# Them and Us?:

## Exploring the Collaboration between Industrial Designers and Engineering Designers

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### Introduction

In the global marketplace, it is essential that well-designed products are produced within the shortest possible lead times. Manufacturers must therefore endeavor to utilize best practice for the efficient control and management of new product development [1, 2]. To enhance competitive advantage, industrial design has been increasingly used as a strategic resource [3] in conjunction with collaboration with engineering design.

This study discusses the findings of empirical investigations undertaken in 2006 that recorded the nature of interaction between industrial designers and engineering designers in Singapore. The research posed the following questions:

i) How and when do industrial designers and engineering designers work together?
ii) What leads to successful or poor collaboration?
iii) What factors influence collaboration and can they be categorized?
iv) Do representation tools affect collaboration?
v) What are the characteristics for a successful tool for effective collaboration between industrial designers and engineering designers.

### Related Work

Existing research in the field of new product development mainly focuses on the integration between engineering design and manufacture [4, 5]; interfaces between engineering design and marketing [6, 7]; engineering design and architecture [8], and the relationships within cross functional teams [6, 9, 10]. Persson and Warell [12] identified working methods and processes adopted by industrial designers and engineering designers and Persson [11] proposed a collaborative workspace through joint mindset, socialization, workspace arrangement, and social organization.

From the available literature, the authors have identified that methods to enhance collaboration have been limited and are centered on communication or social interfaces with no established framework to achieve a collaborative work environment for the two disciplines.

### Collaboration between Industrial Design and Engineering Design

Whilst industrial designers and engineering designers both contribute to new product development, industrial designers have a bias towards appearance and user-interface; whereas engineering designers focus on functionality and manufacture [13]. In particular, engineering design refers to technical activities that apply scientific knowledge, ensuring that the product satisfies the design specification and manufacturing requirements [14].

### Working Approaches of Industrial Designers and Engineering Designers

Industrial designers generally employ sketches (Figure 1), rendered visuals (Figure 2) or physical models as representations [15, 16]. Drawings enhance discussions and improve spatial and perceptual assessment [17].

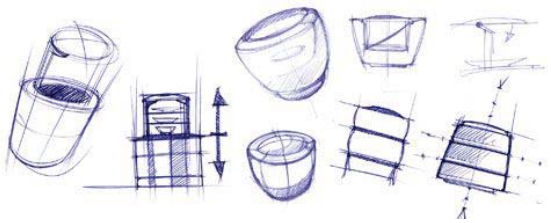

*Figure 1*. Sketch [18].

*Figure 2*. Rendered visual [18].

Engineering designers apply scientific knowledge to ensure that products optimally meet design specifications with representations in the form of engineering drawings (Figure 3) that show requirements based on quality, performance and cost [19, 20]. In summary, Purcell and Gero [21] highlighted that both disciplines adopt different approaches, with engineering designers using known solutions and industrial designers striving to find creative solutions.

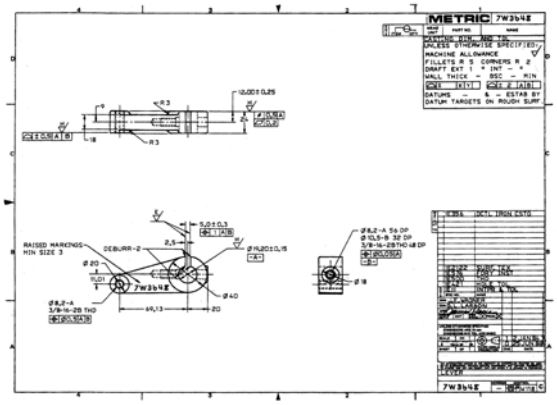


*Figure 3*. Engineering drawing [22].

**Collaborative Design**

Collaboration can be defined as working jointly together [23]. Kahn and Mentzer [24] state that this occurs when individuals with different, but complementary skills work together to seek collective goals, mutual understanding and share resources with a common vision. Jassawalla and Sashittal [10] added that collaboration includes “at-stakeness,” where members have equal project interest; “transparency”, by having awareness through deeper communication; and “mindfulness” through understanding; and “synergy” where the outcomes are achieved beyond those that individual members contribute towards the process.

Besides implementing good communication, conflict resolution mechanisms and integration tools, Persson and Warell [11, 12] propose social and cultural solutions that enhance collaborative interaction. Computer Supported Cooperative Work (CSCW) technologies allow instant communication [25] that include shared screens and videoconferencing [26]. Although they provide enhanced communication, they do not support cooperative work between groups.

**Factors Affecting Collaboration in New Product Development**

Erhorn and Stark [27] have claimed that because each department uses its own vocabulary for its activities, it has difficulty communicating and understanding other departments. Differences in the use of tools and methods have made collaboration between groups difficult [28]. In addition, members have a different focus, experience and cultural backgrounds that can lead to limited understanding. Engineering professionals use scientific methods to solve technical problems [3], while industrial designers focus on social and cultural values of the product, making it difficult for engineering designers to perceive solutions accurately [29]. Other factors affecting collaboration include preconceived notions, lack of trust, personality/cultural differences, and physical barriers [6].

**Research Procedure**
An empirical study employed interviews and observations with industrial design consultancies specializing in electronic products. This was conducted in Singapore over a ten week period. The interviews were undertaken with 4 large (> 10 design staff); 8 medium (6–10 design staff); and 5 small design teams (< 5 design staff) (Figure 4). The subjects comprised 31 professional industrial designers and engineering designers with varying levels of experience.

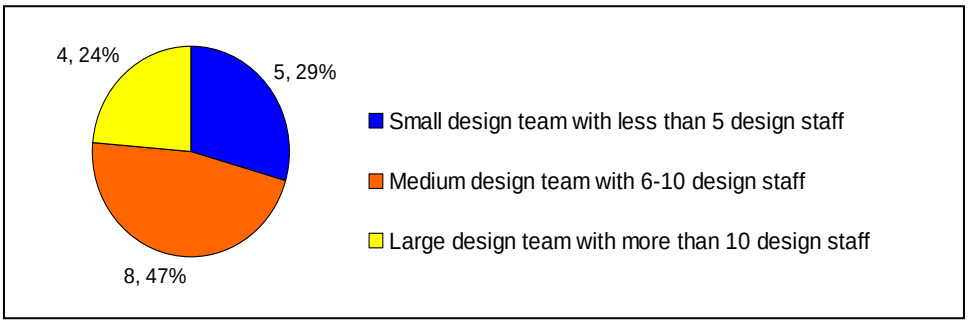


*Figure 4*. Distribution of consultancy size.

Reliability was achieved by conducting investigations in the natural work environment. Interruptions were avoided during work and clarifications made during breaks. To achieve a wide span of responses, a mix of large, medium, and small industrial design companies with equal management and nonmanagement positions were interviewed.

An observation study was also conducted within an industrial design consultancy to provide in-depth information within a controlled work environment and to obtain an immersive experience of how design development was undertaken.

**Interview Study**
The interviews provided a greater understanding of the nature of professional collaboration. This was achieved by employing background questions followed by open-ended questions to explore personal experience. Data collection was carried out by note taking and the results confirmed with the interviewees.

Interviews were undertaken with 9 industrial designers; 4 engineering designers; 2 cross-disciplined respondents; and 16 managers.

**Interview Results**
The interviews identified 61 issues (Figure 5) that were condensed into a matrix (Figure 6) using coding and clustering techniques on the basis of recurrence and importance [30].

| | |
|---|---|
| Limitations to technology | Having knowledge of the other field |
| Creativity and flexibility of individual | Conflict in principles |
| Budget issues | Choosing the right tools and methods |
| Language barriers | Communication skills |
| Knowing who is in charge | Different representation methods |
| Roles & responsibilities | Understanding each other |
| Being specific | Fixed mindset |
| Losing focus | Individual differences & attitudes |
| Using standard codes | Direction of project manager/team leader |
| Having multicultural teams | Use of rapid prototype |
| Having multidisciplinary teams | Difference in personal values |
| Fostering team spirit | Having a common goal |
| Complexity of project | Updates/milestones |
| Marketing department and arising issues | Informal meetings |
| Understand constrains | Understanding through experience |
| Testing, reviewing, changing, refining | Translation from 2D to 3D |
| Reaction time | Company emphasis |
| Engineering issues affecting design aesthetics | Educational background |
| Client changes affecting design development | Western & Asian approach of working |
| Understanding viewpoints and perspectives | Conflict in interest |
| Cost affecting design aesthetics | Fixed working protocols |
| Difficulty in explaining visual effects | Location of support members |
| Company & organization values | Trust as a high-level understanding |
| Software incompetence | Technical requirements & issues |
| Justification to decisions | Working towards joint solutions |
| Technology for enhanced communication | Production & manufacturing limitations |
| Changes in design due to safety requirements | Company culture |
| Client involvement | Understanding roles of the other party |
| Education to bridge knowledge gaps | Teamworking & team dynamics |
| Difference between a designer and an artist | Standardized computer file format |
| | Time constrains |

*Figure 5*. List of 61 issues identified during interviews.

The matrix in Figure 6 further consolidates the 3 most occurring issues into three categories (A, B, C) that can be seen in the right hand column. Each category is now discussed:

Category A: Conflict in values / principles and aims
The interview results identified differences in values and working principles. For instance, the engineering designers tend to work in a logical way with measurable solutions based on efficiency or cost-saving. In contrast, industrial designers favored an open-ended approach.

Category B: Different representation methods and tools
The investigations noted the impact on the different methods of representations used by industrial designers and engineering designers. It was recognized that while engineering designers used technical jargon including calculations and precise technical specifications, the industrial designers preferred informal freehand sketching to communicate ideas.

Category C: Educational differences
From the interviews, it was identified that although most industrial designers were taught basic engineering knowledge, they were unable to communicate effectively with engineering designers in terms of detailed technical information. Similarly, engineering designers who were trained in interpreting technical drawings had difficulty in understanding the informal freehand sketches from industrial designers.

| | Issues | Company | | | | | | | | | | | | | | | | Occurances | Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | |
| 1 | Having knowledge of the other field | | | | | ■ | ■ | ■ | ■ | ■ | | ■ | | | ■ | | ■ | | 8 | A |
| 2 | Conflict in Principles | ■ | | ■ | | | | ■ | ■ | | ■ | | ■ | | | | | | 6 | A |
| 3 | Choosing the right tools and methods | ■ | ■ | | | ■ | ■ | ■ | | | | | | ■ | | | | | 6 | B |
| 4 | Communication Skills | ■ | | | | | ■ | | | ■ | | | | ■ | ■ | | | ■ | 6 | B |
| 5 | Use of Representation | | | | ■ | ■ | ■ | | | ■ | | ■ | | | ■ | | | | 6 | B |
| 6 | Understanding each other | | | ■ | ■ | | | | | | | ■ | | | ■ | | ■ | | 5 | A |
| 7 | Fixed Engineering Mindset | ■ | | | | | ■ | | | ■ | ■ | ■ | | | | | | | 5 | C |
| 8 | Individual Differences & Attitude | | | ■ | | | ■ | | | | | ■ | | | ■ | ■ | | | 5 | C |
| 9 | Direction of Project Manager | | | | | | | ■ | | | | | ■ | | ■ | ■ | ■ | | 5 | A |
| 10 | Use of Rapid Prototype for Representation | | ■ | | ■ | | ■ | | | | | ■ | | | | | | | 4 | B |
| 11 | Designers and Engineers having Different Values | | ■ | | | | ■ | | | | ■ | | ■ | | | | | | 4 | C |
| 12 | Having a Common Goal | | | ■ | | | ■ | | | | | | | | ■ | | | | 3 | A |
| 13 | Get-together updates / Milestones | | | | | | ■ | | ■ | | | | | | ■ | | | | 3 | B |
| 14 | Informal Meetings | ■ | | | | | ■ | | | | | | | | ■ | | | | 3 | A |
| 15 | Understanding through Experience | | | | ■ | | | ■ | | | | | | | ■ | | | | 3 | C |
| 16 | Translation from 2D to 3D | | | | | | ■ | | | | | ■ | | | | | | ■ | 3 | B |
| 17 | Company Emphasis on Design or Engineering | | | | | ■ | | | | | | | ■ | | | | | ■ | 3 | A |
| 18 | Educational Background of Individual | | ■ | | | | | ■ | | | ■ | | | | | | | | 3 | C |
| 19 | Western vs Asian approach of working | | ■ | | | | | | | | ■ | | | | | ■ | | | 3 | C |
| 20 | Conflict in Interest | ■ | | | | | | ■ | | | | | | | | | | | 2 | - |
| 21 | Fixed Working Protocols | | | | | | ■ | ■ | | | | | | | | | | | 2 | - |
| 22 | Location of support members | | | | | | ■ | | | | | | | | ■ | | | | 2 | - |
| 23 | Trust as a high-level understanding | | | | | | | | | | | | | | ■ | ■ | | | 2 | - |
| 24 | Knowing the technical requirements | | | | | | ■ | | | | | ■ | | | | | | | 2 | - |
| 25 | Working towards Joint-Solutions | | | | | | | | | ■ | | | | | ■ | | | | 2 | - |
| 26 | Production & Manufacturing Limitations | | | | | | | ■ | | | | ■ | | | | | | | 2 | - |
| 27 | Company Culture | ■ | | | | | | | | | | | | | | ■ | | | 2 | - |
| 28 | Engineers do not Understand Role of Designers | ■ | | | | | | | | | | | | ■ | | | | | 2 | - |
| 29 | Teamworking & Team Dynamics | ■ | | | | | | ■ | | | | | | | | | | | 2 | - |
| 30 | Having standard Computer files | | | ■ | | | ■ | | | | | | | | | | | | 2 | - |
| 31 | Limitations in Time leading to Poor Engineering | | | | | | ■ | | | | | | | | | | | ■ | 2 | - |
| 32 | Limitations to size of Electronic Components | | | | | | | | | | | | ■ | | | | ■ | | 2 | - |
| 33 | Creativity and Flexibility of Engineer | | | | | ■ | | | | ■ | | | | | | | | | 2 | - |
| 34 | Marketing controls Budget affecting Design Quality | | ■ | | | | | | | | | | | ■ | | | | | 2 | - |
| 35 | Language as a Probable Barrier | | | | ■ | | | | | ■ | | | | | | | | | 2 | - |
| 36 | Knowing who is in charge / Roles & Responsibilities | | | | | | | | | | ■ | | | ■ | | | | | 2 | - |
| 37 | Team Dynamics | | | | | | | ■ | | | | | | | | | | | 1 | - |
| 38 | Being specific | | | | ■ | | | | | | | | | | | | | | 1 | - |
| 39 | Designers getting carried away & fall behind time | | | | | | | | | | ■ | | | | | | | | 1 | - |
| 40 | Using standard codes | | | | ■ | | | | | | | | | | | | | | 1 | - |
| 41 | Having Multi-cultural Teams | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 42 | Having Multi-disciplinary Teams | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 43 | Fostering Team-spirit | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 44 | Complexity of Project | | | | | | | | | | | ■ | | | | | | | 1 | - |
| 45 | Marketing Understand Designers Working | | | | ■ | | | | | | | | | | | | | | 1 | - |
| 46 | Designers Understand Manufacturing Constrains | | | | | | | | | ■ | | | | | | | | | 1 | - |
| 47 | Testing, Reviewing, Changing, Refining | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 48 | Marketing should be faster to React | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 49 | Engineering Issues affecting Design Aesthetics | | | | | | | | | | | | | | ■ | | | | 1 | - |
| 50 | Client Changes affecting Design Process | | | | ■ | | | | | | | | | | | | | | 1 | - |
| 51 | Designers not understanding Marketing Viewpoint | ■ | | | | | | | | | | | | | | | | | 1 | - |
| 52 | Trimming Cost affecting Design Aesthetics | | | | | | ■ | | | | | | | | | | | | 1 | - |
| 53 | Difficulty in Explaining visual effects to Engineers | | | | | | | | | | | ■ | | | | | | | 1 | - |
| 54 | How Company & Organization Values each field | | | | | | | | | | | | | | | | | ■ | 1 | - |
| 55 | Software Incompetence | | | | | | | | | | | | | | | | | ■ | 1 | - |
| 56 | Proper justification for each decision to Understand | | | | | | | | | | | | | | | | ■ | | 1 | - |
| 57 | Using Technology for Enhanced Communication | | | | | | | | | | | | ■ | | | | | | 1 | - |
| 58 | Changes in Design due to Safety Requirements | | | | | ■ | | | | | | | | | | | | | 1 | - |
| 59 | Client Involvement in Design Stage | | | | | | | ■ | | | | | | | | | | | 1 | - |
| 60 | Education as a means to close gap btw Eng & Des | | | | | | | | | | ■ | | | | | | | | 1 | - |
| 61 | Difference between a Designer and Artist | | | ■ | | | | | | | | | | | | | | | 1 | - |

*Figure 6*. Matrix of issues tabulated from interviews.

**Observation Study**

A two-week observation study was undertaken during the design of an electronic communication device. The overall design process is summarized in Figure 7. The observations with the industrial design consultancy verified the interview results and provided a deeper insight to interaction between the industrial designers and engineering designers in their normal working environment, focusing on the project manager, the industrial designers and the engineering designer. Additional data was collected from sketches and project documents. The study took place from the start of the project to the client handover stage with 3D CAD renderings.

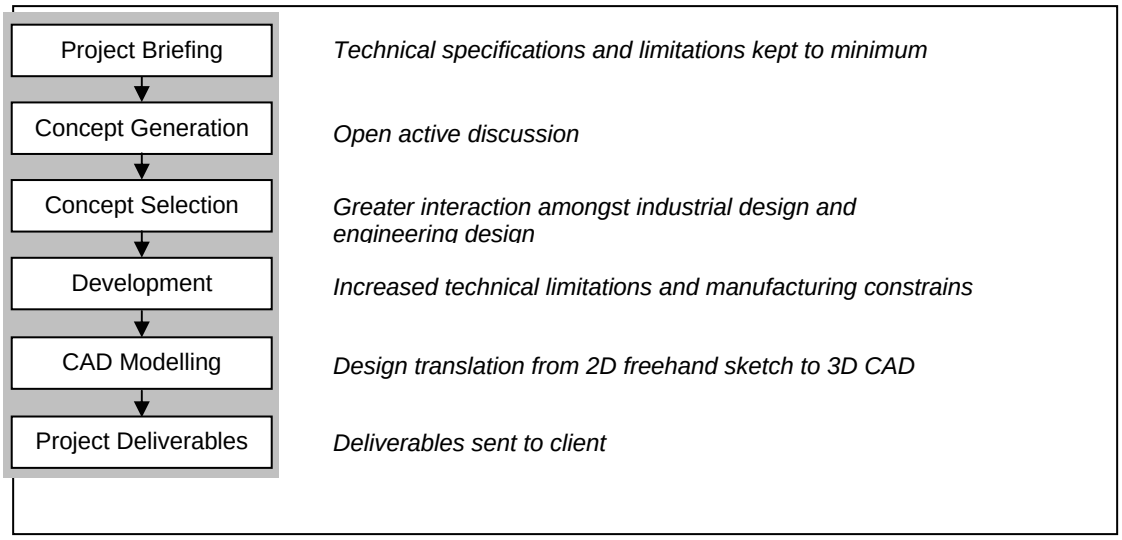


*Figure 7*. Overall design process and key observations.

**Observation Results**
In addition to the interview findings, the observations established that:

- Formal and informal meetings such as short discussions increased collaboration
- Co-located members in close proximity enhanced collaboration
- Open discussions clarified decisions that enhanced understanding
- The use of a single CAD package provided good control during information transfer
- Leadership from the project manager provided good control over the project

**Summary of Results**
From the literature review, collaboration is seen to be the main factor in achieving product success [10, 11,] and elements including communication, management support, and social and technical structures must be in place. The interview study identified three issues that had a detrimental impact on collaboration: A. conflicts in values/principles and aims; B. different tools / methods of representation; and C. education differences. In addition, observation results indicated additional activities necessary for successful product development such as informal meetings and co-location.

**Conclusion**
This paper reveals factors influencing the level of collaboration between industrial designers and engineering designers. Through empirical studies, problems in the work environment and a lack of a collaborative platform for both disciplines was identified. Answers to the research questions set at the outset of the study can be identified as follows:

i) How and when do industrial designers and engineering designers work together?
The study indicated that product development requires the contribution of both industrial designers and engineering designers throughout the development process and interaction took place in the form of information exchange, discussions, sharing and informal dialogues.

ii) What leads to successful or poor collaboration?
Successful collaboration was achieved through set goals led by a shared process with mutual understanding and a common vision. Achievement of set goals can be accomplished through the use of systematic tools, methods and procedures. Collaboration between the functional teams is supported by having good communication, co-located workspace, management support and strong leadership with social and technical elements in place.

iii) What factors influence collaboration and can they be categorized?

Successful collaboration is achieved through a set of supporting elements described in 5 ii). The interview study found 61 issues (Figure 4) that were consolidated into 3 key issues:

- (A) Conflict in values / principles and aims;
- (B) Differences in tools or methods of representation;
- (C) Educational differences.

iv) Do representation tools affect collaboration?
Common representation tools and techniques enhance communication and interaction, leading to improved collaboration. The study noted that engineering-based methods (such as technical drawings favored by engineering designers) and soft representation methods (such as sketches and models were favored by industrial designers). Despite the fact that both methods approach representation differently, it is in-line with researchers [31] who agree that representations play a central role in product development.

v) What are the characteristics for a successful tool for effective collaboration between industrial designers and engineering designers.
The authors have noted that existing approaches do not fully achieve enhanced collaboration between industrial designers and engineering designers. This study brings attention to the need for the development of an integration tool to provide support for a collaborative work environment in the product development process. Importantly, this tool should function with a common understanding between industrial designers and engineering designers and encourage open engagement.

**Future Work**
Future work will be directed towards developing an integration tool to provide support for a collaborative work environment within professional practice. A long-term observation study will allow opportunities to uncover issues and to provide testing and validation of the tool. It is anticipated that this framework will be useful in supporting the development of further collaboration tools and also for developing and expanding existing research.

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