Design became increasingly separated from consumption; however, as Plante (1997, p. 77) observes, the differences between designer, consumer, user, and used are not clear-cut. For example, the deskilling of production may be mirrored by the deskilling of associated end-user tasks, as in the case of automated camera production and function. Conversely, production deskilling can result in the effective transfer of skills from professional to end-user. The do-it-yourself market is a manifestation of this transference, where many traditional construction or making skills have been replaced by less demanding and more flexible installation and assembly skills.

Skills – keeping ahead professionally, socially and psychologically

Little theoretical analysis of skills occurred until comparatively late in the post-war period of industrial development, when attempts were made to define them in relation to professional certification, resulting in an artificial division between professional (white collar) and non-professional (blue collar and usually manual) skills. To distinguish clearly between the knowledge differences within the skill-base of each, the former were deemed to be knowledge-based; the latter were deemed implementation skills.

In both groups, skills varied from habitual, unconscious reflexes performed repetitively – e.g., riding a bycicle or playing a keyboard, to high-order skills associated with specialist knowledge requiring concentration and risk assessment – e.g., performing surgery or manipulating advanced representational software. The key factor is practice context. Habitual skills are appropriate for repeated consistent application; high-order skills respond to complexity, changing conditions, unpredictability, and are frequently associated with risk.

Computers perform an infinite range of tasks and software developers have attempted to translate high order into habitual skills, regulating tools to make actions predictable, repeatable, and reversible – for example, the use of a "paintbrush" in computer-aided design (CAD) software no longer requires an understanding of paint viscosity. Commonality is increasing with the use of standard interface symbols which allow previously unique operations to be identified generically across a range of software. The flexibility and variety of control options makes it impossible to compartmentalize computer skills, for, like the skills deployed in playing the guitar, they operate at almost every skill level. Customized operating systems are becoming ever more intelligent, adapting to the user's competencies in all but the high-order end of the spectrum.

Initially, most representational technologies deskill, simplifying control and removing the unpredictable. There is a cascade effect with the decreasing cost of data processing impacting design functions, as high-order tools in a few practised hands become habitual tools in the semi-skilled hands of the many (Figure 8.1). Once deskilled sufficiently by data processing, the average person can learn many design skills "playing" with the software, developing skills seamlessly and acquiring simple habitual skills en route. The extensive capabilities of current representational software mean that the trained user is unlikely to acquire skills in all functions, particularly as, unlike many manual tools, their technological counterparts generally lack integration with one another. This lack of truly integrated design tools poses difficulties, particularly in the initial development of a design: the sketch and concept model early stage.

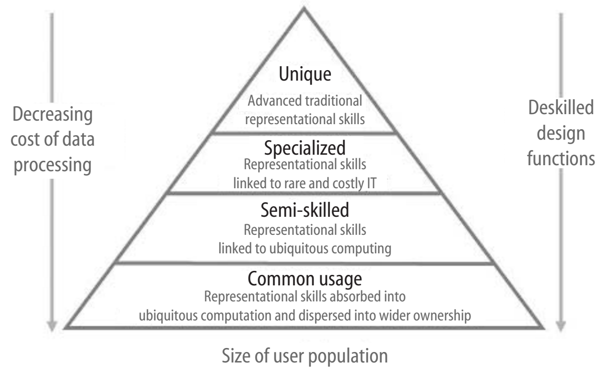

Figure 8.1 The diffusion of representation technologies into wider ownership.

While the power of data processing has brought about increasing efficiencies, particularly in the repetitive or mechanistic aspects of design, the removal of the unpredictable is closely associated with the loss of intimate interaction. The removal of creative serendipity by data processing bypasses and therefore ignores the levels of skill that determine the difference between the "unhappy accident" and the creative breakthrough. Indeed, it might be argued that highly refined or perfected skills militate against such abrupt advances by limiting the exposure of the skilled operative to fresh, if accidental, possibilities. In addition, making the tool, as well as using it, can be seen as extending this exposure to new stimuli by multiplying the expressive variables through which skills are applied. Furthermore, directly experiencing and reflecting on the representations made with the tool can also be seen as reinforcing the knowledge of the tool's known and unknown potential. This knowledge can ultimately determine the form, performance, and appearance of the resultant artefact in use.

Exercising coherent and integrated manual skills within the triad of tool making, tool use, and tool outcomes was a powerful creative force within the pre-industrial world that might be assumed to have little contemporary relevance. However, there are unifying parallels in design communications and computing that suggest that the potential already exists for similar creative gains in contemporary professional practice if required:

- *Tool making* equivalents exist in the reprogramming or reconfiguration of software controls and the construction of highly adaptable, manually operated, data input devices.
- Skilled *tool use* occurs during as in the operation of advanced design software controls in combination with such devices.
- *Tool outcomes* occur through engagement with the virtual artefact via increasingly vivid representational output devices or through the more tangible results of rapid prototyping.

Such realistic forms of representation arguably constitute "intermediate products" in which the barriers between non-working prototype, working prototype, and end product are dissolved by digital means. This process is complete in areas such as multimedia.