Important Engineering and Technology Concepts and Skills for all High School Students in the United States: Comparing Perceptions of Engineering Educators and High School Teachers.

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Abstract

Engineering and technology education (ETE) are receiving increased attention as components of STEM education. Curriculum development should be informed by perceptions of academic engineering educators (AEEs) and classroom technology teachers (CTTs) as both groups educate students to succeed in the technological world. The purpose of this study was to identify ETE concepts/skills needed by all high school students in the United States, and to compare perceptions of AEEs and CTTs relative to their importance. This research was carried out using modified Delphi research methodology involving three survey rounds interspersed with controlled opinion feedback.

Consensus was found on 14 of 38 survey items within five ETE domains (design, modeling, systems, resources, and human values) that are repeatedly referenced in the literature. The most important competencies for HS students to learn were to: 1) identify/discuss environmental, health, and safety issues; 2) use representational modeling to convey the essence of a design; 3) use verbal/visual means to explain why an engineering design decision was made; and 4) show evidence of considering human factors when proposing design solutions. The study established a consensus between AEEs and CTTs that contributes to the body of knowledge about what HS students should learn in ETE. Study results can inform curriculum development and revision of the U.S. national standards for technological literacy (STL).

Keywords: STEM; high school; survey; engineering and technology education; Delphi.

Introduction

Due to the essential roles engineering and technology play in addressing societal and environmental challenges, support for PreK-12 engineering and technology education (ETE) programs in the United States has been rapidly growing (Katehi, Pearson, & Feder, 2009). There is growing recognition that school-based ETE experiences can be pedagogically valuable for all students—not only in providing an effective way to contextualize and reinforce STEM skills, but also in mobilizing engineering thinking as a way for young people to approach problems of all kinds (Brophy & Evangelou, 2007; Forlenza, 2010). This study compared the perceptions of two constituencies whose missions focus on preparing students to succeed in our technological world through engineering and technology education: Academic engineering educators (AEEs) who prepare future engineers at the university level; and high school (HS) classroom technology teachers (CTTs) who teach engineering and technology courses at the secondary school level. The study established a consensus among the groups about the most important ETE concepts and skills that all students in the United States should learn by the time they graduate from high school.

Literature Review

A literature review established a basis for identifying competencies for the initial item set in the study's survey instrument. The review also determined how to optimally use Delphi research methodology to converge expert opinion to arrive at consensus (RAND, 2011); and examined differences between engineering and technology and the preparation of professionals in those fields.

Differences between Engineering and Technology

Engineering. Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind (ECPD, 1979 as cited in NRC, 1986, p. 74). The definition advanced by the Accreditation Board for

Engineering and Technology (ABET) is that “engineering is the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination” (ABET, 2000). Bloch (1986, p. 28) wrote that engineering is the process of investigating how to solve problems that leads to a body of engineering knowledge consisting of concepts, methods, data bases, and physical expressions of results. Wulf & Fisher (2002) describe what engineers do as “design under constraint.”

Technology. The National Assessment Governing Board (NAGB) defines technology as “any modification of the natural world done to fulfill human needs or desires” (NAGB, 2008). According to de Vries (2005), technology is “the human activity that transforms the natural environment to make it fit better with human needs, thereby using various kinds of information and knowledge, various kinds of natural (material, energy) and cultural resources (money, social relationships, etc.).” Kline (1985) suggests that technology is viewed in four ways: as an artifact, as a methodology or technique, as a system of production, and as a sociotechnical system. Swyt (1989), at the National Institute of Science and Technology, differentiates between engineering and technology by explaining that engineering is oriented toward the solution of specific problems, while technology is oriented toward development of new capability.

Preparation of Academic Engineering Educators and Classroom Technology Teachers

Academic engineering educators and classroom technology teachers in the US come from different educational traditions, although both groups advocate the importance of technological literacy for the general population. Engineering emerged as a separate subject with the founding of the first schools of engineering and professional societies in the 18th century. AEEs typically have post-graduate degrees in engineering. In the United States, technology education emerged from industrial arts, and worldwide, technology education had its roots in crafts teaching. State-certified CTTs typically have master’s degrees in technology education.

ABET Program Standards for Engineering Programs

The Accreditation Board for Engineering and Technology (ABET) *Criteria for Accrediting Engineering Programs* (ABET, 2000), state that engineering graduates must have the ability to: apply knowledge of mathematics, science, and engineering; design and conduct experiments; analyze and interpret data; design a system, component, or process to meet desired needs; function on multidisciplinary teams; identify, formulate, and solve engineering problems; communicate effectively; and use the techniques, skills, and tools necessary for engineering practice. Graduates must understand the impact of engineering solutions in a global and societal context; recognize the need for lifelong learning; and understand contemporary issues. ABET requires educational programs to include a major engineering design experience that builds upon the fundamental concepts of mathematics, basic sciences, the humanities and social sciences, engineering topics, and communication skills. Engineering topics must include subjects in the engineering sciences and engineering design which, according to Section I.C.3.d.(3)(b), have their roots in mathematics and basic sciences but carry knowledge further toward creative application (ABET, 2000, 2012).

NCATE Program Standards for Technology Education Programs

NCATE (The National Council for Accreditation of Teacher Education) is the education profession's mechanism to help establish high-quality teacher preparation programs (NCATE, 2003, 2008). NCATE has developed program standards that define the criteria for accrediting technology education programs in much the same manner as ABET has defined criteria for accrediting engineering programs. NCATE standards state that technology education teacher candidates must develop an understanding of the nature of technology; technology and society; design; and the designed world. Candidates must also develop use a variety of effective teaching practices that enhance learning of technology; design, create, and manage learning environments that promote technological literacy; and engage in professional growth (CTTE, 2002).

A comparison of professional competencies required by ABET for engineers and NCATE for technology teachers (Hacker, 2005) not surprisingly shows a focus on technical content preparation for engineers and on pedagogy for teachers; but a high degree of alignment is evident with respect to other competencies. Both professional groups are well prepared in areas of professional practice, design and problem solving, team functioning, ethical and professional responsibility, communication skills, social and cultural impacts, and professional growth. A clear difference is how engineers are much more rigorously prepared in mathematics and science.

Projects Oriented Toward Formulating an ETE Knowledge and Skill Base

Major projects that have identified student learning outcomes in ETE include the Standards for Technological Literacy (STL) (ITEA, 2000); National Academy of Engineering (NAE) reports (Katehi & Pearson, 2009; NAE, 2010); the National Research Council's Framework for Science Education and the Next Generation Science Standards built upon it (NRC, 2011; NGSS, 2012); the National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Framework (NCES, 2012); and studies conducted by Custer, Daugherty, and Meyer (2009); Childress and Rhodes (2008); and Rossouw, Hacker, and de Vries (2010).

Standards for Technological Literacy

The International Technology Education Association (ITEA, now renamed ITEEA) developed *Standards for Technological Literacy* (STL) to identify what students should know and be able to do to be technologically literate (ITEA, 2000). Five knowledge categories (comprising 20 content standards and 98 benchmarks at the grades 9-12 level) include: the nature of technology, technology and society, design, abilities for a technological world, and the designed world.

The **National Academy of Engineering** committee on standards for K-12 engineering education reviewed eight prior studies and identified 16 categories of engineering concepts, skills, and dispositions for K-12 education. These included: Design, STEM Connections, Engineering and Society, Constraints, Communication, Systems, Systems Thinking, Modeling, Optimization, Analysis, Collaboration and Teamwork, Creativity, Knowledge of Specific Technologies, Nature of Engineering, Prototyping, and Experimentation (NAE, 2010).

The ***Next Generation Science Standards*** **(**NGSS) grew from a framework developed by the National Research Council (NRC, 2010). NGSS integrated disciplinary core ideas, practices, and crosscutting concepts related to technology and engineering (including design, modeling, and systems) into student performance expectations (NGSS Lead States, 2013).

The **National Assessment of Educational Progress** (NAEP) is an assessment of what U.S. students know and can do in various subjects. In 2015, the NAEP Technology and Engineering Literacy Assessment was administered to 21,500 students in grades 8 and 12 (NAGB, 2016). The assessment consists of technological content areas and technological practices among which are design and systems, information and communication technology; and technology and society.

In a study titled ***Formulating a Concept Base for Secondary Level. Engineering: A Review and Synthesis***, Custer, Daugherty, and Meyer (2009) identified thirteen major engineering concepts (among them design, systems, and modeling) that were drawn from a variety of sources, and by two focus groups of engineering experts (Sanders, Sherman & Watson, 2012).

Childress and Rhodes (2008) examined what engineering students in HS should know and be able to do prior to entry into a postsecondary engineering program. Categories identified included engineering design, applications of engineering design, engineering analysis, engineering and human values, engineering communication, engineering science, and emerging fields of engineering.

Concepts and Contexts in Engineering and Technology Education (CCETE)

In 2010, Delft University of Technology (The Netherlands) in collaboration with Hofstra University in New York State conducted a Delphi study with 32 international experts from nine countries to identify overarching themes and contexts that can be used to develop curricula for education about engineering and technology was developed (Rossouw, Hacker, & de Vries, 2010). See table 1.

Table 1. CCETE Overarching Themes and Sub-concepts

Themes	Sub-concepts
Design	Optimization and tradeoffs; criteria and constraints; iteration.
Modeling	Representational, explanatory, predictive.
Systems	Systems/subsystems; input-process-output; feedback and control.
Resources	Materials, energy, information, time, tools, humans, capital.
Human Values	Sustainability; technological assessment; creativity/innovation; ethical decisions.

This *Comparison of Perceptions study* used the five themes that emerged from the CCETE study as organizing categories since they aligned so well with those identified by other major projects. Further specificity about important ETE concepts and skills within these categories was added.

Summary of the Literature Review

Through the literature review, the researchers identified ETE knowledge and skill sets that scholars believe to be important for all high school students to learn within their fundamental education. These concepts and skills informed the set of items that comprised this study's Round 1 survey instrument. They established the basis upon which expert panelists suggested additions, changes, or deletions to survey items in subsequent Delphi rounds.

Research Questions

The research questions that this Comparison of Perceptions study attempted to answer were:

RQ1. Where does the strongest consensus exist among the expert panelists relative to the importance of specific ETE concepts and skills that all high school students in the U.S. should attain as part of their fundamental education?

RQ2. Which ETE concepts and skills does the expert panel perceive to be most important for high school students to attain as part of their fundamental education?

RQ3. Where are there significant differences between academic engineering educators' and classroom technology teachers' perceptions of the importance of ETE concepts and skills?

RQ4. What concepts and skills that the study elicits do academic engineering educators and classroom technology teachers agree are highly important for HS students in the United States to attain as part of their fundamental education, and are not presently addressed by *STL*?

Methodology

This study employed *Delphi survey research* methodology, as it is effective in soliciting and converging experts' opinions to obtain consensus (Salancik, Wenger & Helfer, 1971). Delphi methodology assures anonymity, provides ongoing feedback to participants, and reduces the effects of bias due to group interaction (Dalkey, 1972).

The purpose of a Delphi study is to "obtain the most reliable consensus of opinion of a panel of experts through a series of intensive questionnaires interspersed with controlled opinion feedback" (Dalkey & Helmer, 1963). Studies comparing Delphi with other methods (Ulschak, 1983) confirmed its effectiveness in generating ideas and using participants' time.

Typically, a Delphi study starts by asking participants to respond to a specific question or issue. In subsequent rounds, participants are asked to consider feedback from the previous round and the instrument is modified to reflect experts' opinions. Quantitative feedback is given to each participant (Uebersax, 2000). When respondents' estimates for an item do not fall within the range of group responses, they are asked to reconsider their position and, when justified, change their response. Thus an attempt is made to achieve consensus (Wicklein & Rojewski, 1999).

As often done in Delphi studies (Chalmers, 2014; Greer, 2008; Iqbal & Pipon-Young, 2009; Scott et al, 2006), this study used open-ended text boxes to invite panel members to provide feedback during survey rounds and at the conclusion of the survey.

Modified Delphi Methodology

This study used modified Delphi research methodology which is similar to a full Delphi in terms of procedure (i.e., a series of Rounds with selected experts) and intent (i.e., to predict future events and arrive at consensus) (Custer, Scarcella & Stewart, 1999). Modifications included: 1) beginning the Delphi process with a set of preselected items that were drawn from the literature review and validated by experts; and 2) adding validation panel meetings. Starting with a set of preselected items improves the initial Round response rate and provides a solid grounding in prior work (Custer, Scarcella & Stewart, 1999). Meetings of a validation panel verified the importance and level of abstraction of initial items, vetted prospective panelists to confirm their expertise, and added structure to the survey (Rossouw, Hacker, & de Vries, 2010).

Seven stages characterized this study's Delphi procedure, in accordance with the method suggested by Fowles (1978).

Stage 1: Define the research questions.

Stage 2: Assemble the panel of experts (with help from the validation panel).

Stage 3: Design and validate the initial set of survey items (with validation panel help).

Stage 4: Conduct the three round Delphi survey.

-Round 1 included a beginning set of concepts drawn from the literature review;

-Round 2 reflected changes based on panel input and solicited additional suggestions;

-Round 3 included further changes based on final panel review.

Stage 5: Analyze survey results.

Stage 6: Summarize Conclusions.

Stage 7: Convene validation panel to review researchers' conclusions and reach consensus.

Three Delphi rounds were conducted and have been found to be sufficient to arrive at consensus (Brooks, 1979) as after three iterations, not enough new information is gained to warrant the cost of more administrations (Altschuld, 1993). Panelists were asked to rate each concept on a seven-point Likert scale using these descriptors: 7, Strongly agree; 6, Moderately agree; 5, Agree; 4, Indifferent; 3, Moderately disagree; 2, Disagree 1, Strongly disagree. Panelists were invited to suggest and justify items that should be added or deleted. Panelists were informed that based on their suggestions, items would be modified and were invited to reconsider item ratings if theirs were at variance with whole-group median ratings.

Participant Selection and Panel Size

As the success of the Delphi technique relies upon experts' judgment, selection of panelists was critical and random selection was not considered. Large numbers of panelists generate too many items and ideas, making the summarizing process difficult (Ludwig, 1997). Delbecq, Van deVen, & Gustafson (1975) suggest that ten to fifteen panelists are sufficient. Dalkey, Rourke, Lewis & Snyder (1972) reported that reliability, with a correlation coefficient approaching 0.9, was found with a panel size of 13. Wells (2013) suggested that in research concerned with intra-group and inter-group judgments, sub groups of 16 panelists be recruited. This study recruited 18 AEEs and 17 CTTs (35 panel members in total) to allow for attrition.

Selection Criteria

Participants were selected on the basis that they were leading authorities in their fields with a) documented participation in initiatives linking engineering and K-12 education; b) a minimum of five years of experience teaching engineering or technology education; c) proven ability to formulate their thinking through research and/or active involvement in major funded projects. They were identified through recommendations from professional organizations and agencies: the American Society of Engineering Education (ASEE), ITEEA, NAE, NSF, NYS Technology and Engineering Educators Association (NYSTEEA); and validation panel members.

Validation Panel

The validation panel was comprised of the researchers; two AEEs with over ten years of K-12 ETE involvement; and two CTTs who are professional leaders with over ten years of K-12 ETE involvement. Validation panel meetings were three hours in duration. A meeting was held at the onset of the study to assist the researchers to select panelists and validate survey items. The second meeting was held after the study concluded to discuss results, frame conclusions, and establish a *cutoff point* for items to be deemed as highly important for all high school students to learn.

Instrumentation and Data Analysis Methodology

The survey was tested and conducted online using Qualtrics survey software. Data was exported to SPSS V22.0 for analysis. With Likert scale data, the use of median scores is strongly favored (Hill & Fowles, 1975; Eckman, 1983; Jacobs, 1996). Data were treated as ordinal data (Comrey, 1973) and were reported using descriptive statistics (medians, frequencies, percentiles, and interquartile range (IQR) statistics. A non-parametric test (the Mann-Whitney U) was used to determine statistically significant differences between the two study groups and p-values were reported at the $\alpha = 0.05$ level. Data provided insight into the study's research questions as follows:

Methodology Relative to Research Question 1 (Determining Consensus). Data analysis determined the *strength of consensus* on each item by subgroup and whole group. According to Rojewski & Meers (1991) "consensus is determined using the interquartile range (IQR) of each concept statement. Interquartile Range refers to the middle 50% of responses for each statement (i.e., distance between first and third quartiles)." Low IQRs are one measure of strong consensus on an item.

This study used a 7-point scale and whole-group IQRs ranged from 0.79 to 1.98. After an analysis of scores within each quartile for each item, the researchers and the validation panel established that an IQR of ≤ 1.61 should be considered an indicator of strong panel consensus, because:

- Sixteen of the 17 highest rated items (with median ratings of ≥ 6.00, "agree") displayed IQRs of ≤ 1.61 (indicating whole-group agreement that those items were of high importance).
- Three of the four lowest rated items (medians ≤ 5) displayed IQRs of ≤ 1.61 (indicating whole-group agreement that those items were of lower importance).

As suggested by Rayens & Hahn (2000), the IQR may be an insufficient criterion for determination of agreement. Frequency distributions are also often used (McKenna, 1994, cited by Na, 2006), and the criterion of some percentage of panelists responding to any given response category is used to determine consensus (Loughlin & Moore, 1979, p. 103; Seagle & Iverson, 2002, p. 1; Putnam, Speigel, & Bruininks, 1995; as cited by von der Gracht, 2008).

In this study, factors determining consensus included the whole-group IQR and frequency of responses at the high end of the scale (respondents choosing scale points 6-7) and at the low end of the scale (respondents choosing scale points 1-4). These "consensus factors" are displayed in table 2.

Table 2. Consensus Factors

Item Importance Level	Determinants of Consensus
Consensus that an Item is of Higher Importance	If IQR ≤ 1.61 and frequency of high scores (6-7) ≥ 80%
Consensus that an Item is of Lower Importance	If IQR ≤ 1.61 and frequency of low scores (1-4) ≥ 25%

Methodology Relative to Research Question 2 (Determining Importance). The study examined Round 3 panelist median ratings for each item. Whole-group and subgroup (AEE/CTT) median ratings for each survey item were determined using IBM SPSS V22.0 software. The medians were ranked using the data ranking function of Microsoft Excel. The ranking indicated which of the survey items the subgroups and the entire panel perceived to be most important. Because median ratings for all items were quite high (ranging from 6.71 to 4.60 on a 7-point scale), the validation panel set the item cutoff point for "high importance" at median ratings of ≤ 6.0. No survey items were deemed to be unimportant by the validation panel.

Methodology Relative to Research Question 3 (Determining Significant Differences). The Mann-Whitney U nonparametric test was used to analyze if intragroup median item ratings were significantly different. Nonparametric tests compare medians rather than means and, as a result, the influence of outliers is negated (Hayes, 1997). At the conclusion of the third survey Round, a lack of consensus on any survey item reflected sustained differences between the groups in that *perceptual differences persisted despite the use of the Delphi instrument as a means to develop consensus*. An alpha level (α) = 0.05 was used for all statistical tests of significance. The null hypothesis (H_o) was: There is no significant difference between AEEs and CTTs in their perception of the importance of ETE concepts and skills. P-values of ≤ 0.05 on any survey item led to a rejection of the null hypothesis for that item.

Methodology Relative to Research Question 4 (Gap Analysis with STL). The study identified competencies deemed important for all HS students to attain as part of their fundamental education. The researchers did a gap analysis with STL to compare survey items rated "important" by the Delphi panel to existing benchmarks in the HS level Standards. If items were similar, rewording based on survey item wording was suggested. The validation panel confirmed the gap analysis.

Findings

Findings indicated where consensus between the AEEs and CTTs was reached about items that were of higher or lower importance. In discussing findings, items that were rated highest by the whole group and each subgroup are identified; significant differences between subgroups are illuminated; and potential revisions to STL are suggested. Additionally, findings determined the internal consistency (reliability) of the survey instrument and the mean value of the participants' responses with regard to design, modeling, systems, resources, and human values.

Initial survey items were based on the literature review and on recent projects probing the importance of ETE concepts. As a result of pre-launch trials, the Round 1 survey instrument was revised 11 times prior to first Round administration as part of a continuous improvement process.

The response rate to survey Round 1 was 88.6% and 192 comments were received from panelists. Based on panelists' suggestions, numerous changes were made. The researchers attempted to be responsive to all suggestions however comments were sometimes contradictory and the researchers chose to accept changes in wording when suggestions improved the clarity of the item. New items were added when two or more experts suggested its inclusion. Sixteen questions were re-worded and five new questions were added for the Round 2 survey.

The number of survey items increased from 32 items in Round 1 to 37 items in Round 2. In Round 2, panelists were asked to give high scores sparingly since the study was aiming to develop a list of the most essential concepts and skills. The response rate was again 88.6%. In Round 2, the IQRs of 13 of 32 items (40%) converged attesting to the efficacy of the Delphi method at driving consensus.

In the final round, of the 34 panelists who were sent the Round 3 survey, 34 submitted responses (a 100% response rate). Respondents included 18 AEEs (four females and 12 males) and 16 CTTs (three females, 13 males). Appendix C presents the median ratings, standard deviations, percentiles, and whole-group IQRs by item. Findings are discussed below.

Findings related to RQ1: Where does the strongest consensus exist among the expert panelists relative to the importance of specific ETE concepts and skills that all high school students in the U.S. should attain as part of their fundamental education?

AEE/CTT **consensus** about high importance was reached on 14 of 38 survey items, based on both consensus factors (IQR $\leq$ 1.61 and frequency (6-7) $\geq$ 80%) being satisfied. The **strongest consensus** that items were **highly important** related to students being able to: identify and discuss environmental, health, and safety issues involved in implementing an engineering project (Item R7); and use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design (Item M1). AEE/CTT consensus about lower importance was reached on two survey items, based on both consensus factors (IQR $\leq$ 1.61 and frequency (1-4) $\geq$ 25%) being satisfied. The **strongest consensus** that items were **of lower importance** related to students being able to: provide an example and an explanation of how design solutions can integrate universal design principles to help meet the needs and wants of people of all ages and abilities (Item D8); and describe, through an example, how the reliability of a system and the risks/consequences associated with its use have or have not been adequately considered prior to its implementation (Item D12). Appendix A portrays items where consensus was reached about higher and lower importance.

Findings related to RQ2: Which ETE concepts and skills does the expert panel perceive to be most important for high school students in the United States to attain as part of their fundamental education?

The ETE concept/skills perceived by the combined group to be **most important** for high school students to attain are: identify and discuss environmental, health, and safety issues involved in implementing an engineering project (Item R7); use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design (Item M1); explain why a particular engineering design decision was made, using verbal and/or visual means (e.g., writing, drawing, making 3D models, using computer simulations) (Item D6); show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions (Item HV6); and safely and correctly use tools and machines to produce a desired product or system (Item R4). Appendix B displays panelists' perceptions of the most important ETE items for HS students to learn, by whole-group median ratings and rankings.

Findings related to RQ3: Where are there significant differences between academic engineering educators' and classroom technology teachers' perceptions of the importance of ETE concepts and skills?

Data analysis using the Mann-Whitney U test indicated that subgroup ratings were significantly different on four survey items at the $p < 0.05$ level (see table 3). All of these except the third were rated higher by AEEs than by CTTs. Not surprisingly, engineers, more than teachers, emphasized applying science and mathematics to the solution of design problems.

Table 3. Significant Differences in Median Item Ratings between AEEs and CTTs based on the Mann-Whitney U Test.

ITEM	Survey Wording of Item	AEEs (n=18) Medians	CTTs (n=16) Medians	Mann-Whitney U Value	D.f.	p -value Exact Sig. (2-tailed)
D2	Solve engineering design problems by identifying and applying appropriate science concepts.	6.35	5.80	81.00	33	.012
D11	Provide examples of how psychological factors (e.g., bias, overconfidence, human error) can impact the engineering design process.	5.27	4.69	91.00	33	.049
S5	Explain the difference between an open-loop control system and a closed-loop control system and give an example of each.	5.17	5.85	88.50	33	.040
S6	Develop and conduct empirical tests and analyze system and analyze test data to determine how well actual system results compare with measurable performance criteria.	6.21	5.36	89.00	33	.046

Findings related to RQ4: What concepts and skills that the study elicits do academic engineering educators and classroom technology teachers agree are highly important for HS students in the United States to attain as part of their fundamental education, and are not presently addressed by *STL*?

The validation panel suggested that survey items with median ratings of ≥ 5.70 be considered for inclusion in the next iteration of STL. Recommendations are made that the next iteration of the STL add, substitute, or reword standards based on 16 survey items that panelists agreed are highly important for HS students to attain as part of their fundamental education, but are not presently addressed by STL. Proposed changes to the STL are suggested in Appendix D.

Most STL benchmarks were written in terms of what students should learn; in this study, survey items were written in terms of what students should be able to do. Survey items might thus provide additional clarity to teachers and curriculum developers relative to measurable performances that would define important student capability. As an example, the present STL Standard 2 (Z) indicates that students **should know that**: Selecting resources involves tradeoffs between competing values, such as availability, cost, desirability, and waste. The study suggests that students would **demonstrate that understanding** in that they would:

- D4. Improve an engineering design by identifying, making, and evaluating tradeoffs.
- HV4: Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns.
- D9: Engage in a group problem-solving activity to creatively generate several alternative design solutions and document the iterative process that resulted in the final design.

Additional Findings related to psychometric properties of the survey instrument (internal consistency reliability); and to comparing mean scores for all items within each of the five domains (subscales) of design, modeling, systems, resources, and human values.

Reliability. Often, when investigating reliability of instruments using continuous or interval data, Cronbach's alpha is used as an index of reliability. However since this study's data results from panelists' responses to items rated on a Likert scale (scale points 1-7), data is ordinal; therefore, an *ordinal alpha* index of reliability is used as an alternative. Thus, reliability coefficients for each subscale were determined using statistical methods better suited to ordinal data analysis.

The SPSS Categories procedure *CATPCA* (a nonlinear Categorical Principal Components Analysis) uses optimal scaling to statistically transform ordinal data into a quantitative numerical variable

(Meulman, Van der Kooij, & Heiser, 2004). CATPCA provides an ordinal alpha reliability measure, and the reliability coefficient calculated is for the transformed variables (IBM, 2013).

To compare and confirm reliability statistics, both Cronbach's Alpha and CATPCA ordinal alpha analyses were conducted (using SPSS), and the results are shown in table 4. Alpha reliability coefficients normally range between 0 and 1. A reliability coefficient of 0.70 or higher is considered "acceptable" in most social science research situations (UCLA, undated; George and Mallery, 2003; Kline, 1999). It is not surprising that the values for ordinal alpha were higher (since ordinal data is being analyzed) than those for Cronbach's alpha, which treats Likert scale data as interval data.

Mean values of responses by category. It is worthy of note that although participants' answers to individual survey items are on an ordinal (Likert) scale, the answers to a **group of items in a category** can be regarded as close to normally distributed interval data. Therefore, these data were analyzed using mean values. A comparison of the means of each subgroup by category is displayed in table 4 and graphically in figure 1.

Table 4. Mean Values of AEEs (n=18) and CTTs (n=16) Final Round Responses Related to the Five Categories in the Questionnaire (Scale Points 1-7)

Category	Number of items	Group	Mean	Std. Deviation	Cronbach's Alpha	CATPCA Ordinal Alpha
Design	12	AEEs	5.8102	.63517	.783	.857
		CTTs	5.5885	.50412		
Modeling	6	AEEs	5.5926	.98389	.773	.877
		CTTs	5.6458	.62620		
Systems	6	AEEs	5.5926	.82490	.595	.728
		CTTs	5.7083	.40597		
Resources	7	AEEs	6.1429	.64635	.623	.810
		CTTs	6.2589	.53253		
Human Values	7	AEEs	5.6825	.90159	.794	.917
		CTTs	5.5357	.53579		

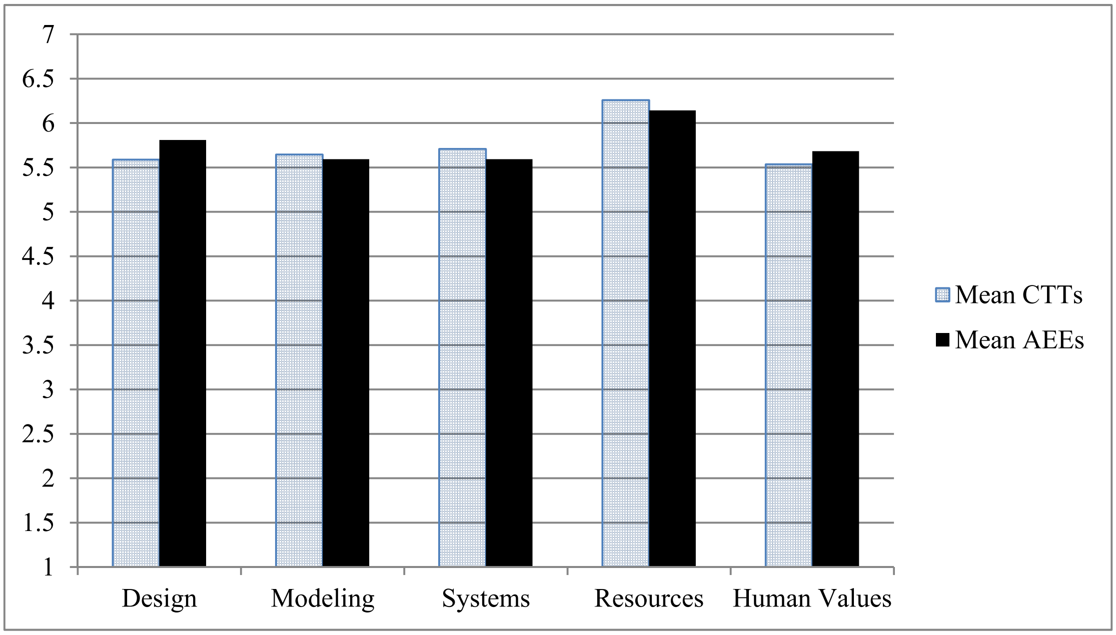

Figure 1. Mean Scores for all Items on each Subscale, by Subgroup

The highest mean scores for both subgroups were obtained in the Resources category. The lowest mean score for CTTs was in the Human Values category. For the AEEs, the lowest mean scores were in the Systems and Modeling categories (tied).

In summary, salient findings included:

- Descriptive statistics including median ratings, standard deviations, and the Interquartile Range (IQR) for each item.
- A ranked analysis of the engineering and technology concepts and skills perceived to be most important for the general education of HS students by whole-group median rating.
- An identification of items where differences between subgroups were statistically significant.
- A list of concepts and skills that experts agree are highly important for high school students to attain as part of their fundamental education and that are not presently addressed by *STL*.
- Internal consistency reliability measures of the subscales.

Conclusions

Because engineering and technology education are receiving greater attention as components of STEM education, support for the establishment of PreK-12 ETE programs in the United States has been rapidly growing. Although university level academic engineering educators are an ideal professional constituency to be allied with and support secondary school ETE programs, prior to this study it was uncertain whether they held similar perceptions (about the fundamental knowledge and skills high school graduates need for life in a technological world), as did the classroom technology teachers who develop curriculum and deliver secondary school ETE instruction.

We have examined the alignment of the two constituencies' perceptions about the importance of key concepts and skills that all high school students in the United States should learn as part of their fundamental education. Our findings demonstrate there is indeed a greater degree of concordance than there are perceptual differences between the two constituencies.

From a **theoretical perspective**, this research contributes to the body of knowledge about the most salient ideas and skills students need to learn and understand in five overarching domains of engineering and technology that are repeatedly referenced in the literature: Design, modeling, systems, resources, and human values. Additionally, this study provides the first research-based comparison of perceptions about important ETE ideas and skills between two constituencies whose missions focus on preparing students to succeed in our technological world through engineering and technology education.

From the **methodological perspective**, this study illustrates how the Delphi technique can be employed within a research study in the education field where the emphasis is on eliciting and comparing the perceptions of different groups of experts. On one hand, the Delphi technique was utilized to identify perceptual differences between expert groups with different backgrounds; on the other hand, it was used to bridge differences in background in order to forge consensus. The Delphi research methodology used in this study was modified from the classical Delphi approach in several ways. Modifications that could be considered by other researchers include: 1) beginning the Delphi process with a set of carefully preselected items that were drawn from the literature review; 2) adding validation panel reviews and meetings to help identify panelists and initial survey items and to reach post-survey consensus; 3) establishing a set of selection criteria for choosing expert panelists; 4) including open-ended text boxes to solicit and present arguments for or against items being included in the list of "important" survey items, 5) establishing an IQR range on a Likert scale as being indicative of strong consensus, and 6) establishing frequency distribution percentage criteria for responses at both the high end and the low end of the scale.

Within the framework of this research study, a method for examining internal consistency reliability suitable to interpreting ordinal data is proposed based on Categorical Principal Components Analysis (CATPCA), as a replacement for the Cronbach's alpha coefficient that is typically used to interpret interval data.

From a **practical perspective**, this research contributes to engineering and technology education by:

a. Establishing a basis for educators to develop local, state, and national ETE curriculum frameworks, instructional materials for students and teachers, and assessments of teaching and learning (one such recent curriculum project was the *Engineering for All* project funded by the U.S. National Science Foundation, grant # 1316601 (see http://www.hofstra.edu/academics/colleges/seas/ctl/efa/index.html)

b. Informing a revision of the U.S. national standards for technological literacy;

c. elevating the status of school-based engineering and technology education by improving the rigor and robustness of curriculum and by increasing the advocacy of university faculty/engineering educators;

d. Guiding the design of proposals to foundations and government agencies to fund improvement of ETE curriculum and instruction.

Finally, it is worth mentioning that a limitation of the present research related to the selection of the expert panelists: there was a considerable imbalance between more experienced (presumably older) and less experienced (presumably younger) panelists. Thus, perspectives of younger educators who might have reflected more contemporary views of the importance of certain ideas and skills may not have been adequately considered. Therefore, it is recommended that in selecting panelists for future studies, targeted efforts should be made to recruit younger panelists to determine if their perceptions about the importance of knowledge and skills related to contemporary technologies differ significantly from their more experienced, presumably older, colleagues.

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ITEM	**Survey Item Wording for Items Reflecting Higher Importance**	**IQR**	***freq.***

R7	Identify and discuss environmental, health, and safety issues involved in implementing an engineering project.	0.79	100
M1	Use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design	0.82	100
D6	Explain why a particular engineering design decision was made, using verbal and/or visual means (e.g., writing, drawing, making 3D models, using computer simulations).	0.91	94.1
HV6	Show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions.	0.91	94.1
R4	Safely and correctly use tools and machines to produce a desired product or system.	1.00	95.3
D1	Iteratively design and construct a model or full-scale product, system, process, or environment that meets given constraints and performance criteria.	1.09	82.3
R3	Evaluate technological and scientific information for accuracy, and authenticity of sources.	1.15	87.8
D9	Engage in a group problem-solving activity to creatively generate several alternative design solutions and document the iterative process that resulted in the final design.	1.34	85.3
R6	Identify and discuss privacy issues involved in using information resources.	1.31	88.3
S1	Label and explain a diagram of a familiar technological system (e.g., a home heating system) that specifies inputs, processes, outputs, feedback, and control components.	1.26	88.2
S2	Identify and explain the function of the interacting subsystems that comprise a more complex system.	1.27	82.4
D2	Solve engineering design problems by identifying/applying appropriate science concepts.	1.23	88.2
D3	Solve engineering design problems by identifying/applying appropriate math concepts.	1.3	82.3
M2	Develop a fair test (changing only one factor at a time) and use it to analyze the strengths and limitations of a physical or virtual model of a design.	1.29	80.0
ITEM	**Survey Item Wording for Items Reflecting Lower Importance**	**IQR**	***freq.***
D8	Provide an example and an explanation of how design solutions can integrate universal design principles to help meet the needs and wants of people of all ages and abilities.	1.58	32.4
D12	Describe, through an example, how the reliability of a system and the risks/consequences associated with its use have or have not been adequately considered prior to its implementation.	1.61	44.1

Appendix A. Items Reflecting Consensus about Higher and Lower Importance

Appendix B. Most Important Competencies for HS Students to Attain (Median ratings of ≥ 6.00)

Item	Item Wording	Whole Group Median	Whole Group Rank
R7	Identify and discuss environmental, health, and safety issues involved in implementing an engineering project.	6.71	1
M1	Use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design.	6.68	2
D6	Explain why a particular engineering design decision was made, using verbal and/or visual means (e.g., writing, drawing, making 3D models, using computer simulations).	6.63	tie 3/4
HV6	Show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions	6.63	tie 3/4
R4	Safely and correctly use tools and machines to produce a desired product or system.	6.59	5
D1	Iteratively design and construct a model or full-scale product, system, process, or environment that meets given constraints and performance criteria.	6.57	6
R3	Evaluate technological and scientific information for accuracy, and authenticity of sources.	6.54	7
D9	Engage in a group problem-solving activity to creatively generate several alternative design solutions and document the iterative process that resulted in the final design.	6.38	tie 8/9
R5	Practice safe, legal, and responsible use of information & communications technology	6.38	tie 8/9
R6	Identify and discuss privacy issues involved in using information resources.	6.33	10
S1	Label and explain a systems diagram of a familiar technological system that specifies inputs, processes, outputs, feedback, and control components.	6.27	11
S2	Identify and explain the function of the interacting subsystems that comprise a more complex system.	6.11	12
D2	Solve engineering design problems by identifying and applying appropriate science concepts.	6.10	13
M5	Create and test a physical model of an artifact, process, or system using tools and materials to ensure that a design solution meets given criteria and constraints.	6.08	14
D3	Solve engineering design problems by identifying and applying appropriate mathematics concepts.	6.07	tie 15/16
R1	Identify resources that technological systems use to turn desired results into actual results, as fitting into categories of people, capital, energy, information, materials, time, and tools.	6.07	tie 15/16
D5	Give an example where making a design decision involves weighing tradeoffs between positive and negative impacts and explain the costs and benefits of those tradeoffs.	6.00	17

Appendix C. Round 3 Descriptive Statistics for 38 Survey Items with Significant Differences

Note that (*) represents items where $p \leq 0.05$

SURVEY ITEM BY CATEGORY *DESIGN*	AEE Median	CTT Median	Group Med	Rank	IQR	p-value
D1. Iteratively design and construct a model or full-scale product, system, process, or environment that meets given constraints and performance criteria.	6.64	6.50	6.57	6	1.09	.624
D2. Solve engineering design problems by identifying and applying appropriate science concepts.	6.35	5.80	6.10	13	1.23	.012*
D3. Solve engineering design problems by identifying and applying appropriate mathematics concepts.	6.25	5.85	6.07	tie 15/16	1.3	.171
D4. Improve an engineering design by identifying, making, and evaluating tradeoffs.	6.15	5.75	5.96	18	1.449	.177
D5. Give an example where making a design decision involves weighing tradeoffs between positive and negative impacts and explain the costs and benefits of those tradeoffs.	6.27	5.56	6.00	17	1.63	.092
D6. Explain why a particular engineering design decision was made, using verbal and/or visual means (e.g., writing, drawing, making 3D models, using computer simulations).	6.59	6.67	6.63	tie 3/4	0.91	.685
D7. Engage in a socially conscious engineering design activity that relates to a community-based need or global issue (such as providing potable water, providing sustainable agriculture, or utilizing renewable energy sources).	6.08	5.60	5.79	tie 25/26	1.85	.181
D8. Provide an example and an explanation of how design solutions can integrate universal design principles to help meet the needs and wants of people of all ages and abilities.	4.77	5.00	4.86	36	1.58	.722
D9. Engage in a group problem-solving activity to creatively generate several alternative design solutions and document the iterative process that resulted in the final design.	6.40	6.36	6.38	tie 8/9	1.34	.931
D10. Evaluate the effectiveness and appropriateness of the design of common items (such as a can opener, toothbrush, door handle, etc.).	6.00	5.69	5.83	tie 21/22	1.47	.403
D11. Provide examples of how psychological factors (e.g., bias, overconfidence, human error) can impact the engineering design process.	5.27	4.69	5.00	35	1.39	.049*
D12. Describe, through an example, how the reliability of a system and the risks/consequences associated with its use have or have not been adequately considered prior to its implementation.	4.82	4.67	4.74	37	1.61	.783

SURVEY ITEM BY CATEGORY *MODELING*	AEE Median	CTT Median	Group Med	Rank	IQR	p-value
M1. Use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design.	6.67	6.69	6.68	2	0.82	1.000
M2. Develop a fair test (changing only one factor at a time) and use it to analyze the strengths and limitations of a physical or virtual model of a design.	6.13	5.73	5.92	19	1.29	.142
M3. Use mathematical modeling (e.g., using the equation for conductive heat flow, $Q=kA\Delta T/L$, to design a shelter) to quantitatively describe and predict the effects of variables on a design.	6.08	5.50	5.77	27	1.57	.109
M4. Use simulation software to investigate complex systems and issues.	5.25	5.09	5.17	33	1.7	.750
M5. Create and test a physical model of an artifact, process, or system using tools and materials to ensure that a design solution meets given criteria and constraints.	5.73	6.33	6.08	14	1.445	.060
M6. Create and test a virtual model of an artifact, process, or system using simulation software to ensure that a design solution meets given criteria and constraints.	5.07	5.23	5.15	34	1.396	.607

SURVEY ITEM BY CATEGORY *SYSTEMS*	AEE Median	CTT Median	Group Med	Rank	IQR	p-value
S1. Label and explain a systems diagram of a familiar technological system (e.g., a home heating system) that specifies inputs, processes, outputs,	6.40	6.13	6.27	11	1.26	.272

feedback, and control						
S2. Identify and explain the function of the interacting subsystems that comprise a more complex system.	6.20	6.00	6.11	12	1.27	.534
S3. Explain the differences and effects of negative and positive feedback in a system.					1.4	.281
S4. Design, construct, test, and explain the operation of a system composed of several subsystems to accomplish a given goal.	5.27	5.60	5.43	32	1.96	.403
S5. Explain the difference between an open-loop control system and a closed-loop control system and give an example of each.	5.17	5.85	5.52	31	1.59	.040*
S6. Develop and conduct empirical tests and analyze test data to determine how well actual system results compare with measurable performance criteria.	6.21	5.36	5.79	tie 25/26	1.84	.046*

SURVEY ITEM BY CATEGORY ***RESOURCES***	**AEE Median**	**CTT Median**	**Group Med**	**Rank**	**IQR**	**p-value**
R1. Identify resources that technological systems use to turn desired results into actual results, as fitting into categories of people, capital, energy, information, materials, time, and tools.	5.83	6.27	6.07	tie 15/16	1.32	.201
R2. Select and use appropriate material, energy, and information, tools, and processes to accomplish desired technological results safely, economically, and efficiently.	5.67	6.14	5.91	20.0	1.4511	.198
R3. Evaluate technological and scientific information for accuracy, and authenticity of sources.	6.67	6.38	6.54	7	1.15	.316
R4. Safely and correctly use tools and machines to produce a desired product or system.	6.43	6.73	6.59	5	1	.190
R5. Practice safe, legal, and responsible use of information and communications technology.	6.43	6.33	6.38	tie 8/9	1.5385	.752
R6. Identify and discuss privacy issues involved in using information resources.	6.47	6.15	6.33	10	1.31	.162
R7. Identify and discuss environmental, health, and safety issues involved in implementing an engineering project.	6.72	6.69	6.71	1	0.79	1.000

SURVEY ITEM BY CATEGORY ***HUMAN VALUES***	**AEE Median**	**CTT Median**	**Group Med**	**Rank**	**IQR**	**p-value**
HV1. Explain, using examples, how intelligent/smart information technology (e.g., artificial intelligence, image enhancement and analysis, sophisticated modeling and simulation, smart houses, smart appliances) is transforming the world of information and knowledge, with profound effects on society.	5.83	5.77	5.80	tie 23/24	1.36	.805
HV2. Redesign an engineering design solution to increase sustainability (such as reducing the embodied energy of the product, lowering its energy use, and/or using recycled materials).	6.00	5.69	5.83	tie 21/22	1.5	.475
HV3. Explain and give an example of how different cultures' engineering design solutions vary based upon the desire to satisfy their cultural values.	5.92	5.42	5.67	29	1.5404	.159
HV4. Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns.	6.00	5.46	5.70	28	1.55	.122
HV5. Effectively use social media without violating accepted social norms (e.g., not posting personally offensive/rude posts about a person, inappropriate images, or engaging in verbal "fights").	4.64	4.56	4.60	38	1.98	.909
HV6. Show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions.	6.69	6.56	6.63	tie 3/4	0.91	.556
HV7. Provide examples of how the societal impact of engineering failure may lead to changes in laws, regulations, and design and use of technologies.	6.00	5.62	5.80	tie 23/24	1.38	.232

Appendix D. Comparison and Gap Analysis between STL Standards and Benchmarks and Survey Items with Item Medians ≥ 5.67

Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 1: Students will develop an understanding of the characteristics and scope of technology.** M. Most development of technologies these days is driven by the profit motive and the market.		
Survey Item(s) Related to STL Standards	HV4. Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns. **(Also noted relative to STL Standard 4.)**	Whole-Group Median Rating	Recommended Action
		5.70	Substitute or Add to Std. 4
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 2**: **Students will develop an understanding of the core concepts of technology.** Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. Z. Selecting resources involves tradeoffs between competing values, such as availability, cost, desirability, and waste.		
Survey Item(s) Related to STL Standards	S1. Label and explain a systems diagram of a familiar technological system (e.g., a home heating system) that specifies inputs, processes, outputs, feedback, and control components.	Whole-Group Median Rating	Recommended Action
		6.27	Add
	S2. Identify and explain the function of the interacting subsystems that comprise a more complex system.	Whole-Group Median Rating	Recommended Action
		6.11	Add
	R1. Identify resources that technological systems use to turn desired results into actual results, as fitting into categories of people, capital, energy, information, materials, time, and tools.	Whole-Group Median Rating	Recommended Action
		6.07	Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.** I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. J. Ethical considerations are important in development, selection, and use of technologies. K. The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.		
	R2. Select and use appropriate material, energy, and information, tools, and processes to accomplish desired technological results safely, economically, and efficiently.	Whole-Group Median Rating	Recommended Action
		5.91	Add
Survey Item(s) Related to STL Standards	HV4. Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns. **(Also noted relative to STL Standard 1).**	Whole-Group Median Rating	Recommended Action
		5.70	Add to or substitute for Std. 1, M.
	HV6. Show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions.	Whole-Group Median Rating	Recommended Action
		6.63	Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 5: Students will develop an understanding of the effects of technology on the environment.** H. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.		
Survey Item(s) Related to STL Standards	HV2. Redesign an engineering design solution to increase sustainability (such as reducing the embodied energy of the product, lowering its energy use, and/or using recycled materials).	Whole-Group Median Rating	Recommended Action
		5.83	Add

Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 6: Students will develop an understanding of the role of society in the development and use of technology.**		
Survey Item(s) Related to STL Standards	HV3. Explain and give an example of how different cultures' engineering design solutions vary based upon the desire to satisfy their cultural values.	Whole-Group Median Rating 5.67	Recommended Action Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 8.** Students will develop an understanding of attributes of design. H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.		
Survey Item(s) Related to STL Standards	D1. Iteratively design and construct a model or full-scale product, system, process, or environment.	Whole-Group Median Rating 6.57	Recommended Action Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 9. Students will develop an understanding of engineering design.** No benchmark speaks specifically to applying mathematics and science concepts in solving design problems; although in Standard 13, a benchmark suggests that a design solution could be evaluated using mathematical models 11, P). No benchmark speaks to how psychological factors can impact the design process.		
Survey Item(s) Related to STL Standards	D2. Solve engineering design problems by identifying and applying appropriate science concepts.	Whole-Group Median Rating 6.10	Recommended Action Add
	D3. Solve engineering design problems by identifying and applying appropriate mathematics concepts.	Whole-Group Median Rating 6.07	Recommended Action Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 11, Students will develop abilities to apply the design process.** Q. Develop and produce a product or system using a design process.		
Survey Item(s) Related to STL Standards	D1. Iteratively design and construct a model or full-scale product, system, process, or environment.	Whole-Group Median Rating 6.57	Recommended Action Reword 11Q
	D9. Engage in a group problem-solving activity to creatively generate several alternative design solutions and document the iterative process that resulted in the final design.	Whole-Group Median Rating 6.38	Recommended Action Add
Grade 9-12 STL Standard and Benchmark Most Related to Survey Item	**STL Standard 13: Students will develop the abilities to assess the impact of products and systems.** J. Collect information and evaluate its quality.		
Survey Item(s) Related to STL Standards	R7. Identify and discuss environmental, health, and safety issues involved in implementing an engineering project.	Whole-Group Median Rating 6.71	Recommended Action Add
	R3. Evaluate technological and scientific information for accuracy, and authenticity of sources.	Whole-Group Median Rating 6.54	Recommended Action Substitute for 13 J
	HV4. Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns.	Whole-Group Median Rating 5.7	Recommended Action Add

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