

FIGURE 2.4 A five-stage prescriptive model of the design process that shows (in dashed lines) feedback loops for: (a) *verification*, internal feedback during the design process; and (b) *validation*, external feedback obtained from users when they actually use the designed object.

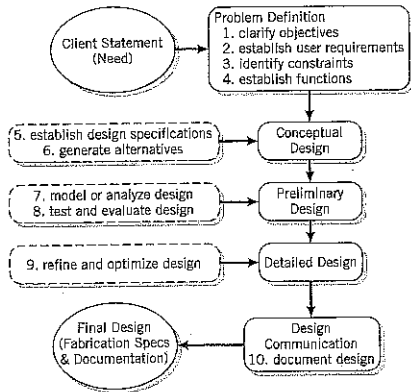


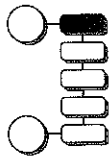
FIGURE 2.3 A five-stage prescriptive model of the design process. Like the descriptive model of Figure 2.2 this model also styles the process as a linear sequence of artifacts (*need* and *final design*) and design phases, within which are situated the design tasks.

1. During *problem definition* we clarify the client's objectives and gather the information needed to develop an engineering statement of the client's wants.

Input: *client's statement*

Tasks: *clarify design objectives (1)*
establish user requirements (2)
identify constraints (3)
establish functions (4)

Output: *revised problem statement*
refined objectives
constraints
user requirements
functions



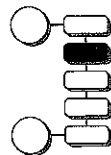
The *sources of information* during problem definition include literature on state-of-the-art, experts, codes, and regulations. *Methods* include objectives trees, pairwise comparison charts, function-means trees, functional analysis, and requirements matrices. The *means* include literature reviews, brainstorming, user surveys and questionnaires, and structured interviews.

2. In the *conceptual design* stage of the design process we generate concepts or schemes of candidate designs.

Input: *revised problem statement*
refined objectives
constraints
user requirements
functions

Tasks: *establish design specifications (5)*
generate design alternatives (6)

Output: *conceptual design(s) or scheme(s)*
design specifications



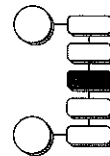
Competitive products are the additional principal *sources of information* for conceptual design. *Methods* include the performance specification method, quality function deployment (QFD), and morphological charts. *Means* include brainstorming, synectics and analogies, benchmarking, and reverse engineering (dissection).

3. In the *preliminary design* phase we identify the principal attributes of the design concepts or schemes.

Input: *conceptual design(s) or scheme(s)*
design specifications

Tasks: *model, analyze conceptual designs (7)*
test, evaluate conceptual designs (8)

Output: *a selected design*
test-and-evaluation results



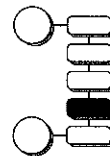
The *sources of information* include heuristics (rules of thumb), simple models and known physical relationships. *Methods* include refined objectives trees and pairwise comparison charts. *Means* include metrics definition, laboratory experiments, prototype development, simulation and computer analysis, and proof-of-concept testing.

4. During *detailed design* we refine and detail the final design.

Input: *selected design*
test-and-evaluation results

Task: *refine and optimize the chosen design (9)*

Output: *proposed fabrication specifications*
final design review for client



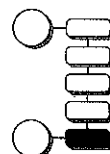
The *sources of information* for detailed design include design codes, handbooks, local laws and regulations, and suppliers' component specifications. *Methods* include discipline-specific CADD. *Means* include formal design reviews, public hearings (if applicable), and beta testing.

5. Finally, during the *design communication* phase we document the fabrication specifications and their justification.

Input: *fabrication specifications*

Task: *document the completed design (10)*

Output: *final report to client containing*
(1) fabrication specifications
(2) justification for fabrication specs



The *sources of information* during the design communication stage are feedback from clients and users, and itemized lists of required deliverables.

We now have a "checklist" we can use to ensure that we have done all of the "required" steps. Lists like this are often used by design organizations to specify and propagate approaches to design within their firms. However, we should keep in mind that this and other detailed elaborations add to our understanding of the design process only in a