A SYNOPSIS OF MATERIALS AND MANUFACTURING EXPERTISE FOR TRAINEE INDUSTRIAL DESIGNERS

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ABSTRACT
This paper presents a synopsis of research into the expertise trainee industrial designers need to possess for choosing product materials and manufacturing processes. The motivation is to ensure good correspondence between degree courses and contemporary professional practices. Sources of empirical evidence include interviews with nine industrial designers, a design engineer, a designer-maker, and documentary data from a product design project. The primary message is that trainee industrial designers would likely benefit from materials and manufacturing curricula devised to fuse selected pragmatic and epistemological facets of both engineering *and* crafts domains.

Keywords: materials, manufacturing, industrial design, expertise, training

1 INTRODUCTION

Production artefacts are literally *materials* worked into *manufactured* forms. In fact, most products are *assemblies* of such forms, where each component can be expected to have individual requirements for material properties and manufacturability. The demarcation of assembled forms, and the associated materials and manufacturing choices for components, are therefore fundamental decisions for professionals working in product design, innovation and new product development (NPD). A grounding in manufacturing routes (combinations of materials, manufacturing processes, secondary finishing processes, and assembly methods) is accordingly crucial in the training of product design graduates. This is a non-contentious position, demonstrated by the wealth of materials and manufacturing content in product design courses worldwide.

Product design is performed largely by two groups of specialists with quite different training: industrial designers and design engineers. Some exceptions apply, notably graduates of hybrid courses that combine industrial design with engineering principles (e.g. pioneered in the UK by *RCA/Imperial*, *Glasgow*, *Napier*, *Loughborough* and *Brunel* universities). The aim of the research reported in this paper was to establish the extent of responsibility that present-day industrial designers have for materials and manufacturing decisions, and to link the findings to revisions in course curricula.

The most comprehensive previous attempt at such a review was the Myerson report [1], which addressed how 1990s UK industrial design courses should (and had) changed in the face of rapid technological advances. Myerson revealed that course design was influenced by the consultancy experience of lecturers, input from external examiners and advisory boards, and feedback from graduates. However, direct conduits from professional practice were notably absent. Whilst it is plausible to influence and monitor courses by employing professional designers as specialist tutors or advisors, it is only through a more fundamental review of general practices that a strong case may be made for pedagogical change.

Post-Myerson there has been a lack of re-examination of the issues, with only a handful of new instructional texts that target materials and manufacturing to an industrial design audience [2, 3, 4, 5]. Product design in the twenty-first century has evolved significantly, exemplified by the changing relationships between business, innovation and globalisation [6]. It was reasonable to assume that industrial designers' responsibilities for materials and manufacturing had also evolved, and it was important to find out: to help ensure that any new initiatives (e.g. information sources, advisory systems, design management, pedagogy) would be aligned with contemporary practices and thus contribute positively to students' training. Two research questions were posed.

- What experiential base do industrial designers possess for choosing product materials and manufacturing processes? ('pragmatic perspective')
- Do industrial designers have a 'distinct way' of expressing, generating and applying materials and manufacturing expertise? ('epistemological perspective')

2 INDUSTRIAL DESIGN AS A SPECIALTY

It is helpful to briefly state what is understood to be the industrial designer's specialty within product design: fitting products to people. This contrasts with the specialty of the design engineer, which is broadly understood to be fitting technology to products. A useful definition of industrial design is therefore *the profession responsible for ensuring that manufactured products have special appeal to people*. Industrial designers' humanistic perspective leads them to take charge of the "external integrity" of products [7], exercising their prerogative to achieve *utilitarian* and *supra-functional* [8] success. In other words, they seek in their designs a combination of practical function (usefulness, usability, comfort, technical performance etc.) with human factors that transcend utility and define the desirability of a product to "own, use and behold" [9]. It is this combination of utilitarian and supra-functional success that essentially determines users' experiences (good or bad) of a product.

3 RESEARCH METHOD

A prior art review and internet forum thread (ID-Forum) was initiated to identify areas requiring clarity and areas of conflict and agreement on materials, manufacturing and product design The following were found to be comprehensively covered: materials science, engineering material properties, and appraisals of product manufacture and assembly. Most of the prior art dealing specifically with industrial design perspectives focused on critiques of existing products and were absent of decision-making or methodological insights (considered essential to improve support for design practices). Thus the need for empirical research was founded, around the following two-stranded analytical framework, which was used to direct data collection.

- Pragmatic analysis – concerned with creativity, management and the operational factors that influence decision-making.
- Epistemological analysis – concerned with the nature of information, knowledge, values and skills.

Data sources were used that would deliver detailed evidence not obtainable through a survey. It was known that research based on a few cases was especially useful when the area under investigation was complex and new, and when the concern was to provide practical insights and examples rather than rules [10].

- Interviews (design engineer, designer-maker). The work practices of these creative professionals have historically been positioned 'either side' of industrial design, so it was not unreasonable to expect elements of each profession's attention to materials and manufacturing to be retained in contemporary industrial design practice. Interviews were therefore undertaken with the Director of Loughborough University's *Engineering Design Institute*, and the Course Leader for the *3D Design (Ceramics)* degree at Loughborough University. Both interviewees were also practicing designers.
- Interviews (industrial designers). The nine interviewed designers were based at UK manufacturing companies (in-house design departments), design consultancies and freelance businesses, and included staff at Nokia (mobile phones), Samsung (electronic and household products), Kenwood (electro-mechanical kitchen devices), Flymo (powered gardening equipment), Pentagram (consultancy) and BIB (consultancy).
- Design project case study (polymer acoustic guitar). This was a longitudinal project undertaken by the first author over 227 days, for which a diary was kept to systematically capture attention to materials and manufacturing [11]. The diary contained 312 detailed entries and formed substantial project documentary evidence, from project brief to delivery of prototype instruments.

All of the interviews lasted up to two hours and utilised a semi-structured approach to promote discussion around a prepared agenda. Data from all sources were transcribed into tabular form and underwent content analysis based on the analytical framework.

4 RESULTS

4.1 Pragmatic Analysis – Industrial Design Perspective

The empirical data clearly showed that a fundamental responsibility of industrial designers is to mediate a decision on product materials and manufacturing that is to the satisfaction of the three main project stakeholders (clients, makers and users). The perspectives of the design engineer and designer-maker were valuable in illuminating the nature of the required mediation. Industrial designers' work aligned most closely with that of design engineers (i.e. expertise across material families; product consistency viewed as desirable and expected; plans – but does not undertake – manufacture; involved in one-off through to high-volume manufacture). Only one element of designer-makers' work aligned with industrial design: supra-functional uses of processed materials. This essentially refers to choices of manufacturing route being led as much by sensorial properties and human factors (e.g. the construction of perceptual cues and semantic associations in users' minds such as quality, intrigue, status, expression, fun, aspiration) as technical performance and utility. Indeed, the interviews revealed that in fiercely competitive hi-tech markets (e.g. electronic consumer goods), it is surface finishes that are dominant in the marketing and sale of products, often eclipsing product utility or concept. Visual and tactile material properties were found to be prevalent amongst industrial designers' considerations. Researchers at TUDelft (amongst others) are investigating this area further, identifying "intangible characteristics" of materials: how they may be measured, their effects on people and products, and their integration into design advisory systems [12].

4.2 Pragmatic Analysis – Operational Factors

The research identified for the first time the variety of operational factors originating from project stakeholders that serve to reduce or set direction (i.e. 'drive') industrial designers' materials and manufacturing choices. The client and maker perspectives are mapped in Figure 1, combined with the user perspective (end user, retailer, service personnel) previously outlined in section 2, for which it is proposed that a positive overall product experience is the goal, rather than an outward concern for how a product is manufactured or from which materials. The interviewed industrial designers were vehement that creativity in product form creation and material selection was dependent on attending to these operational factors.

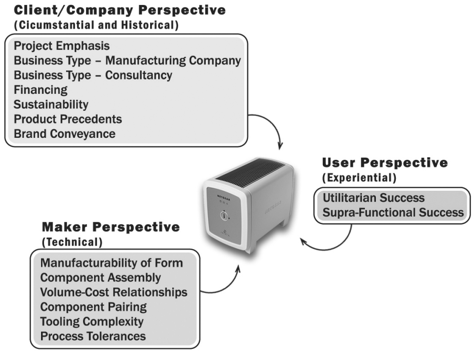

Figure 1: Tripartite materials and manufacturing decisions in industrial design

4.3 Pragmatic Analysis – Management and Extent of Involvement

The literature contained much ambiguity over how industrial designers manage their involvement with materials and manufacturing throughout a design project. Figure 2 summarises the new research findings in this area by utilising Ulrich's & Eppinger's NPD phases [13] as a template. A distinct narrowing of the contemplated manufacturing routes is detectable as NPD phases are completed. As with many models of design activity, Figure 2 presents a linear progression but this may be interrupted at any time, for example to responsively resolve an issue of detail or revisit a conceptual matter. The 'typical deliverables' are modelling media that industrial designers use to convincingly simulate and communicate their proposals for product manufacturing routes.

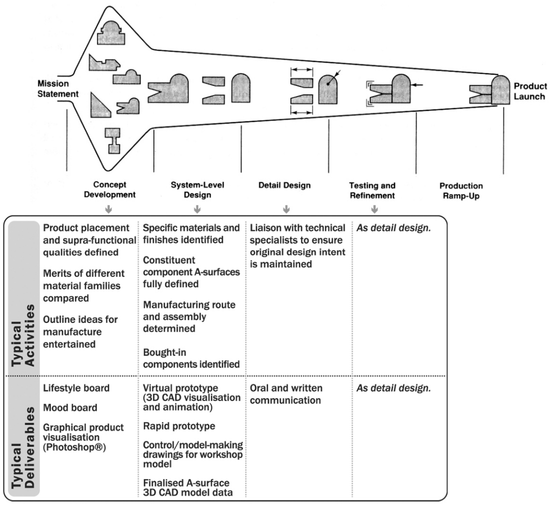

Figure 2: Managing materials and manufacturing in industrial design – partial © [13]

4.4 Epistemological Analysis – Information and Knowledge

Industrial designers' experiential base for materials and manufacturing decisions was found to extend far beyond propositional knowledge. It can be described as a synergy between attentions that are the specialty of the designer-maker, where knowledge is expressed and generated first-hand 'by doing' or 'by acquaintance', and those that are the specialty of the design engineer, where pre-prepared quantified materials data and selection charts are used, especially for specifying product performance.

Designer-makers' materials and manufacturing knowledge is fascinating because it often has a tacit dimension (i.e. not amenable to verbal articulation), as a direct result of apprenticeship learning. There is no suggestion here that industrial designers possess a level of personal affinity and understanding of materials comparable to that of designer-makers. However, industrial designers *were* found to place emphasis on extending their materials and manufacturing expertise through combinations of workshop-based designing-and-making, uses of personal or corporate material sample/product libraries, and – with importance stressed – casual product interactions.

It has been argued that material properties conveyed through written or numerical data may not be conducive to manipulation in the 'mind's eye' and may therefore not be particularly compatible with industrial designers' visually dominant modelling methods [14]. This view is given credence from the findings here that industrial designers seek much of their knowledge augmentation through vocational means. The logical implication for industrial design education is to ensure adequate 'hands-on' teaching of materials and manufacturing.

Such approaches are not without precedent. A 'top down', 'studio based' or 'project led' delivery was the primary means of materials and manufacturing teaching on Loughborough University's industrial design courses during the mid 1980s [15]. However, the University's present-day courses have shifted significantly towards a 'bottom up' (engineering principles and materials science) approach, in response to increased student numbers, course modularisation, and use of expert staff from outside the host department [16]. Such a shift is not likely to have been unique to Loughborough. Its effect has been a somewhat strained separation of the teaching and learning of materials and manufacturing from the core activity of designing products.

5 CONCLUSIONS

Instructors are well aware that industrial design students are not especially enamoured by the subjects of materials and manufacturing when taught out of context. Given the centrality of the subject for successful product design, it is vital that all efforts are made to enthuse students, via relevant and stimulating course content and delivery.

Materials and manufacturing expertise has a pivotal role in securing the industrial designer's main prerogative: the combined achievement of supra-functional and utilitarian product success. In developing students' capabilities in these areas, the research established that curricula devised to fuse selected pragmatic and epistemological facets of engineering *and* crafts domains, traditionally situated 'either side' of industrial design, would likely reap benefits.

Consequently, the present-day pedagogical challenge is seen by the authors as a need to develop in students a level of sensorial attentiveness and technical expertise that leads to confident connection between product ideas, selection of materials and finishes, and manufacturability of product form. The research indicated that a strong vocational and empirical element would be beneficial in this regard (echoing objectives of material sample libraries including *Material ConneXion*, *MADE Materials Resource Centre*, *Materia Inspiration Centre*, *Material Lab*, *IDEO Tech Box*). Modest exposure to other professionals' involvement with materials (e.g. from sciences, arts) would likely impact positively on students' general awareness.

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