

# THE DEVELOPMENT OF A DESIGN TOOL TO IMPROVE COLLABORATION BETWEEN INDUSTRIAL DESIGNERS AND ENGINEERING DESIGNERS

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## ABSTRACT

As two distinct professions working in the field of New Product Development (NPD), difficulties encountered during collaboration between industrial designers and engineering designers are widespread and well documented (Persson and Warell 2003, Cross 1985, Kim 2006). Having acknowledged the challenges faced during interaction between these two professions, the authors undertook a three year research programme to produce a tool that would remove or significantly reduce some of the problems encountered. Working with a PhD student, the methodology employed by the research team involved a literature review; identification of problems via practitioner interviews/observations; definition of a taxonomy of design representations (34 in total); development of a design tool; and final validation by interviews and design diary. The paper describes the development and nature of the design tool, called 'CoLab' which comprises a set of cards divided into three packs. The central feature of each pack is the provision of information on the role and significance of design representations used during NPD. When employed, the cards facilitate the use of a common vocabulary, creating shared knowledge and empathy towards the related yet distinct working practices of each group. Following a pilot validation and minor modifications, interviews to assess the significance of the cards was undertaken with 29 industrial designers and 36 engineering designers. Many of the interviewees were senior designers from multinational companies. Having employed the cards, when asked if the Colab system would foster enhanced collaboration, the feedback was overwhelmingly positive, with 68% of industrial designers giving a positive response (27% neutral) and 63% of engineering designers (37% neutral).

*Keywords: Industrial design, engineering design, collaboration, design tool*

## 1 INTRODUCTION

In an increasingly competitive commercial environment, organisations are under constant pressure to operate at optimum efficiency. In terms of the interaction between industrial designers and engineering designers, it has been noted that without managed collaboration, the direction of work can diverge with task fragmentation reducing efficiency (Jevnaker, 1998, Persson and Warell 2003). This paper investigates the collaboration between industrial designers and engineering designers and focuses on three distinct problem categories: conflicts in values and principles, differences in design representation, and education differences. The outcome of the research was a card-based design tool that promoted the use of a common language to improve communication and create shared knowledge. The aim of this PhD-based research was to develop a tool for improved collaboration between industrial designers and engineering designers.

## 2 DIFFERENCES BETWEEN INDUSTRIAL DESIGNERS AND ENGINEERING DESIGNERS

In differentiating working approaches, industrial designers prefer open-ended solutions, adopting trial-and-error and intuition to ensure individual expression to the design. Industrial designers view problems as ill-defined, while engineering design's view problems as distinct. These dissimilar views can, at times, generate conflict (Persson and Warell 2003). Besides deep-seated differences in cognitive styles (Cross, 1985), another key difference is that industrial designers focus on appearance and user-interface; whereas engineering designers focus on functionality and manufacture (Kim, et al., 2006). The engineering designer produces technical drawings and computer aided design geometry for the manufacture of a working product based on quality, performance and cost (Flurschein 1983). In contrast, industrial designers produce representations such as rendered sketches and appearance models.

Effective communication is essential when engaging in new product development and Clark and Wheelwright (1993) note the importance of communication in achieving greater bonding and efficiency. This is developed by Chiu (2002) who suggests the importance of transmitting communication symbols precisely; ensuring symbols carry their meaning without interference; effectively receiving the intended meaning; and reaching the right audience through accurate distribution. Having acknowledged means for effective collaboration, studies indicate that engineering designers do not understand the vocabulary used by industrial designers. Fiske (1998) notes that industrial designers found it difficult to understand engineering design-related issues such as technical specifications. In addition, words may not have the same meaning for all members of a design team, with Persson and Warell (2003) acknowledging that communication becomes more effective once the team develops a common vocabulary by understanding communicative codes and the language, e.g., symbols, product reproductions and message content.

Erhorn and Stark (1994) noted that because the various participants have their own vocabulary suited to specific activities, there can be difficulty in communicating and understanding others. Although the language may be similar, identical words can have different meanings (Ashford 1969). Collaboration and communication can be considered as being intertwined. Despite the availability of methods to support effective collaboration, these approaches have not produced a common ground and are of limited value when attempting to enhanced collaboration between industrial designer and engineering designers.

### **3 RESEARCH METHOD**

An empirical study was undertaken with the aim of investigating the barriers to effective collaborative between industrial designers and engineering designers during new product development. The ten-week study was undertaken with 17 design consultancies specialising in electronic consumer electronic. The subjects were qualified industrial designers and engineering designers with varying levels of experience. The fieldwork constituted 45 hours of in-depth interviews and another 80 hours of observations. The empirical studies utilized a qualitative research methodology, incorporating semi-structured interviews and the observation of participants during a commercial project.

The interviews comprised open-ended questions that allowed respondents to fully describe their personal experiences (Stauffer et al., 1991) relating to group interaction; reasons for project success and failure; and methods used during the project. To improve reliability, a mix of large, medium and small companies with an equal number of industrial designers and engineering designers were interviewed. The data was first encoded into a spreadsheet which identified 61 problem categories. By adopting A coding and clustering technique, the results were then condensed into a matrix based on recurrence and importance.

The matrix highlighted 19 most frequently occurring problems (occurring 3 or more times), further categorised into the following three distinct headings:

#### **1. Problem Category A - Conflict in values and principles**

Engineering designers work in a logical way with quantified solutions with a focus on efficiency. In contrast, industrial designers favoured an open-ended approach and adopted open solutions.

#### **2. Problem Category B - Differences in design representation**

A lack of a common medium for both disciplines represented an obstacle towards effective collaboration.

#### **3. Problem Category C - Education differences**

Due to differences in background and education, the two groups had different capabilities, specialisations, approaches and expectations.

Observations were used to allow the researchers to obtain detailed information by being close to the field of study. The 2-week observation study was based on the design of an electronic communication device requiring collaboration between industrial designers and engineering designers within a design consultancy. Analysis of the results enabled the researchers to identify that:

1. Formal and informal meetings were valuable for healthy discussion and increased collaborative opportunities.
2. Co-located members in close proximity enhanced collaboration.
3. Different approaches in the design process affected collaboration. Engineering designers focused on technical properties and cost, while industrial designers concentrated on form and expression.
4. Problems in translating a 2D hand-sketch to digital 3D CAD model had a negative effect on the working relationship.
5. The lack of a common language in design representations made it more difficult for industrial designers and engineering designers to understand each other.

#### **4 DESIGN REPRESENTATIONS**

A representation is defined as a model of the object it symbolises (Palmer, 1987). Internal representations encompass imagery and cognitive activity. External representations are visual or verbal (Goel, 1995; Goldschmidt, 1997) and are expressed through language, graphics or actual objects. This research focuses on external representations encompassing physical and digital formats. In the early stages when the design solution is ill defined, unstructured representations such as sketches are used. As the design develops, more structured drawings appear. According to Tang (1991), sketching allows visualisation, communication and information storage, while Larkin and Simon (1987) point out that representations could externalise and visualise problems as they emerge. Other studies highlight the importance of product representations in enhancing team communication (Ulrich and Eppinger 1995) and as a thinking tool (Ferguson, 1992). Suwa et al (1998) noted that sketches provided visual cues for further work and for functional thoughts to be constructed. Other uses of representations include “referential sketches” to record observations and discoveries (Graves, 1977); to verify decisions (Herbert 1993); and to allow a range of interpretations to a design solution (Scrivener 2000).

Sketches are sometimes incomplete and could be interpreted differently by industrial designers and engineering designers. This ambiguity enabled designers to re-interpret them and gain new insights (Goel, 1995). While this ambiguity could help spark new designs and facilitate negotiation, it could also be inaccurate and inconsistent. A key goal was for the use of representations was for them to be consistent between the two groups. To help facilitate this, some professions employ formal systems such as ISO standards and engineering terminology. The design profession, however, has less established representation types and ones that are ill-defined and imprecise (Saddler, 2001). Consequently, industrial designers apply drawing conventions that make it hard for engineering designers to comprehend and recognise how visual solutions work in relation to product’s technical elements. Highlighting differences in the vocabulary of each discipline, Smith (1997) suggested having a common understanding of shared definitions. By having a common ground in representations, communication and interaction should be enhanced, leading to improved collaboration.

#### **5 DESIGN TOOL**

The aim of the emerging tool was to provide a uniform definition of design representations (providing industrial designers and engineering designers with a common vocabulary); key design/ technical information (serving as a decision-making guide); and help identify the design representations used during stages of the design process (allowing users to be aware of each others working processes and facilitating effective planning). Numerous formats for the tool were evaluated and physical card was selected on the basis of portability, availability. The cards integrated the following content:

Design Stages - Information regarding the stages of new product development would allow users to gain an overview of the design process.

Design Information - Key design information related to industrial design working practice included data on such areas as form and detail, visual character and colour.

Technical Information - Key technical information related to industrial design working practice included data on such areas as mechanisms, assembly, and construction.

Design Representations - A compilation of 34 representations used by industrial designers and

engineering designers, categorised into sketches, drawings, models and prototypes.

The cards were divided into 3 sections. Section 1 illustrates key design stages of the new product development process. The front face presents a definition of the design stages where industrial designers and engineering designers collaborate during the design process. The back shows information about the types of design representation used. Section 2 describes key design and technical information used by industrial designers and engineering designers in the design process. The front face shows the definition of design and technical information with the back face showing the popularity of specific representations to communicate design or technical information. Section 3 gives the representations used by industrial designers and engineering designers during the design process. The front face gives a definition of the design representation and the reverse face shows the design/technical information that is embodied in the representation and the popularity of the representation when used during a design stage.

## **6 VALIDATION**

The validation of the cards commenced with semi-structured interviews with participants from 15 design companies and academic institutions. The questions comprised a set of statements referring to the format, layout and if the cards would improve design collaboration. The respondents could either agree or disagree according to a five-point Likert scale that had a 'neutral' option. When asked about the physical card format, 86.4% of industrial designers and 89.5% of engineering designers gave a positive response. There was equally positive feedback by industrial designers (86.4%) and engineering designers (89.5%) who agreed that the tool would provide them with enhanced understanding and clearer definition of design representations. The respondents (industrial designers 86.4%; engineering designers 84.2%) also agreed that the system would create a common understanding of design representations. When asked if the system would foster enhanced collaboration, there was an overall positive outcome, with 68.2% of industrial designers giving a positive rating and 27.3% of industrial designers being neutral. There were no poor ratings from the engineering designers and 36.8% gave a neutral feedback. The results indicated that most respondents felt that the tool would provide a common ground in design representations, contributing to enhanced collaboration.

The final validation employed a 3-week case study during which the cards were used during a live client-based project. The case study approach allowed data to be collected within a real-life context (Yin, 1989) with observations being conducted within a natural work environment to obtain an immersive experience. A design diary captured the activities enabling an analysis of the activities on a daily basis. The case study validated the relevance of the design representations used in the cards along with the use of the design/technical information. The cards were shown to be useful as a clarification tool during the design process. In the third week, it was recorded that both industrial designers and engineering designers used identical keywords picked up from the cards during discussions which helped minimise misunderstanding. The case study provided further positive feedback which reinforced the capacity of the cards to facilitate collaboration in a multi-disciplinary environment.

## **7 CONCLUSIONS**

The research indicated how the use of a systematic methodology that employed a high degree of data collection from practitioners resulted in the development of a viable tool that was found to enhance collaboration between industrial designers and engineering designers. Central to the research was the need to have a member of the research team that had the capability to translate features required of the cards into a graphic design solution that was suitable for further evaluation. As a card-based tool that was for use by designers, it was essential that the cards had a visual quality that was appropriate for this user group. Without a member of the team having graphic design capability, the project would have been much more expensive (a graphic design consultant would have been required) and the three year timescale would have been extended due to the required meetings and iteration. The use of design representation cards was found to build a common ground between industrial designers and engineering designers, effectively enhancing collaboration. By having a unified understanding of shared definitions, the application of representations was found to be more precise and effective. The research contributed

new insights into factors that have a detrimental impact on collaboration, namely: conflicts in values and principles; differences in design representation; and education differences. In addition, the research proposed a taxonomy of design representations, clearly defining the types and roles of sketches, drawings, models and prototypes used by industrial designers and engineering designers during new product design development.

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