contextualize, visualize and make decisions within a single coherent communication process. It will change the use of the sketch from an essential but discontinuous process, to the status of a readily transmissible resource carrying information forward to further, more accurate representational stages, as part of an evolutionary flow of data. Integrating continuous reflection with design practice adds a new dimension to the "reflective practitioner" model developed by Schön (1998, p. 21), pointing the way to the accelerating pace of individual enquiry at the root of much experimental design. Coyne further suggests that:

> All enquiry begins with engagement. Tensions and irresolutions require response. Reflection can be defined as the process of going outside the immediate situation – "to something else to get a leverage for understanding it" – and involves the search for an appropriate tool. The tool is part of the active productive skill brought to bear on the situation. The tools that feature in the reorganization of the experience include theories, proposals, recommended methods, and courses of action. The applicability of the tool is worked out in the situation.
>
> *(Coyne 1995, p. 39)*

In this context, continuous representational data flow will present new opportunities for reflective commentary which both overlay and increasingly intertwine with visualization and perhaps serve as a timely reminder that text is as significant a modelling material as clay or graphite.

The elements of the design process – initial ideas, concept generation, research development, testing, and prototyping – have become part of a continuous data flow that facilitates productionization: moving seamlessly from conceptual development and prototyping, to manufacture, using a single evolving data resource. The continuous transmission of representational data that enables design development phases to run concurrently provides several advantages. This transmission has implications for design beyond speed and increased flexibility, greater fluidity and risk reduction, and marks a profound change in the fundamentals of design practice. This change in design protocol is potentially as significant as the change that occurred when design separated from production.

The control of skills

The transition of skill throughout history, from the development of man the toolmaker to the evolution of data processing, suggests changes that are both intrinsic and extrinsic, and indicates an evolving personalization of skill choices and organization, engendered by both socio-economic and technological forces. The development and use of representational skills closely parallel this historical transition, which is identified in Figure 8.3. The degree of individual control over the acquisition and exercising of design/making skills since the early industrial period has shifted from prescription to autonomy, and suggests a further development whereby the skills of leading-edge practitioners might be largely self-determined.

The control of tools and the development of skills can be traced through four generic phases:

1. "*Prescribed or regulated*" *skills* were commonly associated with early mass production when requisite skills were specified in great detail and

uniformly developed through apprenticeship training in order to fill the more complex gaps in incomplete automation. This situation occurred primarily because creativity and origination skills were viewed as direct threats to uniform quality control.

2. *"Evolved" skills* were associated with traditional crafts where techniques and tools evolved over generations, primarily in response to the inherent difficulties of fabrication by hand and, to a lesser degree, by the vagaries of demand. A degree of self-selection with regard to skilled technique was often tempered by practical tradition, with creativity and origination skills being largely confined to the perceived qualities of workmanship and the interpretation of traditional requirements.
3. *"Self-directed" skills* are addressed by the autonomous contemporary designer/maker whose learned skills are controlled and redirected under individual control, with creativity and origination skills prioritized and integrated within technical and making skills.
4. *"Self-originated" skill* applies to broad design data processing and has little historical or evolutionary precedent, since broadening diversity and functionality demands new skills of a high order to accommodate continuously evolving practices. Such skills cannot be "handed down"; they require the practitioner to become proactive in their origination, development, and ownership, with creativity and origination skills prioritized in all aspects of technical, design, and skills development.

Significantly, it is the amalgamation of self-directed and originated skills that is most likely to influence the emerging "cybercrafts" driven equally by designer-producers and designer-makers.

In terms of the training required for many computer-assisted modelling systems, the acquisition of appropriate interactive skills is usually overlooked

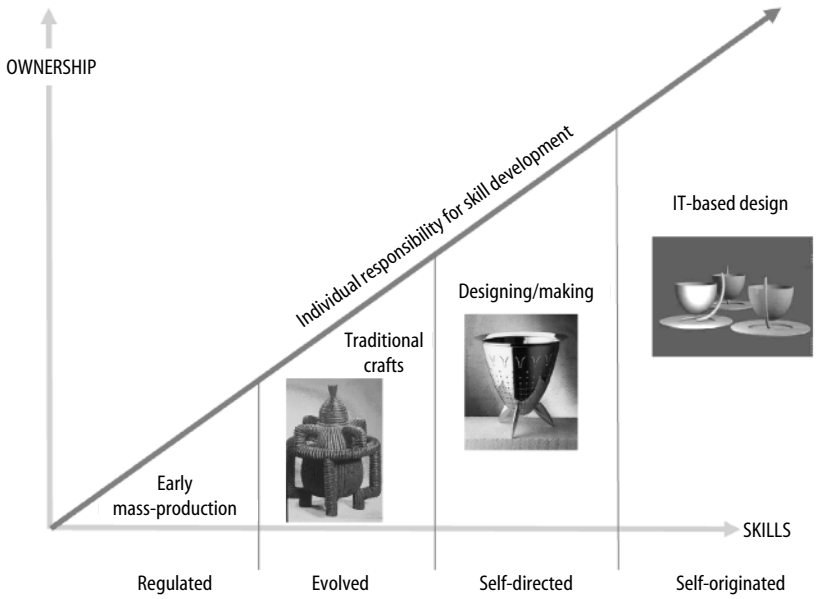

Figure 8.3 The evolving ownership of skills.