

Design and Assessment: Theory and Practice*

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This paper draws parallels between the theories of engineering design and assessment in higher education. Examples of context within which both concepts arose are cited. The paper concludes by arguing that when engineering faculty engage program and classroom assessment, the very principles of engineering design are reinforced.

INTRODUCTION

AS THE TWENTIETH century closes, engineering and higher education in America exhibit compelling similarities. Both reside regally atop their respective mountains of technical and scholarly achievement. Yet both are plagued by clouds of public skepticism. Their respective responses—design and outcomes assessment—are interventions that have the potential to clear away negative perceptions darkening the otherwise magnificent skies above engineering and higher education. Where engineering design keeps the creation of technical artifacts in touch with human expectations and needs, outcomes assessment similarly keeps the intersection of teaching and learning anchored to the expectations and needs of the publics it serves. Thus, both design and assessment keep their respective enterprises connected to their social purposes.

The following pages examine first the similarities between the separate domains of design and assessment in their theories and origins. Secondly, the integration of design education with assessment is explored in terms of natural consequence, educational congruence, and curricular opportunity in engineering design education.

THEORIES OF DESIGN AND ASSESSMENT

Recognizing that both design and assessment are auxiliary to the larger purposes and more encompassing theories associated with both engineering and higher education, the theory of assessment is nonetheless highly suited for a discussion within the context of design theory. Using the definition of Dym and Little, as an example, the theory of engineering design is stated as [1]:

... the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints.

The term ‘evaluation’ is key in this definition, just as it is a key concept in the theory of assessment. Indeed, many consider the terms evaluation and assessment as equivalent. Using the language of Dym and Little, the theory of assessment could be similarly stated as:

The systematic, intelligent generation and evaluation of student learning outcomes whose characteristics and properties achieve stated objectives and satisfy specified criteria.

For the purposes of this discussion, it is also helpful to state the theory of assessment grounded in its own literature. T. Dary Erwin defines assessment as [2]:

... the systematic basis for making inferences about the learning and development of students. More specifically, assessment is the process of defining, selecting, designing, collecting, analyzing, interpreting, and using information to increase students’ learning and development.

Using a comparative construction, the theories of design and assessment are revealed to have at least four common elements, as follows:

- identified goals, objectives, and criteria;
- systematic generation of information;
- systematic evaluation of information generated;
- systematic comparison of information generated against known goals, objectives, and criteria.

Most importantly, the role of evaluation in both theories is to improve outputs or outcomes by means of a feedback loop. These similarities in engineering design and assessment may have to do with social conditions giving rise to their prominence at the end of the century. The following section briefly discusses commonalities in their ascent.

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ROOTS IN DISCONTENT

Beyond commonalities of underlying theory, both engineering design and assessment arguably arose by way of concerns at the intersections of engineering with its users and higher education with its constituents.

In the case of higher education, I propose that although the nation has developed a powerful higher education system in terms of faculty, researchers, and leaders, there is evidence that this system is failing in some fundamental ways as evidenced in the following observations:

- The Sylvan Learning Centers are now offering a distance-learning masters program in teacher education [3]. Sylvan is representative of a wave of privatization and commodification in higher education—suggesting that the traditional system has failed to meet society's educational needs.
- Corporations like Motorola now offer their own courses such as process mapping, teaming, project management, product and process design to their employees [4]. These extensions of higher education by corporations suggest that higher education may leave gaps in preparing students for productive work.
- Finally, the institutionalization of student outcomes assessment by states, accrediting and granting agencies, indicate that the system's constituents have become skeptical of the claims of higher education.

These examples signal that college and university faculty and leaders have not kept up with, do not appreciate, or have not adequately communicated connections between the higher education system and the needs of the society it purports to serve.

In the case of engineering, highly visible events as well as less visible but substantial forces have influenced the system. Highly visible events include:

- the 1981 collapse of a suspended walkway in the newly constructed Hyatt Regency Hotel in Kansas City sending 114 people to their deaths [5];
- an escape of lethal gas in 1984 from the Union Carbide pesticide manufacturing plant at Bhopal, India, killing 4,000 and injuring 30,000, [6];
- the 1989 collapse of San Francisco's double-deck Nimitz Highway in an earthquake, crushing motorists travelling on the lower deck [7].

The less visible events are described by Robert Pool as [8]:

The past couple of decades have been a confusing, frustrating period for engineers. With their creations making the world an ever richer, healthier, more comfortable place, it should have been a time of triumph and congratulation for them. Instead, it has been an era of discontent. Even as people have come to rely on technology more and more, they have liked

it less. They distrust the machines that are supposedly their servants. Sometimes they fear them.

To close the gaps in real and perceived public fear and distrust, engineering design has grown in prominence as a means to make 'proper use of science and technology—their timely and wise application to help people with their problems, enhance their opportunities, and provide them with acceptable means to satisfy their requirements while maintaining a good balance of safety, health, and protection of the environment' [9].

Rooted in discontent, the theories of assessment and engineering design converge powerfully in engineering design education. The concepts now come together to provide educators an extraordinary means of demonstrating to students the integration of engineering design theory and educational practice—reinforcing the social purposes of engineering design through classroom assessment. The following section discusses similarities and possibilities in this convergence of assessment and engineering design.

THE PRACTICES OF DESIGN EDUCATION AND ASSESSMENT

In practice, the *feedback loop* concept is present in both engineering design and assessment. The feedback loop is a systematic means of checking actual outcomes against intended goals. In engineering design, the concepts of **verification** (internal feedback during the design process) and **validation** (external feedback obtained from users when they actually use the design object) are analogous to **formative** assessment (information gathered for the purpose of developing program) and **summative** assessment (information gathered for the purposes of determining program effects).

Other similarities between design and assessment practices include:

- Both require clear objectives. Neither of these processes can proceed unless client objectives in the design construction and educational goals in assessment are clearly stated.
- Translation may be involved in both cases. Client objectives are translated through the design process into the 'kinds of words, pictures, numbers, rules, properties, etc., that we need to characterize and describe the artifact being designed and its behavior [10].' Similarly, the assessment process may require the translation of goals into statements of assessable outcomes.
- Common tools are used in design and assessment, including: literature review, brainstorming, user surveys and questionnaires, interviews with users and stakeholders, benchmarking, and defining metrics.
- Design and assessment are processes used to keep the work of engineers and faculty consistent with the needs of users through systematic communication.

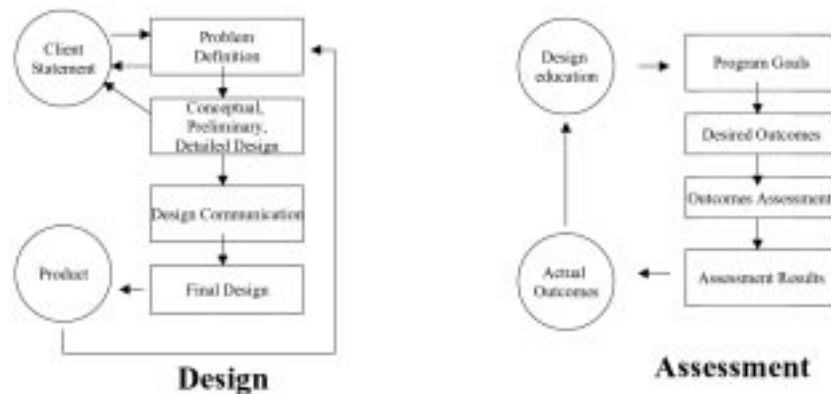


Fig. 1.

The feedback mechanisms and tools of design are the heart of assessment. Just as engineers begin with a problem definition and rely on feedback to determine whether their design and eventual product have satisfied the conditions of the problem definition, so faculty begin with educational learning objectives for their students and rely on assessment to inform them if the program achieves those learning objectives.

It is important to note that assessment is about program performance, as distinguished from student performance and from faculty performance. At Harvey Mudd College, faculty administer grades to measure how well students perform in mastering course content, and students complete course evaluations to measure faculty performance in delivering course content. Program performance, however, is assessed through the assessment process.

The similarities in assessment and design theory and practice suggest that faculty who teach engineering design are predisposed to the purposes and methods of assessment and have a special opportunity to demonstrate through their own actions the very principles of their subject matter

(engineering design) when they incorporate the processes of assessment in their daily classroom work.

CONCLUSIONS

I wonder if teachers ever fully realize the power they have to shape our lives. With each word and gesture, a **teacher** places a stone on the scale of life. If an idea doesn't add weight to our knowledge, it subtracts—either as a fallacy that misleads our thinking or a triviality that blurs it [11].

Engineering design faculty powerfully demonstrate their belief in design when they use classroom assessment to demonstrate they are interested in learning from their students how effectively the design of their program and courses meet programmatic learning objectives and goals. Assessment thus presents a unique opportunity for educators in engineering design to demonstrate and reinforce the principles of their teaching. By incorporating assessment into the teaching of design, a stone is placed which adds weight to the very concept of design.

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