ME450: DEFINING THE DESIGN PROBLEM

The very first step in the design process is to define what the problem really is. Since the goal of design is to satisfy a need we must understand what are the needs of the user. Satisfying these needs is the *design intent*.

The problem as first stated by the user may not be the actual problem but a consequence of it. For example, if someone states a need for a better bed (softer, harder, larger, higher, …) we may want to understand where this need comes from. We then find that the need for the better bed comes from the fact that he does not sleep well. Upon further query we may find that he has serious personal problems that affect his sleep. So a "better" bed is unlikely to satisfy his need and the perceived design intent is false.

In trying to uncover what is the actual problem and clarify the design intent one should always attempt to reach a deeper problem causality by asking a series of "why" questions:
"I need a softer bed."
"Why?"
"I can't sleep well."
"Why?"
"I wake up at night a lot."
"Why?"
"I am thinking about this problem at work."
"Why?'
….and so on.

This may seem artificial but it does help you and the user get closer on understanding the needs that the designed artifact will try to satisfy.

User needs stated in their original form are not always obviously quantifiable. For example, someone may need a room that is comfortable to work in through all seasons. "Comfortable" will need to be understood more precisely. What contributes to comfort? Possibilities include room temperature, humidity, barometric pressure, lighting, and furnishings. From these "comfort variables" we must decide which we can control, how easily (or at what cost) we can control them, and which might be the most important contributors to comfort. Suppose that temperature and humidity are the most important ones. These can be addressed by installing a heating/air conditioning system and possibly a humidifier/dehumidifier. To complete defining the problem we must decide the range of temperature and humidity values that we must be able to maintain, say, 60 – 80°F and 30-80%, respectively.

Although the technical problem may appear completely defined there may still be design criteria that have not yet been stated. For example, the cost (installation and/or operational) of maintaining the stated comfort levels is an obvious consideration. The size of the units and the ability to locate them may be another consideration. Cost, packaging, and manufacturing requirements will need to be quantified and included as part of the design problem definition.

The design intent can be summarized into a set of design requirements or *design objectives*, which should be expressed in the most quantitative way possible. As the design evolves we will need to ascertain that it meets our design intent. The simplest way to do this is to check how well the design meets the stated design objectives. The better an objective is quantified the easier it is to check its (degree of) satisfaction.

Transforming user needs to design objectives is the first step in the product development process represented in Quality-Function-Deployment (QFD). The "voice of the customer" in QFD is represented by creating a comprehensive list of the user needs *as the user understands them*, the list of "customer requirements." Next, the list of "design requirements" is created, which is the effort to translate the user needs to quantifiable design objectives. Showing which design requirement relates to which user need, and how strongly, is represented by the "relationship matrix." An actual number or range of numbers for each quantified design requirement is shown as the "target." These targets are part of the statement of design objectives for the problem at hand.

User needs and the attendant design requirements may often be in conflict with each other. For example, a requirement for high rigidity may conflict a requirement for low weight. How design requirements relate to each other is represented in QFD by the “correlation” matrix, which completes the so-called “house of quality.”

The value of the QFD process is in forcing us to think about the proper definition of user needs and the quantifiable design requirements that express them. An early QFD house of quality should be created before the generation of design alternative concepts. Once the user needs and attendant design requirements have been defined, the divergence process can be initiated to generate possible solutions.

At the conclusion of the divergence process some design concept must be selected for further development, the design embodiment. User needs are again called up to help make this decision. In the so-called Pugh Chart user needs are listed as columns and design concept solutions as rows. Each solution is then judged in terms of how well it meets each user need and a score is assigned based on some scoring convention. The concept with the highest overall score is then selected for further embodiment.

Before embarking fully on the embodiment of the selected concept a new QFD study is undergone that examines the same issues but now more specifically for the concept at hand. Although user needs will likely remain the same, design requirements etc. are likely to be modified and be more detailed. In essence the design objectives are restated in as specific way as possible for the relevant concept.

In summary, the following activities must be completed.

1. Creation of the user needs list.
2. Transformation of user needs to design objectives.
3. A pre-concept QFD study to create a generic house of quality.
4. Generation of alternative solution concepts.
5. Selection of most promising concept for embodiment using a Pugh Chart.
6. A revised QFD study to create a concept-specific house of quality.

Although these steps are described in a linear fashion, the actual design process is likely to be much more nonlinear, with overlapping steps and iterations. Yet the overall direction of activity will be roughly as defined above. The moment of truth is when the commitment to embodying a concept becomes irreversible because time and resource commitments force us to move forward.

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