Research Brief
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Considering Life Cycle During Design: A Longitudinal Study of Engineering Undergraduates

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In this age of global warming and diminishing fossil fuel stores, society is becoming increasingly aware that seemingly small decisions can have surprisingly far-reaching implications on the environment and future generations. Accordingly, today's engineers must approach design problems with a holistic, broad view of the impacts, environmental and otherwise, of their solutions.

The notion of life cycle provides a structured, comprehensive approach for assessing the impact of an engineering solution, whether it takes the form of a product, a service, or a process. Many engineers have long valued life cycle analysis as an important tool in the design process, and life cycle is discussed in the literature of numerous engineering disciplines.

Using the life cycle framing (see full paper for a complete discussion), the present analysis examines the degree to which engineering students consider design problems in a temporal context, i.e., considering the full life span of the design artifact, from conceptualization to disposal.

Implications of Findings

The findings from this study provide a baseline assessment of how broadly engineering undergraduates approach design with respect to life cycle considerations. Our assessment suggests that there is a great deal of room for improvement in this regard, justifying the increasing interest in courses and curricula concerning life cycle and other sustainability-related topics for all engineering students. This study also highlights the utility of life cycle as a framework for assessing and facilitating the development of student ability to approach design with a broader perspective. In particular, the use of life cycle in assessment shows promise in research like ours and is likely to be equally applicable to formative goals in design courses and curricula.

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Methods and Background

To date, most of the engineering education literature's treatment of life cycle has been limited to discussion of innovative exercises and courses. In particular, there has been little examination of how much engineering students consider life cycle during design or of rigorous approaches for assessing students in this regard. To help address this gap in the literature, this paper reports on empirical research on undergraduate engineering students' design processes as assessed from a life cycle perspective. The study design, coupled with oversampling of women, provided a unique opportunity to address the following research questions:

RQ1. How broadly do engineering undergraduates consider life cycle when evaluating design alternatives?
RQ2. How are gender and class standing related to the breadth of life cycle consideration?

Data for this paper were collected as part of the Academic Pathways Study (APS), a multi-institution, multi-method, longitudinal research study. APS was the main activity of the NSF-funded Center for the Advancement of Engineering Education and focused on students' experiences as they move into, through, and beyond their undergraduate engineering educations. Data collection for this study occurred during a four-year period at four U.S. institutions.

In their original form, data analyzed for this paper were drawn from a set of handwritten responses to an engineering design task. In the task, participants were asked to design a method to allow pedestrians to cross a street at a busy intersection. Specifically, they were given 15 minutes to respond to a sequence of four open-ended questions about the problem and their design solution. This street crossing design task was administered to the APS participants twice – once in their second year of engineering study, and once in their fourth year. The data set consists of 131 responses collected from self-identified engineering majors in Year 2 and 61 responses collected in Year 4. Of the latter 61 responses, 59 were from repeat participants, i.e., matched pairs of longitudinal data from students who completed the task in both their second and fourth years and were still enrolled as engineering majors in Year 4.

For a detailed discussion of data collection and analysis methods, please see the full paper at the link below.

What We Found

Overall, findings for RQ1 indicate that the majority of the engineering students in the longitudinal sample did not consider the life cycle stage "design and construction" in their solution evaluation in either year. The proportion of those who considered the life cycle stage "maintenance and disposal" was even smaller in both years, in spite of the fact that in the street crossing task (as with many engineering design problems), maintenance typically represents the longest period in a solution's life cycle.

Two main findings emerged from the RQ2 analyses. First, the full sample (131 students) of responses available in Year 2 indicated that women were more likely than men to consider "design and construction" in evaluating solutions. Although the smaller size of the longitudinal sample (59 students) limited the power of within-year gender comparison, proportions and differences for the longitudinal subset of data were similar to those observed in the full Year 2 sample. This is consistent with our conjecture that the lack of statistically significant difference in the longitudinal sample is due more to its size than to substantive differences between the 59 longitudinal participants and the 72 for whom we have only Year 2 data. Second, analyses of Year 4 data indicated similar proportions of men and women who considered "design and construction" in evaluating their solutions (both with the full and longitudinal samples). Together, these two findings suggest that the gender gap for this aspect of life cycle consideration narrows after the second year of undergraduate engineering study. Small sample sizes prohibit conclusive analyses within gender, but this narrowing appears to be due to the men "catching up" with the women, whose consideration of "design and construction" did not appear to change between Years 2 and 4. The street crossing design task is a tremendously rich source of data, and this study represents only the first steps with one of many analytical lenses we are applying.