The Engineering Design Process

1 Introduction

The engineering design process is a rigorous method of moving from a stated need to a product or system that meets that need. It is a creative and iterative process that is multidisciplinary and, in its fundamental form, is often applied in fields outside of engineering.

As with other creative processes, design tends to defy universal definition. There is, however, a commonly accepted form of the design process that you will use to guide your work in this course (Figure 1).

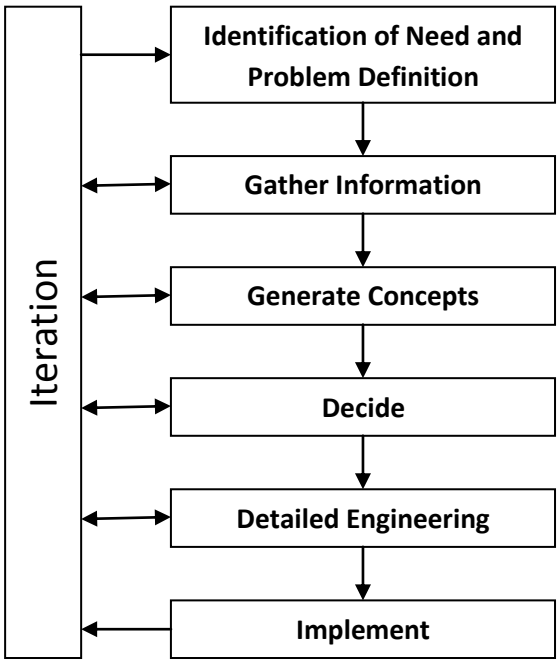

Figure 1 - The Engineering Design Process

2 Description of the Engineering Design Process Stages

The following sections describe each stage of the process indicated in Figure 1.

2.1 Identification of Need and Problem Definition

Of all the stages in the engineering design process, *identification of need and problem definition* is the most important. A small investment of time at the start of the project to understand the need thoroughly and to define problem accurately can save much time later in the design process.

2.1.1 Client Need

What a client perceives as their need, and what they actually need can be two different things. When a client states their "need", they may actually be presenting an assumed solution. Your job as a design engineer is to eliminate bias, evaluate assumptions, and separate your client's fundamental need from their vision of a solution.

For example, a client may state that they need tire enhancements designed for their wheelchair. Upon further investigation you may discover that the fundamental need is for increased mobility on rough terrain. The tire enhancements may be the solution to this, but there are other alternatives you should explore.

2.1.2 Problem Definition

Once the client's fundamental need is determined, a design engineer must create a clear and concise problem definition. This problem definition is NOT a solution. It is open-ended and does not presuppose any approach, method, technique or discipline.

2.2 Gather Information

The information needed for an engineering design is often more diverse and less readily available than that needed for a research project. Some of the questions that need to be answered at this stage include:

- Has someone else already solved this problem?
- Are there any existing patents that serve a similar function?
- What industry or governmental codes and standards govern this issue?
- What are the environmental implications of solving this problem? Social implications? Ethical implications?
- Is there relevant published information in the public domain? In academic journals? In trade journals? In print and web-based media?
- Are there existing libraries or frameworks that can be leveraged?
- What system architectures that can be used?
- Are there any design patterns you can follow?
- Are there any domain experts with whom you should consult?

The primary objective of this stage is to ensure that you benefit from the work of others (i.e. don't reinvent the wheel!). In this investigation, it is important not to limit yourself to the immediate field in which the design will be used.

Upon completion of this stage you should be familiar with the broad range of information that may be relevant to your project.

2.3 Generate Concepts

This is often the most creative stage in the engineering design process. This creative aspect makes team consultation particularly important. Your team is to generate a list of alternative designs. These designs are preliminary conceptual designs and not complete engineering designs. At this stage no design is too outrageous; this is the stage for generating designs, not evaluating them. Even seemingly impractical designs can become elegant solutions when seen from a different point of view. The primary product of this stage is a portfolio with many conceptual designs.

2.4 Decide

At this stage you must narrow your list of conceptual designs down to a single preferred option. The tools, methods, and tests by which you conduct this reduction will vary from project to project. However, in all cases your selection must be clearly justified on facts and sound logical reasoning.

2.5 Detailed Engineering

Most of the analytical content of the project is undertaken in this stage. The outcome of this stage will depend on the type of design project. In all cases, however, this stage will contain sufficient detail that another engineer or technical expert could reproduce your analysis (*i.e.* check the analysis) and implement your design based on your documentation. Possible aspects include: component selection, geometric dimensioning and tolerancing, stress and failure calculations, static and dynamic UML diagrams, use cases, test cases, etc.

2.6 Implement

In this stage, your detailed engineering work is used as the basis to produce a product or system. Depending on the type of design there are two different implementation options. For large systems, or when time and resources are insufficient, a model can be built that allows testing of critical aspects of the design but that does not have all of the desired functionality of the final product or system. This is often called a *proof-of-concept model*. The second option is a *prototype* which is a fully functional product or system.

In either case, the primary outcome of this stage is the testing of your proof-of-concept model or prototype. The testing methods will vary, but should be based on logical methodology that will allow future design projects to improve upon your design.

2.7 Iteration

It is important to note the iterative nature of the engineering design process. Various stages may be visited multiple times during the evolution of your design. For example in the process of generating your conceptual designs you may discover that you require additional information from the client and must revisit the *identification of need and problem definition stage*. You should feel free to jump back and into previous stages as your design needs dictate.

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<http://appsci.queensu.ca/courses/APSC381/2008/CourseNotes.php>