University of Cincinnati

Date: 5/9/2017

I, Parvaneh Maleki, hereby submit this original work as part of the requirements for the degree of Master of Design in Design.

It is entitled:
How can industrial designers work more effectively with engineers to have a successful collaboration

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How can industrial designers work more effectively with engineers to have a successful collaboration?

A thesis submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements for the degree of Master of Design

Summer 2017

In the School of Design of the College of Design, Architecture, Art and Planning

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Abstract

Certain companies are having successful integrated industrial design in their engineering teams and other companies are following suit. The collaboration between designers and engineers can be challenging because they have different training and perspectives. While engineers are detail oriented and mainly concerned with technical features, designers are empathetic and concerned with aesthetics and user experiences. This thesis focuses on the complications in interdisciplinary teamwork between engineers and industrial designers in a product development project to provide guidelines for industrial designers to have efficient collaboration in future multidisciplinary settings. In this thesis, I conducted a literature review on new product development and successful collaboration criteria, and addressed the challenges by that surfaced from two research methods: a case study and interviews. The case study examines my experience as the sole industrial designer in a group of engineers, together designing a new type of aerial transportation mode for daily commuting purposes in the Aerospace Engineering Department at the University of Cincinnati in collaboration with Workhorse Group. By interviewing industrial designers and engineers, I sought to find out their experience in collaboration with the other profession.

Based on my findings, I have developed five guidelines for industrial designers to overcome challenges in collaborating with engineers. These guidelines are:
1. Get clear about your role in the group and in which areas you are going to contribute to the project

2. Learn the required knowledge related to the project and seek advice from experienced colleagues if required

3. Be aware that engineers also do design, but it is different than industrial design, and industrial designers should have realize its value

4. Use your knowledge and skills to present your ideas and learn how to communicate and defend your concepts when discussing with engineers

5. Prepare questions to ask from engineers about technical limitations and learn how to work with those limitations

I think by applying these guidelines during collaborations with engineering teams, industrial designers can overcome challenges effectively and enhance their experience as a significant teammate.
To my wonderful FAMILY, for their absolute unconditional support and trust.
Acknowledgements

This thesis would not be possible without a group of people whose discussion, guidance, and endless support helped me find the results. I would like to thank my professors and classmates of the Masters of Design program at DAAP, University of Cincinnati, for such a great guiding, learning atmosphere and precious time we spend exploring new knowledge and experience. I would like to acknowledge and intensely show my gratitude to my thesis committee members. To my committee chair, Craig Vogel, who has become a great counselor for me and inspired me with his professional knowledge and thoughtful viewpoint of design. Thanks for always giving me a fresh outlook throughout my thesis journey. Gerry Michaud for questioning my opinions and help me think deeper on my arguments. Without your insights and help, my thesis would not come to these results. Mark Turner, with his experience and great encouragement throughout my Co-op project at Aerospace Engineering Department, he thought me a lot.

I would also like to express my deep appreciation to my Co-op adviser, Beth Herrin whose unconditional support and advisement helped me to know myself better as a designer and focus on my skills and interests to fine perfect matches in my job search.
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CHAPTER 1 / INTRODUCTION:
1-1 Introduction:

The fact that multidisciplinary teamwork in new product development facilitates the process is undeniable because each discipline has a valuable set of knowledge and skills to bring to the process. Moreover, the value of having an industrial designer on product development teams is clear since the designer will increase the aesthetics and experiential quality of their products [Vicens, Quentin, and Philip E. Bourne, 2007]. Certain companies have successfully integrated design in their engineering teams and other companies are following suit. However, the collaboration between designers and engineers can be challenging given that they have different perspectives on a product, come from different backgrounds, and are trained differently. Engineers are detail oriented and mainly concerned about technical features, while designers are empathetic and concerned about aesthetics and user experiences. Their approach to problem solving is different: engineers start quantitatively and continue quantitatively but designers take quality over quantity. Designers use a qualitative approach at first, but continue quantitatively, in order to create multiple sketches reflecting differing ideas or sketches that, through iteration, improve the theme and direction of the brief.

For over a third of the century designers have been trying to integrate successfully into product development process, though it continues to be a challenge to do so effectively (Edmondson & Nembhard, 2009, p. 123-138). This
thesis focuses on the complications in interdisciplinary teamwork between engineers and designers, and provides guidelines to support efficient collaboration.

1-2 Thesis goals and objectives

The goal of this thesis is to propose a set of guidelines to help industrial designers navigate collaboration with engineers. The objective of the study in this thesis is to identify the conditions for a successful collaboration between an industrial designer and individuals from different engineering disciplines in a product development project. In this thesis, one case study will be used to make problems and proposed solutions more understandable.

1-3 Benefits of the study

The benefits of this study include:

1. Helping designers to communicate with engineers, and to present their skills and knowledge to increase their integrity as a team member in product development teams.

2. Helping designers to have an efficient and successful collaboration with engineers, which will increase success of the product’s development.
3. Helping designers to understand the differences between design and engineering disciplines in order to have a clear understanding of their different roles and goals in product development.

4. Helping designers to understand the step-by-step process of new product development in order to see what they can do in each step to add value to the project.

5. Helping designers to see collaboration challenges in advance by providing examples from case studies and the potential solutions.

6. Helping designers to show how their skills and knowledge can be a benefit to not only the team, but also the whole project.
CHAPTER TWO / LITERATURE REVIEW
2-1 PRODUCT DEVELOPMENT SIDE

2-1-1 What is product design and development

Since different disciplines have their own methods, there can be different ways of performing product design and development according to different circumstances in the process.

Generally, product development is a process in which a new product is created to be sold to specific or general customers or clients by a business. In this regard, design refers to the activities of generating the product's form, style, and feel, as well as working on the technical features, materials, manufacturing processes, and engineering the components needed to make the product work. Development refers to the whole process of finding a new product opportunity in the market, designing and engineering the product based on the customer’s needs and market requirements, and testing, modifying and refining until the product is completely prepared for production. A product can be any thing from a pen, book or informational products, to a complicated engineered product, such as a computer or transportation vehicles. This thesis is focused on the development process of engineered products.

There are two major design activities in product design including engineering design and industrial design. When we talk about product design, it usually has an indirect relation with ‘industrial design’ and ‘engineering design’. In many
cases, product design refers to industrial design [Lorenz, 1986; Tjalve, 1979] and in the other many cases, it is considered as the subject in engineering design [Haik, 2003; Hollins, 1990; Pugh, 1996; Ullman, 2004]. Horváth (2004) illustrates that product design is positioned between industrial design and engineering design, with industrial and engineering design overlapping with product design (Fig.1). Although industrial design and engineering design have their own significant characteristics and area of specialty, they both are involved in the process of product design and development to some extent [Kim & Lee, 2010].

![Diagram of product design and development process](image)

**Figure 1. Position of Product Design (Horváth, 2004)**

### 2-1-2 New Product development process

1. **Problem Definition and Customer Needs Identification**

   Through market studies, detecting similar products, and discussions with manufacturers and potential buyers, researchers identify the consumer needs.

2. **Product Requirements and Specifications**
The team analyzes the technological, economical, and structural requirements based on several conditions. Later, after designers have generated primary concepts, the product specifications are created as an output of the requirements generation process, in order to provide explicit technical, manufacturing, and economic information about the product.

3. **Conceptual Design and Selection**

Designers create a number of product concepts to illustrate what types of products are both technically feasible and would best meet the requirements and constraints. Cost, safety, operating compatibility, efficiency and other criteria are considered for selection.

4. **Product Detail Design**

During this phase, engineers and designers develop analytical fabrication 2D-3D drawings for each part of the product, taking into account tolerances, materials, manufacturing processes, production cost, weight/strength ratio, ease of assembly, ease of maintenance etc. Two-and three-dimensional software packages are used.

5. **Prototyping**

After detail design, prototypes are constructed and functional tests are performed to determine whether the performance of the product matches the specifications, and to uncover design shortfalls and gain in-the-field experience with the product in use. Rapid manufacturing’s technologies
support this phase, in order to rapidly build prototype components from plastic material, enabling production cost reduction and dramatically shortening time-to-market of new products.

6. Testing and Optimization

Finally, through testing, adjusting, modifying, and re-testing the prototypes, the team optimizes the prototypes in order to be more efficient, cost effective, and desirable with competitive advantages within the market.

2-2-3 Two design approaches in product design and development

There are two types of designs in product design: engineering design and industrial design. In a product design project, engineering design is responsible for designing product systems and components, and the outcome is the mechanical design and considerations to make the product work. Industrial design is responsible for designing the product aesthetics and human factors, and its result is the outside form and the related user experiences and interfaces [Kim & Lee, 2010].
Because the two designs are core parts of product design, manufacturers focus on incorporating engineering designers and industrial designers to develop successful products. Based on the task difference between the two designs, there can be two types of design approaches, the inside-out approach in which internal design precedes external design, and the outside-in approach in which the users’ experience are outlined before the internal function of the product is defined [K. M. Kim and K. P. Lee, 2010].
The role of an industrial designer in new product development

According to the definition given by the Industrial Designers Society of America (IDSA), industrial design (ID) is the "professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer." An industrial designer links creative form and style with engineering specifications, and balances the human values communicated through form, color, and texture with the mechanical certainties to show a comprehensible message to the users who experience the product. Industrial designers have broad education in art, as well as training in basic engineering and manufacturing processes, as well as some marketing knowledge. Dreyfuss (1967) lists five essential goals and values that industrial designers bring to a team of a new product development.

- **Utility:** The product's human interfaces should be safe, easy to use, and intuitive. Each feature should be shaped so that it communicates its function to the user.

- **Appearance:** Form, line, proportion, and color are used to integrate the product into a pleasing whole.

- **Ease of Maintenance:** Products must also be designed to communicate how they are to be maintained and repaired.

- **Low Costs:** Form and features have a large impact on tooling and production costs, so the team must consider them jointly.
• **Communication:** Product designs should communicate the corporate design philosophy and mission through the visual qualities of the products.

### 2-2 COLLABORATION SIDE

#### 2-2-1 Who are involved in a new product development process?

Several different disciplines are involved in the product development process. Ulrich and Eppinger (2008) said that the core team members for product development are the industrial designer, the mechanical designer, the electronics designer, the purchasing specialist, the manufacturing engineer, and the marketing professional. In their argument, the product they mention is an electro-mechanical product of modest complexity, which covers a significant portion of the consumer product market these days. Roozenburg (1995) also claims that engineering design, industrial design, ergonomics, marketing and innovation management are the disciplines nearly always involved in product design.

However, some of the above-mentioned professions are actually people supporting design but who are not directly involved in design practice. For example, manufacturing engineers mainly work in manufacturing processes and focus on the realization of product forms and functions determined by engineering designers and industrial designers. Marketing people support design activities by delivering market and consumer data to the product design team [Kim & Lee, 2010].
Therefore, engineering design and industrial design are considered the major parts of product design that work directly in the practical design activity among the specialists believed to be involved in the product development process known as ‘product design’ [Kim & Lee, 2010]. Lindbeck (1994) also pointed this out by mentioning the importance of the role of engineering designers and industrial designers in product development: “manufacturers who are properly concerned with product quality will engage teams of engineering and industrial design people to create artifacts that work, look nice, and are easy to produce”.

![Diagram](image)

Figure 4. Two major disciplines in product design and development

2-2-1-1 Differences between engineering and industrial design perspectives

I conducted a review on industrial design and engineering undergraduate program curriculums to see what are the main topics these programs focused on, and what their students are trained for.

In reviewing the engineering curriculum, I found out that they are mainly focused on Mathematics and Calculations by providing courses such as Calculus I,
Calculus II, multi variable Calculus, and so on. But, there were no courses related to aesthetics, human factors, and user-centered design.

However, in industrial design undergraduate curriculum, the main concentration is on aesthetics, design thinking, and user-centered design by offering courses like design visualization, product design studios, design thinking methods, interdisciplinary user-centered design, and human factors for industrial design. The students also get some knowledge of materials and manufacturing by taking courses like materials and processes, making of things, and design technology.

The above comparison between engineering and industrial design undergraduate curriculums shows how differently professionals are trained in each discipline, which can result in some challenges in their collaboration in a product development project, and adversely affect the project outcome if they cannot overcome those challenges.

2-2-2 Critical factors for a successful collaboration

There is not a shadow of doubt that not all collaborations are successful. In order to have a productive and successful collaboration there are some helpful factors that need to be considered by companies and their members. Paul Mattessich and Barbara R. Monsey (2001), in their book reviewing critical factors for successful collaboration, divide all factors in six different categories and explain each factor as below:
1- Environment

2- Membership

3- Process/Structure

4- Communication

5- Purpose

6- Resources

1-Factors related to Environment:

A) History of collaboration or cooperation in the community

Trying to solve problems through collaboration has been common in the community. It’s been done a lot before.

B) Collaborative group seen as a legitimate leader in the community

• Leaders in the community outside the collaborative seem hopeful about what members can accomplish.
• Others in the community who are not part of this group would generally agree that the people and organizations involved in this collaborative are the “right” ones to make it work.

C) Favorable political and social climate
The political and social climate seems to be “right” for starting a collaborative project.

2-Factors related to membership

A) Mutual respects, understanding, and trust

People involved in the collaboration always trust one another and respect others.

B) Appropriate cross section of members

- The people involved in a group represent a cross section of those who have a stake in what they are trying to accomplish.
- All organizations with members involved in the collaborative group are engaged.

C) Members see collaboration as in their self-interest

The organization will benefit from being involved in this collaborative.

D) Ability to compromise

People in the collaborative are willing to compromise on important aspects of the project.

3-Factors related to process and structure

A) Members share a stake in both process and outcome
• The organizations that belong to collaborative group invest sufficient amount of time in their member’s effort.
• Everyone who is a member of the collaborative wants this project to succeed.
• The level of commitment among the participants is high.

B) Multiple layers of participation

When the collaborative group makes major decisions, there is always enough time for members to take information back to their organizations to confer with colleagues about what decision should be made.

C) Flexibility

• There is a lot of flexibility when decisions are made; people are open to discussing different options.
• People in the collaborative group are open to different approaches to how they can do the work. They are willing to consider different ways of working.

D) Development of clear roles and policy guidelines

• People in the collaborative group have a clear sense of their roles and responsibilities.
• There is a clear process for making decisions among the partners in this
E) Adaptability

- The collaboration is able to adapt to changing conditions, such as fewer funds than expected, changing political climate, or change in leadership.
- The group has the ability to survive even if it has to make major changes in its plans or add some new members in order to reach its goals.

F) Appropriate pace of development

- The collaborative group tries to take on the right amount of work at the right pace.
- Members are able to keep up with the work necessary to coordinate all the people, organizations, and activities related to this collaborative project.

4-Factors related to communication

A) Open and frequent communication

- Communicate is regular and transparent
- People are informed as often as they should be about the collaboration.
- The people who lead the collaborative group communicate well with all of the members.
B) Established informal relationships and communication links

Communication among all of the people in the group happens both at formal meetings and in informal ways.

5-Factors related to purpose

A) Concrete, attainable goals and objectives

• Members have a clear understanding of what the collaborative is trying to accomplish.
• People in the collaborative have established reasonable goals.

B) Shared vision

• The people in the collaborative group are dedicated to the idea that they can make the project work.
• Everyone’s idea about what the group wants to accomplish in the collaboration should be the same.

C) Unique purpose

• Members should believe what they are trying to accomplish with their collaborative project would be difficult for any single organization to accomplish by itself.
• Members should believe no other organization in the community is trying
to do exactly what they are trying to do.

6-Factors related to resources

A) Sufficient funds, staff, materials, and time

- Collaborative group has adequate funds to do what it wants to accomplish.
- Collaborative group has adequate “people power” to do what it wants to accomplish.

B) Skilled leadership

Those in leadership positions have good skills for working with other people and organizations.
3-1 Research methods

In this thesis, in order to have a broad study on the challenges of collaboration between an industrial designer and a team of engineering in a product development project, I have used two different research methods.

1- Action research: I used a case study in which I was the solo industrial designer as a co-op student at the Aerospace Engineering Department at University of Cincinnati in collaboration with Workhorse Group.

2- Interviews: I interviewed five individuals, including three industrial designers and two engineers; one of the engineers was the project manager in Surefly project.

3-1-1 Introduction to the case study

During the summer between my first and second year of my graduate studies at the University of Cincinnati, College of Design, Architecture, Art, and Planning (DAAP), I served as the industrial designer/co-op student in a project called “Surefly” housed in the Aerospace Engineering Department at the University of Cincinnati in collaboration with Workhorse Group. I have used this project as a case study and action research for this thesis.

Brief description of the case study (Surefly project):

In collaboration with the Aerospace Engineering Department at the University of Cincinnati, Workhorse Group decided to design and produce a new type of aerial
transportation mode, a combination drones- helicopter that can be used as a daily commuter vehicle, which could lead to a new level of daily traveling.

There were around 20 people from different disciplines collaborating in this project, including mechanical engineers, aerospace engineers and an industrial designer. Working in this team was challenging for me since I was the only industrial designer there, and most of the team members had no prior experience working with an industrial designer.

3-1-2 Interviews

Interview with engineers and industrial designers:

**Interviewees:**

There were five interviewees: two professional industrial designers teaching industrial design at DAAP, one design graduate student who has a background in mechanical engineering, a professional aerospace engineer who is a professor in the Aerospace Engineering Department at the University of Cincinnati (and the project leader in Surefly project), and a PhD candidate in biomedical engineering who had some experiences working with industrial designers.

**Goals:**

In order to find out how industrial designers can work more effectively with engineers to have a successful collaboration, it is necessary to understand
design from the point of view of both engineering disciplines and industrial designers.

Two of my objectives in conducting these interviews include: finding challenges that both disciplines face in collaboration with each other and determining possible solutions for those. I also sought to distinguish engineers’ expectations from those of industrial designers, and how an industrial designer can meet their expectations in a way that results in a productive collaboration.

**Questions:**

I used two sets of open-ended questions—one for engineers and one for industrial designers—in a semi-structured interview. Open-ended questions are questions that cannot be answered by a single word or fact. They encourage the candidate to elaborate and provide the interviewer with valuable data.

Open-ended questions do not have to:

- Begin with the words what, where, when, who, why or how
- End with a question mark

I used questions below with the initial subjects of my interview; however, sometimes I had to ask questions in different ways to achieve the goal of interview.

**Engineers’ questions:**
1. Why do you think industrial design is important in a product development process?

2. How do you define industrial design?

3. What is your definition of a process for successful product development?

4. What is the role of the industrial designer in this process?

5. What challenges did you face working with an industrial designer?

6. How do you define successful collaboration?

   a. How have you done a productive collaboration with an industrial designer?

7. What can industrial designers do to integrate into a multidisciplinary team?

**Designers’ questions:**

1. Why do you think industrial design is important in a product development process?

2. How do you define industrial design?

3. What is your definition of a process for successful product development?

4. What is the role of the industrial designer in this process?

5. What challenges did you face working with an engineer?

6. How do you define successful collaboration?

   a. How have you done a productive collaboration with an engineer?
7. What can industrial designers do to integrate into a multidisciplinary team?

8. How do you get instructed about your role in the project?

a. How in the past people described your role in the product development?

b. What questions can a designer ask engineers?

9. When discussing with engineers, how do you defend your ideas?

10. How do you deal with the limitations that engineers give you on form, structure, material, etc.?

11. If the engineers are talking about something that you do not have the knowledge of, how do you manage the situation?

12. If you do not have the expertise of what the engineers asked you to do, what would you do?
CHAPTER FOUR/FINDINGS:
4-1 List of problems I faced with my case study (results of action research) and my solutions from the case study

• I was not completely clarified about my role in the group and in which areas I am going to contribute to the project

Project managers of Surefly project wanted the design of their product to be user friendly and visually pleasant, so they had communicated with UC PAL, the division of Professional Assessment and Learning at the University of Cincinnati, to add an industrial design student in their team. They knew an industrial design student with relevant experience in transportation design could bring something new and valuable to their team, as they were designing a new type of aerial transportation vehicle. However, they thought that an industrial designer could do any kind of design—like communication design. The Surefly managers also assumed an industrial designer would be proficient in 3D animation (which shows how the design works), however, I had no experience and knowledge of how to make a 3D animation. It proved to be a big challenge for me to learn 3D animation in a short time without having an instructor.

• There were some criteria that engineers considered that was different than my criteria:
The engineers did not see the product holistically, but as separated parts. For example, for the product that I was working on—an Octocopter—I had some ideas for the landings that were aesthetically appropriate and went well with the whole concept, but they did not agree as they were looking for something aerodynamic and that matched their technical calculations.

*Engineers approach prototyping first, while industrial designers utilize prototyping as a final step, once we have found our ideas feasible*

In the Surefly project, the engineering team was concerned about prototyping first, and they asked me about the methods of prototyping that could be used for our product. They also asked me about 3D printing and clay modeling; however, as an industrial designer I was not able to execute modeling before ideation. I needed to ideate first, select the final concept, and then decide on prototyping based on that concept.

*The engineering approach to problem solving is different: Engineers start quantitatively and continue quantitatively, while industrial designers begin with a qualitative approach and then follow with a quantitative approach*

When I started working on the Surefly project, the engineers asked me to search for the dimensions of some aerial vehicles, like helicopters, and then try to define the dimensions of our product. In the beginning, we had several meetings to discuss the measurements of different parts of the
product. This is contrary to the process of industrial design, in which we start ideation first, and then after selecting the final concept, we work on product sizes and details. This influenced my ideation, as I had to consider specific dimensions in my design concepts.

• **There was no user research; I did not have the chance to interact with potential users and interview them**

As designers, we need to be empathetic to our users, and concerned about their actual needs and how they interact with the product that we design. However, in the Surefly project, there was not a defined target group as our users, so I was not able to conduct user research and interview the users during the design process to get their feedback.

• **I lacked a background in aerospace engineering**

Industrial designers, as advocates of users and humanizers of technology, need to have knowledge of the users of their products and their actual needs. Industrial designers must also learn what kind of technologies are going to be used in their products to be able to design a successful, practical, technology-driven and user-friendly product.

In the Surefly project, I had no familiarity with aerospace engineering, and experienced difficulties communicating with my teammates—who were mostly aerospace and mechanical engineers—and had sufficient knowledge and expertise on the basics of this field. We had weekly meetings to discuss the progress of the project, but sometimes I could not
follow the conversation, as I was not familiar with aerospace engineers’ concepts and rhetoric.

In order to have a basic understanding of this field, I had to look for related online sources, ask questions from my supervisor, and talk to one of our faculty members at DAAP who had experiences in designing aerial products.

- **I had no familiarity with engineering limitations on an aerial product and did not know how to work with them**

In every product development project, there are specific technical limitations on form, measurements, material, cost, structure and so on. As an industrial designer, you need to ask engineers about such limitations and what expectations they might have that should be considered in your design regarding those limitations. You may also need to know about the kind of manufacturing process used to make this product and the type of technology used in the product.

In the Surefly project, limitations were not clarified at the beginning, and I had to ask for those limitations at each step of the design process. Sometimes, I had to redo my work because I did not ask for the exact measurements, form and structure. I had to work with a specific airfoil designed by engineers, while I lacked knowledge of designing aerodynamic forms. I also did not have an understanding of the manufacturing process and materials that could be used in the product.
• **I lacked experience discussing my ideas with engineers**

  Industrial designers have proficiency in presenting their ideas visually through hand sketching, 3D modeling, rendering, and making physical mockups. While these skills are necessary to present your ideas, in order to convince engineers to side with your idea, you must be able to convey it in a way that is attractive and familiar to them”? Since engineers and designers have different perspectives and follow different processes in product development, as an industrial designer you need to be confident to talk about your solutions and problem solving methods to bring engineers on board.

  In the Surefly project, I lacked experience discussing my ideas in a way that could be convincing for engineers. I was able to bring ideas and visualize them, but I had difficulties in persuading engineers that my solution was the better route.

**4-2 Results of interviews**

After the interviews, I transcribed them, and then used HyperResearch software to code them. The codes were relevant mentioned points to my goals, which were then categorized into groups titled by the areas I was trying to gather information and insights about.

Transcriptions are attached as an appendix. The table below shows results from interviews, how I sorted them into the groups, and the frequency of each piece of
feedback.

The most frequently voiced feedback is listed below:

**Industrial designers’ challenges with engineers**

- They like to solve one thing and have a solution for it and then go to the next one
- It is hard to convince them that there may be a different way
- Engineers want a logical solution and most times, the logical solution is not the most elegant solution
- Making arguments about money, resources, creating value, and monitoring user value
- Arguing for the form because they may not be able to include that mold cost, and at the end the product looks chunky and does not reflect client’s value
- Disconnect in understanding why there are certain aesthetics built into products because engineers are driven by numbers, data, simple manufacturing techniques; it could be difficult sometimes to explain character lines, aesthetics, and user testing to engineers
- Picking a material that makes sense aesthetically

**Industrial designers’ solutions for challenges with engineers**

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• Having patience and being very scrutinizing and selective about where you impose your battles

• Keep the integrity and intent of the original design

• Understand the manufacturing process, materials, and electronics to design effectively and demonstrate some technical ability

• Develop a working vocabulary that allows you to be taken seriously and communicate effectively when sitting down with engineers

• Consider engineering and manufacturing in your design

• Consider the users, and translate their wants and needs using rhetoric the engineering team can understand

• Have common ground to have a conversation around…?

• Knowing new technologies and new limits of technologies

**Engineers’ challenges with industrial designers**

• Arguing for the form and the size of components (designers are able to design forms that are really cool and have organic shapes, but sometime it is really hard to pack them into packaging?).

• How to make it more than the end usability and aesthetics

• Disconnection in engineering thinking about things from designer’s point of view.

• Industrial designer not having enough of an aerodynamics background

**Engineer’s solutions for challenges with industrial designers**
• The earlier you use industrial design, the more helpful it can be

• The team should recognize what strength the industrial designer can bring to the table, and then figure out where that happens in the design process

• Industrial design should equally lead the project

• Some level of knowledge in manufacturing and materials is required for industrial designers

**Overall criteria of successful collaboration**

• Time, experience and relationship building

• Trust each other and understanding how each discipline works

• Asking questions, constant back-and-forth communication, and compromising

• Respect and value differences in perspectives and honor each other’s profession

• Be aware as much as possible to what other members are up to and what tasks they are fulfilling Speaking the same language

• Building the project in the least amount of time with the least amount of negativity from the other side

• All parties need to be open-minded and willing to teach and learn

• Everybody’s opinion gets heard and opinions are evaluated based on the end product goal and not any individual’s perception
• The collaboration has to feel what every member of team felt and
everybody should feel that they were contributing and that contribution
was needed at the end of the day

The role of an industrial designer in a team

• Look at the solution from usability, aesthetics and then a practical sense of
how the product will be used
• Focus on what the true needs of a user are, and make sure that those
needs are incorporated in the product’s design
• Design for positive interaction between the product and the user;
determine the human interface as well as ergonomics to foster better
experiences
• Build empathy and value in the product that goes beyond its mechanical
functions
• Maintain design integrity; implement marketing and engineering
specifications in a cohesive package
• Justifying the functionality, and make sure that the form matches the
function of what engineers build

4-3 Finding common challenges in the case study and
interviews

Appropriate guidelines should address side challenges—the industrial designer’s
side and the engineers’ side. To develop solutions that benefit both industrial designers and engineer I consulted challenges mentioned in the interviews and challenges that arose in the case study. The next step involved determining if challenges for both industrial designers and engineers could be met with the same solution. In the end, five guidelines were developed as solutions.

Figure 5: Finding common solutions for challenges in case study and interview results
CHAPTER FIVE/ CONCLUSION:
5-1 GUIDELINES FOR INDUSTRIAL DESIGNERS IN COLLABORATION WITH ENGINEERS

5-1-1 Get clear about your role in the group and in which areas you are going to contribute to the project

If you are the one who is expected to take care of an industrial design approach in an interdisciplinary team, make sure the project plan is fitting the ID approach. You need to present a comprehensive design plan to the team and explain how you can apply the best design method to each stage, the goal of each stage, and that the end goal is not achievable without this plan. Make sure everybody understands the benefits of this plan and agrees to be committed to it.

When joining an engineering team, there is often this challenge that members of the team may have different assumptions about the role of the newly enrolled industrial designer. They may be sure that this person is bringing something different to the team, but might have different ideas about what that “something” is. To overcome this challenge you need to explain all the abilities you have at different stages of design process (i.e. research skills, analytics skills, prototype making, user tests and user interactions, and/or visual design). If a superior, like a project manager, chose you to contribute to a specific part of the project, you need to make sure that your fellow teammates are aware of that specific role in the project.
5-1-2 Learn the required knowledge related to the project and seek advice from experienced colleagues if needed

In a new product development project, you need to learn what technologies, materials, and manufacturing processes are to be employed. You can seek advice from experienced people not involved in the project. Asking someone in the team who has the most relevant knowledge in the field to teach you some of the basic lessons can also be helpful. Try to absorb knowledge from different conversations with the team or with users. You can also always refer to online resources to learn project- and engineering-specific knowledge. And of course, asking questions is always beneficial.

5-1-3 Be aware that engineers also do design, but it is different than industrial design, and industrial designers should appreciate its value

As mentioned in chapter two, there could be two types of design approaches in product design and development: the “inside-out approach” and the “outside-in approach,” which can explain the difference in design by engineers and design by industrial designers; engineering design focuses on product systems and components design, while industrial design involves product aesthetics and human factors design.
Industrial designers need to be aware of these two types of design and the differences between them, and acknowledge value in engineering design for its ability to make a product functional, and as a critical part of a product’s development.

5-1-4 Use your knowledge and skills to present your ideas, and learn how to communicate and defend your concepts when discussing with engineers

As an industrial designer, you should have proficiency in presenting your ideas visually and physically through hand sketching, 3D modeling and rendering, making physical mockups, and focus on the interaction between the product and the user to include empathy in your designs. Learning how to communicate effectively is a huge step to successfully collaborating; so you need to learn how discuss your ideas with engineers in ways that foster mutual understanding. If the engineers are insisting to do any part of the project their way and you think there is another, better way, to convince them, you need to convey your idea in a way that speaks well to engineers. Most engineers want a logical solution and often the logical solution is not the most elegant solution.

5-1-5 Prepare questions to ask engineers about technical limitations and learn how to work within those limitations
In every product development project, there are technical limitations regarding measurement, form, material, cost, structure, and so on. So, you need to ask engineers what those limitations are and how they define form, measurements, etc. within the scope of the project. You may also need to inquire about the kind of process used to make the product, piece part quantities, the number of units, and the kind of technology used in the product.

To be able to work within the product’s limitations, you need to have an understanding of manufacturing processes, materials, electronics, etc. You do not need to be able to do those things, but having an understanding of them enables you to understand in order to design effectively.

5-2 How do the guidelines accomplish the objectives and benefits of the study?

By studying this thesis and examples of the challenges, industrial designers can have a better understanding of the probable difficulties in collaboration with engineers. They can benefit from the guidelines to prevent these challenges. By applying these guidelines to the collaboration efforts, both industrial designers will have clear idea about:

- Project plan, their role and the area in which they have responsibilities
- Engineering design, capabilities and skills of engineers in the team
- How to talk and discuss their ideas with engineers to be understandable and acceptable for them
• Technical limitations of product and how to design based on those limits
• The required amount of the background knowledge of different disciplines for a better communication goal

This clear image helps to improve the acceptance of the industrial designer in the team. In addition, team will have a more efficient collaboration, which will result in enhancing the achievements in the team.

5-3 How do the guidelines relate to critical factors for successful collaboration?

First guideline, “Get clear about your role in the group and in which areas you are going to contribute to the project” is interrelated to factors related to process and structure, section D (development of clear roles and policy guidelines).

Second guideline, “Learn the required knowledge related to the project and seek advice from experienced colleagues if required” is related to factors related to purpose, sections A (concrete, attainable goals and objectives), and section B (shared vision).

Third guideline, “Be aware that engineers also do design, but it is different than industrial design, and industrial designers should have appreciate its value for that” is related to factors related to membership, section A (mutual respects, understanding, and trust), and factors related to process and structure,
section C (flexibility).

Forth guideline, “Use your knowledge and skills to present your ideas and learn how to communicate and defend your concepts when discussing with engineers“ is related to factors related to process and structure, section C (flexibility), factors related to communication, section A (open and frequent communication) and section B (established informal relationships and communication links), and factors related to purpose, section B (shared vision).

Five guideline “Prepare questions to ask engineers about technical limitations and learn how to work within those limitations” is related to factors related to process and structure, section B (multiple layers of participation), and factors related to communication, section A (open and frequent communication) and section B (established informal relationships and communication links).

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Interviewee: Steve Dohler, Industrial Design Associate Professor = S

Interviewer: Parvaneh Maleki = P

Date: October 27th, 2016

P: How do you define Industrial design?

S: Advocators of users and humanizers of technology

P: Why do you think industrial design is important in a product development process?

S: Depending on what kind of designer you are; user-centered designer is going to really focus on what the true needs of a user are and make sure that those needs are incorporated in the product. Pleasure and emotion; there is an emotional aspect and then there is justifying the functionality and the final goal is to make positive interaction between the product and the user.

P: What is the role of the Industrial designer in this process?

S: It depends on where are you in the product development process. If you are in a very early stage, it is a process of understanding what the needs of the customer or users or stakeholders are. As you move forward, it is visualizing those needs in a package or system that someone can understand and relate to,
and then as you go forward, it is putting form and function to those scenarios and then it goes to working with others like marketing people and engineers and how to maintain design integrity and how you implement marketing and engineering expectations into a cohesive package. The industrial designers are that glue and communicator that is between marketing and engineering. Industrial designers are kind of people who can take the information and develop it into something that people can relate to either through presentation, concept iteration, models or whatever the form it is. It is kind of taking those bullet points and creating a vision for it.

**P: What is your definition of a process for successful product development?**

**S: Well, the base I guess is probably a four or five-step process;**

1. **Understanding phase:** the designer can meet with people, can interact, can have empathy for people’s needs, can understand the technology, and can understand the marketing trends and so on. So, there is a big area at the beginning, just like knowledge gathering, understanding what products are already out, who is successful, why they are successful, some people call it research and some others call it understanding phase.

2. **Conceptualization phase:** at this phase, you take that information and put it into ideas and then visualize the ideas that have come off of that. So, you are taking your primary and secondary research and dumping it into your mind and then creating something that expresses all that. And, I think
in that point before you start to create, you have a list of requirements that the product must have in order to be successful and that is what your concept should be formed from. Whether it is a very small project or a very big one, you have criteria that it has to meet for success.

3. Validation phase: this phase is usually not done but I think it is probably the most important step and that is getting your ideas from your stakeholders and getting feedback on how it is going to be placed into the task that you are going to do and what is good about it and what is bad about it and what should be improved. Then, you take those learning and go to the refinement. Many times validations stops at the clients, so you go over the marketing and engineering departments and it is like okay, that is good, let’s do this. But, I mean a real way to do this, is to go out and get feedback from the people who are going to actually buy and use the product. So, you understand what is going to hit the market and then you go to refine based on those information.

4. Finalizing phase: at this phase, you are getting everything ready for production, so, you are making sure that your geometry is correct and you have proper draft on everything. Manufacturing specification have been communicated to designer from engineering. You get as far as you can get it, then you have to work with engineers in order to make sure that the design intent is kept. Engineers are doing the fine details, but it feels really bad, so the designer’s role and add is to say how can we make nice
product that feels better. So, the quality and integrity of the design from all these sensory standpoints are met.

5. Production phase: at the production point, you are getting things off of the tool and you are inspecting to make sure that the design is right and that the tool was cut properly. So, you do not have a big piece that goes across in the material or in the texture, and if it does, you talk to the toolmaker stuff to see how to fix it and then, it goes to the market.

P: What challenges did you face working with an engineer?

S: I think with engineers, there is a real kind of trend that they like to solve one thing and have a solution for it and then go to the next one and it is sort of experimenting. I think that is the biggest part to convince them that there may be a different way. Many times, what you have to do, to convince somebody that there is a different way, is actually to do it and show that it can be done, and then they are on board. Most, engineers want a logical solution and most times, the logical solution is not the most elegant solution.

P: How do you define successful collaboration?

S: It comes from time and experience and relationship building. The most successful collaborations that I have had, have been with engineers who trust me, and trust what I am doing is the right thing to do. And I trust them because when they say it cannot be done, it really cannot be done or for one reason it is going to be prohibited to do it that way. So, I think collaboration is about not only
understanding how each other works but also building relationship and trust between the two disciplines. If they know I want it to be done in a certain way, they know it is not just because I want it is. There is a reason behind it and same thing on their side. So, then it comes to the compromise point and we have to be really compromised.

**P: What can industrial designers do to integrate into a multidisciplinary team?**

S: Blessing and being very scrutinizing and selective about where you imposing your battles, is helpful. It is about keeping the integrity and intent of the original design. So, what do you stand up for?

**P: How do you get instructed about your role in the project?**

S: It depends on the situation; if I am working for a corporation, roles are pretty much set. It usually comes from whoever the project leader is. So, project leader often time is a marketing person and sometimes an engineer, depends on the project. Basically, what happens is that they give you expectations of what needs to be done and then you develop a proposal based on that, which says this is what I am going to do? Usually, in a product development process, you have a marketing specification and an engineering specification. So, the marketing specifications say to the engineers that these are what you need to have in this device to compete in the market. Then, the engineers come back and say here is specification of what we should do to meet the marketing objectives. And then,
the designers in the middle, say okay, I am going to take this and that and I am
going to put them together into concepts, hypothetic of what the product could be
and then it is basically ranked against the marketing and engineering expects
and then that is where all the compromises come in.

a. What questions can industrial designers ask from engineers?

S: What are the technical limitations?

How many people are going to buy the product in a year? (Which will determine
what kind of process we can use to make it)

What kind of technologies is going in this product?

P: How do you deal with the limitations that engineers give you on form,
structure, material, etc.?

S: What we need is to understand manufacturing process, materials, and
electronics to design effectively.

P: If the engineers are talking about something that you do not have the
knowledge of, how do you manage the situation?

S: Asking questions, constant back and forward, and compromising

P: If you do not have the expertise of what the engineers asked you to do,
what would you do?
S: You should be honest. You can say let me check in it and get some consulting.

Interviewee: Peter Chamberlain, Industrial Design Associate Professor = P

Interviewer: Parvaneh Maleki = P

Date: October 26th, 2016

**P: How do you define Industrial design?**

P: Improving human’s lives and the quality of experiences of people’s lives. Industrial design has been reformed and different kinds of design like fashion design (bags, shoes and so on) and communication design (interaction design) are now around industrial design. To be effective as a designer, you need to be knowledgeable of materials and manufacturing processes and some of the realities of trying to put something new out into the world because if you do not understand that, it is sort of magic and dreams. I say to our students that I wish to have them with their head into clouds like dreamers and visionaries, but with a foot into the ground too. Reading the reality of materials, manufacturing, sustainable practice, and a big portion of our built society has a basis in industrial design.

**P: Why do you think industrial design is important in a product development process?**
P: Marketing is developing products, engineering is developing products, industrial design is developing products, and it is almost as multifaceted as design itself. It matters much about what the product is. One of my answers would be that industrial design and endeavors of industrial designers are the product development process. If we call product development a team effort, industrial designers are inventors and one of their roles is to be visionary and can show people visions of what the product could be. Industrial designers are problem-solving experts and it has been proved to be valuable within ID and outside it.

**P: What is your definition of a process for successful product development?**

P: Idealistically, it would be a product that hits the mark in terms of satisfying whomever the users are and what their actual needs are, and recognizing the actual cost of bringing this product into the world (not only the cost, but also cost in terms of social responsibility, sustainability, material usage, limitation of waste and things like that. So, in a nutshell, maximized human experience, minimum cost on the back end in terms of degradation of environmental toxicity to people.

**P: What challenges did you face working with an engineer?**

P: A general response is about making arguments about money, resources, making value and monitoring user value. You should argue the value of your design to show that is an adding to the experience of that product, arguing the form to show that this is the form that it needs to be, but they say we cannot do
that because that is going to make a seven-part mold and we cannot include that mold cost, and at the end the product looks chunky and does not reflect people’s value.

**P: What can industrial designers do to integrate into a multidisciplinary team?**

P: Industrial design students should have a vocab of experience and a vocab of language that lets them to be taken seriously when they are sitting down with engineers to discuss their design that they proposed for production or manufacturing.

**P: How do you define successful collaboration?**

P: It is about respect and the value. I think people need to respect to others seriously and value differences in perspectives. I think designers, on a team with engineering and marketing, who does not understand anything about the materials and about the market, should not be taken seriously. Industrial designers need to be valuable to the contribution of others and be hungry to learn what other people are doing. Be aware as much as possible to what other members are up to and what they fill to. We want to know at least a little bit about a whole of different things.

**P: How do you get instructed about your role in the project?**
P: It depends on where you work. In a corporate you need to learn about their culture and what they think of an industrial designer.

a. What questions can industrial designers ask from engineers?

One of the main questions is: what is our real value proposition to the users?

We must make sure that at the end of the day, our team is focused on that we are fostering the relationship between different things like users and product and its function. We need to make sure that the human side is presented.

P: How do you deal with the limitations that engineers give you on form, structure, material, etc.?

P: That is about the collaboration. Hopefully, it is not an adversarial relationship where they say your way or my way. Common ground is the key. A good back to respect, trust other’s ideas and knowledge.

Interviewee: Josue Ricardo Campos, Bachelors in Mechanical Engineering (Product Development) - Mater’s in Design = J

Interviewer: Parvaneh Maleki = P

Date: October 19th, 2017

P: How do you define Industrial design?

J: I define industrial design as the design of a product for its mass production. Essentially, this is what I define ID as, but there is a lot that could go into the
P: Why do you think industrial design is important in a product development process?

J: Because industrial designers use research methods that allows to gain insight into users. So, it is more user-centered research and allows industrial designers to build empathy in the product and a value that goes beyond its mechanical functions.

P: What is your definition of a process for successful product development?

J: There are many formulas for a product to be successful, it depends what the product is and what are you defining as successful. I found that the methodology of design thinking has been very valuable because it allows you to be wrong, to build prototypes and test them versus engineering that you want to get %100 and sometimes you do not make sure it is good, but you tend to look at it in a straight line versus more exploratory design method. Engineers are more focused on making things work, so they might make things a little bit simpler for it to work and they are not so worried about the user-centered design.

P: What is the role of the Industrial designer in this process?

J: It depends on the company, if you are in a small company, the role of industrial designer is going to be the designer, and the marketing person, the engineer, the material scientist, the ethnographic researcher, and they would do all of that. The bigger company you have, the more projects and more responsibilities you have,
so you need more people and there are more roles available, so that work can be split up. So, you can work in a company where industrial designers are just worried about concept or aesthetics and trying to build empathy through that aesthetic language, or you might be in a company where you are trying to develop aesthetics along with functions, so when you pass it down to the engineers, they can work with that. But, good industrial designers always think about the whole process from the research to the concept, design, sketching, engineering and manufacturing.

P: What challenges did you face working with an engineer?

J: Working with engineers, I can see how they are disconnected to reason of why it is that way. There is a disconnection in understanding why there are certain aesthetics built into products and it is not only picking a material but it is also picking a material that makes sense aesthetically and fits to the whole product, project, company and the whole product line. It might be picking a material that is more expensive, but that gives you more value and sometimes engineers do not understand that because they are driven by numbers, data, simple manufacturing techniques that allow them to make the product function and make it easier. As an industrial designer, it could be difficult sometimes to explain them character lines, any sort of aesthetics, user testing and things like that.

P: How do you define successful collaboration?

J: Successful collaboration would be one that the whole design thinking process is implemented and is handed down to the engineers, but during this process, the
engineers have their impact because of their large experiences with manufacturing techniques, material science and that they can address some of the issues right away instead of waiting until industrial designer does all this work and then engineers coming back saying no, this is all wrong. So, it is about speaking the same language and having respect for each other’s profession. And, building the project in the least amount of time with the least amount of negativity from the other side, so engineers and designers are talking and they are respecting each other. And, they want one thing the best for the product and the company. And ultimately, the way that the whole team has envisioned it, is the same, or if it is not the same, makes sense to them how it has involved for the better of the product and the company.

P: How do you deal with the limitations that engineers give you on form, structure, material, etc.?

J: In a project, engineers made one solution, however they missed the certain points when there was an interaction with the user. So, as an industrial designer, I saw the opportunity to raise the value in the product by making it user-friendlier and ate the same time, make it aesthetically pleasing. Also, the cost of manufacturing was lowered and the product was overall integrated better into the bigger product. There was consideration for engineering and manufacturing and consideration for the users, and it was translated well to what the engineering team could understand.

P: What can industrial designers do to integrate into a multidisciplinary
J: I think we need more knowledge on manufacturing and some technical ability, not only aesthetical feeling. So. To get integrated better into engineering team, that would be the best to have common ground to have a conversation around and knowing new technologies and new limits of technologies. Because sometimes engineers might say no, that is not possible, but you know it is possible because a lot of industrial designers are so connected to the media and to new technologies, but engineers are always on the textbook, so they cannot learn outside interest.

Interviewee: Andrew Jajack, Biomedical engineering PhD candidate = A

Interviewer: Parvaneh Maleki = P

Date: November 22, 2016

Working with Livewell Collaborative and Children’s Hospital trying to make non-invasive sensors that can be on skin and can analyze and metabolize that stuff that you would not be able to measure by Fitbit and Apple watch.

P: Why do you think industrial design is important in a product development process?

A: Working at Livewell was my first time collaborating with designers and I really liked the design thinking process; research phase, ideation phase, making and
testing prototypes and so on because it allows you to design and refine your ideas several times.

**P:** How do you define Industrial design?

A: When I think of industrial design, I think of things like tangible products. When you go to a store of home appliances, you see all the different form factors, but they are all the same product like blenders, but then you want a blender more because of the form of it.

**P:** What is your definition of a process for successful product development?

A: I think a successful product development project is one that meets the end goal with the most efficient user resources and it is like that we are trying to make something and as part of our decision, we can choose components based on cost and stuff like that. When we had designers in team, they were trying to keep user experience to be the best as well and that is kind of a balance.

**P:** What is the role of the Industrial designer in this process?

A: Industrial design makes it clear how to do it (what the product is supposed to do?). It does not make sense if you only build the blender and do not know how to use it. So, part of the product development is design and that is how industrial design fits into the role. If the team does not have a person to make sure that the form is matching the function of what engineers build, the product does not make sense.
P: What challenges did you face working with an industrial designer?

A: In a project, we had to fit the components really small and it was one the big requirements that we want it to be not bulky. So, there was a lot of back and front because the designers were able to design forms that were really cool and had organic shapes, but it was really hard to pack them into the case. That was one of the biggest challenges to figure it out how to make that happens because they really invested in a form.

P: How do you define successful collaboration?

a. How have you done a productive collaboration with an industrial designer?

A: I think all parties need to be open-minded and be able to understand that in any collaboration, somebody has their own opinion and other people may challenge. So we need to know at what point we should accept their opinion because they may know more. Also, there are other aspects like give and take or teach and learn.

a: At Livewell, there were people who knew more about something like using Fusion to design a model, so that was great to learn from them. And then, I could bring more about electrical design and the physical quantity that we had to have and I could educate the designers. So, all parties need to be open-minded to learn and teach and to accept other opinions and that could be the best collaboration.
P: What can industrial designers do to integrate into a multidisciplinary team?

A: I think that earlier collaboration is better because sometimes, it happens that we design a lot of the parts in a non-form process like electrical stuff and the functions that we had built, and the prototype was a mess and really ugly and it was too late to start to put it in a form. If we would have started to decide on what we wanted it to look like in the very beginning, we would be able to make it better. The earlier you use industrial design, the more helpful it can be.

Interviewee: Dr. Mark Turner, Associate Professor, Aerospace Engineering Department, University of Cincinnati = M

Interviewer: Parvaneh Maleki = P

Date: February 10th, 2017

P: Why do you think industrial design is important in a product development process?

M: I think industrial design is important in a process of what that solution would be. First, you have a need and then you are going to think of having a solution, and industrial design helps with how product really would get utilized and how the users will interact with it to satisfy that need. I think industrial designers do that better than engineers. Engineers can figure out how to do it but I think most the
times Industrial designers try to figure out the human interface as well as ergonomics to make a better experiences and how to use it.

**P: How do you define Industrial design?**

M: I look at industrial designer as the person who is going to look at the solution from usability, aesthetics and then a practical sense of how the product will be used. And, in that sense, it is very broadly speaking, it is like not just a skill set, but a mine set on how that trained person is going to really interact with the design process to create a product that is more usable at the end.

**P: What is your definition of a process for successful product development?**

M: The first thing you need is to have a clear idea of what the need of the product is and once you can understand that, you can start to formulate the themes and expertise that needs to go to figure out what that product has to do and then assemble the groups and teams to figure out how to actually make it and solve it. But, until you have the core idea of what the product does, you are going to be in some type of requirement and are stocked.

**P: What challenges did you face working with an industrial designer?**

M: The biggest challenge for me as an engineer is more in terms of how to make it more than the end usability and aesthetics, and I think there was a disconnect in my thinking about things from that other point of view. But, also an industrial
designer not having enough aerodynamics background to see how the physics of
the airflow will interact with the design, was another challenge.

**P:** What can industrial designers do to integrate into a multidisciplinary
team?

**M:** The first critical thing is that whatever teams are coming together to create a
product, they should recognize what strength industrial designer can bring to the
table and I think that is very much lacking. So, most of the time, that
understanding of what the industrial designer brings to the table first has to be
known by people doing the product development and then figuring out where that
has to happen. The other thing is that in many situations, engineering and
industrial design should be at the equal level leading the project, which could be
really helpful. Also, I think some level of knowledge in manufacturing and
materials is required for industrial designers because at the end of the day, you
need to make the product and you need to make it cheap or at the expense that
people can afford to buy it. And, cost is built mostly through how it gets
manufactured. But, at the other side, there are lots of ways to make products. So,
understanding some aspects of manufacturing will make that better.

**P:** How do you define successful collaboration?

**M:** I think in a successful collaboration, everybody’s opinion gets listen to and
opinions get corporate based on the end product goal and not any individual
perception. So, the collaboration has to feel what every member of team felt. All
ideas won't get to the final product, but everybody should feel that they were contributing and that contribution was needed at the end of the day.