ELEN4000/4011: Student Approach to Design

Introduction

This document is a rough guide to assist a student with effectively framing their approach to the design project for ELEN4000 and/or ELEN4011. This document should be read in conjunction with the Course Brief and Outline, the introductory lecture and the marking grid for the project. This document is not intended to be a full guide to engineering design, but rather to provide context for the importance of this process in the degree programme and how a student might expect to encounter similar expectations when working as a professional.

The tone and style of this document is intentionally informal and should be considered as if it were a lecture or introductory talk.

Some important aspects of a design project will be discussed in the following subsections:

- The purpose of a paper design
- Design different to implementation
- The design process
- Why simulate the client experience?
- Consequences of a design with deficient elements.

In the introduction to course, the concept of simulating a client experience in the design meetings will be expanded upon in the following sections.

The Purpose of a Paper Design

The paper design is often the first process in a large engineering project. It is a document produced to convince someone that a project can be realised, i.e. it is possible to solve the problem. It is a relatively cost-effective step where the use of fundamental engineering knowledge which is incorporated to model expected system behaviour and indicate that specifications can be met.

A convincing design report should have the following key points:

- it must be fit-for-purpose,
- assumptions are reasonable for the level of abstraction,
- logical and coherent analysis and,
- justified in choices and conclusions.

A paper design is NOT the implementation of a project; implementation implies that a product is involved, be it based in hardware or software. Paper design is the planning stage of a potentially big, expensive and resource-intensive project.

It fundamentally addresses the question, “What if we had the budget and resources to achieve this goal or outcome?” At the graduate-level abstraction, the projects are specified in the realm of the possible. The key is how that possible outcome will be achieved. Depending on the type of design, this means that the specifications and boundary conditions need to be well stipulated towards solving for the intended theoretical outcome. Each of these need to be believable steps, that another engineer, reading the report, should be able to agree that the proposed steps will work the way it is reported upon.

Design Different from Implementation

In many aspects in engineering, it is very expensive to have an idea, then build, then test and validate that it is working the way that you expect. Mistakes or ill-conceived plans can be very expensive to try to recover from and has the potential to ruin the reputation of the implementing company.

Design is the first step to convincing someone that resources (money, time, man power, capital expenditure) should be allocated to implementation. This is a relatively in-expensive step.

Undergraduate courses prepare an engineer with the underlying physics, maths and electrical models to determine the performance of an input to an output of a process. Tests and examinations are often evaluating a students ability to manipulate the models towards a desired outcome. Consider how you can use the knowledge gained from undergraduate courses to build towards a coherent and logical set of steps to convince non-technical client and/or senior engineers to go ahead with your design. This links back to the production of a convincing design. Each step in the process and each decision made needs to be well justified. Assumptions need to be well defined.

The Design Process

The design process is non-linear; and it should not follow a pre-defined set of rules or steps. There is a creative element to engineering design, and therefore, it is expected that it should take on an iterative nature.

The design process is well documented, and so this is not an attempt at recreating that knowledge. You should be familiar with some basic design principles from software development and previous design courses. Please refer to design lifecycles and design processes for greater depth on the topic.

This is intended to provide a guide toward some of the key aspects you should expect from an engineering paper design and some questions you might ask yourself at different stages of your proposed design:

- **Initial phases:** assume that anything within the laws of physics is possible towards solving the problem. We are not concerned about the cost of resources, whether the component-level specifications exist or not. Instead, you need to use well-defined models to arrive at a theoretical solution that is viable.

- **First viable solution:** This is the first solution you can propose based purely on the simulated outcome (a.k.a minimum viable product, MVP). It is likely that you have already iterated through the formal design process in order to achieve a simulated outcome that “will work”. If we had access to the parts that have these technical specifications or behaviours, the system could be built to be fit-for-purpose. This is a great achievement, but you are not done.
- **Optimisation phase:** Depending on the type of project, there is usually an optimisation phase; and this optimisation may occur at different levels of abstraction. How can you refine your solution towards its intended purpose with better performance criteria? This is usually only the technical aspects without cost and resourcing considerations.
- **Towards implementation phase**: Some projects will require commercial viability, where actual part numbers and costing should be considered. Some of these factors may impact the optimisation phase. The initial assumption to ignore costs and realistic components should now be revisited. At this stage, the decision to converge to implementable components and cost limitations should be justified by the optimised performance of the simulated design.

Good designs iterate through many of these phases to arrive at a proposed design that can be passed to implementing engineers.

Why simulate the client experience?

In the introductory lecture, we discussed how you should approach the project as if you are a professional already working for a company and have been placed on a project to propose a solution for a client. Therefore, you should approach the weekly meetings as if they are client meetings, where the topic supervisor is a non-technical client who wants you to present progress on solutions.

You might ask why we simulate this experience. Right now, we think you are great. You have successfully completed three years of UG engineering courses and you have passed all the courses in the curriculum that are designed to prepare engineers with the foundational knowledge required, but we need to see that knowledge applied towards a problem. Many of the prior courses rely on tightly scoped projects with limited focus and ultimately do not directly examine some of the Graduate Attributes that need to be individually assessed as part of the ECSA requirements for graduate engineers.

Therefore, before the School can indicate to the world that you are a capable engineer that can independently solve technical problems, we need to test it with a simulation through a capstone project. You can view it as the School simulating a student response to the professional world. The key aspects of this simulation are the weekly meetings and the final design report.

Weekly meetings

Assume weekly meetings are client meetings, in order to present your client with progress on your proposed design. Consider that the client is paying you for your time and professional expertise to produce weekly updates. The client does not understand electrical engineering concepts and requires YOUR professional input and insights towards the problem.

- Arriving late or non-attendance to a client meeting is a poor reflection of your professionalism. Technical issues are also not a very professional excuse. One should find a way to have a presence at the meeting; at the very least send apologies ahead of time and send some proof of progress with whatever questions you were hoping to have clarified.
- Arriving at a client meeting without showing sufficient progress is also a poor reflection of yourself, and the company that employs you. You should be demonstrating in the meetings WHY someone should continue paying you for the work you are producing.
- You are not expected to be a perfect engineer just yet, but you are training towards it. Therefore you should ask questions when you require clarification. You should not be attending meetings expecting to react to material covered. You should show initiative and ask questions; although, in true EIE form, you may not always get a straight answer.
- The topic supervisor may put on the "senior engineer" hat to prevent you from going in the completely incorrect direction.
- Your silence in the session is at your own risk. It may result in your proposed design being rejected (or ultimately, failure of the course).

The design in report form

Assume the paper design that you are submitting to your client is a submission for potential implementation. Your client needs to decide if they are willing to spend the money to implement your proposed solution. The report that is presented should be understood by an implementing engineer without needing to contact you, i.e. sufficient detail needs to be present with justification for each design decision. It should be a convincing document.

To have confidence in your work, you may ask yourself: "If I had access to the money and resources required to implement the project based on my own evaluation of costs and expected performance indicated in the final report, would I spend the money to implement?"

If the answer is "yes, but.." think about what that "but" refers to, and can you spend some time refining it? There is also a danger that you answer "yes" to this question from a position of limited experience - you should be cautious to answer positively if that is the case. For instance, if you have only undergone one iteration through the design process, it is likely that your "yes" is severely uninformed.

Consider that your examiners will be asking themselves the same question when evaluating your report. Their "yes" will be an informed one.

Consequences of a design with deficient elements

It is difficult to discuss designs with deficient elements, but as engineers, we must always consider the impact of decisions and actions taken. Imagine your job is on the line when presenting the paper design:

Scenario 1: If the design is deficient and therefore the project is not chosen by the client based on your report, this is problematic. You have spent 6 weeks of paid time to put together a proposal that the company did not obtain income for.

- Employer may be asking whether s/he should keep you on the job.
- Luckily, the Design groups are not set with a single tender awarded, but this should factor into your thinking as you conduct yourself in sessions.

Scenario 2: If the project gets chosen, but there were deficient issues with the design, i.e. the costs were calculated incorrectly, products suggested do not exist, or even worse, someone builds according to your plans but it does not perform as you report.

- In this case, the client loses money and may have to pay extra to get it fixed. The company may pay penalties due to poor design.
- The client may never use the company you work for again, since this failed design would be a poor reflection of you and the company.
- Your employer may be asking who approved the project and all the people associated with the project may fall under scrutiny.
- If you are a registered engineer, your membership may even be revoked, depending on the scale and impact of the issue.

Conclusion

This document serves as a rough guide to assist a student with contextualising his/her approach toward Engineering Design, a capstone course for the degree of Electrical and Information Engineering. The student should understand the purpose of a paper design, which is fundamentally different to the implementation stage of a project. A completed design that has not iterated through the design process is likely an unrefined solution. The student should understand the value of a convincing design and simulate him/herself as a practising engineer in both conduct at meetings as well as the quality of the document that is produced.