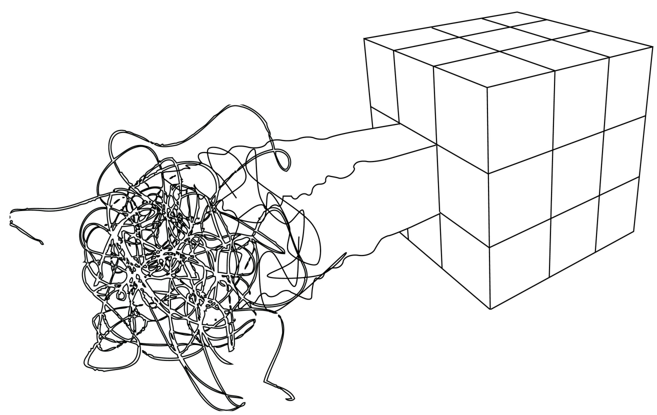
Annual PACE Forum 2007

Technische Universität Darmstadt

Darmstadt, Germany

July 23-28, 2007



High Performance Interdisciplinary Teamwork, A Continuum of Expertise

Revising Perceptions of Design and Engineering Roles in Collaborative Product Development

Brigid O'Kane

Associate Professor of Design
University of Cincinnati, College of Design, Architecture, Art, and Planning
Industrial Design Program, Transportation Track

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Abstract
Collaborative development processes are vital to the success of a product. This paper presents research based on experience with collaborative teams that demonstrates the inherent gaps in perception between engineers and designers by clarifying their importance and value in the product development process. Some perceptual gaps include, project vision, aesthetics and function, approach to problem solving, and decision-making. These gaps can cause conflict and difficulty when collaborating. New collaborative practices must overcome these gaps, with both engineers and designers seeking creative ways to become high-performing interdisciplinary team members. Through ongoing collaborative projects as case studies this paper offers insight and solutions to overcome these perceptions. Strategies developed in real world collaborative practice are presented to help integrate and evaluate teams for optimum results.

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Introduction and Overview

1.1 Purpose of Paper

In any product development process, team collaboration is a key to success. In present context, people's perception towards even the smallest product they use in their daily lives is changing. Today, product development demands more creativity from engineers and greater attention to technology from designers than ever before. To fulfill such demand, the development process requires balanced input from both disciplines that is in harmony with each other. But establishing this balance is not a straightforward task due to many fundamental gaps between engineers and designers. The purpose of this paper is to present research based on experience with collaborative teams that demonstrates the inherent gaps in perception between these two disciplines and to clarify the importance and value of both design and engineering within the product development process. This paper will also introduce strategies for overcoming these gaps in academic and industry environments. These strategies have developed over a period of time through collaborative experiences and research in professional and academic settings.

1.2 University of Cincinnati and College of DAAP

I have been an Associate Professor of Industrial Design at University of Cincinnati (UC) since 2001. Before that I was employed at General Motors for 10 years; a job that gave me numerous opportunities on a daily basis to observe, interact, and collaborate with teams of engineers and industrial designers. In addition, my father's experience at General Motors as an engineer for 38 years has given me unique insights into both the industrial design and engineering disciplines.

There are many collaborative opportunities at University of Cincinnati within different schools and colleges across the campus. The University is known for its capacity to partner with industry and assemble many different types of interdisciplinary teams. The College of Design, Architecture, Art, and Planning (DAAP) is unique because it houses four different schools within the same college. One of these schools, the School of Design, maintains a Transportation Track within the Industrial Design program. The College of Engineering and the Industrial Design program exist comfortably within different colleges and conduct ongoing collaborations throughout the academic year. As Partners for the Advancement of Engineering Education (PACE) collaborative projects continue to grow Professor Sam Anand from Mechanical Engineering and I are taking the lead on PACE activities at the University.

1.3 The Center for Global Design and Manufacturing

The Center for Global Design and Manufacturing (CGDM), fondly referred to as the PACEsPACE, was established in 2005 and serves as the primary PACE Center at the University of Cincinnati. Currently it functions as the focal point for collaborative projects among Industrial Design and Mechanical Engineering, with additional participation from other disciplines across campus. The present Center grew out of a long history of collaborative projects. One project, the Senior Transportation Design Collaborative Project sponsored by General Motors in the fall quarter of 2005, proved to be a catalyst for the Center's establishment. This project focused on small alternative fuel-sourced vehicles, and involved students from Industrial Design, Mechanical Engineering, Business, Fashion Design, as well as faculty members from each respective discipline.

Designers and Engineers – A Comparison

2.1 The Role of the Designer

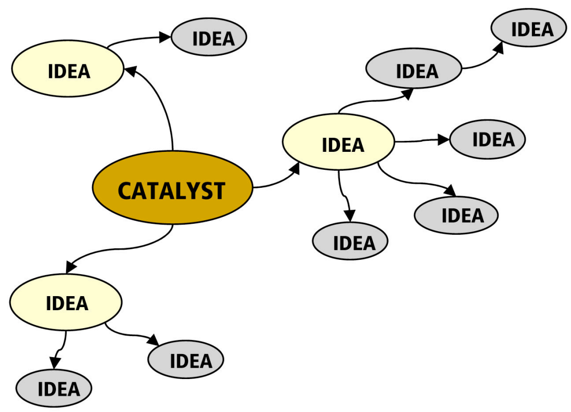

Figure 1: Divergent Thinking

The role of the designer is often described as being concerned mostly with styling and aesthetics. Industrial Designers often look at products from a non-traditional approach, and this methodology can contribute greatly to the product development process. *Overall vision* is one of the areas in which designers can contribute the most. That is, the visualization of the broadest picture for a product while suggesting "blue sky" or "outside the box" ideas. This broad creative viewpoint can influence the direction of a product and significantly affect its success or failure. Designers also supply a multitude of product concepts and innovations throughout the design process usually through different forms of *visual communication*, the fundamental means of which is drawings are used to visually communicate ideas. They usually practice *divergent thinking* (Figure 1), which is intuitive, emotional, and may generate many ideas in response to open-ended questions (Gardner 1999). Such thinking is directed by the elaboration of ideas that originate from an initial source of inspiration or a *catalyst*. Divergent thinking provides the designer with great authority over the decision-making process.

2.2 The Role of the Engineer

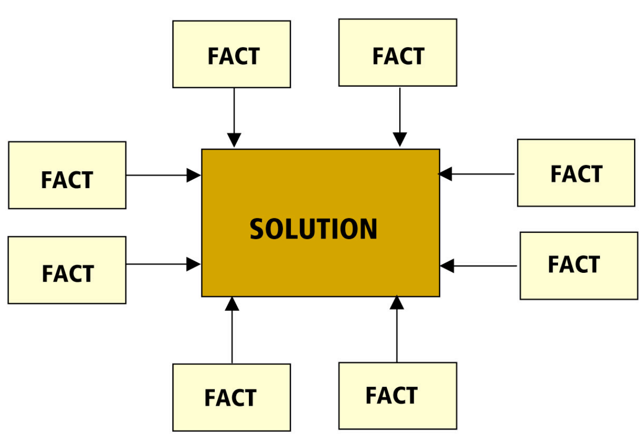

Figure 2: Convergent Thinking

In the product development process the engineer is primarily concerned with the function of the product. Engineers typically take the most direct path to a solution as they are problem-solving driven. Technological innovations are important to engineers and this influences creative direction and the final product. Engineers usually focus on performance, technology, structure, and manufacturing, and use a more technical language for communication. They practice *Convergent Thinking* (Figure 2), which is rational, orderly, empirical, and logical, greatly influencing their decision making process. *"Convergent Thinking involves the pursuit of a predetermined goal, usually in a linear progression and using a highly focused problem-solving technique."* (Stewart 2002, 5-6)

2.3 The Hairball and the Cube

The roles and thinking patterns of designers and engineers are well-understood within both disciplines. Whether in academia or industry, both have to work in collaborative teams throughout the product development process. However, due to their ways of thinking, there is continuous friction generated by differences between the two partners. Quite often this results in the kind of friction that actually contributes creative energy to the momentum of joint efforts. However, sometimes the friction is corrosive and causes *breakdowns* in the progress towards a final successful goal.

The *Hairball and the Cube* (Figure 3) is a graphic representation of the different approaches to design. It relates industrial designers with the *hairball* and engineers with the *cube* (Cherry 2006). Ultimately, a *bridge* between the two disciplines is needed to establish a shared space for understanding. This bridge acts as a common place for effective communication and constructive exchanges.

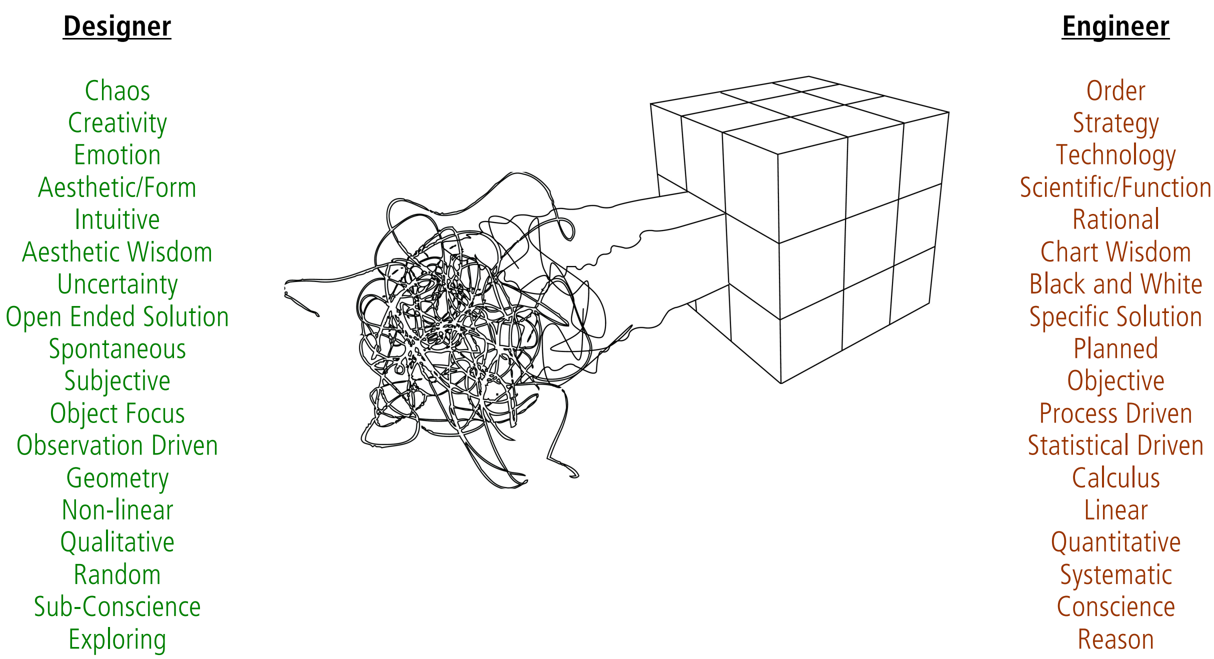

Figure 3: The Hairball and the Cube

Within collaborative teams different thinking patterns can be researched, observed, surveyed and documented. The differences between designers and engineers are listed in Figure 3. These differences are also the result of two different kinds of understanding developed by designers and engineers. Robert M. Pirsig, in his novel *Zen and the Art of Motorcycle Maintenance*, divides human understanding into two different kinds; *classical understanding,* which is more in line with rational thinking (the cube), and *romantic understanding*, which is more in line with emotional and inspirational thinking (the hairball).

When a common bridge of understanding is effectively in place the blend of these differences often brings a needed balance to collaborative projects. It is important for team members to not only recognize the need for balance, but also build relations through the acknowledgment and appreciation of the differences and values of these distinguishing patterns of thought and understanding within multidisciplinary teams. This recognition is not only important for balance but also for building strong team *unity*. In the product development process collaborative teams interact in many ways, both directly and indirectly. The bridge of understanding can provide clarity by establishing a common language, ground rules, team unity, and mutual respect for the design process regardless of how the teams are interacting with each other.

2.4 Perceptual Gaps

In previous sections we compared the basic role and inherent thinking process of designers and engineers. The fundamental differences between the two also evolve from their formative education as well as the perceptions they develop through their experience of the profession over a period of time. In other words, the culture perpetuates itself. When it comes to product development, engineers are trained to focus on cost and time, quantitative ergonomics, and manufacturing; whereas designers are taught to focus on aesthetics, visual order, qualitative ergonomics, and cultural trends. Such differences are called *perceptual gaps* (Figure 4*), "the differences in perspectives that team members have that stem from discipline specific thinking"* (Vogel and Cagan 2002, 144). Another reason for perceptual gaps is the inherent personality differences (perceptions of each other) between designers and engineers.

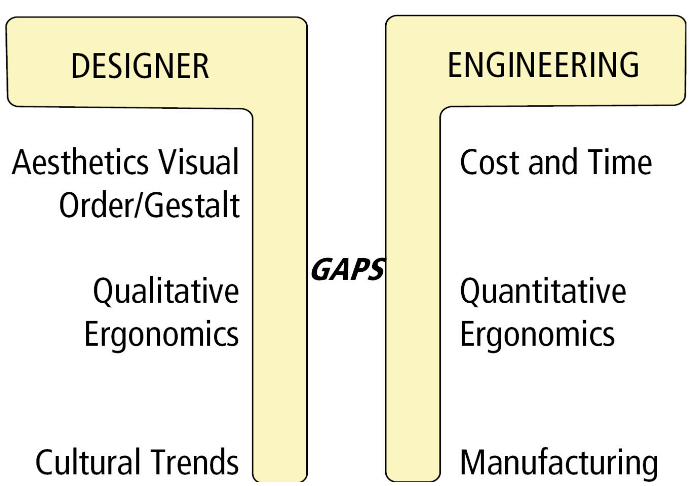

Figure 4: Perceptual Gaps among Designers and Engineers
Source: Vogel and Cagan 2002, 144

Understanding the difference is critical in effective collaboration.

There are two sides to such perceptual gaps. On one hand, the gaps could be very helpful in creating innovative products as designers and engineers both criticize the product from their own perspectives *(creative friction),* which removes all the anomalies related to design and technology. However, such product development requires high-performance collaboration between different disciplines. On the other hand, perceptual gaps can be disruptive if the differences become major conflicts, which negatively affect the overall quality of the product. Therefore understanding the differences (perceptual gaps) is critical in effective collaboration.

2.5 Perceptions of Each Other

In addition to perceptual gaps, the other source of serious trouble in the collaborative process is the mutual perception of engineers and designers (how each views the other). To an industrial designer the engineer often appears to be dull, awkward, or out of touch. To engineers, industrial designers have an appearance of being frivolous, irrational, erratic, pleasure-seeking, and shallow. Such perceptions do not allow teams to work in a unified, balanced, and harmonious way.

Surveys are conducted as part of the process of obtaining feedback from industrial designers and engineers collaborating within the studios and labs at the University of Cincinnati. This information can be used to inform continuous improvements in meetings, activities, and projects involving mixed teams. In one survey of 34 industrial designers and 34 engineers, were asked to list descriptive words that describe the other discipline. This survey was conducted prior to any collaborative experiences. Notably, the mutual impressions of the disciplines were overwhelmingly negative. Obviously, within a collaborative environment these notions are not constructive and have damaging influence on the product development process.

Descriptions From Designers

- They don't care about how the product looks as long as it works
- Math people
- Technical
- Orderly, boxy
- Unimaginative
- Simplistic and practical
- Function over form

Descriptions From Engineers

- Abstract
- Think outside the box
- Impractical
- Short sighted
- Eccentric
- Adds cost to a product for no reason
- Too good for their own good
- Hindrance to functional design

Can There Possibly be Similarities?

After discussing the many differences between engineers and designers, can we really think of any possibility of establishing common ground or similarities between two disciplines? In order to achieve high quality product development through high-performance collaboration we need to overcome all these differences. The first effort has to be made in training so designers and engineers are able to change or adapt to new ways of thinking. Such changes in the basic thinking pattern can dramatically reduce the negative effect of differences between the two disciplines, and help create a bridge for effective collaboration.

3.1 Dominance in Thinking Pattern is not an Absolute

In order to expand or change the existing thinking pattern of engineers and designers, we need to understand basic concepts of the function of the mind since the dualistic attitudes of these two disciplines is related to the common hemispherical function of the brain. There are two halves of the brain – left and right – each of which operates in a different mode. People use each side of their brain more or less actively based upon their training, pre-disposition, and preference. It is similar to being left-handed or right-handed, an engineer or a designer.

Research has demonstrated that each hemisphere of the brain is responsible for different manners of thinking. The left-brain works in a logical, sequential, rational, analytical, and objective manner. Engineers naturally use the left side of the brain and they dominate such left-brain thinking. In contrast, designers prefer right-brain thinking, which works in random, intuitive, holistic, synthesizing, and subjecting manner. Very few people are *"whole-brained"* or equally adept at using both sides of the brain. Such people practice both creative and logical thinking.

Figure 5: Left-Brain/Right-Brain
Source: *The Body Paradox #12* by Angela Katona-Batchelor
Boise State University

If the human brain is trained or expanded to think in such an ambidextrous manner, it is possible to obtain skills of both disciplines. The key is that our dominance is a preference, not an absolute. We use and have access to both sides of the brain. If engineers and designers make an effort to develop their thinking by engaging the lesser-used side of the brain then there may be a possibility of establishing common ground and similarities. An appropriate balance of using both sides of the brain and becoming "whole-brained" can significantly help in removing all the conflicts between two disciplines, which results into high-performance collaboration.

By following the characteristics of left-brained thinking, *function* of a product is the primary focus in decision making for engineers. The right-brained thinking helps designers to be creative in many different aspects of the *form* of a product. For best practices of high quality products, "form is function" (Figure 6). If engineers and designers practice "whole-brained" thinking, then they will be able to develop their sensitivity towards form and function mutually. Such an in-between approach helps in developing common perspectives, which generates healthy relations and understanding between two disciplines, and superior products.

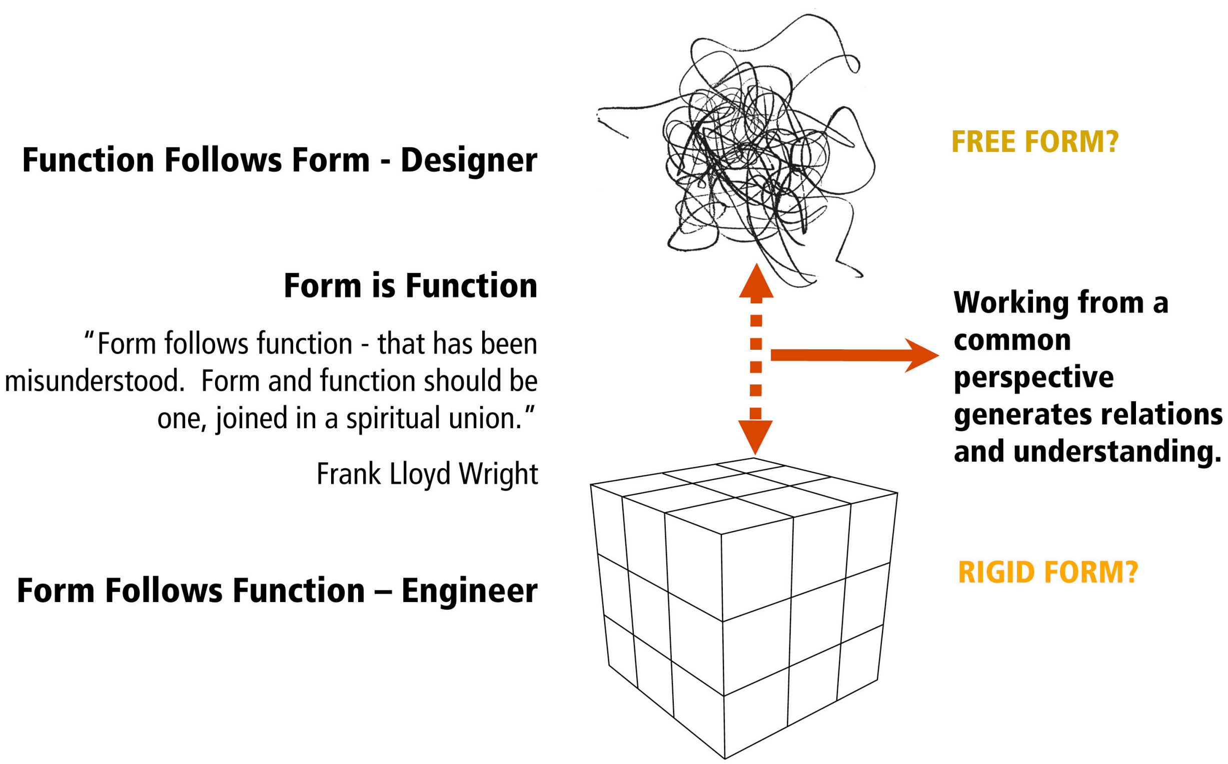

Figure 6: Possibilities of Common Perspective Between Designers and Engineers

3.2 Building Common Ground - The Logic of Intuition and Creative Engineering

Despite the existence of many differences between engineers and designers, there is still possibility to establish common ground. If we closely look at the concerns of both the disciplines in the product development process, we can find some similarities that are still priorities for both. For example, the words design and designer are common between industrial designers and engineers. There are some other common concerns listed in Figure 7.

Industrial designers are becoming increasingly aware of *function*. Designers were once called '*stylist*' but currently prefer to be called *'designer'*. A stylist is someone who consults on appearance, decoration, dress, or beauty. An industrial designer does not merely provide decorative surfaces, but creates overall plans relating to form, function, system, and structure. Similarly, engineers are increasingly exposed to the creativity of designers and they support such creativity by developing technology that helps in building innovative products. The engineer's role is not merely limited to the function of a product, but also to developing sensitivity to form, aesthetics, and creative engineering.

DESIGNERS and ENGINEERS

- The term design/designer
- Usability of product
- Form, function, and structure
- Common platform of safety and reliability issues
- The ergonomics / human factors
- Selection of material
- Manufacturing / disassembly
- Universal laws
- Emerging technologies

Understanding the common ground builds a platform of understanding, which is critical to effective collaboration.

Figure 7: Common Ground among Designers and Engineers

The Necessity for Collaboration

As generations have done before, we are addressing some challenging issues facing humanity. We are integral to the solutions that may resolve contemporary problems. Ironically, many of these problems have to do with perceptions. Overcoming perceptions for the sake of a successful collaboration offers many opportunities within the product development process to enhance and improve innovation by seeking solutions to problems from many different points of view and from different disciplines.

From my experience people generally want to work together in collaborative teams because they see potentials, or innovative opportunities, that they could not achieve by themselves. Individuals often choose the fields of industrial design or engineering because they are intentionally seeking out problems to solve in order to improve the quality of life for others. Collaborative team structures can better explore many more innovative solutions, which can push and enhance the product's potential, while also improving performance and driving excellence within the individual team members involved. Those who have such experiences learn early on the importance of productive team efforts within a safe setting which encourages exploration, giving individuals confidence to carry this practices into industry.

Technology makes a difference, but it is the human dimension that ultimately determines the nature and extent of that difference.

(Walton 2003)

Figure 8: Collaboration
Source: *Triad 02* by Sun Kyoung Kim
University of Illinois Urbana Champaign

A core reason for collaboration within academic settings is that industry is primarily motivated by profit where institutions of education are driven by knowledge, teaching and learning. Far from being this black and white, there is, nevertheless, a fundamental difference in these two approaches that will push the development process in different directions, incongruously making industry and academia perfect collaborative partners.

The issue of sustainable design is more important than it ever has been before. Professors, students, and professionals cannot solve many of these problems solely within their respective disciplines, so collaborative efforts are necessities for driving change and innovation relating to sustainable design and mobility in the broadest sense. The automotive and transportation industries are facing some of the most challenging problems within their history and are on the brink of colossal change as resources deplete and political pressure mounts. Regardless of what scientists conclude about the environment and global warming, *Eco-Design* or *Efficient-Design* just makes good sense and is currently part of the criteria for *design excellence*. Collaboration breeds exponentially more advanced insights into design solutions, and the opportunity to drive change and innovation greatly influencing future industries.

Collaboration creates a feedback loop that you don't get on your own. The more different ideas you have the healthier your intellectual culture is. Working in a team environment is more likely to lead to new and surprising innovations. (Franz 2007)

The Collaborative Process for Engineers and Designers

5.1 Finding Common Ground in the Collaborative Process

Creating favorable conditions for engineers and designers within all stages of the design process can be challenging since the process itself often goes through enormous transitions. These transitions bridge the spectrum of intuitive thought, abstract concepts, and chaotic visions, resolving into strategic order, solidified development, and ideas that have been rationalized and proven (Figure 9). Different phases favor different disciplines. However, a diverse range of ideas and contributions improves the final product and it is necessary for both disciplines to interact at appropriate times within *all* the different stages. Maintaining a continuum of expertise throughout establishes a unity of thought at all stages, generating momentum in addition to a strong vision to guide the team.

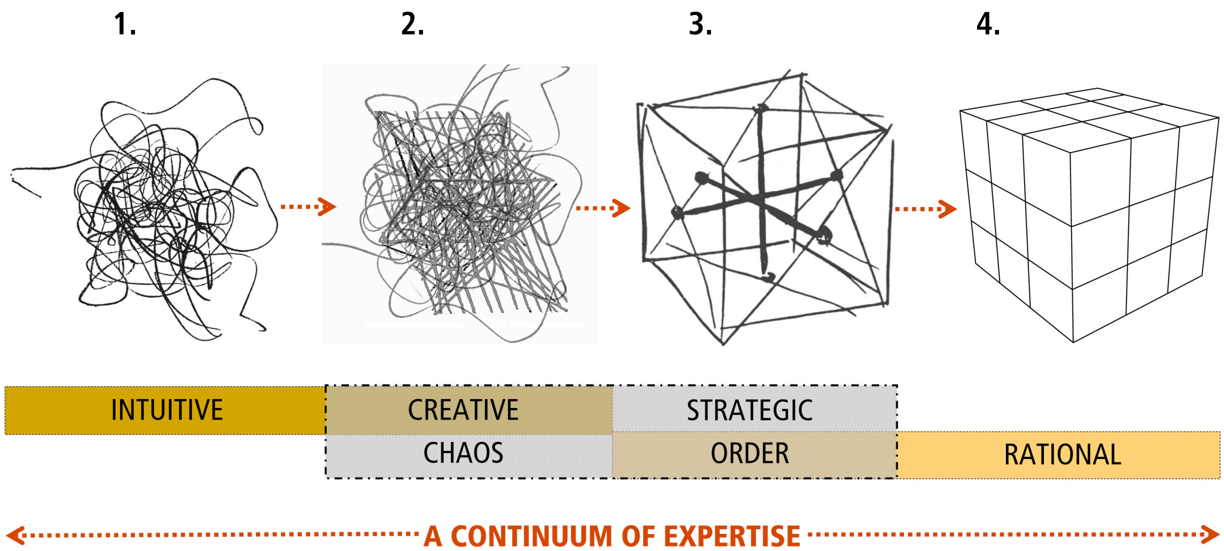

Figure 9: Transitional Stages of Collaborative Process for Engineers and Designers

<u>1) Hairball (Intuitive):</u> Getting the process started, which is often called the *fuzzy front end* or *Phase 0* is loosely structured with brainstorming and mind mapping to generate as many ideas as possible.

<u>2) Building Concepts and Visions (Creative and Chaotic):</u> At this time concepts and visions are formed that guide the product through the design process. This may consume a considerable amount of time, up to 30% - 50%, depending on the project deliverables. This kind of development is essential to achieving successful results and may be periodically revisited at appropriate times throughout process.

<u>3) Focused Design Process (Strategic and Orderly):</u> The design process continues through various stages and finally focuses on a single design proposal for the last phases, which include high levels of refinement and precision.

<u>4) Influence of Engineers (Rational):</u> Often within industry the designers develop a product to a point and then 'pass it over the wall' so engineers can finalize the details in this last stage leading up to the *start of production* (SOP). However, this critical part of the process can compromise the product if both sides do not interact and see the product through to the end.

5.2 The Organic Growth of Innovation

Innovation is a powerful contributor to the development of a successful product. Without innovation we are simply doing what has already been done - recreating what already exists. Striving to push the use of technology, such as a specific software, within the development process may result in a better method, but may overshadow one of the most important parts, product innovation. There are many ways that innovation can be infused into team activities. Establishing and cultivating a culture of creativity that thrives on innovation takes continuous effort. Ongoing conversations about advancements help to establish expectations guiding teams in a more progressive direction.

Innovation can originate from many different realms. The following charts describe three different realms: *the expert's realm, the designer's realm,* and *the engineer's realm,* where innovation can be purposefully nurtured. The reality of a healthy system is a process or structure most conducive to *the organic growth of innovation*. This section describes how these three different realms best work independently and collaboratively.

The Expert's Realm

The expert is a person who has a functional understanding of design *and* engineering, who often expresses a genuine interest in, and capacity for, both. The expert resides within both realms. They have the ability to see the value and importance within each discipline, and crosses over into each realm effortlessly (Figure 10). Creative Engineers and Visionaries are *hybrids*. All team members know the role of this person. These individuals provide vast amounts of insight to both the design and engineering aspects of the process. When these expectations are clear this crossover participation is greatly desirable.

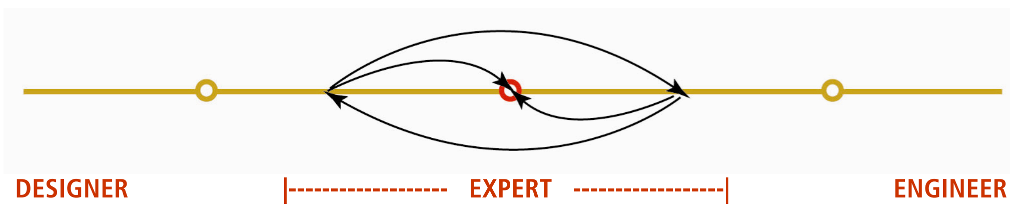

Figure 10: Expert's Realm

This arrangement may be beneficial in some situations, and conversely very risky, particularly in interdisciplinary situations. For industrial designers and engineers who are collaborating, it is essential that they stay focused within their respective disciplines. Designers who forget that they are designers can often get wrapped up in the more technical aspects of the engineering and ultimately sacrifice the advancement of the design. The same is true for engineers. When collaborative teams are loosely structured and left to evolve in a freeform fashion, there is a danger that team members will have too much freedom and literally forget what they should be focusing on. They can get so caught up in the collaborative experience that at some point it is difficult to bring them back to focus on their discipline specific tasks. In the end, innovation is lost and the product is compromised. Structured meeting times with discipline specific deliverables are needed throughout the collaborative process. This keeps individuals involved in team activities as well as engaged with their respective discipline. This structure acts as a backbone supporting the growth of innovation that will naturally evolve. With such structure in place, the expert's input can be uses to its fullest potential for the benefit of all.

I would not want to drive a car you engineered and you would not want to drive a car that I designed.

(Unknown Engineer to Designer Wayne Cherry)

The Designer's Realm

The designer who is diligently working within their realm can make great contributions while working in isolation. Designers need creative 'play' time within the design process to invigorate their passions for creative solutions and refill their repertoire of inspirational motivators. At times they need to be disengaged from aspects of engineering to explore the boundaries of their creative abilities (Figure 11). Creativity is difficult to harness and control. Through practice designers can learn to channel creativity, turning it on and off like a faucet. In addition, nurturing a focused approach takes advantage of the designer's ability to achieve highs of intuitive creativity, where they are 'in the flow' of creative energy. This enhances their contributions because they are genuinely inspired.

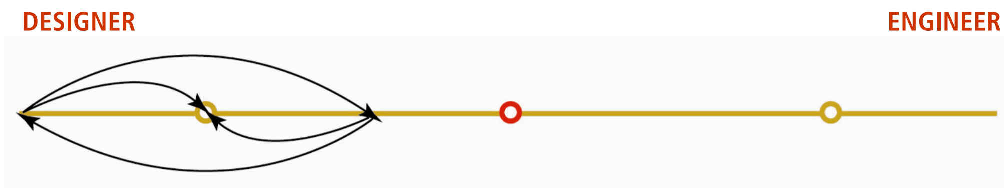

Figure 11: Designer's Realm

The Engineer's Realm

The engineer's realm parallels that of the designer. When working in extreme areas of focused engineering, individuals may invigorate passions and inspirations allowing them to achieve higher levels of productive energy (Figure 12). Knowledge gained when working in the engineering realm offers heightened experiences, which can be greatly beneficial for the overall development of a product. This energy can then be funneled back into the collaborative process when appropriate, enhancing the overall productivity of the collaborative team.

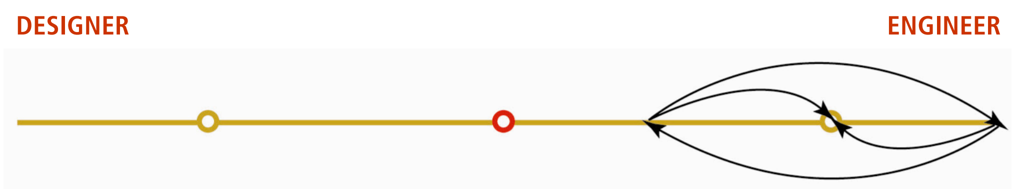

Figure 12: Engineer's Realm

The Organic Growth of Innovation

Intense focus that is discipline-specific allows team members to be saturated to a point where *breakthrough ideas* are more likely to occur. Breakthrough ideas within the design process are achieved when new ideas are applied to the product taking it to higher levels or different directions than had been previously thought possible. Therefore, individuals should be allowed time for intense focus on their respective tasks to advance innovation and product originality. However, if designers ignore engineering aspects there could be difficulties in bringing the product to production or to make the product function properly. In addition, engineers who work in complete isolation for the duration of the development process construct products that are functional but crude in execution and are less likely to be successful within the market place.

The reality of a healthy collaborative system embraces these three realms; the expert's realm, the designer's realm, and the engineer's realm, into one vibrant organism uniting all areas of expertise. This system naturally fosters *the organic growth of innovation* (Figure 13). One way to achieve this arrangement is to organize the design development process in such a way that allows appropriate opportunities for 1) *team specific activities*, and 2) *discipline specific activities.* Creativity should be encouraged for all team members when working collaboratively and individually. When team members anticipate and expect creative input from each other, regardless of discipline, the prospect for innovative thinking increases.

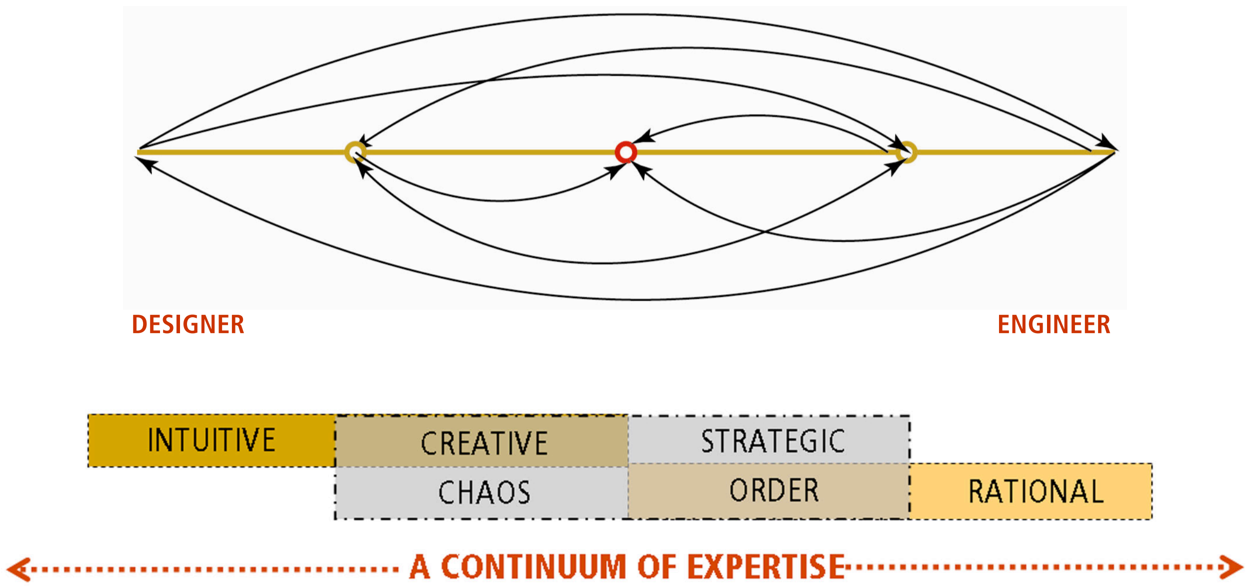

Figure 13: Organic Growth of Innovation

Design and Engineering Survey

6.1 The Purpose and Methodology of Survey

To better understand the relationship between industrial designers and engineers, a survey involving four products was conducted of 68 people in the two disciplines. The four products used were: a colander, a toilet brush, a ladle, and a napkin holder. Two different designs were selected for each of the four products based on material, functionality, and aesthetics. The general functions of the two designs were basically the same. These products are illustrated in the Figure 14. The cost of the product was not considered a critical factor in the survey because each product pair was about the same in price. In the survey, each participant was asked, *"From your perspective choose the best design of the four products?"* and *"Briefly describe why this is the best design."* Participating in this survey were 34 industrial designers and 34 engineers who were undergraduate and postgraduate students, and professionals within the two fields.

6.2 Survey Results

Colander: There were two different designs of the colander chosen for the survey with their own unique characteristics. The first one is made of stainless steel and the second one is molded plastic. Surprisingly, an equal number of engineers and designers selected the respective colanders. 47% of the engineers and designers chose the stainless steel colander and 53% of the engineers and designers chose the plastic colander. From this result, it can be inferred that engineers and designers have similar opinions about the design of both types of colanders. The survey also showed that for both groups material was the major factor for choosing a design. The plastic colander was considered to be a good design according to both engineers and industrial designers because they thought it would work better in very hot cooking environments.

Ladle: As part of the study, two types of ladles were considered. The plastic ladle was considered to be a better design choice among engineers with 20 votes (59%) and designers with 18 votes (53%). The results for the stainless steel ladle were very close. The plastic ladle was chosen mainly for the material, since plastic performs better than steel when used in a very hot cooking vessel (it conducts less heat).

Toilet Brush: One design was an open toilet brush and the other was a covered toilet brush. Material and function of both the products are the same, however the designs were quite different. The survey results for this product were expected to reveal the different aesthetic and design perceptions of engineers and designers. The results concluded that 59% of the engineers and 94% of the designers chose the closed toilet brush. 41% of the engineers preferred the simplicity in function of the open brush as did only 6% of the designers. Engineers also indicated in their comments that they had no concern for the design or aesthetics of the product. Among the designers, the closed toilet brush was most popular specifically because of its design. This product comparison is a good example for demonstrating clear differences between designers and engineers as listed and illustrated in Figures 3 and 4.

Napkin Holder: Similar to the toilet brush, two very different designs of napkin holders made of metal were selected for the survey. The basic function of both designs is the same in that they hold napkins, but the variations in the designs noticeably change the way the products function. The first napkin holder positions the napkins vertically and the second one horizontally. In spite of any similarities in material, the aesthetic quality of both designs varies drastically. The results from the survey concluded that the vertical napkin holder was preferred by 53% of the engineers and the horizontal model was preferred by 62% of the designers.

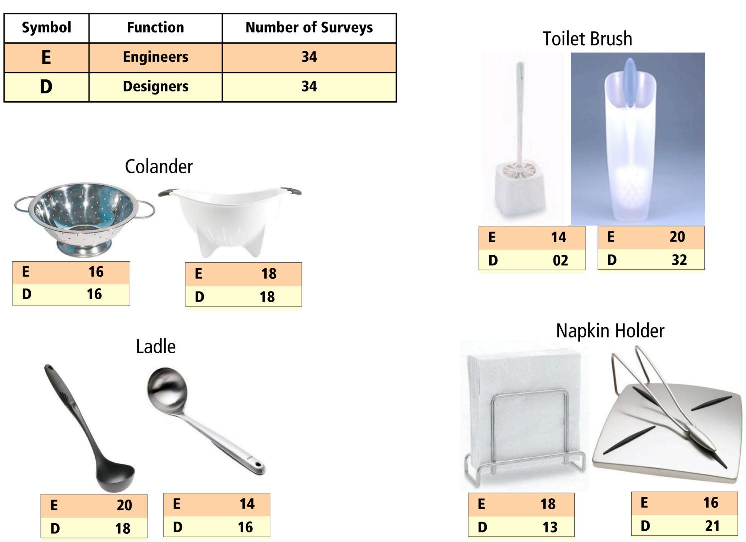

Figure 14: Survey Results

6.3 Inferences from Survey Results

When considerations of material were the main concern, designers and engineers scored similarly. This demonstrates that there is common ground or collective concern between the two disciples regarding decisions about material. Both disciples were clearly concerned with this issue for mostly functional reasons. In addition to function, designers made choices based on the perceived value of the material and current trends, however, function remained the primary concern. This part of the survey clearly demonstrates a common ground between the two disciplines because it proves they share similar interests in material.

When considerations of design were the main concern there were dramatic differences in the way designers and engineers voted. Out of the four products, the napkin holders and toilet brushes had the greatest variation in design, so they are good examples for showing perceptual gaps and differences in thinking between engineers and designers. The results differed significantly for both the napkin holder and toilet brush for both groups, demonstrating the divergence between the two disciplines in terms of design and aesthetic sense of products. This part of the product survey proves that there is a major difference of opinion regarding the aesthetic quality and "design" of products, highlighting the need for collaboration.

High Performing Interdisciplinary Teamwork

The greatest challenge in collaborative practice is overcoming the many differences between disciplines. Differences are the single most destructive factor within the product development process. Previously we discussed how industrial designers and engineers have different functions, views of a product, and ways of thinking. Perceptual gaps and perceptions of each other can disproportionately magnify these differences. The *'hairball and the cube'* metaphor (Figure 3) demonstrates ways of thinking and the differences in thinking patterns. Engineers have bias towards the rational. Their strategy may be tedious while following rules and instructions. Designers can be vague and eccentric. They prefer to be creative in all aspects of the design process and follow their intuition while looking for multiple solutions. In addition, technology is often either engineering biased or design biased, and information can be lost when reformatting files or working with incompatible software. These differences between design and engineering cause *breakdowns* in communication and can cause enormous damage and disruption within the product development process.

Good communication between the two disciplines is a key. This communication should be grounded through a solid understanding of the other side. It takes considerable energy within any partnership to allow for the necessary time to listen to and understand the other person. Comprehending the differences between industrial designers and engineers to eliminate misconception of the other players on the team also aids in effective communication. When good relations exist in addition to a common bridge for communication teams become powerful producers of high quality work. The following section outlines more suggestions about how to create high-performing interdisciplinary teams (Quick 1992).

7.1 Creating High-Performing Interdisciplinary Team

- Build trust
- Maintain balance
- Create an understanding of different disciplines
- Build common consensus
- Build common language for communication
- Overcome misconceptions
- Conduct structured workshops

- Provide informal luncheons or seminars for open discussions
- Schedule structured team meetings
- Establish clear deliverables and responsibilities
- Challenge and/or test ideas to made them stronger
- Create 'Games' around team participation in order to get responses from all the team players

7.2 Avoid Conflict by Establishing the Ground Rules Up Front

- Give credit when credit is due
- Capture relevant information during team meetings and revisit it
- Involve ALL team members for critical decisions and votes
- Remember the team is only as strong as your weakest player
- Avoid side conversations or cliques
- Everyone on the team must participate - On the court not in the stands
- Keep comments positive
- Maintain the philosophy of non-isolation - ownership of ideas belongs to the group

7.3 Resolving Conflicts Within the Team

- Focus on the issues of the conflict
- Conflicts with personalities are best resolved with a facilitator
- Don't play the blame game
- Teams grow stronger when conflicts are resolved
- All conversations are a contested space
- Be sure what is being said is being understood
- Be engaged not just an observer

7.4 Create a Nurturing Environment

- Ensure a supportive Professor/Administration with proper space and equipment
- Create an atmosphere where individuals are willing to take risks
- Allow individuals the opportunity to fail in order to succeed
- Passion + Adrenaline + Momentum = Creative Energy (team fuel)
- Inspire moments of awe and a sense of wonder, and celebrate them

7.5 Generating Team Ownership

- Encourage students to design logos to identify different teams, creating brand identity
- Let students choose the creative and inspiring team name
- Avoid naming teams in a hierarchical way such as numbers or alphabetically
- Encourage constructive comments and responses during critiques

7.6 Mind Flexing

- Being able to identify with others
- Improves communication
- Motivates team members

- Maximizes team productivity
- Develops rapport and respect for diversity
- Promotes learning

7.7 Choosing the Team Leader

When it comes time to choose a leader of a collaborative project, it is usually best to give participants the opportunity to put themselves into that leadership role if they choose instead of the instructor/supervisor appointing a leader. The choice to be the team leader should be based on the participant's appetite to take on such a challenge in addition to them possessing the appropriate leadership skills and knowledge. The selection should be made independent of the discipline. In other words, leaders can be either designers or engineers and he/she should maintain balance in the collaborative process. There must be clear understanding between all the participants to maintain consensus within the group.

New Model for Collaborative Practice

In the leadership of collaborative teams it is very important to be flexible, giving the team the opportunity to change and adapt to unexpected outcomes and situations. These unpredictable happenings are more likely to occur when individuals have different ways of thinking and operating. Throughout the process, wisdom is needed to preserve what works and to eliminate or change what does not work, offering continuous improvements to the product development process. This practice is called *experimental learning and active leading* (Figure 15).

When working with teams that have many differences it is critical to incorporate creative activities of exploration that would appeal to designers, and activities that have a more rational approach to applied knowledge, which engineers will better relate to. This mixture gives way to advancing the body of knowledge learned within the different disciplines. In addition, respect for the other discipline is critical, and understanding the overlaps and similarities gives team members the common ground they need to succeed. Searching for the common factors of different disciplines may be an ongoing process throughout the entire collaborative process.

Figure 15: Experimental Learning and Active Leading

8.1 Workshops at the University of Cincinnati

One of the most successful exercises for finding common ground between students of industrial design and engineering is to conduct workshops that include; 1) structured team meetings, 2) design workshops for engineering, and 3) engineering workshops for designers.

1) Structured team meetings involve all team members and bring individuals up to date on the product development process. It is inclusive since team members on any level can contribute to the general discussion. These meetings are also opportunities to discuss inherent differences and similarities between the two disciplines in an effort to find a common bridge or platform for communication (Figure 16 and 17).

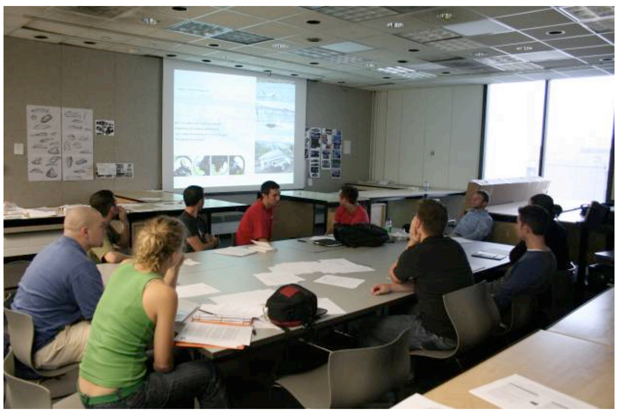

Figure 16 and 17: Structures team meetings with engineers and industrial designers.

2) Design workshops hosted by designers for engineers can also be arranged in different ways. An example of a successful workshop is when designers demonstrate the fundamentals of drawing and perspective and then give engineers the tools to aesthetically design through drawing. This workshop may use traditional methods (pencil and paper) in addition to more contemporary approaches such as digital sketching. Overall, these workshops have had tremendous success (Figure 18).

3) Engineering workshops hosted by engineers can be arranged in many ways as well. One possibility is to offer training sessions for designers in different engineering software giving insight into the engineering process. Designers who participate in these types of activities develop an understanding and appreciation for the engineering side of the collaborative process (Figure 19).

Figure 18: Design Workshop with engineers drawing on a Wacom Cintiq

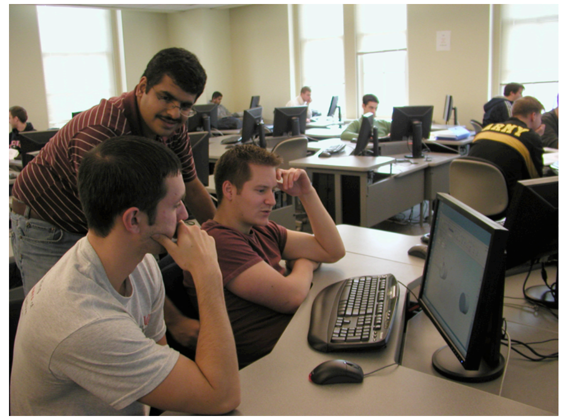

Figure 19: Engineering workshop with designers using engineering software

8.2 Perceptions After the Collaborative Experience

After collaborative activities documentation of the design process is collected and includes surveys. Ideally surveys are conducted at the beginning of the collaborative experience with those who plan to participate *(the experimental group)* and those who plan not to participate *(the control group).* Both groups are surveyed before and after the collaborative to document changes that occur when students do and do not participate. With this information, one can effectively deduce conclusive results. When individuals are surveyed after participating in workshops and exercises relating to similarities and differences, surprising and delightful transitions are documented. After having participated in the collaborative experience their perceptions of each other greatly changed (see table below). These changes in perception allow for excellent team relations and collaborative practice.

Descriptions *from* Designers

- Necessary
- Helpful
- Finding new / innovative mechanisms
- Good sense / respect for design
- Enthusiastic and valuable contributors

Descriptions *from* Engineers

- Creative, skilled, and enthusiastic
- Dedicated, high energy
- Good presentation skills
- Good at brainstorming / finding alternatives
- Adaptive and positive attitude

The New Model - A Continuum of Expertise

The ideas and activities within this paper are suggestions for incorporating the new model into collaborative projects and activities. This new model creates an environment where all team members make valuable contributions to the product development process. Team leaders, as well as team members, are empowered to incorporate experimental learning and active leading through creative and applied knowledge-based activities. Workshops for engineers and designers are activities that focus on each discipline at specific times, building solid relationships between team members, adding immeasurable results and improvements to the product and the development process. The inclusion of these activities speaks directly to *the new model of collaborative practices* (Figure 20). This new model improves interactions between different disciplines while keeping a balance of activities and input from all team members. It mixes the emphasis of all disciplines involved, allowing team members to crossover to other areas outside of their expertise while remaining powerful contributors within their respective discipline.

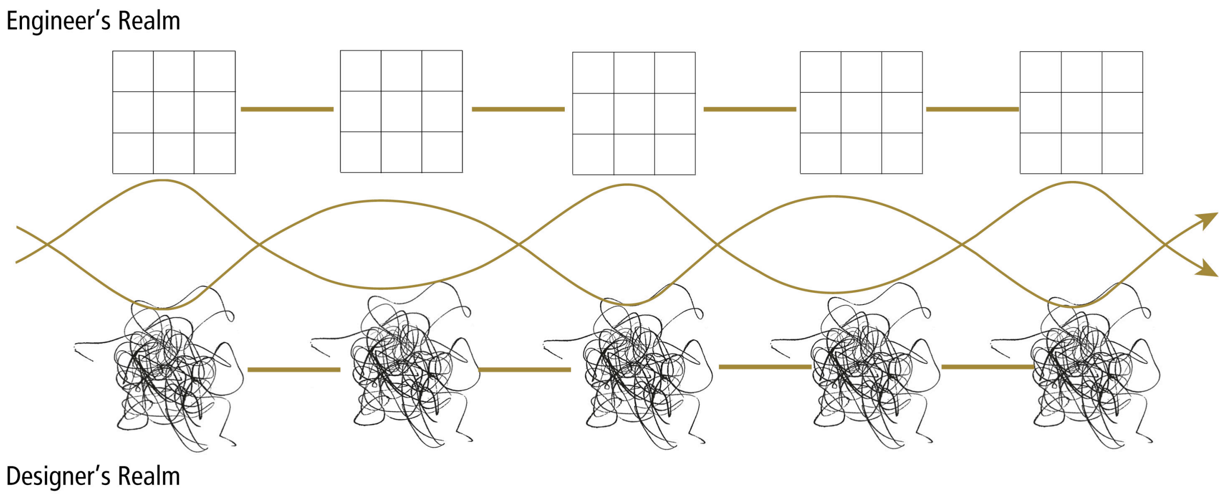

Figure 20: The New Model for Collaborative Practice

A continuum of expertise generates powerful interdisciplinary teams and drives excellence in innovation.

Collaborative practices are not new. Often teams may say they are collaborating, but upon closer examination this practice can be observed to operate on many different levels. Passing the product to the other discipline or *throwing it over the wall* is not as productive a process as true collaboration. We can no longer effectively function in our silos where disciplines operate in isolation. Fully involving teams and individuals appropriately throughout the entire product development process is more conducive to high-performing interdisciplinary teams. It challenges teams to operate on the highest-level possible, not only for quality products but also for quality team experiences. When teams step up to this challenge and strive for excellence in team relations, quality, and innovation within the product and process are more likely to result. Team pride manifests authenticity and integrity, which are both powerful conduits for generating innovation.

Moving Forward / Conclusion

When I write about collaboration I am writing about a much broader and deeper concept than the contents within this paper. One of the reasons I find this topic so interesting is because of the limitless potential team efforts can produce. Collaborating teams are powerful forces of innovation and creativity, and are capable of responding to issues of all kinds and sizes. When working in teams, memories of past experiences and team leaders are with us as the process evolves. The act of constructive collaboration is passed down from generation to generation, and instilling a positive collaborative experience in others makes them more capable of successful collaborative practices in their professional careers, thus having a more powerful positive impact on humanity as a result.

Collaborative teamwork is not just about making a profit, the product itself, or the design development process; it is also about the people on the team and the extended team, in addition to the people who will ultimately benefit from the product. When the human element is genuinely considered within the product development process, broader issues of how and why a product should be developed become more potent issues for progressive product production. This approach is more likely to produce better and more successful products, and in doing this financial rewards are likely to follow. When industrial designers and engineers unite in energetic collaborative efforts the potential for contribution on a magnified scale is amazing.

It is through communication that our relationships are forged, and it is within the context of relationships that the conversations of our lives - both mundane and profound - are played out.

(Miller 2005, 166**)**

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