INDUSTRIAL DESIGN

PRACTICE

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RESEARCH DISSERTATION

APPLIED DESIGN RESEARCH 1

CONTENTS

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ABSTRACT

This research investigates current industry practice in a variety of different workplaces including consultancy, in-house, corporate, and freelance industrial design. A literature review was conducted and found that there is a lack of reporting on current industrial design practice. This prompted the development of three research questions, with the aim to learn more about industry practice through qualitative research methods. Interviews and observations were chosen and conducted. Several key findings were found using affinity diagramming around various industry practices, with the most prominent issue being communication with clients and stakeholders. More specifically, the arrangement of elements and technology results in poor communication outcomes and negatively affects performance of industrial designers. It is proposed that a product, service and/or system is to be developed to address communication outcomes in industrial design practice.

CH.1 INTRODUCTION

INTRODUCTION

The industrial design profession has changed over the years and it is important to understand best practices. Emerging technology is shaping the future of industrial design practice through new design tools and processes for various design activities including concept generation, CAD, Prototyping, Collaboration. It is important for current and future industrial designers to understand best practices to be competitive within the industry and push the boundaries of what industrial design can do for society.

This study will look at the effect of emerging technologies on industrial design practice and how emerging technologies can increase the performance of industrial designers. Performance of industrial designers and practice can be defined by speed, quality and delivery of design outcomes within any given project (Tangen, 2005). Other areas of interest within this topic include the role of design management for emerging technology and how emerging technology is assisting industrial design practice in working remotely, due to the current circumstances of wide-spread social and physical distancing.

The aim of this study is to explore emerging technology usage in industrial design practices and understand how emerging technologies can benefit the modern-day industrial designer. Specifically, this study aims to determine what design tools and processes are being used and why.

Figure 1. provides an outline of the project structure.

Phase 1 consists of initial research into the topic and Pilot studies testing the chosen research methods. Phase 2 will be conducting Interviews and Observations, analysing and discussing the data, and development of a proposal. Phase 3 will follow an adapted version of IDEO's design process for product development: Ideation, Rapid Prototyping, User Feedback, Iteration & Implementation (Usertesting, 2018).

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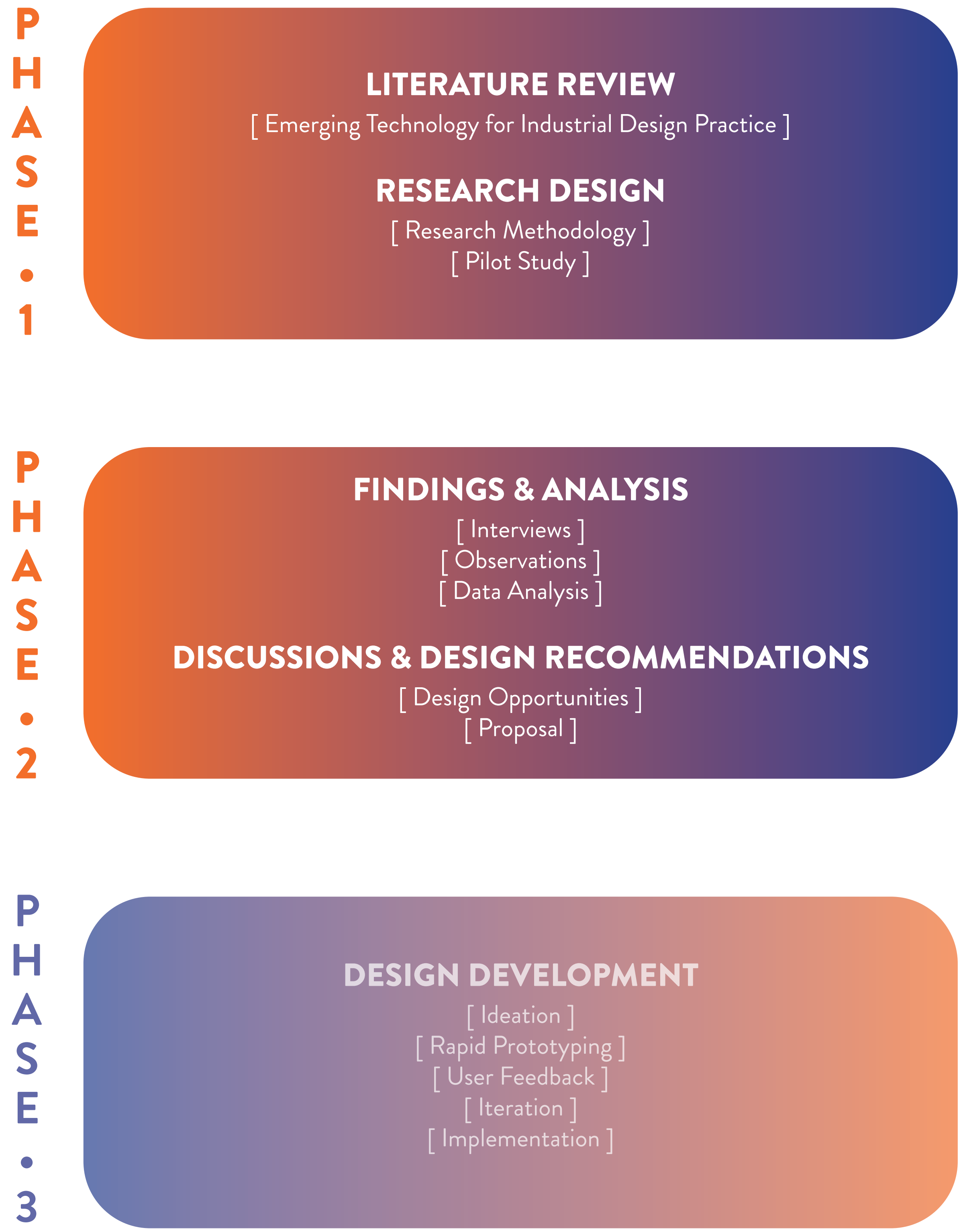

Figure 1. Project Outline (Anderson, 2019)

CH.2 LITERATURE REVIEW

Productivity & Performance in Industrial Design Practice

There are many ways productivity has be defined in academic literature. Attempts to create a singular definition of productivity have been made (Tangen, 2005), with the key underlying themes identified as being profitability, performance, efficiency and effectiveness (Tangen, 2005, p43). Since productivity is a broad term covering many different concepts, it is appropriate to provide a focused study on performance for the purpose and scope of this literature review.

Performance includes profitability, productivity and other factors such as quality, speed, delivery and flexibility (Tangen, 2015, p43). Since the nature of industrial designers is to provide design services, factors like quality of design outcomes, speed of project delivery and flexibility are of utmost importance. Additionally, design management is concerned with profitability, productivity and performance of the business and designers under their employ. For this reason, enhancing the performance of industrial designers using emerging technologies is of interest to the future of industrial design practice.

Literature about differing opinions on the pursuit of performance in current and future industrial design practice was reviewed. While there is minimal academic literature on design performance, one argument against performance is designing for cultures who do not value time or productivity. This concept is difficult for most designers because they lack empathy for how other cultures' value time (Pschetz & Bastian, 2018, p.175). Additionally, many technologies inherently promote modern business values such as productivity. This marginalizes broader socio-cultural aspects on which some activities, like festivals, are influenced by the concept of right time, place, people etc. (Lawrence et al., 2017, p1).

Emerging Technologies in Industrial Design Practice

Emerging technologies has many definitions, one of which defines emerging technology as a relatively fast growing technology with a certain level of consistent advancement persisting over time, with the potential to exert a considerable impact on the way businesses and organisations operate now and into the future (Rotolo et al., 2015). This is especially true for industrial design practice, where the quantity of emerging design tools and processes available is increasing with little clarity around the benefits and drawbacks. This literature review attempts to collate which emerging technologies are useful for performance of industrial designers and the role of design management.

Currently, businesses are changing work practices, collaboration between employees, and leadership approaches to improve performance for teams working remotely. Current circumstances have seen the proliferation of emerging technologies that inspire and induce new ways of doing business (Coetzee, 2019), which will also be demonstrated in the industrial design industry through this study.

Emerging technology can and is being applied to the various activities that occur during the design process to increase performance. These activities include concept development (sketching), 3D modelling and CAD, collaboration and prototyping using physical models. This review discusses emerging technologies' benefits and shortcomings for industrial design practice.

Concept Development

Perhaps the most innovated area of industrial design tools and processes is in sketching and concept development; from the humble pen and paper, to digital sketching using programs like Autodesk sketchbook, and most recently the use of virtual reality (VR) technologies and software such as Gravity Sketch.

The goal of sketching is different in various phases of the design process. For example, the goal of sketching at early stages of the design process is to produce as many ideas as possible. On the other hand, sketching in later stages of the design process are typically high in quality (Barr & MacLachlan, 2019, p6.) because the sketch may be presented to clients.

The benefits of analogue sketching are a higher quantity of ideas compared to digital sketching (Barr & MacLachlan, 2019, p5; Camba et al., 2018, p.147), whilst the disadvantages varies depending on the purpose of sketching, like the need for a lot of equipment, practice and proficiency to create high visual quality sketches.

In contrast, the benefits of digital sketching are enhanced editing capabilities (undo, copy and paste, functions etc.). These capabilities impact on ideation and page layout, the use of layers and underlays, visual quality of the sketch, speed, sketch organisation, and file management. Additionally, digital work reduces the amount of equipment needed to sketch (Camba et al., 2018, p149) However, the disadvantages are equipment issues (battery life, financial cost etc.), initial physical and digital learning curves, a 'lack of feeling' and difficulties adjusting to the reduced friction of the screen (Camba et al., 2018, p149).

Other than analogue and digital sketching, an emerging technology for the concept development phase of the design process is the use of VR. The benefits of VR concept development are interacting with the sketch at true scale and the ability to see different views (Ekströmer et al., 2018, p2 ; Berg & Vance, 2016, p13), the ability to duplicate a sketch for faster ideation and a more immersive workflow which triggers better design decisions for end-user needs (Rieuf et al., 2017, p70). The disadvantages are the same as disadvantages for digital sketching, being the learning curve, equipment issues and financial cost. Also, the benefits of combining VR sketching with physical prototypes remains undetermined (Sang-Gyun et al., 2017).

3D modelling and Computer-Aided Design (CAD)

3D modelling and the use of CAD is an important activity in industrial design. This includes the type of programs currently used for 3D modelling, and emerging technologies such as generative CAD, AR (Augmented Reality) and open-source CAD. 3D modelling can be used at any point in the design process but is typically used in the later phases because it is not suitable for generating initial concepts (Alcaide-Marzal et al., 2019, p145). However, emerging technology has the potential to change this attitude.

One area of emerging technologies for 3D modelling is generative CAD. Generative CAD is a feature of 3D modelling programs which generates alternative design solutions, allowing further ideation of solutions for designers to consider (Alcaide-Marzal et al., 2019). However, there appears to be an underutilisation of generative CAD and other emerging technologies like open-source CAD in industry due to licensing, reliability, and integration with other CAD systems (Nordin, 2018, p.30). Like generative CAD, future AI (artificial intelligence) CAD systems are expected to assist designers and engineers by suggesting solutions for design problems, based on databases and automated algorithms (Hirz et al., 2017). Future AI CAD system also face the same challenges as generative CAD.

Augmented Reality (AR) is another emerging technology which could potentially be used in industrial design practice. Previous studies have investigated its usefulness for engineering education, suggesting that the use of AR models is as effective as physical models for experiencing a product's semantics (Pardo-Vicente et al., 2019, p16). This raises the potential financial and time-saving benefits of using AR models instead of high-fidelity prototypes during early design phases such as user testing and market evaluation. The use of holograms is another interesting emerging technology. Digital holograms, such as those developed Microsoft's Hololens (Microsoft, 2020) are predicted to aid designers in product styling, packaging and manufacturing methods (Hirz et al., 2017).

Another important technology for industrial practice is the Adobe suite. However, no literature was found to support use of the adobe suite of programs beyond education despite the obvious benefits to a wide variety of activities in the design process (Huerta et al., 2019). These benefits include tools for designing documents, graphic visuals, product mock-ups and presentations.

Collaboration

Collaboration in design teams is another important factor for performance. Emerging technology for collaboration includes the use of online products like Miro, Slack, Figma and others. The effects of COVID-19 have seen many industries begin or increase their use of online platforms allowing

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people to collaborate without the need of physical interaction.

In context of design process, sticky notes and their physical attributes are used to capture individual ideas and form categories when brainstorming, support design thinking and assist design outcomes (Dove et al., 2017, p.113) However, there are clear limitations to physical sticky notes including location, replication, portability, capturing of information after using sticky notes and difficulty creating a hierarchy of information when grouping sticky notes (Dove et al., 2017, p. 118) Many of these limitations have been solved through the development of online collaboration platforms such as Miro.

The benefits of using digital sticky notes are reducing time spent on sorting and re-arranging sticky notes, the ability to edit the contents of sticky notes, inputting different media for a particular sticky note, sharing the sticky notes online, and updating sticky notes as the design process progresses throughout a project (Dalsgaard et al., 2020, p170). The benefits of digital collaboration are highly applicable where physical interaction is not possible, for example when design teams are collaborating with national and international clients or for circumstances like the current social distancing measures which are in-place.

Online communication tools like Slack facilitates collaboration within teams (Stray et al., 2019, p111). Implemented properly, the benefits of tools like Slack are increased performance and motivation of employees, making collaboration between team members more convenient, and building trust and awareness within teams through transparency (Stray et al. 2019, p112; Calefato et al., 2020, p10). However, around what communication mediums within teams and externally should be considered when using online communication tools (Calefato et al., 2020, p5).

Design teams may also benefit from collaborating with AI technologies. AI is an emerging technology with the potential to assist industrial designers across a range of tasks within the design process. Although AI technology hasn't yet matured for use in design practice, it is expected to help designers interpret a design brief, suggest where to begin to design solutions that consider client and user requirements, and verify design solutions which must meet manufacturing requirements (Kim et al., 2019, p142). Currently, AI applications like Otter provides some practical assistance with recording client meeting minutes and capturing data from interviews (Jüngling & Hofer, 2019, p1), although has some difficulty recognising speakers which may be overcome using a human-AI hybrid approach (Jüngling & Hofer, 2019, p5). There has been some progress towards development of an AI application to code themes in qualitative research methods, but the authors recognised that further development of the tool is required (Kim et al., 2019, p144). A lack of literature in this area suggests further research is needed to explore how AI technology could make the design process more efficient and increase industrial designer performance.

Prototyping

It is important to define prototypes in this dissertation as physical representations of a product or service, as to avoid confusion around prototypes being generalised as physical or digital. This approach has been taken because digital prototypes have been discussed in previous sections of this paper. The most widespread physical prototyping tool reportedly used in design practice is 3D printing, which utilises techniques from additive manufacturing (Friesike et al., 2018, p735).

Additive manufacturing is a vast topic and has been extensively used by designers to produce aesthetic and functional prototypes due to its fast and cost-effective prototyping capabilities and minimising additional expenses that are incurred in the design process (Ngo et al., 2018, p172). Current limitations of 3D printing depend on the method used. For example, commonly used fused deposition modelling only uses thermoplastic material, is structurally weak and creates prototypes with a layered surface finish (Ngo et al., 2018, p176). Another method to create high fidelity prototypes using 3D printing is powder bed fusion. The benefits of using this method are a high quality and resolution prototype, suitable for late stage design activities that require a prototype close to the final design solution. However, the powder bed fusion of 3D printing is a slow and costly process (Ngo et al., 2018, p176). Other than 3D printing, no other emerging technology or current practice for physical prototyping was found in academic literature.

Table 1. (p13-14) provides a summary of emerging technologies' potential benefits and drawbacks for industrial design practice and increasing industrial designer performance.

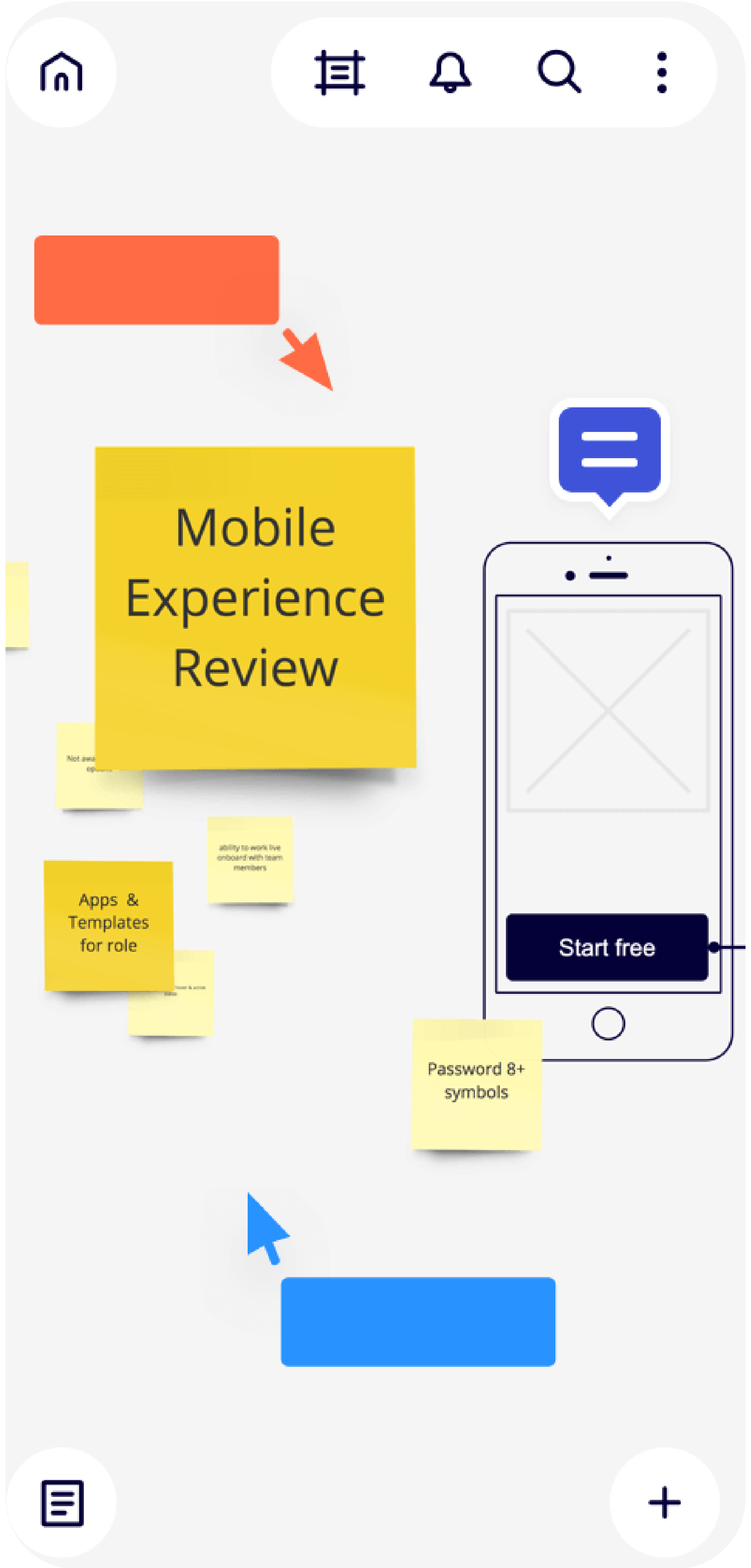

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Table 1. Summary of Emerging Technology from literature review (Anderson, 2019)

DESIGN ACTIVITY	TECHNOLOGY, TOOL OR PROCESS	BENEFITS	DRAWBACKS	SOURCES
Concept Development	**Analogue Sketching**	• High quantity of ideas generated compared to digital sketching	• Physical equipment & proficiency to produce high quality visual sketches	(Barr & MacLachlan, 2019, p5; Camba, Kimbrough & Kwon, 2018, p.147)
	Digital Sketching	• Editing capabilities for page layout, underlays, visual quality of sketches, speed and file managment. • Reduced equipment needed to sketch	• Equipment issues (battery life, financial cost of purchasing etc.) • Initial learning curve • 'lack of feeling' and adjusting screen surface friction	(Camba et al., 2018, p149)
	Virtual Reality (VR) Sketching	• Viewing capabilities & interacting with a sketch at true scale • Duplicating a sketch for fast ideation • Immersive workflow that triggers design decisions for end user	• Learning curve • Equipment issues • Financial cost of purchasing equipment	(Ekströmer et al., 2018, p2 ; (Berg & Vance, 2016, p13) (Rieuf et al., 2017, p70) (Sang-Gyun et al., 2017)
3D Modelling & Computer-Aided Design (CAD)	**Generative & Artificial Intelligince (AI) CAD**	• Generates alternative design solutions for ideation • Suggesting solutions for design problems based on databases and automated algorithms	• Licensing & Copyright issues • Reliability • Intergration with other CAD systems	(Alcaide-Marzal et al., 2019) (Nordin, 2018, p.30) (Hirz et al., 2017)
	Augmented Reality (AR)	• Similar to physical prototype for experiencing product semantics • Time and cost saving when used to replace high-fidelity prototypes, user testing and market evaluation	• Finacial cost of purchasing software and equipment	(Pardo-Vicente et al., 2019, p16) (Hirz et al., 2017)
Collaboration	**Physical Sticky Notes**	• Capture individual ideas and form categories for brainstorming • Support design thinking • Assist design outcomes	• Location, replication, portability, recording information after sticky note brainstorming[1] • Creating hierarchy of information when grouping sticky notes[1]	[1](Dove et al, 2017)
	Digital Sticky Notes	• Reduce time spent sorting and re-arranging sticky notes • Ability to edit contents of sticky notes and input different media • Accessability	• No drawbacks found in literature review	(Dalsgaard et al., 2020, p170)
	Digital Communication Tools	• Increased performance and motivation of employees • Convenient collaboration between team members • Increased trust, awareness and transparency within teams	• Information overload • lack of rules for communication • lack of which communication tools should be used in-context	(Stray et al., 2019) (Calefato et al., 2020)
	Artifical Intellligence (AI)	• Expected to assist with various design activities including collaboration • Otter - provides capturing of client meeting minutes and interview data	• Not yet fully matured for use industrial design practice • Otter - diffculty differentiating speakers' voices	(Kim et al., 2019, p142) (Jüngling & Hofer, 2019)
Prototyping	**3D Printing - Fused Deposition**	• Fast & cost-effective physical prototypes • Reduces time spent making physical prototypes using other methods & can be done in-house	• Can only use thermoplastic material to print • Structuraly weak and not suitable for high-functionality • Layered surface finish	(Ngo et al., 2018, p172, 176)
	3D Printing - Powder Bed Fusion	• High quality surface finish and structure	• Increased print time • Financial cost (equipment, materials and software)	(Ngo et al., 2018, p176)

Design Management & Other Influences on Emerging Technology Use

Implementation

The implementation of new processes, tools and technologies in any industry is largely influenced by management and company leadership (Alnaggar & Pitt, 2019; Rezvani et al., 2017). Past and current research provides little insight into how design management professionals are implementing emerging technologies to increase productivity. Additionally, contemporary tools and processes are also absent from literature. The most likely cause for under-reporting of emerging technology use in industry is that businesses would lose their competitive advantage if they were to disclose any methods, tools or information on their operations. This concept of keeping this information undisclosed is known as trade secrets (USlegal, 2019). An in-context example of this would be the specific CAD programs used at various industrial design workplaces and the performance benefits. Because design management is also responsible for maintaining the profitability, productivity and performance of a business, it is important for design managers to balance this with the advantages and disadvantages of implementing and using emerging technologies in industrial design practice.

Workplace Environments

The recent consequences of COVID-19 have forced many professionals to work remotely. Because environmental structuring is important for performance (Colthorpe et al., 2015), it is important to compare how designers and managers set-up their home office environment as opposed to how they structure their work office environment. The physical work environment and how it affects performance has been the focus of previous studies and provides a strong correlation the two are related in many ways (Shobe, 2018, p4). There is a gap in literature that compares performance of industrial designers working at home and industrial designers working in an office setting.

Expertise

The most important factor identified for performance in industrial design is expertise of technology, tools and processes (Brodersen et al., 2017, p377; Dalsgaard, 2017, p31). Although proficiency is largely responsible for how productive a designer can be, emerging technology has the potential to lessen the learning curve of certain design tools and processes and develop entirely new ones to increase performance. Exploration of emerging technologies may also improve the creative output of industrial designers, resulting in more successful projects and growth of industrial design businesses.

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Current 'State of the Art'

Available literature deals very little with the current 'state of the art' for emerging technology use in industrial design practice. The only mention of emerging technology is the use of 3d printing in product design workplaces for prototyping (Ngo et al., 2018, p172). After review of literature on emerging technology in industrial practice, it is evident there is not enough reporting of technology use by ID workplaces and or research into this area. Further research beyond educational use of emerging technology needs to be conducted to determine best practices for performance of industrial designers in various industrial design workplaces.

Research Gap

There is a research gap between literature and proven implementation of emerging technologies for industrial design practice. As discussed, businesses use trade secrets to stay competitive and are perhaps unwilling to disclose emerging technology use. The benefits and disadvantages of the various emerging technology discussed in this literature review and how they increase performance in industrial design practice is a key research question. Key research questions for areas pertaining to performance such as, the role of design management, and how industrial designers are working in current conditions were formulated during this literature review. These are;

Question 1: What technologies, tools and processes are designers using during concept development, collaborating, CAD and prototyping at different points in the design process, and how do they increase performance?

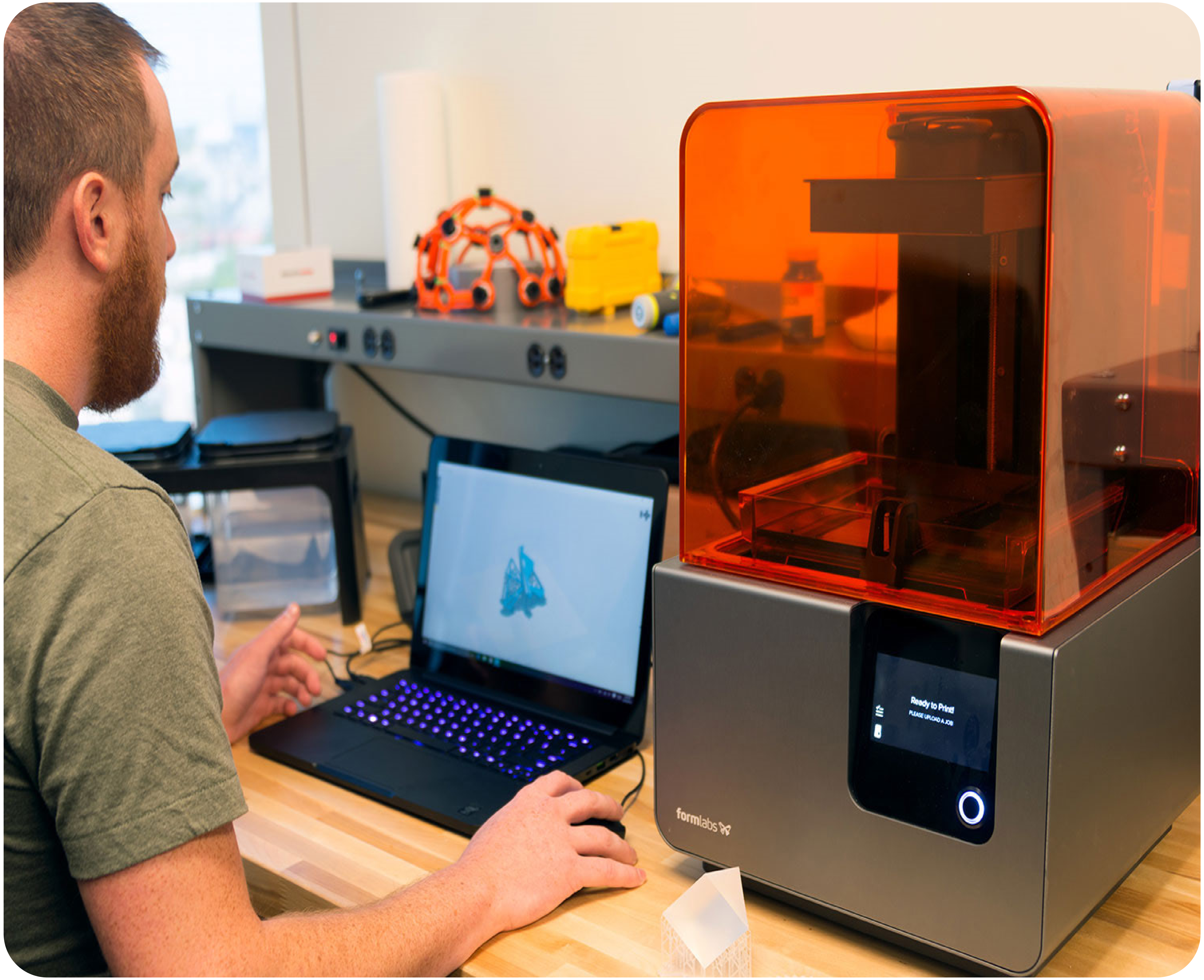
Question 2: Is design management implementing and managing emerging technologies and if so, how are they measuring the effectiveness of emerging technologies on performance?

Question 3: How are designers working from home and what emerging technologies are they using to increase performance?

Literature Review Summary

Emerging technology's influence on productivity and performance in industrial design is multi-faceted. Within the different design activities that occur in industrial practice, there is a variety of tools and processes that utilise emerging technology. Sketching and concept development is enhanced using digital sketching and VR technology. The emerging technology for 3D modelling and CAD is generative CAD, AR, and VR. For collaboration, online platforms provide designers with brainstorming and project management capabilities, and recent developments in AI technology used in other industries, could potentially support industrial designers. Lastly, the emerging technology for physical prototyping is advancements in 3D printing materials and sophistication, suitable for various applications in the design process.

All these emerging technologies have various benefits and drawbacks for a variety of contexts, but it is unclear whether they are being used in industrial design practice. Further research is needed to confirm or disapprove the use of emerging technology in industrial design practice, and what benefits and drawbacks they may have for increasing industrial designer performance and productivity.



CH • 3 RESEARCH DESIGN

Research Design

This study will use qualitative research to identify design opportunities. Qualitative research begins with research questions, as developed from the literature review, and it's purpose is to gain knowledge and a deeper understanding and further inform the research questions (Rossman and Rallis, 2017, p4). Qualitative research takes place in real world scenarios, uses a variety of methods that are ethical towards the participants of the study, and is fundamentally interpretive, emergent, and evolving (Marshall & Rossman, 2014, p2; Rossman and Rallis, 2017, p9). The benefits of qualitative research are that it provides a rich and holistic understanding of an activity within a context, and much like human-centred design provides insights into peoples' experiences (Tracy, 2019, p7). The challenges of qualitative studies are ensuring the research methods are systematic, manageable and flexible, developing a conceptual framework for the study that is informative and succinct, and integrates both of these notions into a coherent argument (Marshall & Rossman, 2014, p6). Figure 2. Provides a graphic outline of the research design for this paper.

Interviews and cultural probes were chosen as the research methods for this study to make use of triangulation and will provide insights for answering the research questions. Additionally, the cultural probes will be used to confirm the reliability of data collected during interviews. For example, an industrial designer might say they use two screens in their home office, but the cultural probe of their home office proves they do not have or use two screens. Using cultural probes to compliment the interviews helps to eliminate what the research participants perceive they do in practice, and what they actually do.

Triangulation is the combination of two or more research methods within the same study, and the purpose is to strengthen the research design and in turn the ability to correctly interpret findings (Turmond, 2001, p1). The benefits of triangulation for studies are potentially increasing confidence in research data, developing new ways of understanding a problem, uncovering unique insights into a particular problem, challenging or integrating theories within the research findings, and providing clarity around a problem (Jick, 1979). The disadvantages of triangulation in research are the increased amount of time needed in comparison to use of a single research method, difficulty understanding the sheer amount of data, potential disconnect based on researcher biases and literature, data conflicting with theoretical framework, and a lack of understanding about why triangulation was used for a particular study (Turmond, 2001, p4).

Participants

Since the aim of this study is to determine best practices for industrial design, the participants will be design professionals who are in management roles and industrial designers. Currently, three design directors have confirmed their interest in participating in the study, along with industrial and other designers they manage, and at least one other industrial designer. Given current circumstances, recruiting more participants may be difficult, although sample size is

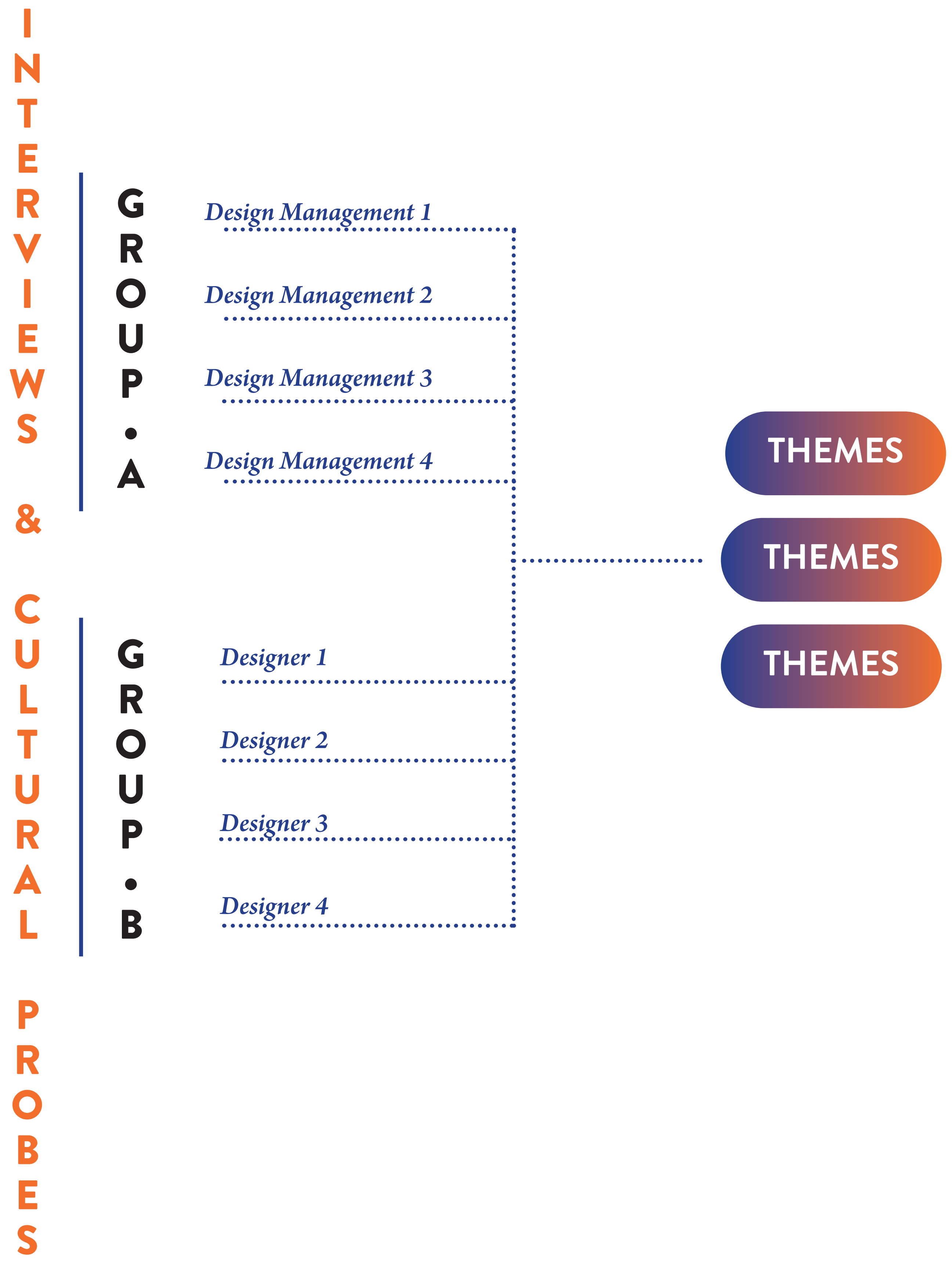


Figure 2. Research Design Overview (Anderson, 2019)

adequate compared to that of past design studies.

Pilot Study

After the research methods were chosen, a pilot study was conducted. Pilot studies are a test study before actual research is conducted. The purpose of a pilot study is to test the feasibility, reliability and validity of the proposed research methods (Afisi et al., 2010). Two interviews and cultural probes were conducted in the pilot study. This was done to ensure that questions asked during the actual interviews were relevant and provoked meaningful answers from participants. The pilot studies also helped the interviewer practice asking non-structured questions and 'spur of the moment' questions, provided opportunity to practice the interviews and proved the tools being used to collect data from interviews and cultural probes are effective. Figures 3. and 4. show samples of the data collected during the pilot study, using the interview and cultural probe methods outlined in the following sections. A sample of pilot study's interview transcripts can be accessed using the following link: https://otter.ai/s/ef2h1IJwSlKiXWNsNexSew . Additionally, the cultural probe data collected and interview transcripts from the pilot study are included in the Appendix.

Research Methods

Interviews

The first qualitative method will be semi-structured, face-to-face virtual interviews. Semi-structured interviews are organised around a pre-determined set of questions and impromptu questions emerge through conversation (Whiting, 2013, p35). Semi-structured interviews were chosen as a research method because this study is investigating uncharted territory with unknown but potential momentous issues and the interviewers need maximum latitude to spot useful leads and pursue them (Adams, 2015, p494) However, there are the limitations of semi-structure interviews such as the time and labour resources needed to prepare, set-up, conduct and analyse interviews. Additionally, the success of interviews also depends on the interviewer's ability to be agile and knowledgeable about the topic in-question (Adams, 2015, p493), and interpret the interviewees responses.

Interviews will be conducted on two groups, A and B. Group A will be design managers who are responsible for implementing emerging technology, tools and processes into designer's workflows. Group B will be practicing industrial designers who use emerging technologies. The tools used for semi-structured interviews will be Zoom and Otter. Zoom is an online meeting platform that utilizes video audio, and allows virtual face-to-face interviews to be possible (Zoom, 2020). Otter is a mobile and web-based application that records and takes meeting notes in real-time (Otter, 2020). Participants will be asked for their permission to record the interviews. Zoom has a plug-in for Otter, allowing recording and transcribing of Zoom meetings. Using this method, qualitative data can be successfully recorded and stored. A pilot study was conducted using the semi-structure interviews method above. Figure 4. shows a sample transcript of an interview conducted for the pilot study:

Cultural Probes

The second qualitative method will be cultural probes. Cultural probes is where participants are asked to self-document certain activities linked to research questions. This provides insights into participants and or end users so that researchers may gain a deeper understanding of activities in context of the research topic (Celikoglu et al., 2017, p86). Cultural Probes were chosen as a research method because a focus of this study it to explore how industrial designers work from home. Each participant from the interview method will be asked to record their home office space in the form of photos or video. The tools to be used for collecting cultural probe will be the participants' smart phones and cameras. This method is suitable for current circumstances and reduces time and labour spent collecting the data. Figure 3. and the appendix give samples of the cultural probe data collected in the pilot study.

Figure 3. Cultural Probe data from pilot study (Anderson, 2019)

Limitations

Like most studies, there are limitations of this study and the methods. Firstly, the method of interviews and cultural probe were changed to adhere to social distancing rules currently in-place during the Coronavirus pandemic. Interviews were now conducted online rather than in-person. This meant that some interpersonal communication was absent whilst using zoom, such as body language and tone of the interviewee due to poor camera and microphone quality. However, for the purpose of this study these factors are less important because when the interviewer interviews an expert about

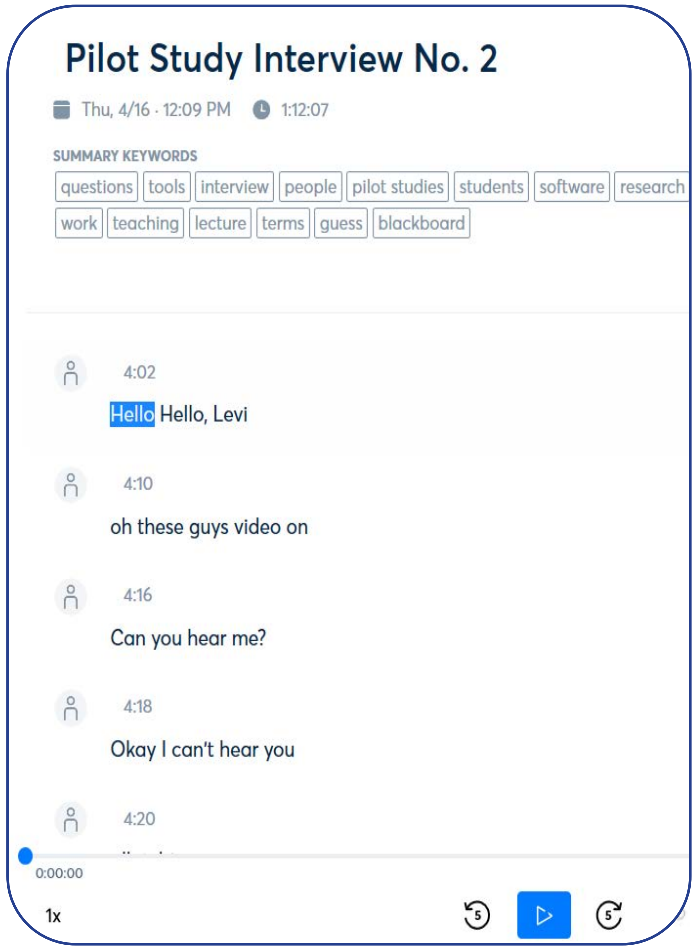


Figure 4. Interview data from pilot study (Anderson, 2019)

topics or persons that have nothing to do with the expert as a subject, then social cues become less important (Opdenakker, 2006, p3). Additionally, Zoom relies on internet connection which can face technical difficulties either on the interviewer and or participant's end. The second research method was also affected. The original method was to observe what emerging technology was being used in office settings and how it was being used. However, the purpose of this study and the research methods has also shifted in response to current circumstances. An opportunity has emerged to investigate how industrial designers work from home and to do this, observational methods were changed to a cultural probes.

Finally, this study is limited to practicing industrial designers and design management in Australia. This was done to ensure that the influence of different cultures, some more technology reliant than others, did not influence the rigour of this study.

Research Design Summary

In summary, interviews and obsersevations have been chosen to collect qualitative data and provide rigour to this study using triangulation. The participants for this study are design management and industrial designers. A pilot study was also conducted to test the effectiveness of the research methods. The data collected from the pilot study is promising in helping to answer the research questions identified in the literature review. The next steps are to complete relevant ethics documentation, and conduct interviews and cultural probes with the research participants.

CH.4 FINDINGS & ANALYSIS

174 years of industrial design experience

512 minutes of conversation

13 Interviews

3 Continents

Figure 5. Research Summary (Anderson, 2020)

Introduction

As mentioned in the previous chapter, interviews and observations were conducted with industrial designers and design managers. Figure 5. Provides a summary of participants, 13 interviews and 4 observations were conducted. Out of these 13 participants, 5 participants were in group A (design managers) and the remainder in group B (industrial designers). In some cases, participants in group A were also considered to be in group B as they were still using design tools in their work. Interviews proved to be highly effective in answering all three research questions. Additionally, questions regarding future design tools and practice pains were used to provoke potential recommendations for design. However, the observations method had low participation, resulting in a small data set but still useful for gaining insights for research question two.

Participants were recruited from all along the east coast of Australia, as well as a participant from the USA and a participant from Germany. The participants were either industrial designers or design managers working in a wide variety of contexts including consultancy, in-house, corporate and freelance roles. Figure 5. provides a snapshot of the research conducted and non-identifying participant information.

Analysis

The chosen analysis methods for both interviews and observations was affinity diagramming. Affinity Diagramming analysis involves recognising and arranging qualitative data into themes and sub-themes using sticky notes and/or other medium (Swann, 2020). Also originally known as the KJ method, Affinity Diagramming is useful for organising complex, immeasurable and behavioural qualitative data (Scupin, 1997). The benefits of this method are that it is a quick approach to qualitative data analysis (Swann, 2020). However, the disadvantages are that a low number of individual data points may cause biases in analysis (Takai & Ishii, 2010). This disadvantage was overcome by conducting many interviews. Affinity diagramming was chosen for this project because of the amount of data collected and time constraints. There are four steps to using affinity diagramming to analyse data: 1) Selecting data points 2) Assigning themed tags (themes or sub-themes) to data points 3) Grouping data points 4) Synthesing data points to develop overall themes and sub-themes (Swann, 2020; Scupin, 1997).

Using Affinity diagramming and transcribed data, three themes directly related to the research questions were developed using individual data points from interview responses: Technologies, Tools and Processes, Working From Home, and Design Management. Under these themes, many sub themes were identified from interview responses. Additionally, a fourth overall theme was developed, where interview responses informed practice pains and opportunities. This theme and its sub-themes are particularly useful as the purpose of this research is to identify areas for innovation within current industrial design practice. Figure 6. provides a visual summary of how the research data was analysed. To see the full version of analysed data using affinity diagramming, see the following link: https://miro.com/app/board/o9J_ksfy3_g=/

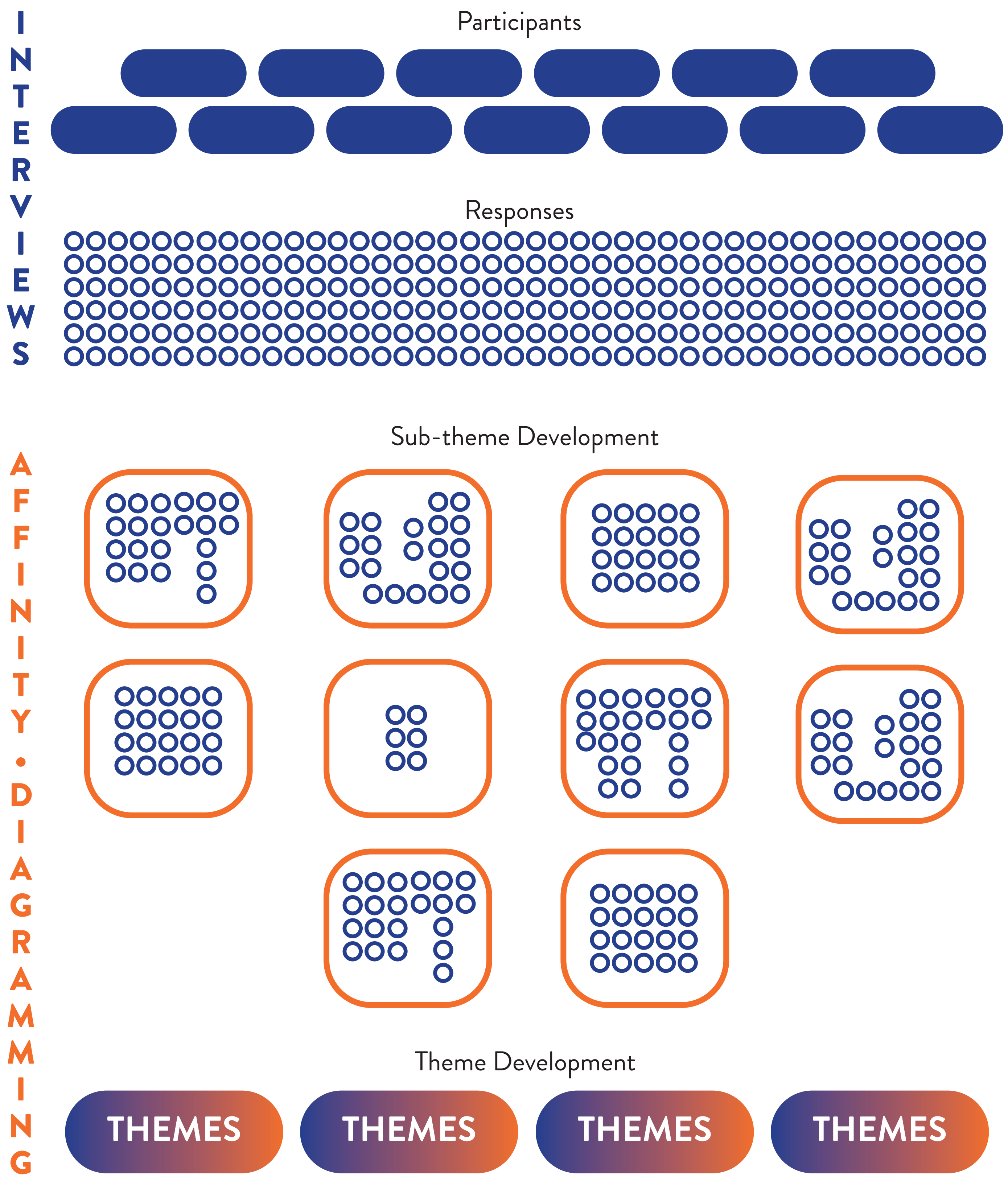


Figure 6. Data Analysis Summary (Anderson, 2020)

Findings:
Technologies, Tools & Processes

To provide answers to the first research question, interview questions regarding the design tools being used in practice including software, hardware and workflows were asked of participants. Analysis of interview responses were developed into several sub-themes. Table 2. Provides a summary of the types of design activity are and what tools and processes are being used. Further details regarding how these tools are being used was analysed from interview responses to these questions. However, the volume and range of responses makes it difficult to summarise in this paper. For in-depth use cases for the various sub-themes and tools, see Appendix 2. Some highlights that focus on performance of industrial designers are outlined below.

"I personally print out an previous design. For example, if we have to redesign a problem, we sketch over and it's a very quick way to do it" P2 (4:46)

For efficiency, some participants reported that they used a underlay either digitally or analogue to quickly sketch something to the correct scale and perspective. This underlay was either a reference image or a quick CAD model.

"I'll go basic 3d CAD model in SolidWorks. Yeah, screenshot at chuckling procreate and sketch over the top" P9 (21:25)

Through the interviews, it was discovered that communication between colleagues and clients is the most important aspect of industrial design practice.

"We've been just using WhatsApp, mostly for discussing. We have a big a big company Dropbox set up. So all of our project folders are in that every time we do a bit of SolidWorks or work on a presentation or proposal, it all gets uploaded, automatically." P6 (5:01)

Online messaging platforms, cloud-based file storage, video-conferencing software and various project management software were all mentioned by participants as tools that helped make their workplaces more efficient.

"SolidWorks for modeling straight into key shot for rendering" P9 (12:10)

With 3D modelling and rendering, primarily Solidworks for modelling and Keyshot for rendering was being used amongst participants. However, some participants mentioned using Alias, Inventor and Fusion360. Additionally, a highlight response gave insights into a workflow that is tailored to project budgets.

"Depending on the budget, we use concept CAD, and that's really block models, usually to serve rendering purposes. They capture the design intent, but not necessarily the design details" P3 (40:07)

"Usually Prototyping with a Ultimaker, sometimes with more advanced Objects. For the fine & better design models we have model making partners, they are the experts" P1 (000)

For physical prototypes, most participants and particularly those working in consultancies outsourced their high-fidelity prototypes to 'model makers' or in other words manufacturing facilities overseas. For low-fidelity prototypes or validating design solutions, 3D printing was reported by participants.

"Illustrator and InDesign to present our work as well to make our presentations" P3 (47:55)

"Any post processes generally done in Photoshop... it's a bit of back and forth between Photoshop and keyshot" P3 (46:06)

All participants reported using programs from the adobe creative cloud suite. For example, presentations were made using InDesign and presentation content was made using Photoshop & Illustrator.

Table 2. Findings for Technologies, Tools & Processes being used in Industrial Design Practice (Anderson, 2020)

Sub-Themes	Software, Hardware or Workflow
Sketching & Concept Generation	• Pen & Paper • Whiteboard & Markers • Digital Sketching e.g Autodesk Sketchbook on Ipad • Wacom Tablets • Using an underlay and sketching over it (Analogue or Digital)
Collaboration & Communication	• Zoom • Slack • Skype • Office-based Servers (Cloud storage) • WhatsApp • PowerPoint/Keynote
3D Modelling & Rendering	• Solidworks • Keyshot • Fusion360 • Alias • Inventor • VR (using Gravity Sketch)
Physical Prototyping	• 3D printing (FDM or Powder-based) for low-fidelity • Outsourcing to 'Model Makers' or manufacturing partners for high-fidelity
Adobe Suite	• Photoshop • Illustrator • Indesign

Design Management

To provide answers to the second research question, it was learnt through interview responses that design managers have little impact on implementing or determining design tool usage. Additionally, most design managers were not considering using emerging technologies, tools or processes to enhance or track industrial designer performance.

"I think that a lot of companies, They get comfortable with one process.." P4 (32:09)

One highlight response from the design manager's responses can be seen below. Only 1 out of the 5 design managers mentioned business development as a key aspect of their work.

"As a small consultancy 50% of my time should be looking for work. Business Development. Yeah, so slack doesn't necessarily help me in terms of my ability to show who I am and what my capabilities are to the rest of the world...I have to have tools that allow me to even communicate to the world that I exist and that I have something to offer" P4 (22:51)

With regards to performance, one design manager mentioned his process for eliminating issues that may affect employee satisfaction. Again this response was an outlier to the other design managers.

"we have what we call a one to one meeting. So basically every week I take the time to talk with everyone. Separately, yeah, about what their career goals are, where they are this week, what's the latest issues, what's causing them drama... You know frustrations or factors that might affect their performance." P5 (15:16)

There were many other interesting responses to questions asked of design managers. However, it has been determined that these aren't critical findings compared to the other themes and consequently design management will not be further discussed in this paper. However, further findings on design management can be found in the Appendix.

Working From Home

To provide answers to the third research question, two sub-themes were developed for this theme: Productivity and Tools & Strategies. Interview questions about participants' productivity at home were asked to determine whether or not working from home has affected productivity.

Firstly, productivity when working from home had varying answers from participants. For example, participants acknowledged that they needed time to work by themselves without distraction.

"So if I know exactly what I have to do, working from them is better because I have less distractions." P2 (26:39)

However, participants also acknowledged that they also needed input and collaboration from their colleagues.

"...Harder to manage all the input you should receive from them or the output you. You need to give to them. Yeah, okay. Yeah. If they're not in the same place, because you have to call them and then call another one.." P2 (26:39)

Working from home also affected performance due to file management and the inability to quickly communicate with colleagues in-person.

"It's slowed down our efficiency because of file management so you know we've obviously got to work on a remote remotely to the server we have large files" P5 (43:11)

Observational data was also collected to inform research questions two and adds to the theme of working from home. Figure 7. shows a sample of observational data. From observational data it was found that industrial designers working from home did not have much space to work and was cluttered. Additionally, all participants had at least 2 computer screens or monitors when working. Finally, the position of webcams allowed for the participant to be seen whilst using video-conferencing software. However, the positioing of participants' webcams makes it difficult to show and present sketches without spending time scanning them or reduced clarity if using current webcam positioning.

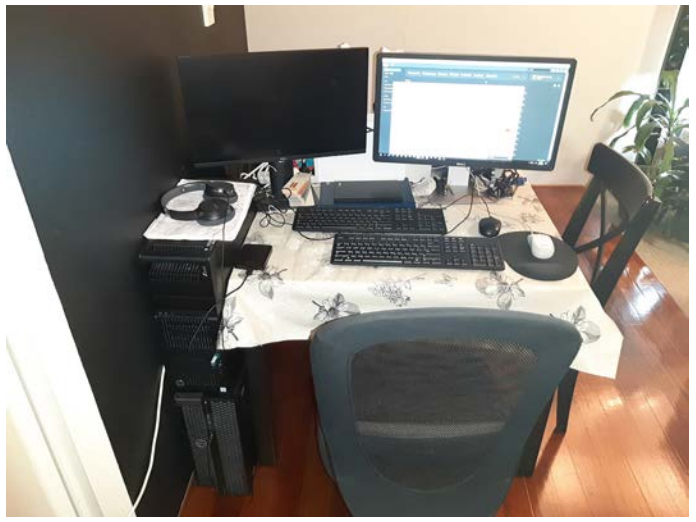


Figure 7. Observations of an industrial designer working from home (Anderson, 2020)

Practice Pains & Opportunities

This theme and sub-themes is most important for the project because it provides areas in which the industrial design processes and activities may be improved. The following three sub-themes were developed from interview responses using affinity diagramming: Time Savers, Time Consumers & Pains, and Future Tools and Ideas.

Time Savers

This sub-theme was developed using participants responses to a question regarding what technologies, tools or processes saved them the most time whilst working. Participant 1 had two highlight responses regarding efficiency around concept generation and sketching.

"Photoshop: I love to do photo bashing - taking the inspiration pictures (from pinterest etc.) and using them directly in photoshop to build something, also quite fast" P1 (000)

"Hand Sketching: I print out a rough CAD screenshot, sketch over it and voila - I can communicate an idea in under 2min" P1 (000)

Other responses included how some workplaces catalogued or kept a record of their past projects, what worked, what didn't work etc. to avoid pitfalls in future projects and to be more efficient during certain phases of the design process. For example, a particpant mentioned that building a company-wide materials library for 3d rendering made it easier to create renderings for clients:

P2 (18:49) "building materials library for the company. So you know, like the first year there was no material done right now. It's almost drag and drop."

Time Consumers/Pains

This sub-theme was developed using participants responses to a question regarding what part of the design process or general work activities took the most amount of time or was most difficult for a variety of reasons. Participants' responses can be found in the appendix. However, a significant time consumer or pain for industrial designers is the process of communicating ideas, sketches, prototypes etc. with clients and stakeholders. Participant 6 summarised the problem:

"Showing sketches is a whole process. You know, it's like, scan them in with a scanner with our phones, put them into a PDF, send them off. It's not, I can't sit across the table from a client anymore and sketch something out and hand it to them" P6 (41:20)

Another significant time consumer is receiving feedback or input from clients and stakeholders during the later stages of the design process. This causes industrial designers to make modifications to 3D models which is time consuming.

Future Tools & Ideas

This sub-theme was developed using participants responses to a question that asked participants to think about a product, service or system that would improve their performance as either an industrial designer and/or a design manager. Table 3. summarises the variety of responses from participant.

Table 2. Findings for Future Tools & Ideas to improve Industrial Design Practice (Anderson, 2020)

Future Tools & Ideas	Descriptions
Digital Clay/ VR Clay	Physical clay that can be manipulated and automatically translates to 3D model on computer programs. OR a VR program that allows you to model using digital clay (inside VR environment) using digital clay modelling tools
AI-assisted Design	Similar to generative design, however this would guide designers in terms of choosing materials, geometry and manufacturing processes for increased sustainability, branding considerations, competitor design languages etc.
Advanced, In-House Prototyping	Ability to prototype a design solution in materials & processes that either replicate or as close to the final product as possible. This would involve the ability to scaleing down processes like injection moulding with different plastics to fit within offices.
Virtual whiteboard	Similar to Miro and Google Docs fatures, with the additional feature to do industrial design style sketches and concepts digitally. This would allow for co-creation with clients locally and internationally via video-conferencing.
New 3D modelling programs	Intergration of polymodelling and parametric modelling techniques into one program to create a variety of designs more efficiently.
Internal Project Database	A record of previous projects, what worked, what didn't work, review of deliverables and insights for efficiency and reference in future projects.

CH • 5 DISCUSSION & DESIGN RECOMMENDATIONS

Introduction

For the purpose of being succinct and discussing the most relevant findings for this project, the Design Management & Working From Home themes will not be further discussed. This is also to ensure that this paper does not exceed the word limit. Technologies, Tools & Processes, and Practice Pains & Opportunities will be discussed. In hindsight, too many areas of research were investigated using the research methods, which ultimately proved the disadvantages of interviews (e.g. too much data to analyse) to be true.

Generally, the findings do not contradict or support existing academic literature. This is because there was a lack of academic research on this topic to begin with. Instead, the findings add significant knowledge to the identified research gap by providing answers to the three research questions and problems within industrial design practice technologies, tools, processes, work-flows and thinking.

Discussion: Technologies, Tools & Processes

Out of all the technologies, tools and processes discussed with participants, the most common aspect was communication with clients and colleagues. Initially the authors had not determined that communication was a key aspect of industrial design practice and therefore was not researched in the literature review. In all the various industrial design workplaces, communication occurs between colleagues, clients, stakeholders and consumers/users.

Use of technologies, tools and processes for sketching and concept generation varied greatly between participants. This was mainly due to the type of workplace and projects that are worked on, as well as the budget for specific projects. For example, one participant mentioned that they use a whiteboard and markers for concept generation, but depending on the project were creating low-fidelity sketches right through to polished, digitally sketched and rendered products for clients.

It is was established through research findings that most industrial design professionals use Solidworks for 3D modelling and Keyshot for 3D rendering. However, some participants mentioned the use other programs such as Alias, Inventor and Fusion360. Programs such as Blender that are in principle polymetric modelling were mentioned very briefly by a few participants.

Physical prototyping of design solutions are mostly done using 3D printers. Interestingly, most industrial designers stated that they use 'model makers' or in other words manufacturing partners to create high-fidelity prototypes. One participant even mentioned this in his workflow whereby the participant would send a design to be prototyped, and whilst waiting for it to be made and shipped he would work on another project to send a design to be prototyped. All particpants stated that it was more efficient with

regards to time and money that it was cheaper to outsource prototyping, particularly for high-fidelity prototypes that were being presented to clients and stakeholders. This finding does agree with what was found in the literature review, which is that 3D printing is being used within industrial design workplaces for prototyping design solutions.

Although there was a lack of academic literature regarding the use of the adobe suite in industrial design practice, it was assumed that the adobe suite and it's various programs were being used in industry because of it's use in educational industrial design courses. Ultimately, the findings proved that the adobe suite was being used in industry for a variety of purposes. Typically, Adobe Photoshop and Adobe Illustrator are being used as a post-processing tool for sketches and 3D renders to present high-fidelity deliverables to clients and stakeholders. These deliverables are then inserted into presentations, slide decks and PDF documents and formatted using Adobe InDesign.

Discussion: Practice Pains & Opportunities

Inevitably there is pains and inefficiencies within any industry practice. However, this provides opportunities and room for improvement. It was found that there a various pains and inefficiencies in unexpected aspects of industrial design practice. Firstly, Communication was found to be the most important aspect of industrial design practice. It was previously assumed that technology, tools and processes were the most important for performance of industrial designers. However, participant pains with communication with clients and stakeholders were numerous.

The most prominent pain was showing clients, stakeholders and colleagues design work remotely. This issue even occurred during one of the interviews, where a participant tried showing a sketch they had done using the front-facing webcam of their computer. The image was unclear, pixelated and grainy. For some design work that is computer-based, the 'Share Screen' feature of most video-conferencing software is effective. However, this raises another issue where viewers have difficulties giving feedback directly related to the work being shown. For example, a PDF slide via screen share displays a 3D model but

Another pain within industrial design practice is the way in which projects are ill-defined. Participants reported that a pain about the design process is making changes to a 3D models which often requires extensive time to make the appropriate modifications.

The future tools and ideas for improving industrial design practice also varied depending on the participants line of work. For example, one participants worked as an industrial designer at a pet product company. His suggestion for a future tool was a photo-booth for products that took photos of from various view points. This photo-booth would be used by the participant's manufacturing partners so that they can clearly show prototypes before shipping them back to the participant.

There are many other responses that could be discussed with regards to future tools and ideas for improving industrial design practice. However, the most common and feasible future tools and ideas have been developed into the following recommendations.

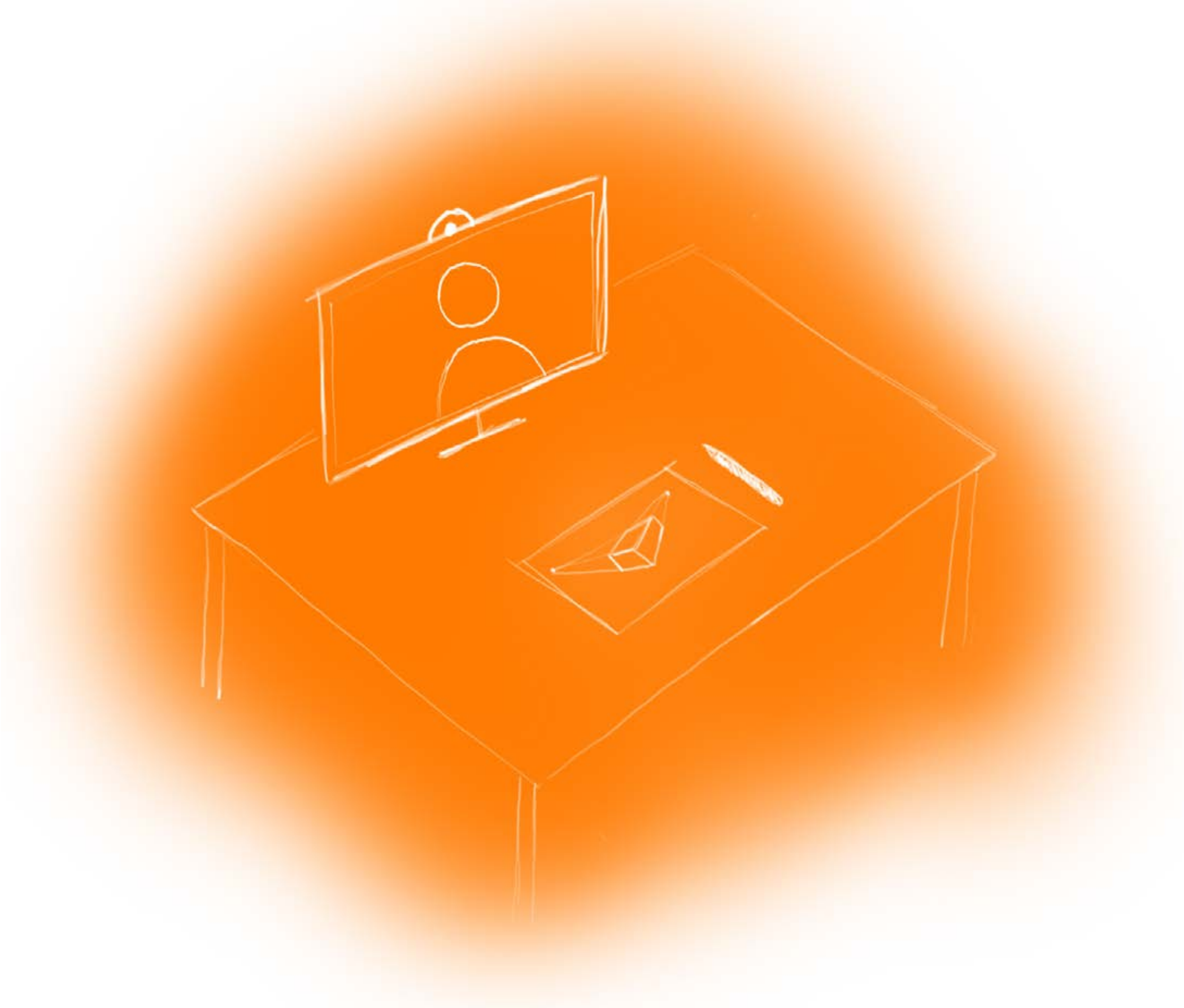
EMERGING TECHNOLOGY FOR ID PRACTICE
Discussion & Recommendations

Recommendation 1: Live Client Communication

The first recommendation is to provide industrial designers and design managers with an adequate solution for showing ideas to client via video-conferencing. This would involve the arrangement of high-quality webcams that are positioned above a workspace and streamed to other meeting participants so that they can see objects in the workspace e.g. sketches, physical prototypes, mock-ups etc. with clarity.

Limitations, Constraints & Considerations

Limitations to this design include difficulty setting up a device, saturation of other similar products on the market and possibly the cost of developing this system. Constraints include intergration with popular video-conferencing software such as Zoom and Skype. Privacy of the user and availability of space within workspaces should also be considered. This idea also fits within the scope of the project (physical product and digital solution)

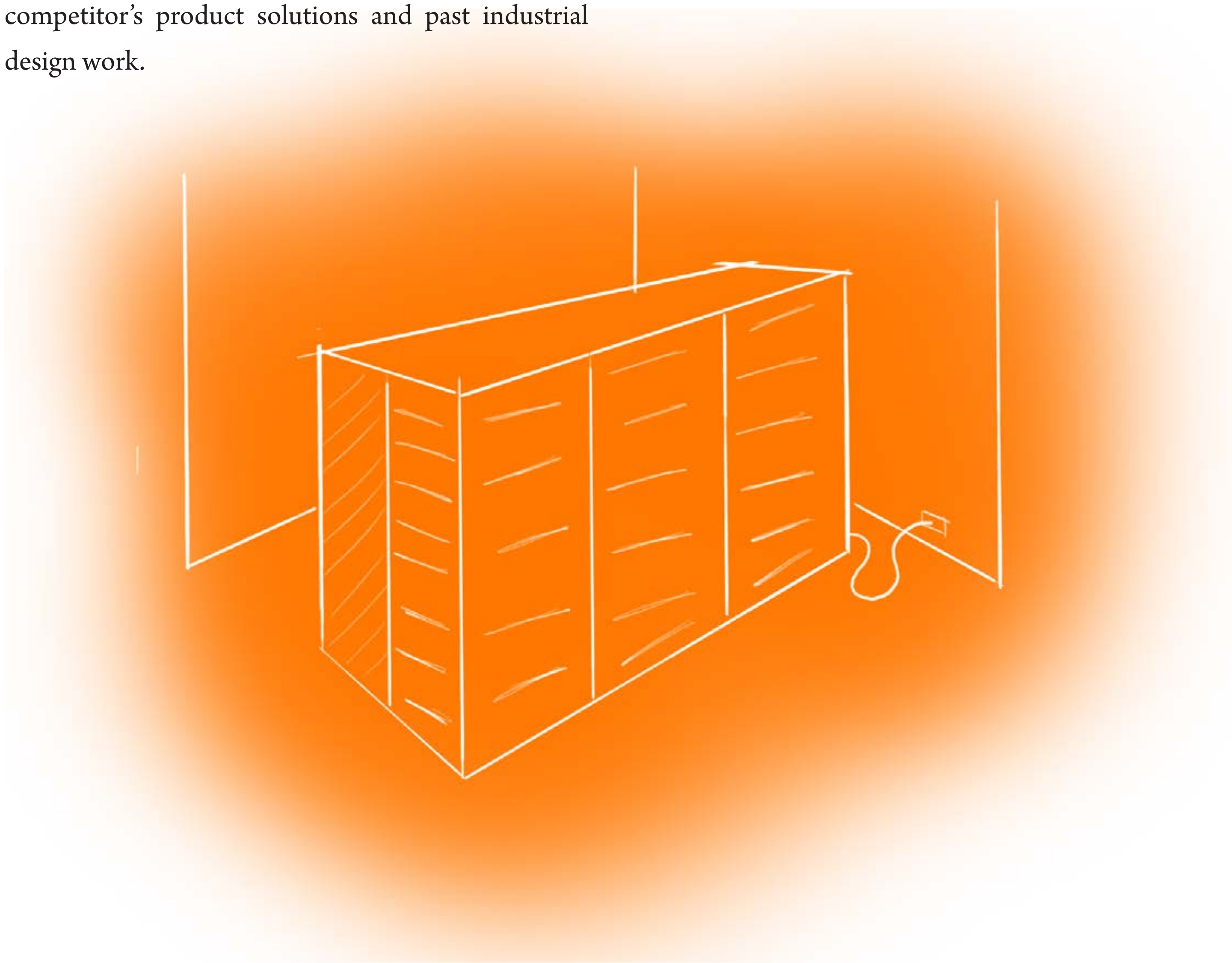


Recommendation 2: AI Design Database

The second recommendation is to establish a database of previous work of organisations and that of other industrial design work in industry. This database could be accessed to ensure that future projects are not affected by previous mistakes (thereby retaining lessons learned in previous projects, good or bad) and make the design process much more efficient. The database may be augmented with the AI so that it suggests how a project/product/design solution may be improved in terms of specified input from users such as sustainability, design language, branding, competitor's product solutions and past industrial design work.

Limitations, Constraints & Considerations

Limitations to this design include the advancements in AI and the cost of establishing a database. Constraints for this solution are the user experience for the database and maintaining the security of the database. AI replacing some of the responsibilities of designers should also be considered. Also this design solution could be implemented internally using simpler file management systems.



Recommendation 3: Digital Clay/VR Clay

There are two similar ideas for the third and final recommendation. The first idea is to create digital clay that can be moulded physically and is automatically streamed to a 3D modelling program. This would work by implanting digital nodes within the clay that scan the surrounding form and upload it to the computer. The second idea is a VR environment that allows the user to mould and sculpt clay digitally. This would allow users to import different types of clay, moulding and sculpting tools for a variety of different prototyping needs.

Limitations, Constraints & Considerations

Limitations to for this solution are the ability to code a VR program and the cost of equipment for individual users. Constraints for this solution include the time available to develop this design solution. However, since use of VR for sketching and modelling is on the rise industrial design practice, it should be considered as potential future design tool.

CH.6 PROPOSAL

Introduction

Design recommendation 1 was chosen due to the number of responses from participants and importance around the aspect of communication in industrial design practice. Current circumstances due to COVID-19 have exaggerated the problem whereby industrial designers have a need to communicate their ideas to clients effectively via online mediums.

Design Intent

To design a product, system or service that improves communication outcomes for industrial designers in a variety of industry workplaces.

Justification

Long have industrial designers struggled with communicating their ideas despite the many advances in technology. Issues with remote meetings such as showing a client sketches (analogue or digital), co-creating design solutions and presenting ideas professionally via online video-conferencing have existed prior to COVID-19 and will continue to exist without a suitable solution. Although some technology issues are inevitable such as internet connection and software capabilities, there is an opportunity to develop a design solution specifically for industrial design practice. This solution would address issues around professionalism when presenting ideas to clients

Context

The context for this product, service and/or system is for use in industrial design practice. This includes any consulting, in-house, corporate or freelance workplaces. The target audience is industrial designers and design managers seeking to improve their communication with clients and stakeholders by providing a seamless experience for online meetings. Additionally, this design solution could potentially be used in other contexts where work activities require the presentation of ideas that are represented physically via online communication mediums.

Objectives

The following objectives have been developed to ensure that design solution addresses the key issues outlined by participants in the findings of this research:

- Enhance remote communication of ideas and collaboration between colleagues, clients and stakeholders with adequate product, service and/or system features

Key Criteria

The following key criteria have been developed to ensure that the product adheres to 'industry standard' as discovered through interviews with participants:

- Must provide a way for users to display sketches (either analogue or digital) live when using video conferencing.

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Proposal

- Must allows for viewers to augment the live communication of sketches, diagrams, products etc.
- Must be compatible with current hardware and software. For example, software plug-in that is compatible with Zoom, Skype, Slack etc.
- Should maintain or improve current features of video-conferencing and webcams such as the ability to see users and share screen

Initial Idea

Figure 12. is an initial idea for a product that allows users to share and co-create ideas using a webcam/project device that connects to computers and video-conferencing programs. Blue represents user 1's sketches whilst orange represents the projector overlay of user 2's ideas and notes.

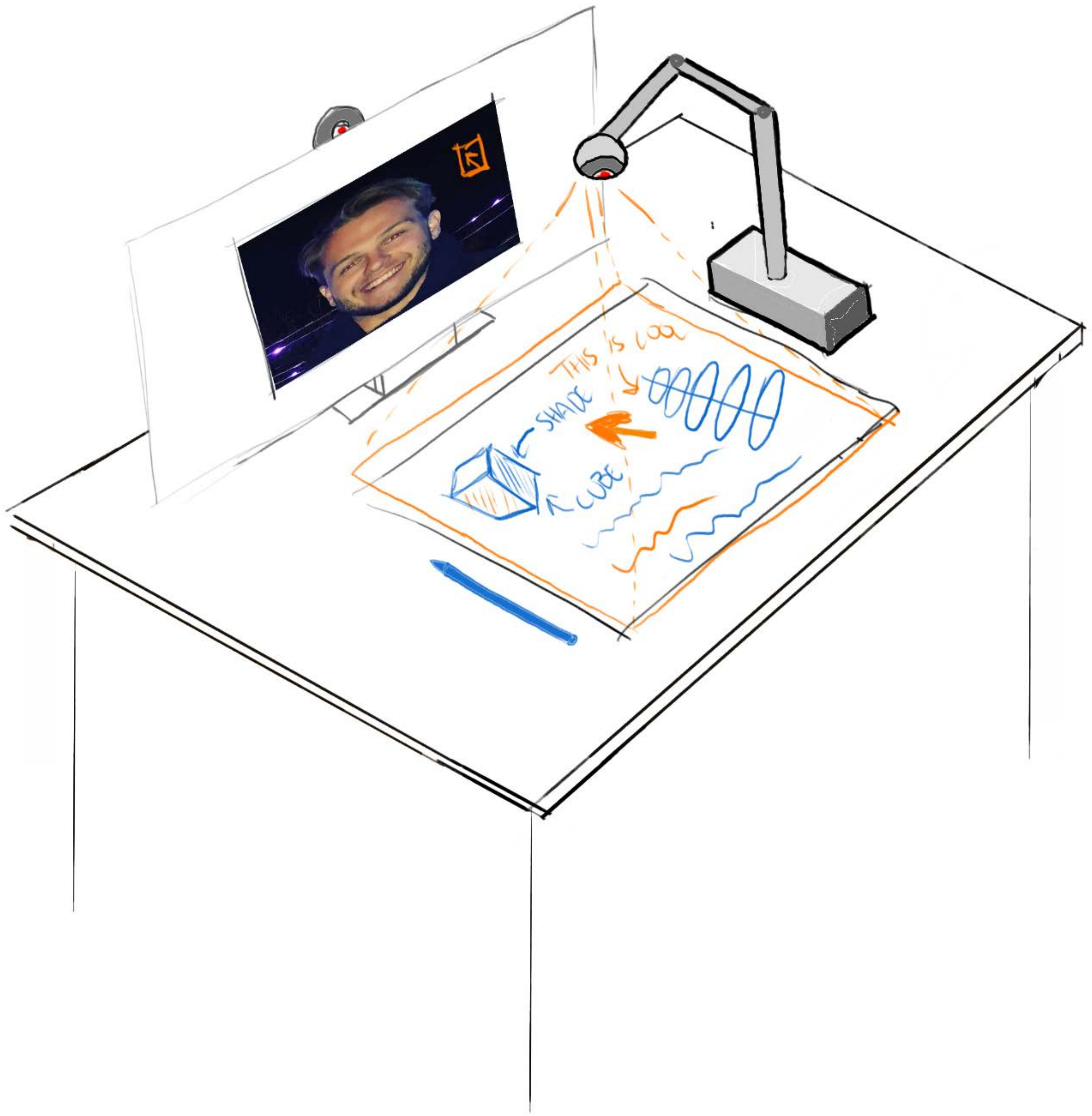

Figure 12. Initial Proposal Idea (Anderson, 2020)

Design Process

A modified version IDEO's design process will be followed to ensure the final design solution for this project is influenced by contemporary design thinking and process. Figure 13. is IDEO's process and Figure 14. details each section of the process and semester schedule. For the purpose of this project, only one round of the process will be done given project constraints such as time and human resources. Observations have been completed in semester one using the interviews and observations from this research. Additional project planning can be seen via the following link: https://miro.com/app/board/o9J_kstpdg0=/

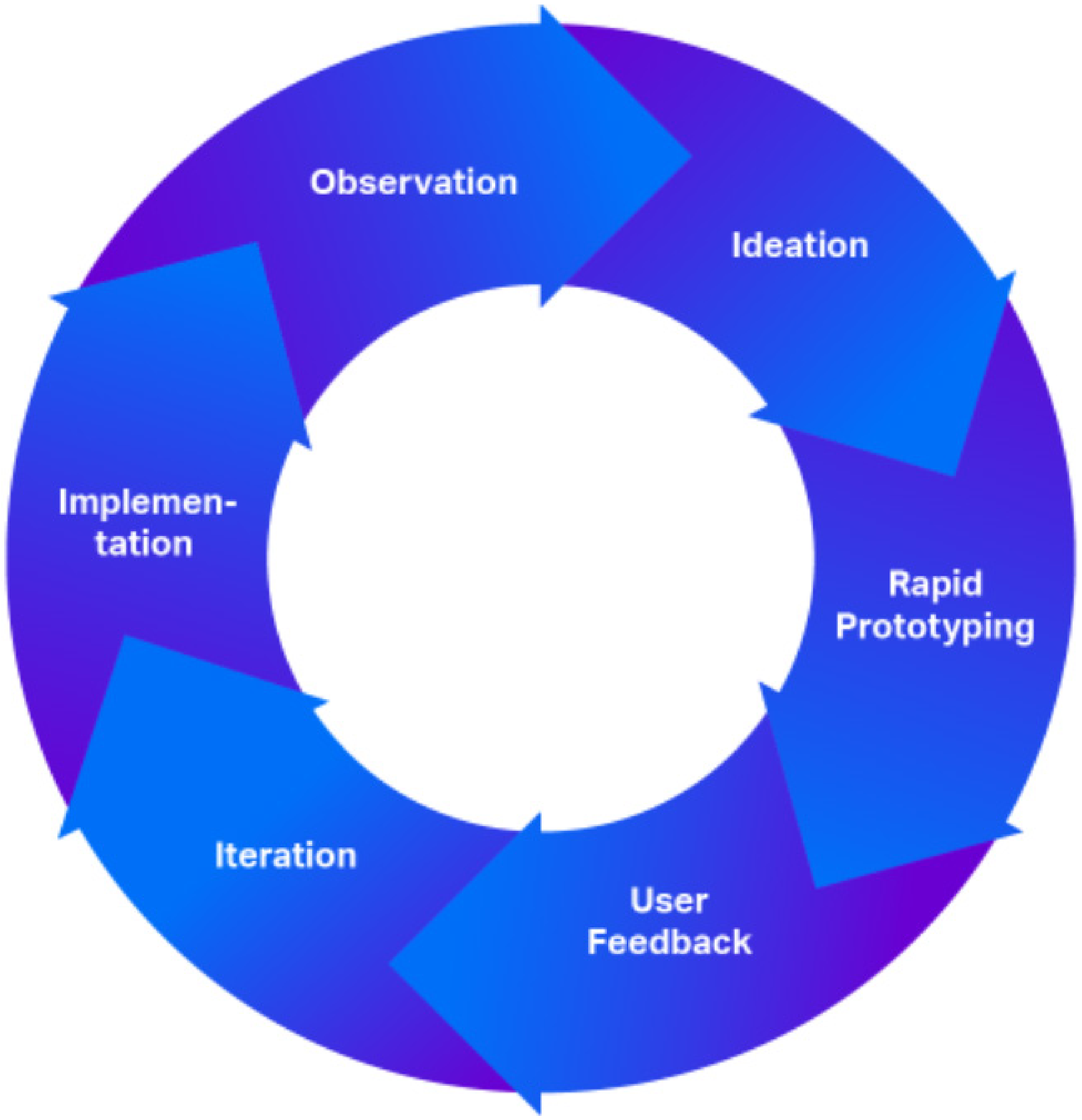

Figure 13. IDEO's Design Process (Usertesting, 2018)

EMERGING TECHNOLOGY FOR ID PRACTICE
Proposal

IDEATION — WK 1 • 3
- Design Direction selected after consulting project stakeholders and colleagues
- Consolidate S1 research into observations and full design solution criteria
- Ideation and Concept Development using mixed media e.g. whiteboard, pen & paper, Ipad + Sketchbook etc.
- Arrange future meetings with stakeholders for user testing of concepts
- Plan deliverables for exhibition vs. my portfolio + documentation of design process

PROTOTYPE — WK 4 • 5
- Finalise initial design solution ideation
- Prototyping of design solution from ideation for self-assessed design evaluation
- Iterate prototype using self-assessed evaluation
- Presentation development for stakeholders (Project brief, design solution, value proposition etc.)

FEEDBACK — WK 6 • 8
- User testing with industry professionals & intergration of feedback into design solution
- Manufacturing research inc. consultancy advice from industry professionals
- CAD and Manufacturing development of design solution using industry standard insights and practice
- Final design solution development (physical product)

ITERATION — WK 9 • 12
- Branding ideation & development (using DVB101 Branding design process)
- UX application ideation & development
- Finalise design details e.g. CMF (Colour, Material, Finish)
- Costings
- Development of deliverables strategy for exhibition and portfolio

IMPLEMENT — WK 13 • 15
- Execution of deliverables for both exhibition and my portfolio with a focus on high-level design quality
  - Product Renders (e.g Keyshot, digital sketching renders & illustrations)
  - Physical Prototype (Ask industry professionals for outsourcing model-making)
  - Digital Application (Using Trello or Adobe XD + Branding)
  - Product Demonstration Video

Figure 14. S2 Design Process (Anderson, 2020)

Conclusion

This research was conducted to uncover insights into the industrial design industry that have been previously lacking in academic literature. Many interesting findings were found and the author acknowledges that not all aspects of industrial design practice could be covered within the scope of this project. However, treating the research as a design project allowed for thorough investigation of problems within industrial design practice. Research revealed that there are various aspects to industrial design practice that may be improved through product, service and/or system design. As industrial designers typically undertake the design process to solve other peoples' problems, participants were prompted to think about the way in which they work and how they might solve any problems or inefficiencies. This also benefited the participant's own industrial design practice.

It is worth mentioning that whilst conducting this research, it was learnt that there are many contemporary industrial design skills and practices that are being used and exist outside the context of academia. The affect of this finding on the author was somewhat demoralizing because the skills learnt and applied to develop this paper are not as important as other industrial design skills. In particular, skills such as sketching, 3D modelling, and 3D rendering were found to be determining factors for industrial designers and design managers looking to hire graduate industrial designers.

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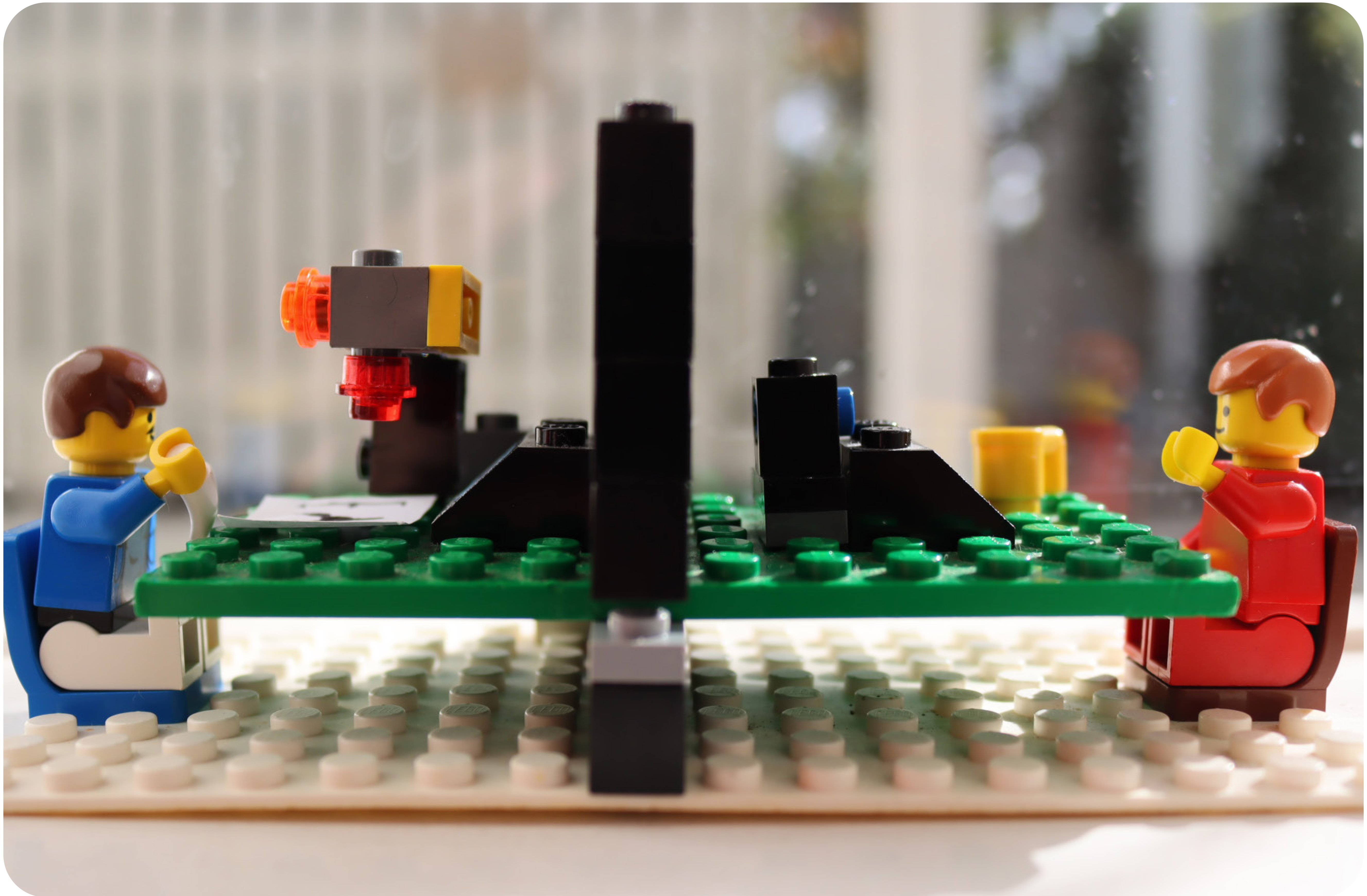
CH.7 JUSTIFICATION



Introduction

As mentioned in the proposal, design direction 1: remote client communication was pursued to develop a design solution for the problems that currently exist for industrial designers. Through interviews with participants, clear issues were identified with the current tools and technologies that are intended to facilitate virtual meetings with clients and stakeholders.

These are the following issues: position and clarity of webcams, loss of body language when using video-conferencing, sketching and communicating an idea in-front of client & live co-creation is difficult, and the ability to leave a good impression on the client. During the interviews, many of these issues were experienced first-hand.

Other factors in deciding to pursue this design direction include the effects of COVID-19 on meeting clients in-person and the overall shift away from physical meetings after COVID-19 is resolved. Additionally, in some cases industrial designers couldn't meet clients and stakeholders in-person for various reasons like clients or manufacturers being based in a different country, purpose of the meeting etc.

The design direction meant that for the second half of this project, a video-conferencing device for industrial designers was designed to address the communications issues discovered through research.

Further Research

Further research into competitors, technology and user testing methods was conducted to ensure the design solution is innovative, novel and addresses the issues discovered through prior research.

Competitors

Any company the produces products that directly or indirectly relate to video-conferencing was researched. This includes but is not limited to: Webcams, Streaming Cameras, Document Scanners & Overhead camera mounts. It was determined that the primary competitor is Logitech, as they have a wide range of video-conferencing products including webcams, streaming and conference-room products. Secondary competitors include companies such as Razer, Microsoft, Ausdom, Mevo etc.

Technology

For the design solution to be novel and innovative, existing technologies and the variety of ways it can be combined was researched. It was found that future projector technology, cameras and application transfer design could be used to create a product that not only addressed current issues but also provides a way for industrial designers to facilitate co-creation during virtual meetings.

User Testing Methods

Before the design phase of this project, user testing was conducted during interviews to determine what industrial designers would like to see improved in industrial design practice. This was done by asking interview participants what a series of questions that ultimately led to innovative design solutions that could improve various aspects of industrial design practice such as sketching, CAD, prototyping and communication (see page 38 for full details).

Further research into contemporary user testing methods was conducted to ensure that any user testing methods implemented into the project were relevant and provide the best design outcomes. IDEO's user testing method cards were examined and two were chosen to be used: Error Analysis and Scenario Testing.

Error Analysis involves listing all the things that can go wrong when using a product and analysing the various possible causes. This user testing method helps the designer to understand how design features either contribute or mitigate human error and technical failures. This user testing method is particularly useful for developing physical user interfaces of the product , making it relevant to the video-conferencing product developed in this project.

Scenario Testing involves showing users possible scenarios and encouraging them to give feedback. This is useful for learning what features of a product are useful within a context or scenario, and helps communicate the value of a concept to clients and stakeholders. This was partially done during interviews with end users, whereby possible scenarios in the virtual meeting context were discussed and feedback was provided by the interview participants about what they thought was useful. For example, some participants gave the feedback that they wanted the ability to show sketches, diagrams and prototypes live and in-front of client when meeting with them virtually.

MIGHT NEED MORE CONTENT HERE

Context & Systems

In summary, a video-conferencing device was developed for industrial designers to use in industrial design practice when having meeting with clients, stakeholders and manufacturers.

People

Primary users of the product are industrial designers and managers. Secondary users include clients, stakeholders and manufacturers.

Activities

Product features allows the undertaking of a variety of activities. These activities include and are not limited to meeting with clients & stakeholders, doing a presentation virtually, showing physical deliverables (sketches, diagrams, prototypes, models etc.) & co-creation between the user and other meeting participants using the projector feature.

Context

The context of use for the product is in office spaces at various industrial design workplaces including consultancies, in-house, corporate and freelance.

A benefit that has been highlighted through user testing and feedback is the application of this device in other contexts. It was identified that the device may be useful for other design disciplines and educational purposes for the same purpose as to provide better remote communication outcomes.

Technologies

Other than the physical technologies involved with the product, the overall user experience is also affected by software. The web cams stream to video-conferencing software to allow other meeting participants to see the product user and their desktop. Additionally, the laser projection can also be seen when in use through the desktop-orientated camera. All of the physical features rely on adequate software plug-ins for existing video-conferencing software such as Zoom, Skype, Messenger, WhatsApp etc.

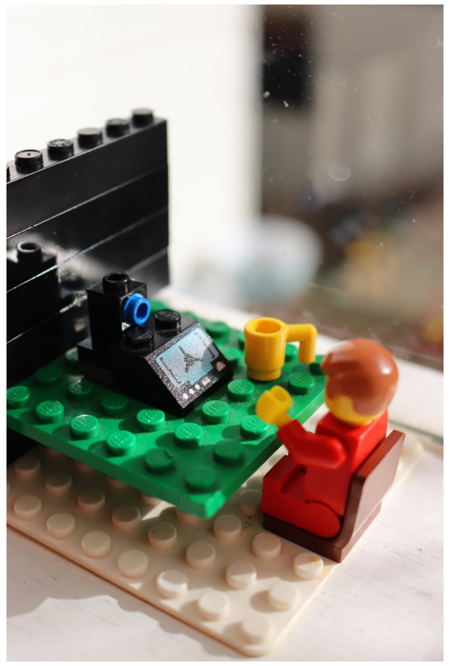
Design Process

My design process, design directions and key phases. As outlined in the design proposal, an adapted version of IDEO's design process was used for this project. To recap, IDEO's design process has six key phases; Observation, Ideation, Rapid Prototyping, User Feedback, Iteration & Implementation.

Observations

For this project, the observation phase was completed in semester 1 and includes the insights and design direction taken. The adapted design process for this project changed the order of the phases, whereby rapid prototyping was conducted after user feedback. This was done because there was a focus on the ideation phase of the project to generate the best concept to move forward with. Additionally, end user testing with rapid prototypes would have been difficult and a health risk to participants due to the COVID-19 pandemic.

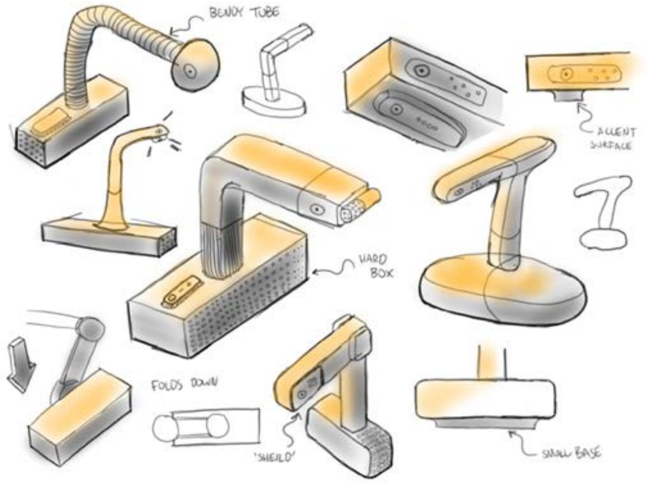
These are the following issues were observed for the chosen design direction: position and clarity of webcams, loss of body language when using video-conferencing, sketching and communicating an idea in-front of client & live co-creation is difficult, and the ability to leave a good impression on the client. During the interviews, many of these issues were experienced first-hand.

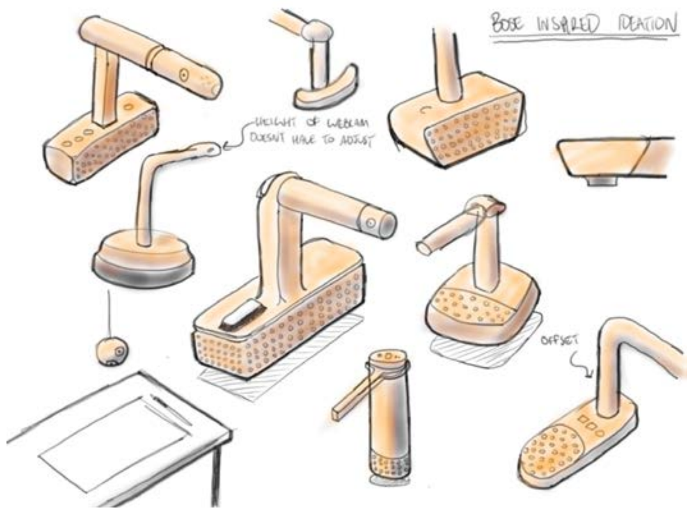


Ideation

For this phase of the project, ideation techniques were researched and implemented into the design process. For example, sketching many concepts with varying changes in form allowed for thorough exploration of possible design solutions for the video-conferencing device. These forms were influenced by market research, CMF / form trends, and BOSE brand products.

After an initial and final concepts, the form of the product was further iterated and simplified to ensure the product is visually attractive and stands out within the chosen context (office spaces)





User Feedback

User feedback on the project and product was gathered using two methods. Firstly, user feedback to validate the design direction and solution was gathered by presenting the project and product to end users. These end users ultimately provided the initial design direction before design development commenced through interview responses. Additionally, these users were consulted after initial and final concepts were developed to ensure that the issues they identified with current remote communication tools and technologies were being addressed through the product and it's features.

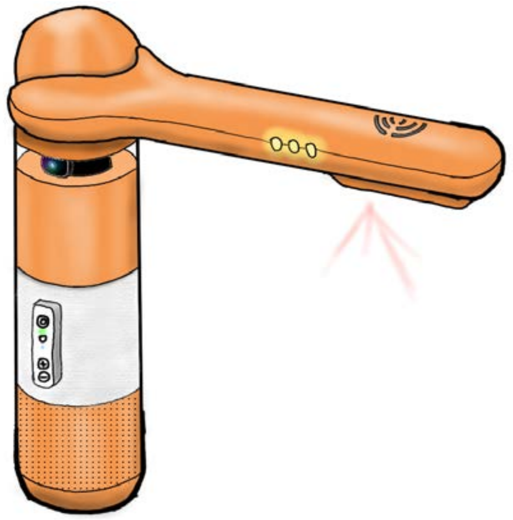
The second method for user feedback was user testing using physical prototypes. This was done after final concepts, as to not waste time testing prototypes of initial ideas that may or may not have been progressed in the project. This user testing also made use of IDEO's user testing method cards. This was done to resolve ergonomics, usability and user experience of the product.

Rapid Prototyping

As mentioned before, physical prototyping of concepts was done because I didn't want to waste time building out prototypes for concepts that changed the following week because of feedback, research or inspiration. However, prototyping to test the overall size and unforeseen usability was done. Additionally, a prototype of the final form/design of the product was done to then test ergonomics, develop the physical user interface on the product, and resolve any usability issues for the final design. Below are some examples of the rapid prototyping done for this project.

Iteration

For this project, the process of iteration occured throughout the project. This involved regularly consultation with tutors to make changes (iterate) on the design of the product. Additionally, through design validation with end users changes were also made to the product. Below is the final concept and final design of the product. Iteration occured due to feedback, research and inspiration at different points during the project, ultimately leading to acceptable product features and form.



Implementation

Due to the project constraints, it is very unlikely that this phase will occur within the project. The product developed in this project is unlikely to be made and shipped to industrial design studios for a variety of reasons. For this to occur, substantial amounts of money would be needed to be produced from crowd-funding campaigns and seed investors, electronic goods manufacturers would need to be consulted to make the product manufacturable, and more than one person would be required to work on the project so that the when the product reaches the market it isn't obsolete.

Design Validation

To validate the design solution, end users were consulted as to what they would like to see implemented into the future of industrial design practice. All end users mentioned problems with the current tools and technologies for virtual meetings in industrial design practice. This design direction was then pursued in the second half of the project.

Upon development of initial concepts and final concept, the design solution was presented to multiple end users. These end users provided positive feedback for the direction and product features of the design solution, thereby validating the video-conferencing product developed in this project.

Audio from interviews, feedback and industrial designers talking about the project was collected to validate the overall design and projection direction. This was then turned into the final video submission and used in the final design presentation.

Andrea Pavan
Industrial Designer, IDEO Tokyo
IDEO

Jason Belaire
Incoming-chairman, Industrial Design Society of America
IDSA

Business Case

The research and development of BARX has resulted in a solid business case as the product has application in many areas other than industrial design practice. For example, the product could be used by any industry that uses Zoom or for streaming content. Examples include other design industries, educational institutions and online platform professionals (YouTube, Twitch, Khan Academy etc.) This means that the product may align with the needs of other industries, creating interest and potential invest from non-industrial design professions.

Primary target market is industrial designers in varying roles and workplaces e.g. consultancy, in-house, corporate, freelance etc. Secondary target market is other industries that utlise video-conferencing to present work. This may include other design fields, educational uses or for online content creators

As mentioned previously, a product like BARX could be produced through crowdfunding activities such as Kickstarter. Alternatively, BARX could be co-produced with existing companies that have the manufacturing and product development capabilities to get it to market.

The timeline for getting BARX to market would be anywhere between 1-3 years, but since the area of video-conferencing hardware and software is long overdue for new innovations it would not be obsolete by the time it reaches market. However, newer generations or new technology would potentially be developed for the BARX product to keep pace with the market.

Final Design Discussion

To recap, the following design criteria were developed in the design proposal:

- Must provide a way for users to display sketches (either analogue or digital) live when using video conferencing.
- Must allows for viewers to augment the live communication of sketches, diagrams, products etc.
- Must be compatible with current hardware and software. For example, software plug-in that is compatible with Zoom, Skype, Slack etc.
- Should maintain or improve current features of video-conferencing and webcams such as the ability to see users and share screen

BARX fulfills each of these criteria for it's various functions and features. Firstly, it provides a way for users to display physical sketches and other objects live through streaming of the desktop-facing camera.

Secondly, the desktop-facing camera and laser projector allow viewers or other meeting participants to augment the live communication of sketches, models, prototypes etc. Viewers or meeting participants can project annotations and notes, inputted through video-conferencing software, on top of the desktop-facing cameras view.

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Thirdly, it has been assumed that with further develop of BARX that it would be compatible with current and future hardware and software such as Zoom, Skype, Slack etc.

Lastly, the wide angle lens webcam (that faces the user) and microphone improve upon the current video-conferencing hardware (associated with standard laptops or PC's) by allowing users to include body language and clearer audio into the virtual communication

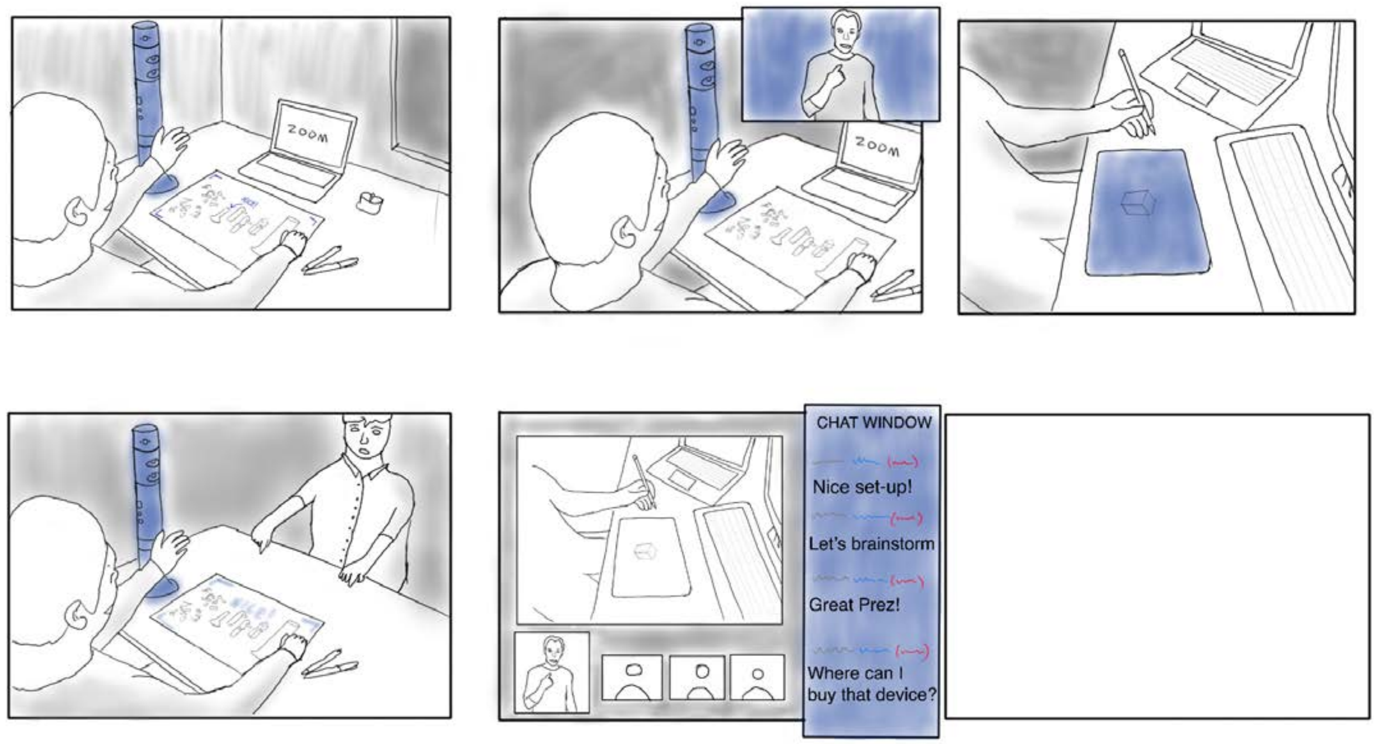
In conclusion, all design criteria laid out in the proposal before design development were addressed within the final design.

Conclusion

Advantages of Proposed Design

The advantages of the proposed design are best explained using storyboards created for the final design presentation. Below are storyboards depicting the current state of video-conferencing hardware and software:

Current State // Value Proposition



trial design skills an The advantages of the proposed design is that it addresses the following issues with the current technology.

The current issues are **(Orange Storyboards)**:

- Poor camera position for users
- Subtle communication e.g. body language is lost
- Difficulty showing physical deliverables
- Limited co creation and interactive opportunities
- Reduced ability to impress meeting participants with work or presentation

BARX adresses these issues by **(Blue Storyboards)**:

- Higher camera position that capture body movement
- Separate desktop-facing camera for showing physical objects near the product
- Projector and Desktop-facing camera provide a physical whiteboard in which meeting participants can interact with each other, collaborate and co-create ideas
- Combination of all these features improves communication of user and therefore the likelyhood of impressing meeting participants with work or presentations

Design Implications

As Andrea Pavan, Industrial Designer at IDEO said "I think this is something that as a society we haven't been iterating on.... Think about next generation of Zoom or even devices that we are going to be using"

BARX has implications for the future of video-conferencing and our virtual communication. BARX is a step in the direction of that next generation of video-conferencing products that people to connect with each other with increased intimacy and clarity.

Additionally, the implications of a post-COVID world means that many workplaces will remain in remote settings. This further increases the need for future video-conferencing products like BARX to provide professionals the ability to collaborate, interact and develop relationships virtually.

Further implications on the future of video-conferencing product design will eventually lead to future technologies like interactive holograms to enhance communication in a virtual context. This was learnt during the literature review into future technologies for industrial design practice.

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Appendix: Phase 1

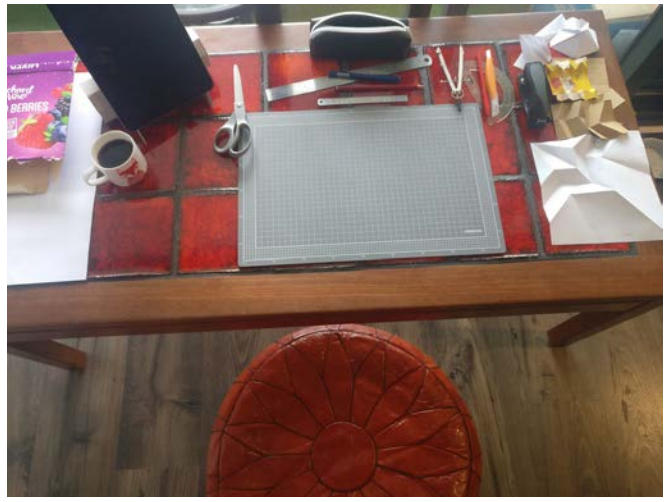
(No information on QUT CITE regarding how to do a QUT APA Appendix correctly)

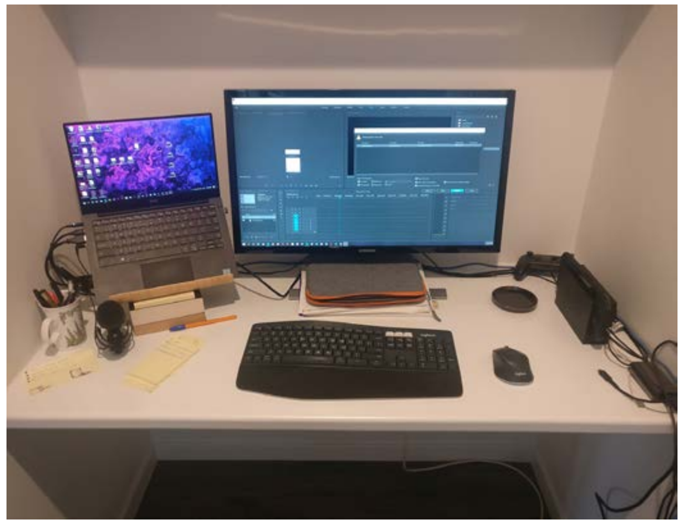
Interview Transcripts Collected during Pilot Studies Using Otter:

https://otter.ai/s/_TGSfkKuTC6QJauelrc0Mg

https://otter.ai/s/ef2h1lJwSlKiXWNsNexSew

Cultural Probes Data Collected during Pilot Studies:





Appendix: Phase 2

Interview Questions fro Group A & B

Interview Structure for Design Managers

Overview of Interview - what the questions are about (productivity, performance, emerging technology use etc.) and explain that ill be asking some impromptu questions and ask if they are ok with doing the self-observations at the

For design management:

- What is your position within the business?
- How many years experience do you have as a design manager and or industrial designer?
- What technologies and design tools do you use currently to run the design practice?
    - Sketching & Concept Generation
    - Collaboration between colleagues and communication with clients
    - 3D modelling and CAD e.g. Solidworks, fusion360, keyshot, Adobe Suite
    - Prototyping e.g. 3D printing, foam modelling, High fidelity physical models

- Which technologies, tools and practices bring the most value for the business? This can be money, time, sustainability, worker satisfaction etc. Have you thought about what emerging technologies could do for the design practice?
- Do you know of any emerging technologies for the design industry and if so would you like to see a widespread use of the technology?
- What work habits or technologies have you adopted to work from home?
- What part of the design process do you think or feel is the most time consuming? Why?
- If you could design something to help make the design process better, what would it be?

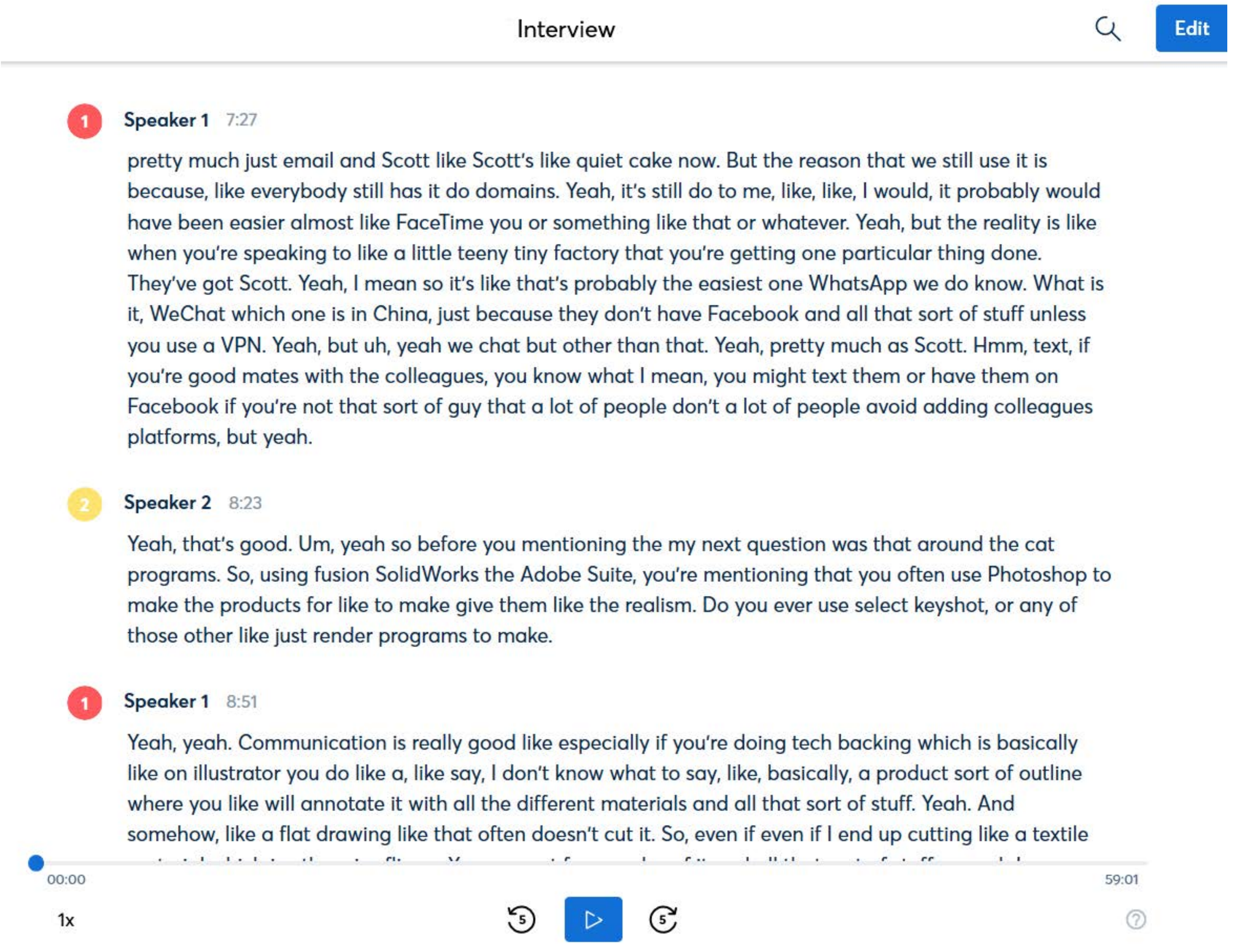
Interview Structure for Industrial Designers

Overview of Interview - what the questions are about (productivity, performance, emerging technology use etc.) and explain that ill be asking some impromptu questions and ask if they are ok with doing the self-observations at the

For industrial designers:

- What is your position or role within the business?
- How many years experience do you have as an industrial designer?
- What design tools and practices do you use everday?
    - Sketching & Concept Generation
    - Collaboration between colleagues and communication with clients
    - 3D modelling and CAD e.g. Solidworks, fusion360, keyshot, Adobe Suite
    - Prototyping e.g. 3D printing, foam modelling, High fidelity physical models
- What would say your proficiency level with the design tools and practices you use everyday?
- Out of these design tools, which would you say saves you the most amount of time and why?
- Out of the design tools you use, which one is most difficult to use and why?
- What design tools would you like to see being implemented into current and future ID practice?
- When do you feel most productive? E.g. At home/working by yourself at work, communal set-up working closely with other designers etc.
- What work habits or technologies have you adopted to work from home?
- Would you be willing to send me photos of your home office set-up?
- What part of the design process do you think or feel is the most time consuming? Why?
- If you could design something to help make the design process better, what would it be?

Sample Interview Transcript


Interview

Speaker 1 7:27

pretty much just email and Scott like Scott's like quiet cake now. But the reason that we still use it is because, like everybody still has it do domains. Yeah, it's still do to me, like, like, I would, it probably would have been easier almost like FaceTime you or something like that or whatever. Yeah, but the reality is like when you're speaking to like a little teeny tiny factory that you're getting one particular thing done. They've got Scott. Yeah, I mean so it's like that's probably the easiest one WhatsApp we do know. What is it, WeChat which one is in China, just because they don't have Facebook and all that sort of stuff unless you use a VPN. Yeah, but uh, yeah we chat but other than that. Yeah, pretty much as Scott. Hmm, text, if you're good mates with the colleagues, you know what I mean, you might text them or have them on Facebook if you're not that sort of guy that a lot of people don't a lot of people avoid adding colleagues platforms, but yeah.

Speaker 2 8:23

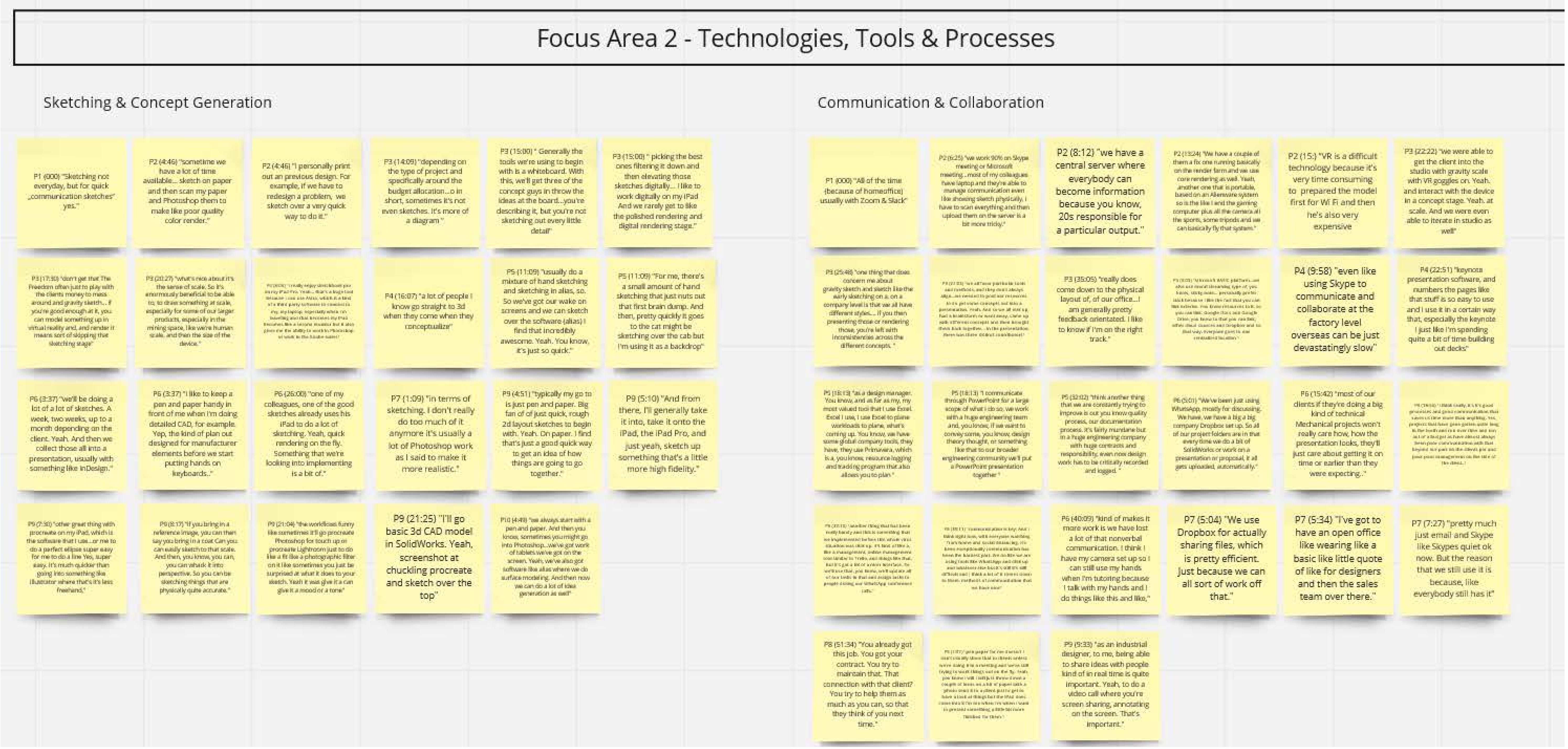
Yeah, that's good. Um, yeah so before you mentioning the my next question was that around the cat programs. So, using fusion SolidWorks the Adobe Suite, you're mentioning that you often use Photoshop to make the products for like to make give them like the realism. Do you ever use select keyshot, or any of those other like just render programs to make.

Speaker 1 8:51

Yeah, yeah. Communication is really good like especially if you're doing tech backing which is basically like on illustrator you do like a, like say, I don't know what to say, like, basically, a product sort of outline where you like will annotate it with all the different materials and all that sort of stuff. Yeah. And somehow, like a flat drawing like that often doesn't cut it. So, even if even if I end up cutting like a textile

Sample of Analysed Interview Data

See full version via the following link: https://miro.com/app/board/o9J_ksfy3_g=/



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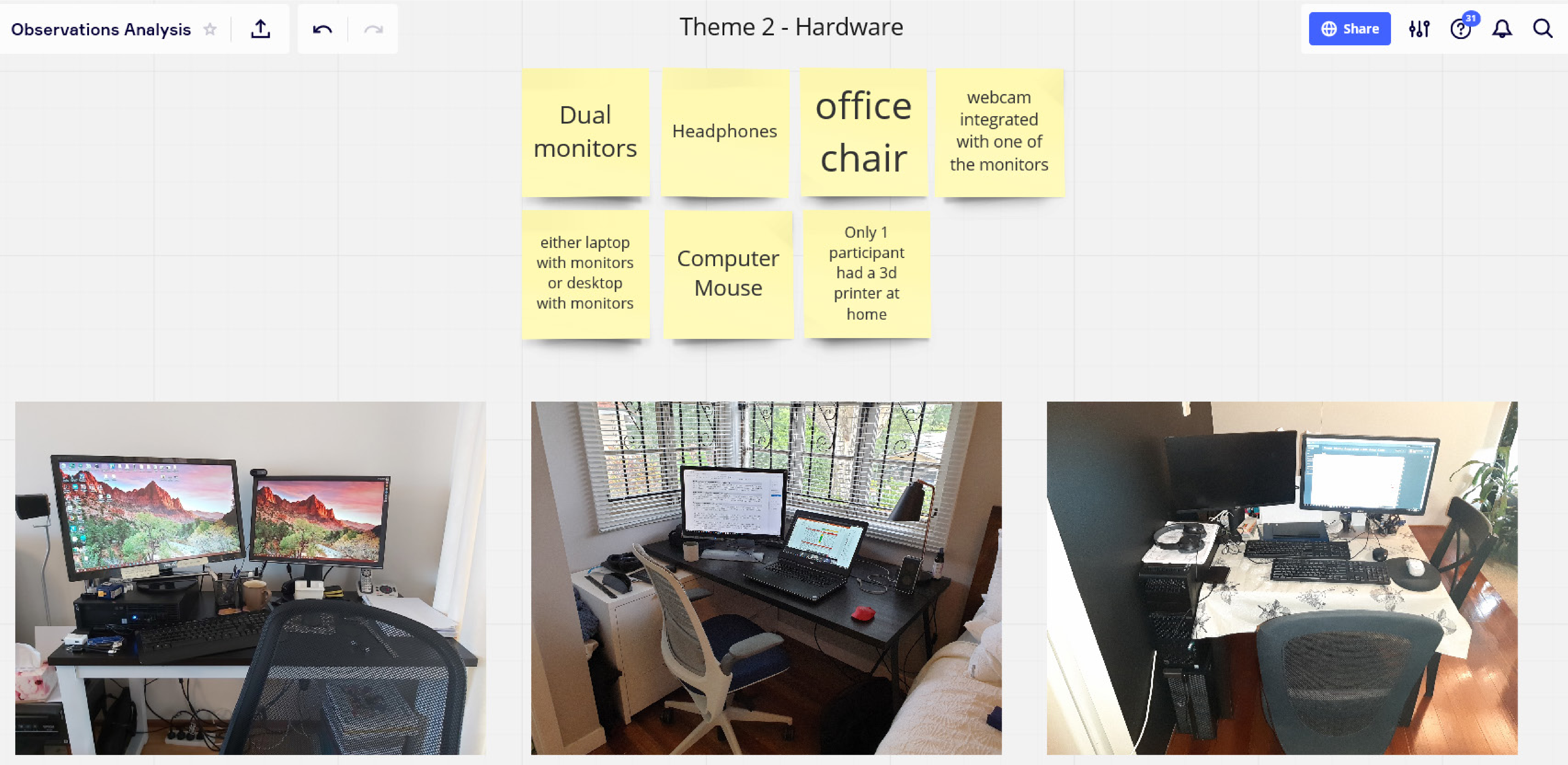
Sample of Analysed Observations Data

See full version via the following link: https://miro.com/app/board/o9J_krQmPLk=/



Leadership & Initiatives

To me, leadership is about identifying what I can do for people by deploying emotional intelligence to understand what is needed. Often this means leading from behind-the-scenes rather than being the guy yelling at the front of the room. However, I've been developing my leadership and initiative for many years in my role as a waterpolo coach which requires me to lead from the front. For semester one, I tried to develop my 'from the back' leadership style for a change of pace.

I did the following activities to display, promote and undertake a leadership role as a 4th year industrial design student:

• Did my thesis on current industrial design practice and interviewed many industry professionals. I obtained a mentor and set-up a WIL internship for S1, 2021 through my initiative.

• Joined IDSA (Industrial Designer's Society of America) and attended IDSA RMT chapter's weekly presentations on a variety of topics.

• Set-up the Airtable platform for 4th year cohort to document our leadership initiatives, plan new initiatives and use as a base for future initiatives. Also shared and created a number of design resources on productivity, professionalism and leadership. This included a pitch to the cohort during class (ironic since I'm trying to 'lead from the back')

• Contributed original artwork (memes) to QUT Stalkerspace to change perceptions around Creative Industries degrees being useless in the real world

• Completed two industrial design portfolio course sby Boostfolio Academy. In these courses I learnt about design quality and industry standard for junior, mid-level and senior industrial design portfolios.

Over the break I have made plans to work on my technical skills as I want to become a junior industrial designer in a consultancy setting. This will involve up-skilling in digital sketching, Keyshot Rendering & 3D modelling software (Solidworks & Fusion360)