INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 99 MUNICH, AUGUST 24-26, 1999

PRACTITIONERS OF DESIGN FOR QUALITY

A.J. Robotham

Keywords: Design for quality, designers

1 Introduction

Building in high quality continues to be the driving force of new product development activity in industry. Yet as we come to the end of the 1990s and look forward to the challenges in Design Research of the new millennium, Design for Quality does not appear to attract the attention or interest of many design researchers. Importantly, if research attention is not paid to Design for Quality, how can we expect to educate and train future design practitioners to master this critical dimension of product development?

The purpose of this paper is to consider the current status of Design for Quality, explore the skills designers require to be effective practitioners of Design for Quality, and to identify some of the challenges the design research community needs to face.

2 Design for Quality

Fundamentally, Design for Quality (DFQ) is the pursuit of quality in product design. The approach demands that products have a range of qualities that will satisfy and delight all stakeholders who interact with the product throughout its life cycle. To achieve this goal, the product must be designed with DFQ understood and implemented with the appropriate tools, techniques and design skills. By doing this, the success of a product development programme could be measured largely in terms of the quality of the resulting product.

In many other respects, the ambitions and goals of any new product development programme and the universal virtues of the product can be fully specified within the framework of DFQ.

2.1 The Work of Mørup

In the field of Design Research, Mørup [1] has published probably the most complete description of DFQ. He recognised that "research in Design for Quality is relatively new" and that "most research efforts have been directed towards individual quality techniques and the theories that match these". Also, he "demonstrated that the process of synthesis in product development is ultimately where the genesis of product quality takes place".

Mørup's doctoral thesis unifies existing and new quality techniques and theories into a framework for DFQ that contains eight main elements, arranged in three aspects:

- *DFQ Preconditions*: Strategy deployment, Quality organisation, Product technologies, and Measuring system for quality.
- *Structured Product Development*: DFQ procedure.
- *Supporting Methods*: Tools and techniques, Methodical design, and Quality mind-set.

The thesis also introduced two new quality concepts:

- *Q-quality*: Q is the customer's qualitative perception of the product.
- *q-quality*: q is the internal stakeholder's qualitative perception of the product in relation to their product related tasks.

This framework describes the totality of conditions, approach and techniques necessary for effective DFQ, whilst not being prescriptive in the detail. This allows specific theories, tools and techniques to be inter-changed with alternative/new approaches whilst preserving the overall goal of DFQ. The concepts of Q and q qualities enable the qualitative perceptions of the product to be divided according to stakeholder type. This approach recognises the significance of the internal customers, but not at the expense of the external customers. It also accommodates the changes in level of the customer's expectations, which occur with time, and/or the introduction of new products in the market.

2.2 Exploitation of DFQ

The exploitation of Mørup's DFQ approach, however, appears to be almost negligible in the domains of quality and product design research (an exception is [2]). For example, there were no explicit references to DFQ in any of the papers presented at ICED 97, and yet many researchers reported results, techniques and theories that make a valuable contribution. Similarly, when design researchers present their principal goals, most claim they "strive to improve our knowledge and capability in design to enable the creation of better products, and to master cost, quality, and lead-time". If this is a true reflection of their ambitions, then they are working with a quality focus and their results add to the development of DFQ. However, it is unfortunate that most appear blind to the DFQ framework in which their contributions could be suitably positioned.

Similarly, explicit references to DFQ by industrialists are also negligible. Yet, without exception across all product sectors, discussions of new product development would be at fault if they did not include reference to "satisfying the customer" and "improving manufacturing quality"; goals accommodated within the DFQ approach.

2.3 So why the poor take up of DFQ?

The easiest way to answer this question is first to consider quality itself.

Quality is a perception. The 17th century philosopher John Locke (see Ayers [3]) provides an early and highly relevant discussion. Locke defined the quality of an object as "its power to stimulate the senses and produce an idea in the mind of the observer". He adds that prior knowledge and previous experiences help create more complex perceptions of an object, enabling the observer to anticipate qualities that cannot, as yet, be perceived.

The implications of this understanding of quality are significant for product development. For example, Hughes reflects the task faced by all product developers, e.g. "we need to create differentiation between ourselves and our competitors in the mind of the customer", "(we) require that our customers perceive and believe our products to be better than our competitors", "customers have become much more sophisticated in the factors which they include in the purchase decisions", and "(we) need to find those extra factors which will deliver such a high level of customer satisfaction" [4].

Mørup states that “quality is experienced when the customer interacts with the product” [1] and the idea of “meta-product” is introduced when this interaction is coupled with prejudices, status, nostalgia, value, etc.[5].

The problem is that quality is a perception in the mind of the customer. Consequently, the achievement of quality is a highly individual, qualitative experience which is difficult to predict. Whilst we can design a product with “hard” properties that can be objectively measured and quantified, ultimately a product must also have “soft” properties that complete the totality of a customer’s perception of its quality. In the context of DFQ, this must be true for all stakeholders. In a similar vein, the DFQ framework also has soft elements. The most notable being the “quality mind-set” (see below).

Perhaps, therefore, the reluctance of researchers and industrialists to embrace the DFQ framework stems from the fact that quality and DFQ both have soft, qualitative aspects that defy easy definition or solution. Certainly, the efforts made in quality-related research have generated theories, tools and techniques that seek to provide quantitative routes to design solutions. In the industrial context, it is quite feasible to introduce practical procedures with appropriate supporting tools (particularly if they are available in a computerised form) which have means to measure the effectiveness of their application. This is reflected in the use of many quality-related tools or procedures, e.g. QFD, FMEA, DFMA, CAD, TQM, and ISO9000. Each has its place in the DFQ framework and, in particular, there is a strong belief amongst managers that TQM and ISO9000 takes good care of quality. In contrast, the industrialisation of procedures to deal with “perception”, “value”, “feeling”, and “mind-set”, is fraught with difficulties, and is not underpinned by a substantive body of research results. It is, perhaps, no wonder that DFQ has failed to be implemented successfully in its entirety.

3 Practitioners of Design for Quality

Without exception, product development is a human centred activity, and the creation of product quality occurs in the synthesis of the solutions. The practitioners of DFQ must have the unique ability of synthesis guided by a “quality mind-set”. In addition, designers with creative skills and an ability to make leaps in concept solution will make the most significant contribution to DFQ. Developing practitioners of DFQ starts with education.

3.1 The Quality Mind-Set

The quality mind-set reflects the attitudes, beliefs and values of each designer in the product development team, and a proper of understanding of the nature qualities and their evaluation. If the mind-set of individuals in the team is not focussed towards achieving the same quality goals, then the outcomes of the synthesis and decision-making processes will not necessarily be to the benefit of product quality. It is essential that a common mind-set, focussed on quality, be developed amongst all the designers in the product development team.

The most effective mechanism for creating the quality mind-set is to focus on the voice of the customer (VOC). In DFQ the VOC is the voice of all stakeholders, i.e. all the people who interact with the product in all life phases. Clausing provides a succinct description of how to collect the VOC and its relationship to the downstream product development processes [6]. The clear message he gives, is that designers must immerse themselves in the context of the product life phases, obtain the voice of the customer, and identify the values they have towards the product. The interaction with customers is essential for understanding “feelings”, sharing experiences, and identifying cultural influences. The purpose is to establish the

difference between success and failure in the mind of the customer. Thus, the quality mind-set is very much related to the customer's mind-set and understanding the meta-product.

But the quality mind-set must also reflect an awareness of the things the customer is unable to express or even have consciously thought about. This can be reflected in the following comment reported by Cross from an architect: "Our job is to give the client, on time and cost, not what he wants, but what he never dreamed he wanted, and when he gets it he recognises it as something he wanted all the time" [7]. It is a theme mirrored by Cullen, who requires "organisations which are tuned to the voice of the customer", and products "which respond to both spoken and unspoken wants and needs" [8]. This requires creativity and innovation.

3.2 Creativity, Innovation and Synthesis

The need for creativity and innovation in DFQ is driven by the ever-increasing demands of the customers. The degree of customer satisfaction is coupled to the quality properties of the products, and today's excitement qualities become tomorrow's basic requirements [9].

Interviews with expert designers show that innovation in product development can stem from adopting a quality mind-set [10]. But once the mind-set is focused on delighting the customer, it is necessary to begin the process of synthesising the VOC into a technically feasible product. QFD is a popular tool and its use is widely reported. The process of clarification, structuring and characterisation of VOC information into a QFD chart is necessary to formulate a product specification [6]. Though, Cullen sees QFD as "a useful discipline, but is essentially secondary to the process of translating the voice of the customer into an excellent product" [8]. The test of excellence comes only when the customer interacts with the product, so it is important that they are given regular access to prototypes to evaluate the quality of the product, and give corrective feedback to the designers. Better results will emerge from the synthesis activities the sooner this interaction starts in the product development process.

At DTU, we are concerned that a lot of valuable information about the VOC is lost in the specification process. Computers benefit the product development process in many ways, but if the designer's interaction with the product becomes more abstract, then synthesis is more constrained. We are experimenting with techniques that enable all the information, which has been collected about customers in each life phase, to remain visible to the designers throughout the product development process. We believe this approach will enable the design team to maintain a high level of awareness of the VOC at all times. It will also allow transient members of the design team to quickly immerse themselves in the VOC, and we see opportunities for much greater involvement of suppliers, who traditionally have access to only minimal information about the customer. We consider this will stimulate greater creativity and innovation in the search for solutions, and provide an instrument for solution synthesis that ensures decisions are made with a conscious awareness of all the life cycle implications.

3.3 Educating Practitioners of DFQ

When we consider the capabilities and skills required of practitioners of DFQ, there is a belief that the attitudes of a designer can be developed through structured education [11]. There is also strong evidence [12] that designers with formal training in design methodologies are more likely to fit our needs, i.e. create more variants, and seek optimum solutions.

But of more interest here is to compare the differences between the education of engineering designers and industrial designers.

On the whole, engineering courses tend to focus upon the application of scientific and technological knowledge. Engineering design often follows a methodical approach, with tightly defined product design specifications. Often, there is little or no consideration of the complete product life cycle, nor an ambition to create quality solutions at the excitement level. Consequently, engineering students tend to create variant solutions, functional in nature, whose performance is demonstrated by calculation, analysis, simulation or test. Computer aided design, unless supported by rapid prototyping technologies, makes it even more difficult for students to interact with their solutions, and to experience and learn about product quality.

By way of contrast, the education of industrial design students is highly focused on the customer and emphasises the visualisation of the product and its use in many life phases. Concept design is not constrained by a tight specification, but encouraged to be searching and draw upon a wide range of influences to invigorate creativity. Concept selection is frequently based upon what the designer judges to be the most innovative and original ideas - ideas that can be formed into products that will excite potential customers. Sketching and drawing skills are well developed, and an emphasis is placed on making facsimile models or prototypes. The models allow customers to interact with the product, assess its quality, and demonstrate to the student how quality is perceived. However, industrial designers are not consciously taught the principles of DFQ, and miss a proper understanding of quality supported by performance qualities like reliability, durability, etc. But, the design practices they learn clearly support the ambitions of DFQ and establish the foundations of a quality mind-set.

The contrast between the two teaching approaches is striking. Engineering courses focus on q-qualities and do not effectively prepare the quality mind-set, whereas industrial design courses are Q-quality focused and emphasise innovation and delight of the customer.

4 Challenges and Conclusions

The totality of product quality is achieved only when all life cycles phases have been thoughtfully considered, and all stakeholders delighted by their interaction with the product.

This paper has argued that Design for Quality provides a robust framework for meeting this objective. However, the DFQ framework must be used by the industrial, research, and educational communities as a platform for improving the skills and capability of the practitioners of Design for Quality.

If engineering designers are to become effective practitioners of Design for Quality, then aspects of their education need to be revised. They must have more physical contact with engineering products, learn about product quality and how it is achieved, and develop a quality mind-set. They should put more emphasis on the visualisation and manufacture of prototypes, and be asked to create novel and innovative solutions. Industrial designers require a formal awareness and knowledge of performance qualities and the DFQ framework.

To support this advance, the challenge for Design Research is to provide deeper insight in to the soft aspects of quality and DFQ, e.g. understanding the quality mind-set and how it is developed, understanding the perception of quality and its relationships to the product characteristics, and what mix of skills and knowledge is required to create high quality

products. Thus, results are required about the relationships between quality, life cycle phases, the meta-product, and innovation. But finally, researchers and industrialists need to embrace the DFQ framework and demonstrate how their results and practical experiences add to the development of Design for Quality. Only then will we achieve consolidation of approach, and have a proper, integral understanding of this complex dimension of product development.

References

[1] Mørup, M., "Design for Quality", PhD thesis, Institute for Engineering Design, Technical University of Denmark, Lyngby, 1993.

[2] Field, S.W. & Swift, K.G., "Effecting a Quality Change: An engineering approach", Arnold, London, 1996. ISBN 0 470 236884.

[3] Ayers, M., "Locke: Ideas and things", Phoenix, London, 1997. ISBN 0 753 801957.

[4] Hughes, C.E., "Happy Customers are Good Business", Proc. Int. Conf. on Design for Competitive Advantage, Coventry, UK, I.Mech.E C482, March 1994.

[5] Monö, R., "Design for Product Understanding", Liber AB, Stockholm, 1997. ISBN 914 701105.

[6] Clausing, D.P., "Total Quality Development", ASME Press, New York, 1994. ISBN 0 791 800350.

[7] Cross, N.G., "The nature and nuture of design ability", Design Studies, Vol. 11, No. 3, July 1990, pp 127-140.

[8] Cullen, J.M., "Managing the new product introduction process for quality, reliability, cost and speed", Proc. Int. Conf. on Design for Competitive Advantage, Coventry, UK, I.Mech.E C482, March 1994.

[9] Kano, N., Seraku, N., Takahashi, F. & Tsuji, S., "Attractive Quality and Must Be Quality", Quality, Vol. 14, No. 2, 1984, pp 39-48.

[10] Cross, N.G., & Clayburn Cross, A., "Expert Designers", Designers, The Key to Successful Product Development, Frankenberger, E. et al (eds.), Springer-Verlag, London, 1998, pp 71–84.

[11] Robotham, A.J., Blount, G.N., "Design with Attitude: A key world class method", Proc. of the 11th Int. Conf. on Engineering Design in Tampere,Vol. 3. Schriftenreihe WDK25, Tampere 1997, pp 535-540.

[12] Günther, J., Ehrlenspiel, K., "How do designers from practice design?", ", Designers, The Key to Successful Product Development, Frankenberger, E. et al (eds.), Springer-Verlag, London, 1998, pp 85-97.

Tony Robotham, Associate Professor
Technical University of Denmark
Department of Control and Engineering Design
Building 358, DK – 2800 Lyngby
Denmark
Phone: +45 45 25 62 59
Fax: +45 45 88 14 51
E-mail: tony@iks.dtu.dk