rendering applications, the question of technology and media in design representation has gained new significance, and representational skills, and their acquisition, have attained an importance of a new order of magnitude.

Skill ownership appears to be the major issue for the individual designer in his private design enterprise. Woolley (Chapter 8 of this volume), who talks about the deskilling of contemporary designers as a result of greater automation in design and its representation, sees a need for reskilling. However, whereas in the past designers acquired skills that were developed by others, i.e., traditional or borrowed techniques, Woolley thinks that reskilling is contingent on the designer's involvement in developing design tools. Accordingly, we may expect breakthroughs in Computer Aided Design (CAD) to depend on the participation of designers in software developments.

A case in point is the state of the art of computational support tools for the conceptual phase of designing, which lags behind other CAD applications that have already had a strong impact on subsequent stages of the design process (the production of technical documents, evaluation, presentation, and more). Current technological limitations are not the only reason for the slow development of support for conceptual design. To succeed, support must address basic cognitive operations of designers (the conceptual phase of designing is by and large a private affair, whether carried out individually or by a team). The introduction of affordable paper, and later of tracing paper, revolutionized the process of designing precisely because it allowed on-the-spot experimentation and representation cycles that are affordable both in terms of human resources (time and energy involved in sketching), and in terms of material cost (of paper). Computer applications that fail to "understand" that directness and immediacy of representation are of the essence in the generation of design ideas, have little chance to support natural design behaviour. It has been demonstrated time and again that the natural attributes of design ideation are most robust, and attempts to ignore, circumvent, or change them have thus far yielded disappointing results. It is therefore estimated that only when designers themselves take responsibility for the development of the computational representation tools they wish to put to work for them, can we expect real progress in this domain. In addition to effectively direct the growth of the offspring of today's CAD (and virtual reality), modelling and simulating, managing data-bases, case libraries, precedents and other computational design support tools must be further perfected. Facilities for collaboration, including at a distance, should allow team design, which is the order of the day. We should also take into account that new technological possibilities always redefine design itself. The relative ease with which we can today animate representations, for example, is already beginning to affect the way we think of hitherto motionless artefacts like buildings. If we can model motion in objects, we are likely to work hard to actually make "the real thing" move.

When we consider the public image of works of design, materialized or unexecuted projects, the technology and media used are, of course, an important component of the effectiveness of the image-making effort. The types of technology and media selected already harbour a message as to the design's general ambiance: "high-tech" buildings, for example, would look a bit ridiculous if represented publicly in a "low-tech" technique. A state-of-the-art presentation, using the latest technological means, is usually seen favourably and has commercial advantages as it projects competence and up-to-date design skills. Indeed, in today's marketplace advanced representational skills are a

valuable asset that is generously rewarded by employers and clients. The public images transmitted by designs and designers are thus not only a cultural matter, an agent for education, influence, and transformation. They are also the single most important ingredient in the kind of public relations that is the threshold requirement for survival in our media-driven culture.

In Conclusion

The central role played by representation in designing is captured in the following quote from the opening statement in *Retrospecta*, an annual (student-edited) publication of the Yale School of Architecture that presents work done in the school during the previous academic year:

> Projects develop through sketches in cardboard and on trace [paper]; they are pushed further through exacting CNC-milled projects and detailed renderings. But students are as likely to work through complex details by hand and to look to the computer as a means to produce quick analytical sketches.
>
> *(Paradiso et al. 2002, p. 2)*

The students' statement reflects more than today's technological state of the art. It also hints at the criticalness of choosing the most appropriate representational means for every phase of any given design task. We hope to have demonstrated the pervasiveness of representation, in particular graphic representation, in designing and in a rapidly expanding design culture, in terms of cognition, history and culture, and technology and media. Representation is part and parcel of the designer's thinking and reasoning, individually and collaboratively. It encapsulates the designer's repertoire and personal preferences, despite its dependence on available technology and the ownership of skills. In the public realm, representation is used to communicate more than design facts – it conveys messages concerning a wide cultural, social, and economical context in which the design has been conceived and is to be interpreted. Taken together, these parameters describe a possible epistemological basis for the study of design representation.

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Note

1. The industrial fabrication of translucent "sketch paper" did not begin until the second or third decade of the 19th century. The first photograph was taken at about the same time.