Work in Progress: Starting Multidisciplinary Product Development Teams: Insights from Industry and Academia

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WIP. Starting multi-disciplinary product development teams: Insights from industry and academia

Abstract

To design a successful consumer product, a diverse team of experts from various disciplines is typically required. These disciplines bring unique insights into the product development process and can be key to creating innovative output. Working in these teams can be challenging, especially if technical language and ideal outcomes are not routinely communicated to the whole team.

This work-in-progress paper examines an industry multi-disciplinary engineering design team. Specifically, this study investigates the communication channels between industrial design interns and an engineering team at an aerospace company in California. Members of this team were interviewed to record their experiences during this three-month project. At this initial research stage, methods of communication used, how effectively they communicated with each other, and what was learned about different design methodologies was captured.
The purpose of this study was twofold as we sought to satisfy questions from the industrial and the academic perspectives. From the industrial viewpoint; what skills can industrial design bring to an engineering company to elevate its design practices, and academically, how might we prepare undergraduate engineers and industrial designers to work together on these teams and facilitate an integrative approach to product development?

A grounded theory approach was utilized to extract repeated ideas and themes from these interview transcripts which can be used in further studies of this nature to generate testable hypotheses. In addition to discussing the merits of this data analysis approach and the key insights that were gleaned, this work-in-progress paper provides recommendations to preempt unclear communication for newly formed multi-disciplinary teams.

I. Introduction

Industrial designers create products that are used the world over, from items you use in your home, to features of the interior of the transport you took home from work. Many decisions are made about the user experience and the aesthetics for those products you own or use. Industrial designers are trained to be user-centric – to create goods and services that do not harm the user nor cause frustrations. They are multi-disciplinary by education. "In professional practice, industrial designers are often part of multidisciplinary teams made up of strategists, engineers, user interface (UI) designers, user experience (UX) designers, project managers, branding experts, graphic designers, customers and manufacturers all working together towards a common goal. The collaboration of so many different perspectives allows the design team to understand a problem to the fullest extent, then craft a solution that skillfully responds to the unique needs of a user" [1]. Interestingly, the professional body for industrial design, Industrial Design Society of America (IDSA), does not call out engineering as a discipline that designers would interact with. It could be argued that "manufacturers" would encompass this discipline, but it does not adequately describe the rich skillsets of the engineering professions and their role in product development.

Despite of the same goal of creating a new product, the relationship between engineers and industrial designers can sometimes be problematic. Ulrich and Eppinger describe how to manage the industrial design process and teach engineers the best times in new product development to time their involvement, dependent on whether and product is user- or technology-driven [2]. This distinction, whilst seemingly arbitrary as internet of things (IoT) products flood the market and our reliance of integrated smart technology continues to increase, comes from the notion that engineers design based on component layout (inside-out) and that design work from the outside-in [3] [4] [5].

There are few published works that look specifically at the interactions between industrial designers and engineers both in the workplace and in the classroom. Of those studies found, all have focused on problematic communication. In a preliminary study conducted in 2014 [5], direct causes of conflict between the disciplines included design specification, material costs, and scheduling errors. Indirect conflicts reported by the engineers related to the perceived lack of knowledge held by industrial designers about design implementation, differences in core values, and difference in working style. For the designers, conflict surrounded who was responsible for the project and design evaluation, and overall differences in disposition between the two disciplines. Conflict in the ownership of the overall process was also found in the relationship between architecture and engineering, raising the question of whether this stems from the design process or design management [6].

Persson and Warell [7] propose a model of common understand based on the objectives of the team. For example, for finding a common understanding of feedback on the design, reciprocal communication should be employed. For simple message transfer, one-way communication was suggested. Other tools have been proposed to ease communication between the fields, including virtual reality software to improve conflict in tolerance management in car design [8], and design representation cards to create a common language [9] for industry and students. Studies found that focused on interaction in an educational setting were limited to extra-curricular one-time efforts sponsored by industry [10] [11]. Both studies acknowledged the benefits of the working groups to designing products and that communication difficulties arose. Both made recommendations for these efforts become regularized in the regular academic session, but no follow up publications have been found.

This work-in-progress study differs in its approach because it sought to explore the interactions that two industrial design interns had in an engineering company. The company, at the time of the summer internships, did not have an in-house industrial design team. With a specific focus on communication, both formal and informal, this exploratory study focused on the responsibilities team members had within design projects, how information was communicated to the different members of the teams, and whether an integrative approach was adopted. Additionally, as the technology we use in product development advances, product development cycles become shorter, yet industry still need to strike the balance between innovative ideas, high quality design and engineering, and profit. To do this effectively, group dynamics across disciplines must be strong. Using coding and theme identification techniques from transcribed interviews, how might we better equip graduating students to work in multi-disciplinary product development teams?

II. Method

A. Data collection

Interviews were conducted with three individuals from an aerospace company in California; two industrial design undergraduate (junior and senior standing) who interned in summer 2018, and one senior aerospace engineer with 20 years of experience in this industry. Two participants who were currently in employment at the aerospace company at the time of this study were interviewed remotely (the researcher and participants are bi-coastally located), and the industrial design undergraduate was interviewed in person when they returned to school to resume study. The interview questions and methods were approved by the university Institutional Review Board (ID 18-401). The interviews were conducted 4 months after the summer 2018 internship program concluded.

The questions asked were open by design, to encourage the interviewee to reflect on their experiences. The questions were categorized as follows: (1) educational background, academic preparation, and role in the company, (2) communication channels on projects, and (3) thoughts on improvements that could be made to communication through altered academic preparation. A subset of the questions posed are listed in Table 1.

Table 1. Subset of interview questions

Category	Question asked
1	• What is your current job role? • Could you detail your responsibilities? • Can you describe some of the key skills you took away from your academic preparation that prepared you for your current job role? • I'd like you to think about a specific project that you have recently completed. What was your role on the team? • What other roles were there on that team?
2	• What were the modes of communications used during the project? • Can you recall any confusing or unclear conversations? • Can you recall a positive project communication?
3	• If you were the project leader, how would you ensure excellent communication between team members? • Knowing what you know now, what skills would you want to improve on in an educational setting?

B. Data analysis

Grounded Theory Method (GMT) was chosen to analyze the word and themes in the interview data, rather than collecting numerical data from very structured, closed questions. The premise of this study was to encourage the interviewees to talk freely and in their own words about their experiences and ask them to reflect on what might have helped them in their undergraduate education to succeed. The goal of using this analysis, as consistent with founders of the methodology [12], is to develop a theory during textural analysis without preconceived ideas on what the solution, or theory, could be. GMT was developed in the 1960's to give sociologists a tool that allowed them to generate new theories. It has begun to be adopted by the design disciplines to help navigate the fuzzy front end of design by coding observations in transcripts, for example. The idea is that stories can emerge, and connections can be made between unrelated ideas and help form potential hypotheses [13]. In this initial coding exercise, word-by-word, and line-by-line coding strategies were employed, as described by Charmez [14].

Once the interviews were concluded, audio files were transcribed. To effectively use GTM, text was arranged into a left aligned column, and set so that each line of text would have no more than 10-12 words per line. The right side of the page was reserved for data extraction notes line by line. Three open coding approaches were used:

1. In vivo - extracting the interviewees own words
2. Eclectic - finding immediate impressions from each line of text to find similarities, differences, frequency of specific details, causation and the order in which information is given in answering questions.
3. Process - determining how the interviewee is making decisions, for example looking for challenges, perceived obstacles, or emotional catalysts that inform behavior. Can be negative or positive.

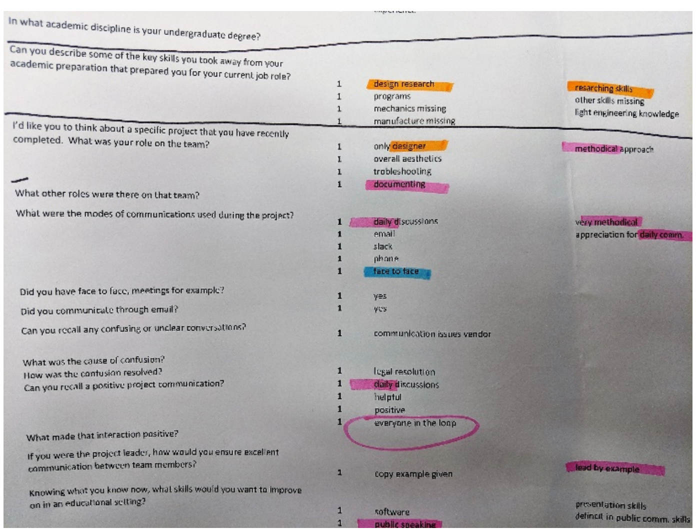
Once coded, common themes and repeated codes were extracted within the interviewee's answers (see example in Table 2), and across interviewees (Figure 1).

Table 2. Initial coding example from two excerpts from interviewee 1. Excerpt 1 shows in-vivi coding, and excerpt 2 shows eclectic coding

Excerpt 1: In-vivo coding (word) Excerpt 2: Eclectic coding (line-by-line)	Transcript
Excerpt 1 **You mentioned something about showing an interest in other people's work.** Interviewee: I would say something that helped create the bond between the engineer's industrial designers was showing an interest in the type of work that they were doing and showing appreciation and respect for it. Not just saying that because they might have the impression of you think that you can do their job better than they can. It's really working as a team and helping both sides understand. What Stan was really trying to do was create a transparency between engineering	 Helped Create the bond Showing an interest Doing and showing Respect Impression Do their job better Team Both sides understand Transparency Help

and design and help everyone understand that it's only going to matter to the outcome in the product. **Excerpt 2** **Did you have to work hard on communicating your ideas to engineers so that they understood?** Interviewee: Getting the engineers to be on board with the kind of design and thought process that industrial designers have was challenging. My advice is always show don't tell, or if you are telling, have something to show them back up what you're talking about. And data is always really important. The feedback that we would get from the flight guys: they would say that they always really enjoyed that we were interviewing the end users and that definitely helped validate what we're doing. Technical engineering conversations were a struggle to keep up initially, but it was more trying to figure out the terminology for the equipment in the technology that they were using within the ground control station to communicate with the aircraft in the different electronics on board.	outcome Aware of difficulties, seeks acceptance Learnt that ideas should be discussed and shown. Showing data to back up ideas and having an answer for 'why'. 'guys' suggest familiarity Enthused by interactions Acceptance from a small cohort after explaining design methodology. Aware of knowledge deficits.

Figure 1. Example of coding. Orange denotes coding for just this interviewee, pink for coded across two interviewees, and blue across all three.



III. Preliminary results and discussion

A summary of these themes and codes are shown in Table 2 for each interviewee with all question categories considered with common codes across at least two interviewees is underlined. Viewed another way, Table 3 shows codes and themes arranged by question category.

Table 3. GMT codes and themes extracted from transcripts of interviewees. Underlining denotes common codes or themes across multiple interviewees

Interviewee	In vivo	Descriptive	Process
1	Users, research, analysis, visual communication, show don't tell, sketching, transparent, manufacturing, bond, respect, involve everyone, prove work, demos, designer, engineer, documenting, design, reinvent, how it is done in industry,	Appreciates structure, values group work, receptive to feedback, honest approach to design	Feels misunderstood, seeks validation as a designer, enjoys building relationships, need to refine creative solution to communicating idea, understanding technical knowledge, inhibited by sketching skills.
2	Planning, development, user, face-to-face, formal, informal, active, participate, listening, ideas, development.	Values structure, interactive team member, versatile leader, lead by example.	Demands accountability, solution motivated, stronger link between education and industry expectations, success through positive interactions, systems and order, seeks buy-in from colleagues, cooperative personality.
3	Design, research, documentation, face-to-face, daily, sketching, designer, engineer, manufacturing, in the loop, public speaking, concepts, user.	Research driven, methodical, lead by example.	Lacking presentation confidence, perceived lack of fundamental design skills, limited technical knowledge.

Table 4. Coding arranged by question category.

Category	Coding and themes across all interviewees
1. Education and job function	Users, research, analysis, development, planning, design, concepts, leader.
2. Communication at work, and leadership	Formal, informal, structure, listening, face to face, active, participate, visual communication, plans and deadlines, seeks approval, show don't tell, validation, daily, sketching, prove, leader, lead by example, in the loop, needs to refine creative solution to communicating idea,

	documentation, inhibited by sketching skills, public speaking, demos, feels misunderstood, seeks validation as a designer, enjoys building relationships.
3. Academic suggestions	Manufacturing, designer, engineer, documentation, sketching, inhibited by sketching skills, public speaking, stronger link between education and industry expectations, bond, transparency, honest approach to design, how it is done in industry, accountability, cooperative personality, appreciation, respect.

Category one coding showed that industrial design and engineering have similar goals and function. The user is central to the research and development phase of product development. Analysis of concepts and product function were also themes that stood out in all interviews.

Category two coding was more revealing about the interviewees function within teams, how the company structured its communication, and how they felt about their experience. Differing language around confidence could be attributed to experience, but all interviewees were seeking 'buy-in' or involvement in all discussions about the project. Transparency was a commonly used term, specifically around knowing what everyone on the team was doing. This was also captured by the term 'in the loop'. Communication within the team was reported as structured, regular, and a mix of formal and informal interactions with most communication happening face-to-face. Unclear communications were not uncommon beyond the design team, but within, strategies such as demos were used to teach the engineers about industrial design techniques and strategies. Visual communication, such as well documented concept sketches, photos and videos, promoted a show don't tell mentality that was adopted by the interns and supervisor. Through process and descriptive coding, uneasiness and lowered confidence in presentational (both oral and visual) skills was observed and feelings of anxiety with showing concept sketches. One might also propose that the need for validation could be linked to feelings of skill deficits. Overall, communication methods were varied and successful in the company and did appear to incorporate the early rational modes of communication: one-way, reciprocal, and interaction communication [7]. As the multi-disciplinary team matures into year two, observation of collaborative communication relating for the co-development of new knowledge and articulation of common goals will be an interesting next step.

Suggestions for academic action were captured through all three coding techniques. A clear overlap in product development skills for both disciplines related to knowledge of manufacturability. Skill deficiencies coded in communication skills were repeated for educational enhancement. Cross-disciplinary projects that are ongoing at the company were discussed, with repeated use of 'transparency', 'appreciation for other skills', and an 'honest approach to design'.

Increased practice for core industrial design skills was reiterated. A stronger link between academia and industry was also coded. Finally, desired and perceived personality traits that were captured in this category related to reliability, cooperation, and accountability. 'Teachability' was coded in interviewee two's transcript. In context, this related to the skills that the engineer was looking for in a graduate hire. The theme of teachability was wider reaching. Interviewee one talked about needed hands-on opportunities to learn about the technology inside the product they were designing, and a need to learn about manufacturability constraints from other engineers on the team. For the other perspective, some of the engineers wanted to be taught how to draw like the industrial design interns, perhaps out of interest, or to improve their own visual communication skills. The interns had noted a difference in concept development strategies. Whilst the designers opted for multiple quick sketches of as many ways to design the product as possible, adding in the human form for scale representation, the engineers preferred to develop much fewer ideas directly into CAD. It is possible that in initial concept development, the two disciplines follow the stereotypical behavior discussed early; outside-in versus inside out. This does appear to be an optimal starting point for understanding of each-others processes thus determining the best way to utilize two very important design skillsets concurrently.

IV. Limitations

This paper discusses an exploratory project with one industrial partner who has in the last year introduced industrial design to its in-house operations. As such, data is limited because the initiative began with the hiring two interns, one of which has now been employed full time. The industrial partner will seek to hire two more interns this coming summer which will allow for more interviews, thus more data and allowing for possible quantitative analysis methods. Interviewing allows a researcher to capture something that already happened and relies on accurate memories of the interviewee. In this paper, the interviews were conducted four months after the conclusion of the internship program in summer 2018. It is proposed that interviews in 2019 are conducted as the interns start, and as they end their experience. This would allow for a comparison of expectations and what occurred. Other qualitative tools such as observation, journaling and journey mapping may provide another perspective on the experience of multi-disciplinary group work in a predominantly engineering work environment.

The findings presented are specific to this specific work environment. Another avenue for exploration could be to examine other companies who are working towards an integrative approach to product development. Furthermore, the opposite working environment could be observed; engineering in a predominately creative company, such as a design consultancy. Irrespective of the approach, as the relationship between the School of Design and College of Engineering and Computer Science develops at Syracuse University, more opportunities to explore communication across these disciplines should emerge. Fostering a dialog with companies that support students through internships or seek to hire from specific programs is vital. As industries evolve and become ever more cross-disciplinary, academia should be responsive and ready to simulate these work environments to allow students to hone these necessary communication skills. The challenge is finding an opportunity to create these experiences in curricula that are filled with classes required by accreditation bodies. Perhaps the best approach would be to create an elective class open to both disciplines and evaluate student success after they move in to the work force.

Grounded theory method is a useful tool in uncovering themes and repeated ideas in interview transcripts. With three interviews, the insights are limited to the initial coding stages. More data is needed to build testable hypotheses on how we might develop courses to support stronger communication skills in our undergraduate designers. Additionally, there would be benefit in working with another researcher to interpret transcripts and create more coding insights.

V. Continued study

Since the completion of the internship in summer 2018, one intern has been employed fulltime at the same company as their first industrial designer. In summer 2019, two more industrial design interns will be joining the product development team. It is intended that the author will interview these interns after their time at the company. To address one limitation of this study - that insight pertain to one company - further interviews will be conducted with other students who intern in non-industrial design industries. Additionally, it is planned to look at a more longitudinal study of experiences with newly graduated industrial designers to investigate how their experiences have shaped their communication skills within engineering design teams.

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