Information Literacy Skill Development and Assessment in Engineering

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Abstract

Prior literature, as well as our own research findings, indicate that undergraduate students have underdeveloped self-directed learning skills, especially in the area of information literacy. This lack of knowledge and skills, which are critical for life-long learning, present a hurdle for engineering graduates who must constantly renew and expand their skills in our rapidly changing knowledge-based society. While research on college students’ general self-directed learning and information-literacy skills is rich, many of these studies and related assessment instruments focus on topics in social science and rarely explicitly include, or are specific to, engineering. In addition, while there are assessment instruments that address these skills, most of them focus on information search skills. In this project, we aim to develop two valid and reliable information literacy assessments (a multiple choice skill test and a Likert-scale perception survey) that can be used to diagnose engineering students’ self-directed learning with a focus on information literacy skills and attitudes. Through a partnership between engineering and library faculty, we developed and pilot-tested two assessment instruments. These instruments were psychometrically evaluated and then compared to a more authentic and direct measure of information literacy. While the preliminary results provided some promising validity and reliability evidence for these instruments, further evaluation is necessary prior to wider dissemination. This two-year project will focus on the evaluation of improvement of these two instruments.

Introduction

Research findings from multiple studies indicate that undergraduate students have underdeveloped self-directed learning skills, particularly in the area of information literacy\(^1\text{-}^3\). This lack of knowledge and skills, which are critical for life-long learning, can challenge engineering graduates who must constantly renew and expand their skills in our rapidly changing knowledge-based society.

The curriculum of technical majors has been estimated to have a half-life of less than five years\(^4\). Thus, one of the most necessary skills students can take away from a technical education is the ability to become life-long learners. Life-long learning has historically been recognized as important to the engineering community, as articulated in the final report of the Goals Committee on Engineering Education\(^5\). More recently, life-long learning has taken on renewed importance with its inclusion as one of the core student outcome criteria (3.i) of ABET\(^6\). This criterion requires that all accredited engineering programs demonstrate student attainment of outcomes related to life-long learning.
Life-long learning is a complex construct that is difficult to define and measure. Engineering education, adult learning, and library science agree on common characteristics; continuous, voluntary, and self-motivated. Students who can take control of their own learning are better able to adapt to our increasingly knowledge-driven economy and stay abreast of change in science and technology and thus remain relevant to the modern workforce.

**Purpose**

In order to address these gaps, we need robust curricula that target information literacy skills and attributes necessary to enable life-long learning. Even more importantly, however, we need useful assessment tools that will provide a better understanding of engineering students’ self-directed learning skills and a valid measure of how these skills improve. While there are assessment instruments that address these skills, most of them focus on information search skills and a non-engineering application.

In this project, we aim to develop two valid and reliable information literacy assessments that can be used to diagnose engineering students’ self-directed learning with a focus on information literacy skills and attitudes. The two assessments constructed consist of a multiple-choice instrument and a Likert scale self-assessment of student behaviors related to engineering design. Preliminary work was carried out under a Purdue Engineer of 2020 seed grant. The project goals and objectives are summarized in Figure 1.

These instruments will situate self-directed learning within an engineering context by: 1) focusing on skills used in the engineering design process, 2) using technical and scientific topics relevant to engineering and engineering grand challenges, 3) being designed and evaluated by engineering faculty and tested and validated using data collected from engineering students.

Initial instrument development has focused on the primary questions making up the first tier of the proposed two-tier assessments. Two-tiered questions have two main benefits over conventional one-tiered questions: 1) the two-tiered format allows for the assessment of higher-level understanding. In the first tier, students are asked to answer a factual or conceptual question, and the second tier asks for an explanation probing deeper learning; 2) this approach decreases measurement error. For example, in a one-tiered multiple-choice question with five possible choices, there is a 20% chance of correctly guessing the answer. Because a two-tiered question is considered correct only if both tiers are answered correctly, a student responding to a question with five choices in the first and five in the second tier will have only a 4% chance of randomly selecting a correct answer.
An instrument must have validity and reliability evidence to ensure its psychometric soundness and justify the inferences derived from its sources. We will establish the psychometric soundness of our instruments by following instrument development guidelines and conducting item analysis, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA).

**CELT instrument development**

In the Critical Engineering Literacy Test (CELT), our multiple-choice instrument, the first tier of each item will consist of a factual question with four or five choices. The second part (tier) of each item will contain a set of four to five justifications for the answers to the first part. These justifications will include a correct answer and distractors derived from students’ alterative explanations gathered from our prior studies.

The objective of the CELT instrument is to provide a semi-authentic, contextualized information task with selected response test items that are easily scored for rapid feedback. The alpha version of the assessment consisted of one engineering-related scenario: a student team composed a memo to a University representative containing recommendations on ways to save energy in the dormitories, and an argument to support their recommendations. Students were required to read the short (one page) memo and respond to a series of ten multiple choice items. The internal reliability of the alpha version of the CELT instrument was poor, with a KR-20 of 0.39 and varying levels of item difficulty ($p=0.16\text{ to }0.91$) and discrimination indices ($d= -0.05\text{ to }0.18$). This was not surprising given the range of information literacy skills targeted and the small number of items. To address the poor reliability, a second scenario was added to the assessment in the form of a letter to the editor regarding the public health and environmental concerns with the use of genetically engineered salmon versus traditional farm-raised salmon, and expanding the potential audience to the larger STEM community. The new scenario was accompanied by eight new selected response items, which included six multiple choice items and two select all that apply items.
The improvements in between early versions were made using data from classical item theory. We will expand our future analysis by using item response theory (IRT), which will help identify issues with the current items and inform the development of new items. Exploratory factor analysis (EFA) will also be used to ensure CELT is measuring the concepts (factors) intended to be addressed.

**ESAPSS instrument development**

In Evidence-based Self-Assessment of Problem Solving Strategies (ESAPSS), our Likert-scale instrument, the first tier of each item will consist of a 5-point scale perception question. The second part (tier) will ask the student to provide examples as evidence supporting their selection. These justifications will enable the student to re-evaluate their decisions and allow us to evaluate reliability of students’ scores in the light of the evidence they provide.

The alpha version of the Likert-scale survey, called Self-Assessment of Problem Solving Strategies (SAPSS) (without the evidence component), included key strengths such as high reliability scores (Cronbach’s alpha=.98). However, more work needs to be done to increase the validity of this instrument. Prior studies show students tend to rate their skills high despite their limited self-directed learning and information literacy skills. Researchers in engineering education, as well as us in our prior studies, found similar results. We will deal with the issue of student perceptions by developing the Evidence-based Self-Assessment of Problem Solving Strategies (ESAPSS), which incorporates a two-tier assessment approach.

**Exploratory Factor Analysis**

The SAPPS instrument was taken by first-year engineering students (n=1631) and these data were used to conduct an exploratory factor analysis (EFA). The data were checked first for normality. Although the skew and kurtosis fell within acceptable ranges (3,10), because the means were quite high, the data was treated as non-normal. Inter-item correlations were assessed and all items were found to have acceptable levels of correlation. An exploratory factor analysis was performed in Mplus using MLE estimation with a Promax rotation. Several models were estimated. Items that did not significantly load on a factor were removed iteratively and the EFA was conducted again. The final model decision was based on eigenvalues, goodness of fit indices provided in Mplus output, and conceptual framework.

Six items were removed from the scale due to low communality or insignificant loadings. Five factors were retained in the EFA. In order to gain a better understanding of how to improve future versions of the SAPSS, items that cross-loaded were allowed to remain. This information can be used to better clarify the categories where there is conceptual overlap. Reliability of the final 20 items was calculated with Cronbach’s Alpha, $\alpha=0.90$.

**Future Work**

Moving ahead, the CELT instrument will continue to be refined and data from students at multiple schools will be included in additional validity and reliability testing. Analysis of prior research data will contribute to the creation of the second tier questions.
The ESAPPs instrument is entering the second version to respond to the factor analysis and ensure all aspects of information literacy as part of self-directed learning are being evaluated with the instrument.

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References


