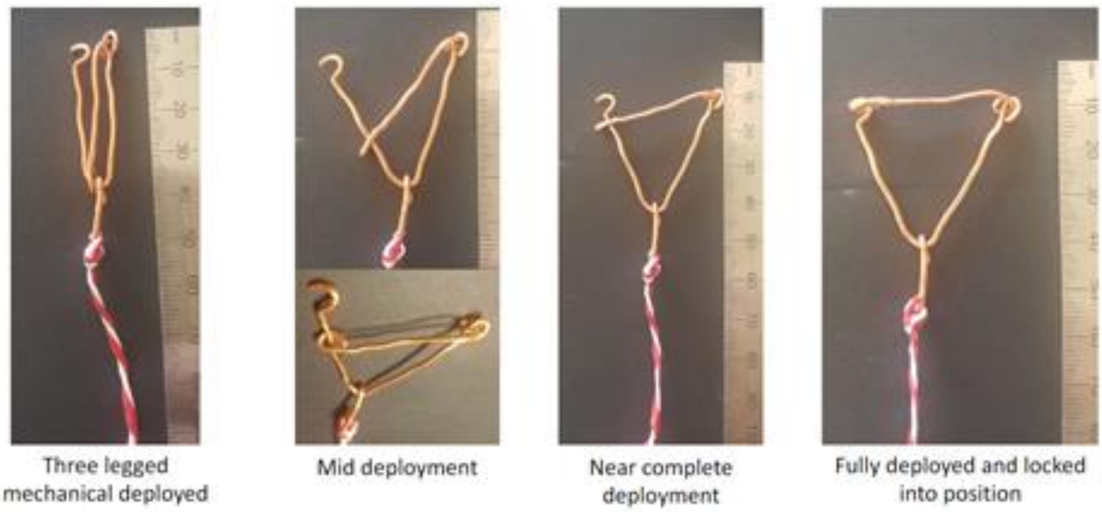

Figure 5: Dave’s early prototyping around IUD deployment

Student reflections on the immersion experience

Overall, the students found the experience to be rewarding

“I felt that the immersion was a very worthwhile experience and really broadened my understanding of the process of immersion as a method of research that I could use in my masters design project and further projects throughout my career.”

“The entire experience of the immersion, findings synthesis and filtering process was very enjoyable and I gained a great understanding and perspective of how the research process works and how healthcare workers operate.”

The process is much nuanced and takes practice and the following reflections highlights how the students learned to appreciate and acquire these skills.

> *“Seek to observe people, procedures and not focus from the outset on the medical products used.-Avoid thinking about solutions right away when I have only defined the problem.- Not to think that an observation is not worth noting. All these details will enable me to be more efficient during the second half of the year to help me design a solution for the speculum in the best possible way”*

> *“All my observations should therefore never be biased by my opinions and always be as factual as possible. I should constantly avoid the: "I think that" to always go towards the "I saw that" or “the medical professional told me that". It was essential to follow this path in order to avoid misinterpretations.”*

Students’ engagements with clinicians were critical in clarifying the bounds of their anatomical knowledge: although they had taken a 15-credit module in Anatomy and Physiology, their design ideas were sometimes more speculative than grounded.

> *“I didn't expect to discover so much in so little time. It should be noted that the help of the nurses and doctors in answering my questions and giving me feedback was key.”*

Later, presenting his work on a IUD ‘introducer’, Jack receives the following question from a clinician specialising in robotic gynaecology:

> *“My question is that, how does this thing locate the exact orifice? And then suppose - the orifice is not always open, and sometimes you have to dilate it and it can be, you know, even when we are dilating, we can even perforate it as well.”*

When Jack explained that he had not had time to research dilation methods, the clinician responds:

> *“It can be done if you have a, like, suppose for example, laryngoscope - when they do it and they have the camera on it.”*

In this way, interaction with clinicians helped students both understand the bounds of their design space, as well as encouraging the student to continue the work by instructing by example reference to another, likely more common, procedure, laryngoscopy.

This section has described some of the analytic findings regarding student’s engagements during their clinical immersion, as well as in presenting their design work (originating in the immersion) to clinicians later through the year. In doing this, students naturally attended to issues of empathy, ethics and ergonomics; used different documentary and reflective methods; and collaborated with consultants not just to gain new knowledge, but also to shape and refine the design space in which they were working.

Findings from the Industry partnership experience

The industry collaboration project involved a four-week project with a medical device company. A brief was co-drafted by the company and the tutors involved in the project. The collaboration with industry partner involved a two-hour on-line kick off meeting to gain a contextual understanding of the requirements in week one and then an online four-hour presentation feedback session with the industry partner in week three. Feedback from the presentation were then incorporated into a final deliverable in week four, which were then sent to the industry partners. Figure 6 provides the project processes

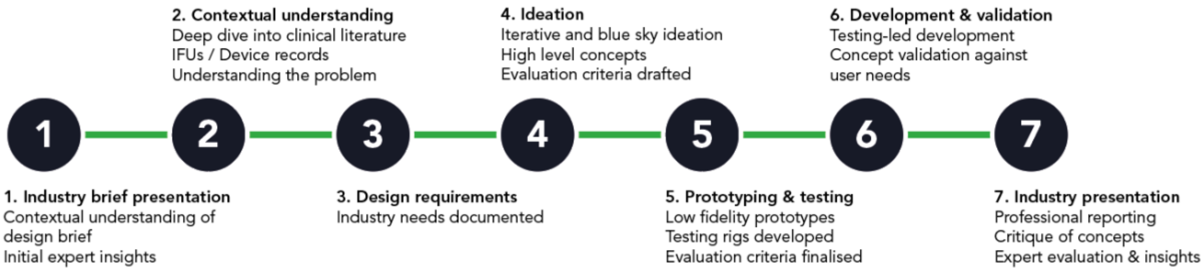

Figure 6 - Industry collaboration project process

Laser lithotripsy project

The design challenge was to design a urethra scope which would allow a physician to adjust laser beam settings during lithotripsy, eliminating the need for assistance from a second person. In advance of the meeting with the industry partners, each student was supplied with a brief, to prepare questions for the subsequent industry partner meeting. The industry partner meeting allowed the students to ask questions and become more acquainted with the context of use of the device, as well as to define specific design goals.

Understanding ergonomic and human factor requirements

From the initial meeting with the company, the students learned that the main focus of this project was in the area of human factors and entailed improving a product to make it easier to perform a procedure without the need for assistance to change settings and controls during use in the operating room. While the brief supplied the students with high-level background information, the students ultimately led their own knowledge acquisition activities. This empowered them to conduct a deep dive into the secondary literature, to examine the commercial landscape of similar products. Competitor analysis also helped to define and prioritise the design requirements in further detail to the brief. Concepts were ideated through brainstorming sessions, low fidelity mock-ups, and user testing, prior to being developed further. Design tools such as sketching were used in early-stage designs but were quickly migrated to digital programs like SolidWorks or Adobe Illustrator for functional detailing and product storyboards, prompting students to be flexible in the media through which they could communicate their ideas, see Figure 7.

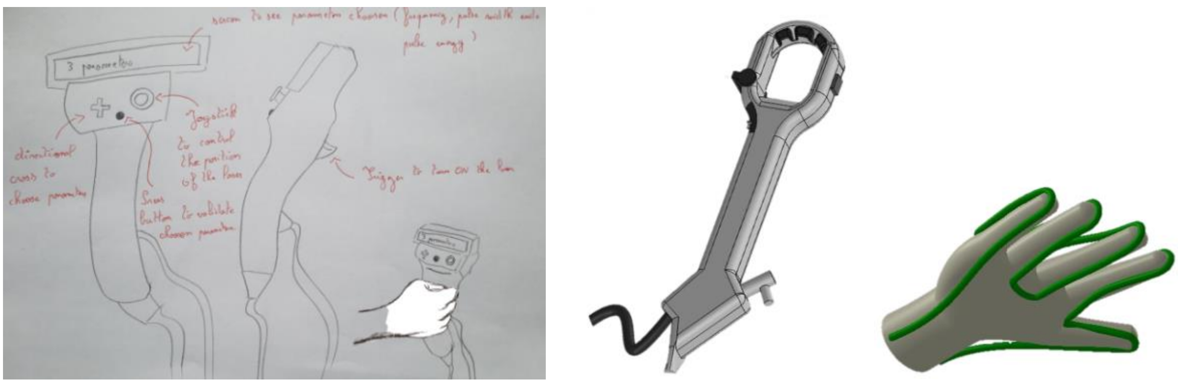

Figure 7: communication media examples

Low fidelity models were also created along with mock-ups of the clinical environment and surrounding equipment so students could test their ideas quickly, discarding those which did not fulfil the brief. This part of the project required students to think creatively, utilising workarounds and readily available materials in order to create a means of verifying the function of their concepts, without resorting to high-fidelity manufacture or in situ testing. These quick-and-dirty prototypes displayed how a solution could demonstrate promise without the need to resolve every detail. Once tested low fidelity models were replaced by 3D versions for final testing, see Figure 8.

Figure 8: Comparison of low-fidelity prototype versus final result. Note the change in design and prototyping methods to account for functional usability and validation as the project progressed.

Mocking-up the clinical environment also demonstrated how concepts could be used in conjunction with the already existing infrastructure, enhancing the overall product development, see Figure 9.

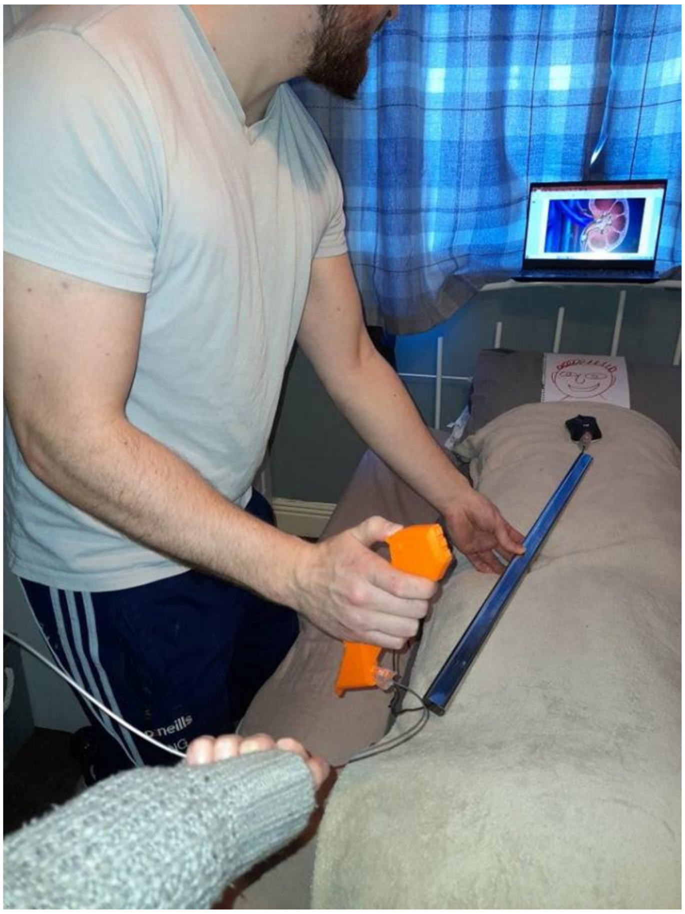

Figure 9 - Students created their own testing environments to enhance their understanding of in situ operation of the device, and to robustly validate their concepts.

Design considerations such as handle articulation, button positioning, and usability/human factors could then be validated robustly using these environments to control external factors which could potentially impact the validation results. Prototyping also helped to communicate and confirm the design solution with the industry partner:

> *"Nice job on the test rig in particular. I really appreciated you going to the point of actually having the screen and actually pushing a mouse towards the kidneys. It was a nice test environment"*

Student industry partner engagement

The Industry collaboration was also beneficial for the company. While reflecting on the projects, a member of the industry team commended the students on their novelty and stated that they intended to progress several of the ideas further to more robustly validate them and determine their commercial viability. It was clear that the students brought fresh insights to the project.

> *"I think it's some really good work and some really, you know, out of the box ideas; definitely ideas there that we wouldn't have thought of, and the presentations will be really useful because... ...there are some really good ideas that I think we might want to talk about how we could you know progress them."*

Expert critique

Expert critique was very welcome, as the deliverable for the brief was a developed concept as opposed to a final solution. In a real-life industry setting, the questions posed by the industry partners would naturally be asked at this point, prompting further development, redesign, and more robust design validation. Both the students and industry partners knew that it would be impossible to account for all risks; however, this expert insight gave the students a snapshot of the real-world equivalent of this stage in the design process, enhancing their overall experience of the project, rooting it in industry-relevant rigour, and signposting to further design development opportunities.

Designing for real world constraints and requirements

When presenting the outputs of this project back for expert insight and feedback from the industry team, the questions posed by the industry team also prompted the students to consider aspects of their solutions that were not previously identified as particular risks, or potential points of failure for their designs.

> *"I would have concerns over the cleanability of that, if there were any fluids around that nylon strap."*

Some questions posed sought to ensure that the solutions proposed by the students were routed in rigorous design choices, which were fully accountable across the entire scope of the project. Some questions also indirectly identified risks, which would also prompt further development in order for them to be mitigated.

> *"When you were considering the button placement at the top of that internal circle area, your reasoning behind having them together, and knowing which one you're pressing, how does the user know that? And did you consider spreading them out more, or was there are a reason for why they were at the top?"*

Student reflections on the industry project

Students got rigorous experience of the reality of industry-based R&D, which is quite fast paced, and results focused. They honed their skills that industry values, while also using their design skills to fully understand the requirements and deliver a solution in a short time, sometimes delivering solutions which, although were unconventional at times, still answered the brief.

> *"I found it hard to identify objects which would be good to prototype with but I am happy with what I produced. Particularly in the short time frame." Quote from MSc student*

These projects by nature also empowered our students to engage in an industry-orientated design project, while also naturally building in risk assessment and mitigation in tandem with the design process, which are important when considering the design of a product with the intention of placing it on the market.

> *"I enjoyed doing the additional risk assessment, to identify potential risks for this product. I think I made some good considerations for how this solution fits into the*

> *environment it will be used in." Quote from MSc student regarding the value of risk assessment*

There were some challenges also expressed by the students. The short time frame and steep learning curve was demanding. Students were required to utilise their resources effectively and collaborate with their peers for support as follows:

> *"I organised some teamwork brainstorming with a colleague when I was feeling overwhelmed by the brief which was extremely helpful." Quote from MSc student*

The students all found it difficult to gather sufficient information to get the full requirements of the project. While they relied on video footage to observe the process, an immersion experience as conducted at the maternity clinics would have supplied more detailed insights. Students were also not able to gain access to cad files or drawings for the current product as the minute details were viewed as trade secrets, purposely kept from public domain. This limitation was referenced by the students; however, they were still able to design within the scope of research they had obtained.

> *"I found it challenging to find information. I presume this is because documents relating to the design of these documents are confidential. I would have liked to speak with engineers and other designers to understand how the original device worked." Quote from MSc student*

The industry collaboration encouraged the students to readily engage with an industry-relevant project with the intention of delivering a functional solution that has real world implications. Access to expert insight as well as the milestone timelines also empowered the students to consider the project deliverable beyond the basic design challenge and to determine how to develop a feasible solution, which could evolve to a point where it is market ready. This type of experience ensures that students prioritise their skills development so that they are industry-relevant. It also expose them to the realities of designing within an industry context, where results matter most. Some challenges were realised such as the steep learning curve in a subject domain and the gaining of access to drawing files but overall the students found the project to be a rewarding learning experience.

Discussion

This article investigates a pedagogic approach that facilitated students to gain real word experience with live projects during the process and external collaborations facilitated by design tutors. The findings highlight that these projects created innovative learning activities that stimulated and maintained student engagement and motivation at different levels. Design problems are highly context specific, require access to specific domain knowledge (Jonassen & Hung, 2015). As highlighted by (Gill, 2021) pedagogy is impeded without the appropriate content knowledge. An important means of acquiring knowledge is by engaging with experts (Deken et al., 2012). These projects created opportunities for knowledge acquisition in a specific domain through the processes of expert engagement and observations.

The project themes varied in nature to expose the students to the adaptive aspects of the design process. The immersion project was predominantly a divergent phase where students to explored needs to provide opportunities for innovation in a ground up approach while the industry collaboration was predominantly a top down convergent phase in the project where specific and at times conflicting requirements had to be consolidated through a process of design, test, evaluate and iterate. This provided two very complementary yet varied experiences for the students.

During the immersion project the students gained the opportunity to speak to experts in a domain that was outside of their own field of design and as advocated by Medola et al. (2021) these are the types of experiences that are the key elements of constructivist learning. Throughout the project, the students gained the skills to carryout research in a clinical environment by observing clinics and procedures in the operating room and interviewing staff members. They also experienced the challenges of documenting the observations to provide the needs that would form the basis of the research. The increasing importance of empathy and understanding of the user in the design process is a key feature of human centred design (Barnes & Du Preez, 2015) and a key aspect of gaining empathy is through immersion within the context of the stakeholders involved (Thomas & McDonagh, 2013). The students provided a variety of accounts that related to issues where the perspectives, dignity and ethical needs of the patients were often overlooked.

The industry collaboration acquainted the students with the realities of designing within industry; the students were provided with many specific constraints for the project and were provided with feedback that was specific to those real requirements. Many of these requirements were around function, human factors, user and patient experience. Design validation skills were honed as students built their own testing rigs to both verify the functionality and validate that the solutions ultimately answered the challenge. A key component of this project was that students presented their refined concepts back to the industry collaborators for review. They received expert critique and insights, which would not be possible otherwise. This was most notable when projects deviated from or overlooked one of the requirements or constraints. While the tutors had knowledge related to design, they did not have the same oversight of the clinical and situational expertise of the partners and were not in the position to provide the detailed critique the students received.

Schön (1987) encourages reflection-on-action by the designer, during the design process to evaluate the project process so that improvements can be made to future projects. Gill (2021 p, 9) states that as well as evaluation of the process it is necessary to evaluate oneself to include "reflection on one's own methods, behaviour, beliefs and development."

It was important that there was mutual benefit to the partners on the programs otherwise, the continuation of such collaborations could not be sustained. As shown by (Gill, 2021) learning between novices and experts can be a two way process. In both projects, the experts expressed the benefit to them. The clinical staff in the hospitals were provided with insights from a fresh perspective to an already familiar environment and were provided with not only possible solutions to enhance patient care but also the expertise to bring elements of the design process to improve their own practices. The industry experts acknowledged that they showed aspects of design fixation, defined as a rigid adherence to a set of ideas or concepts, which can limit the scope for alternative ideas. (Jansson & Smith, 1991). The student design solutions they stated gave them fresh ideas that they had not considered.

Limitations & Future Work

While this paper presents some deep insights into conducting collaborative projects with external partners, the findings are based on content from student course work, recordings from meetings and reflections that were a part of the project. Further studies in the form of surveys and interviews could capture in more detail the student experiences to identify how the learning experience could be enhanced further. Formal interviews with the external partners could also provide further insights into how the engagement might be further improved.

Conclusions

When designing for healthcare, students must be afforded access to the clinical or health care environment to gather the design requirements through close observation and engagement with all stakeholders. Industry-relevant skill acquisition should be the goal of all design education so that students can appreciate the real world requirements and constraints of industry set projects. A Hybrid-approach as described in this paper enhances active and constructivist learning principles and encourages reflection through expert engagement and critique. Multiple experiences enrich the delivery of design education, but also builds the knowledge of the tutors and enables them to determine emerging skills that need to be taught. Finally, these collaborations also created opportunities for further partnerships and employment.

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