Internal	⟶	External
Transient	⟶	Durable
Self-generated	⟶	Ready-made
Abstract	⟶	Concrete (Material)
	⟶	

Figure 4.1 Dimensions of design representations.

Transient vs. durable

Many design representations are transient, produced in the act of designing but never captured. Words articulated and gestures gesticulated in a design discussion are transient external representations. Similarly, transient information produced as a machine is being tested is often never captured. At the other end of the scale, durable representations are those sketches, drawings, and physical prototypes that endure and can be kept and referred to. They are often used as communication devices at meetings and they form the basis for further design developments.

Transient representations play a large part in shaping the design process and the final result. Brereton et al. (1996) demonstrated how words articulated in the negotiations of a design team drive the final product. Designers use negotiation strategies such as referring to third parties, standards and experience in order to promote their preferred design alternatives. Ideas that get discussed and rally support stand a greater chance of being developed into sketches and prototypes.

Self-generated vs. ready-made

Self-generated representations are produced by the designer in the act of designing, such as words articulated, sketches produced, and CAD (computer-aided design) drawings drawn. In addition to generating their own representations, designers often seek out ready-made pieces of hardware in their environment and gesticulate with them in order to help them think through an idea. Ready-made hardware is used because it has particular properties that assist thinking and it is readily available. In many cases a quick model is more important than an accurate model and prototyping or gesticulating with readily available pieces of hardware will get to a useful representation quickly. In the case of gesticulating with pieces of hardware, the representation has elements of ready-made, self-generated and transient. This fact is understandable when one recognizes that representations in design are continually evolving.

Abstract vs. concrete

Representations describe designs at various levels of abstraction. On the more abstract end of the scale lie lists of requirements, sketches, and scale models. A brief written list of requirements is abstract because, although it says what functions the design should fulfil, it does not specify the design. A number of different physical configurations could fulfill the same set of design requirements. Sketches are abstract because they leave much detail undefined.

As a result they can be interpreted in various ways. Sketches are often the preferred means of representation and communication at the idea generation stage, precisely because they do not force the designer to pay attention to details that the designer is not yet ready to consider (this is why it is so frustrating to use a CAD system when one wants to sketch). Issues of physical scale can also be considered on this abstract-concrete dimension. A scale model is usually more abstract than a life-size model. It usually has fewer details defined than the life-size model.

On the more concrete and specific end of the scale lie engineering drawings and physical machines. In contrast to a sketch, an engineering drawing of a design is very specific. Engineering drawing conventions were established to ensure that a trained machinist can interpret a drawing in only one way, so that he or she will build exactly what the designer intends. A drawing specifies a range of tolerances on each dimension and it specifies the materials to be used. However, an engineering drawing is still only a set of instructions to be interpreted. It has none of the three-dimensional, material properties of a real physical machine. Once a machine exists it is a unique piece of hardware, with unique dimensions. Its materials and form embody the history of all the manufacturing processes it has undergone and the cycles of loads to which it has been subjected. It wears uniquely, according to its context of use and its history of manufacture and operation.

Although representations vary from abstract to concrete, this scale alone cannot characterize the level and quality of information in a representation. Different representations make different kinds of information available. The way in which designers must interact with the representation in order to get the information that they need is an important factor for determining the usefulness of a representation. For example, a designer can rotate a shaft in its bearings in a physical machine in order to get a feel for the amount of play in the bearings. However, if the designer wants to know the nominal dimension between two shoulders of the shaft to within a millimetre, a measuring instrument must be obtained. In this case an engineering drawing, which is a less specific representation, would reveal this dimensional information directly through visual inspection. Just because a machine is more specific than a drawing does not mean that it conveys all the information about the machine to the designer more readily. Similarly, a computer simulation conveys different information and allows different design enquiries than a physical prototype. In particular, it is easier to adjust parameters and ask "what if" questions of a computer simulation. In contrast, a physical prototype is durable and cannot be changed easily; however, it can be used and manipulated in a context of use that allows the designer to understand human-machine and machine-environment interactions in a way that is difficult to do with even the most advanced computer models. Employing a physical prototype in a real context of use often reveals unanticipated information, which is one of the strengths of physical prototypes. So, the level of abstraction of a representation cannot characterize the kind of information that is available in a representation. The suitability of a representation to a task depends on the enquiry that is being undertaken by the designer.

It was tempting to include a scale that refers to whether a representation is "direct" or "indirect." The only "direct" representation of a design would be the final built machine. All other representations would be "indirect," alluding to what will be the final design. However, taking this approach would