Design engineering competencies: future requirements and predicted changes in the forthcoming decade

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This paper seeks to address omissions in previous research by identifying a future competency profile for design engineers. A three-phase methodology using both quantitative and qualitative methods was employed. A competency profile for the future design engineer, 10 years hence, was generated. The profile consisted of 42 competencies divided into the following six competency groups (in descending order of criticality): personal attributes, project management, cognitive strategies, cognitive abilities, technical ability, and communication. Furthermore, non-technical competencies were forecast to become increasingly important in the future. Results were discussed with reference to their implications for the design engineering industry.

Keywords: creativity, design behaviour, design cognition, innovation, psychology of design

The present study seeks primarily to identify the future competency requirements of design engineers, a role that little recent competency research has examined. This is an important omission for such a crucial engineering role, as competency-based approaches serve to enhance an organisation's performance and therefore yield a competitive advantage (Lawler, 1994).

A relatively typical definition of the term competency encompasses those underlying motives, traits, values, knowledge, and skills that are causally linked to effective job performance (Spencer and Spencer, 1993). It is important to note, however, that some authors additionally

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include both tasks and roles performed as competencies (Duncan, 1991). Furthermore, others, while distinguishing competencies from roles and tasks, nevertheless include tasks within the overall term competencies (Plonka et al., 1994). Indeed, even experts in organisational psychology themselves acknowledge the wide range of definitions (Schippmann et al., 2000). In the current paper, the operational definition of a competency also includes tasks, where this serves to more clearly illustrate the nature of the underlying behaviours and cognitions of job incumbents. By employing this broader definition, we hope to address two of the most frequent criticisms of competency-based approaches (Illes, 2001). First, we remove the conceptual ambiguity from the term 'competency', and second we enable both task-oriented *and* people-oriented competencies to be incorporated in the same profile.

Although recent research on design engineers is sparse, several technical roles in related fields have been explored, for instance: civil engineers (Leiper and Khan, 1999); software engineers (Turley and Bieman, 1995); construction project managers (Edum-Fotwe and McCaffer, 2000); and technical project managers (Duncan, 1991). Unfortunately, due to the different terminology and categorisation methods used, it is difficult to compare specific competencies across these studies. However, the main competency *themes* to emerge were: role-specific technical competencies; competencies indicating a high level of motivation; the use of intelligence to solve problems and make decisions; teamwork; the management and leadership of others; communication; planning and management of projects and resources; innovation; and strategic awareness of the wider business and customer context. Although not all studies rated the relative importance of the various competencies, in those that did, the above themes were all of at least moderate importance.

Role-specific technical competencies therefore, although clearly essential, are just one of several important competency themes, even for such specialised technical roles. This differs somewhat from traditional views of design engineers' work that have hypothesised that 100% of their time is spent within the 'steps' of the technical design process (Pahl and Beitz, 1984). More recently, however, empirical studies have verified the prevalence of non-technical work. Hales (1993), for example, empirically tested Pahl and Beitz's hypothesised time allocations using participant-observation of design engineers, and found that only 47% of their time was spent engaged in such design process steps. The remaining 53% was spent planning work, reviewing/reporting, estimating cost, retrieving information, interacting socially, and helping others.