Default Question Block

Comparing Perceptions of Academic Engineering Educators and Classroom Technology Teachers
Research Study Survey Final Round (Round 3).

INTRODUCTORY NOTE TO OUR EXPERT PANELISTS

Dear Colleagues,

Your assistance with this final survey round, Round 3, is gratefully appreciated.

Only if you are a new participant, please respond to all the demographic items. Otherwise, please only answer the **THREE QUESTIONS which are preceded by: PLEASE ANSWER this question even in you participated in Round 1 and/or Round 2.** This will make data analysis easier.

Thank you sincerely,

Michael Hacker, Researcher, (Hofstra University)
Moshe Barak, Ph.D., Research Supervisor, (Ben Gurion University, Beersheva, Israel)

Demographic Section:

PLEASE ANSWER this question even if you participated in Round 1 and/or Round 2.

Name (This will remain anonymous except to the researcher)

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2.

With which Institution are you primarily affiliated? (This will remain anonymous except to the researcher)

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2.

Please indicate whether your institution is private or public

- ○ Private
- ○ Public

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

State in which you are located:

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Contact Information (This will remain anonymous except to the researcher)

Email Address

Telephone Number

PLEASE ANSWER this question even if you participated in Round 1 and/or Round 2.

Into which of the two study groups do you (or did you) best fit? Note: Please be sure to pick one of these two study groups.

- Post-Secondary Academic Engineering Educator
- Secondary School Classroom Technology Teacher

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please indicate how many years of educational experience you have.

- 0-5
- 5-10
- 10-15
- 15-20
- 20-25
- More than 25

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please indicate your primary position/role within your institution.

- ○ Post-secondary Engineering Educator
- ○ Community College Faculty Member
- ○ Other Post-secondary Responsibility (Please describe)
  - [ ]
- ○ Secondary School Engineering or Technology Teacher
- ○ Other Secondary School STEM Teacher (Please specify subject taught)
  - [ ]
- ○ Retired secondary school teacher
- ○ Retired post-secondary faculty member

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please indicate the title of the primary course that you typically teach. If you are not presently teaching or have not been teaching for five years or more, please leave this field blank.

[ ]

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please indicate whether you have conducted workshops for K-12 teachers within the last three years.

- ○ Yes
- ○ No

PLEASE ANSWER this question even if you participated in Round 1 and/or Round 2.

What is your gender?

- ○ Female
- ○ Male

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please indicate the highest level of education you have completed.

- ○ Some College
- ○ Two-Year College Associates Degree
- ○ College Graduate, Bachelor's Degree
- ○ Master's Degree
- ○ Doctoral Degree (EdD or PhD)
- ○ Professional Degree (MD, JD, etc.)
- ○ Other

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

Please describe your prior participation in initiatives linking engineering and K-12 education.

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

If you have published recent research papers or journal articles, please list them here.

Note: You may SKIP this question if you participated in Survey Round 1 and/or Round 2

If you have been involved in recent funded projects, please list them here.

SURVEY EXPLANATION AND GUIDANCE (REVISED)

This survey is intended to determine which competencies related to engineering and technology are most important for all students in the United States to attain by the time they graduate from high school. The research will also attempt to determine differences in perception between academic engineering educators and high school classroom technology teachers relative to each of the survey items. The competencies expressed (survey items) are not intended to be of value only for students who would pursue careers in engineering or technology; rather, they are competencies all students should assimilate as part of their fundamental education.

For each of the following survey items please indicate how important you believe the competency is for all high school graduates in the United States to attain. You would rate an item to be important if you believed that it reflects key knowledge or skill, fundamental principles, organizing concepts, significant ideas, major standards or benchmarks, generalizable ideas, or common themes. You would rate an item not to be important if you believed it to be trivial, too complicated for most high school students, or necessitating too many resources (e.g., instructional time, teacher knowledge, facilities, etc.).

You are asked to rate each item on a seven-point scale where (7) indicates that you strongly agree that the item is important and (1) indicates that you strongly disagree that the item is important.

We have included the combined group's Round 2 Median ratings along with each of the Round 3 survey items, and have included all panelists' comments underneath the related item. You might wish to consider these comments when rating the item during this final round. You can choose to change or NOT to change your prior rating.

If you participated in survey Round 2, your itemized ratings are being sent to you in a separate Email as an attached PDF file. Additionally, the second survey is being sent as a PDF attachment, since in Round 3, some wording changes have been made to several of the items. You may wish to refer to these attached documents for reference.

ADDITIONAL NOTES RELATED TO THIS FINAL SURVEY ROUND:

- **In this final survey round, Round 3, some items have been modified based on panelist feedback, and one new item (S6) has been added. The researchers have attempted to honor as many of the panelists' suggestions as possible without unreasonably extending the length of the survey.**
- **A number of panelists have suggested combining some items, however to determine differences in perceptions, we have chosen to keep the items separate in the survey. In discussing findings, these suggestions will be addressed.**
- **At this point in the research process (the final survey round), NO NEW QUESTIONS or MODIFICATIONS TO EXISTING ITEMS will be solicited from panel experts.**
- **In this final round, we are again asking panelists to give high scores SPARINGLY and** please **avoid the tendency to *strongly agree* that each item is important.**
- **For us to able to establish priorities and stratify differences in perceptions between the groups, we are asking you not to hesitate to mark an item lower on the scale so that the most important items will be more easily discernible.**
- **Please keep in mind the importance of a particular item relative to the importance of other items. If you feel that an item is of smaller "grain size" and could either be subsumed under a different (broader) item, or best used as an instructional example, please rate that item lower than if you believe it to be a more significant generalizable, stand-alone idea.**

DEAR COLLEAGUES, ALSO PLEASE NOTE:

It has become apparent that the survey should be completed in one sitting.
CLOSING THE BROWSER AND RE-STARTING THE SURVEY AT A LATER TIME COULD RESULT IN LOST DATA.

DESIGN:

To demonstrate knowledge of important engineering and technology concepts and skills, upon graduation from high school students will be able to demonstrate engineering design capability as follows:

D1. Iteratively design and construct a model or full-scale product, system, process, or environment that meets given constraints and performance criteria.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- There are 3 big ideas in this statement -- the power of iterating on a design, fabricating either models or actual products, and doing so by meeting criteria and within given constraints. Some might give a "7" for only one of these three dimensions, others for more. Are these dimensions separable and worth separating?"
- Iteratively design and construct" too often becomes random trial and error....my observation is that students will move through iterations with little reflection and thought toward improvement... Possible re-word: "Using informed design practices, iteratively construct a ....."
- This competency seems ambitious for the overall high school population.
- Looks good
- Have we missed articulating the importance of applying the problem solving process? I suggest it read "Apply the problem solving process to design... With that, I'd give it a 7.
- I would also like to include the word "simulation" So much design today is first done with a simulation.
- I agree with many of the concepts and My students do not always build their designs but still have iterations in the design process through modeling or calculations.
- Agree, though it may be difficult to complete all stages of the design process (in a comprehensive manner) within a secondary school curriculum.
- I think perhaps the term Engineering Design Process would be a consistent phrase you might want to use. It takes into account what others are saying but with fewer words.
- Perhaps since these are acting as competencies, much of the comments/ further descriptions could be worked out in something like a benchmark document that gives the reader better ideas of how to carry out the competency. Virginia Tech Ed has done this to its courses for teachers looking for resource materials.

D2. Solve engineering design problems by identifying and applying appropriate science concepts.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- I think the words "…identifying and…" might be dropped since the teacher or curriculum author would often be identifying key concepts. However, it is critical for students to apply those concepts once identified so that they are doing "informed designing."
- add "and math concepts" Science and math go together. You can't do one without the other so let's not treat them as separate concepts.
- Students need to be able to identify and apply the appropriate academic concepts to demonstrate valid iterative design (D1).
- good
- Solve engineering design problems by identifying and applying appropriate STEM concepts. I understand that the idea is asking D2 and D3 to see the implementation of concepts "in different areas " I am still conflicted with the separation, it is adding one item that perhaps it is not needed. I strongly agree with this item but in the present times deal about STEM as a unit will be in my opinion more conductive to lead the participants to integrate the concepts and id what the teachers are trying to do today (hopefully)
- I would add: Learning by making mistakes is an important part of the problem solving process.
- I think this is an important part of engineering design and students may be limited by their background knowledge of Science. The point of using science is to reduce the iteration or guess work involved thus creating informed design.
- Learning how to identify appropriate concepts is extremely important, especially in light of misconceptions, bias, etc.
- I would add the "appropriately" to both identify and select. - I would rather say evoke ... as concepts are not just a pick and choose.. the process is much more elusive.
- I would phrase it as ....scientific and technological concepts.

D3. Solve engineering design problems by identifying and applying appropriate mathematics concepts.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- The identification of appropriate math concepts is really the responsibility of the curriculum developer and teacher. Application of properly scaffolded math concepts and practices is vital when appropriate. Not all design tasks lend themselves to mathematical analysis.
- add "and science" Science and math go together. You can't do one without the other so let's not treat them as seperate concepts.
- For the same rationale as D2... If the wording were changed slightly I would favor combining D2 and D3
- good follows with previous question
- see my comments of D2
- At 56 years old I still find myself referring back and making mathematical connections to new things. I also agreen strongly with the statement "I see STEM as a unit, and there is not need to separate science and mathematics"
- I agree with many of the concepts and as an engineer I would include math and science together not separately. Perhaps to help with identifying give the students some guidance or a few choices so they begin to understand how to select appropriate concepts. I think the importance here is not the level of math but the need to use it for informed design. Many levels of math can be used for informed design. I want to build a gate do I get a pile of wood and just keep guessing at the size until it fits or do I measure first then test to see if it works-simple design.
- same as before... I would add that mathematics concepts is not the only thing... it would be mathematical procedures and principles and mathematical layer... Each problem can be represented with different models. I find the 'representation' language not present in this question and the question before. I would change and add.
- STEM is more than a unit as someone hand suggested. It is an integrated approach to solving the technology and engineering problems that we face. The more we think outside of the box and away from the silos of our academic areas the better education will be with our students benefiting.
- can you not combine the two, science and math within one statement? And then work out the details or types of solvable problems in the benchmark

D4. Improve an engineering design by identifying, making, and evaluating tradeoffs.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- I find the wording a bit troubling and so only moderately agree. First, typically tradeoffs are paired with benefits of some sort -- reasoning about both is needed to make an informed decision. I feel the word "improve" is a bit wide of the mark here -- on more than rare occasions, the consideration of a benefit/tradeoff will result in changing a design that results in a drop in overall performance, but one that is more optimal.
- Agree with adding the word "benefits "
- Semantics?.... Iteration: a process used for Optimization: (analysis, criteria, constraints, trade-offs..) as a whole referred to as an "Engineering/Design" model... All students need to understand goal setting, and action planning in all life's problems...no plan or solution is perfect in all cases, as no "design solution" is perfect....our goal is to give the students the skills necessary to use informed iteration in all problem solving.... for them to meet the challenges presented to them
- I have two concerns about this item. First, I'm wondering if the students need to actually improve the design or just describe/model how it could be improved? I do believe that students should understand and utilize the concept of tradeoffs in design, but this item implies both another activity and more time spent. In addition, it would be hard to identify designed objects that aren't too easy or too hard for all high

school students to successfully enact modifications. These distinctions are causing me to rate this item lower. Also, there is no requirement for documentation or justification. As stated, a student could think about it and do it, but never have to explain to anyone else why they did what they did. I think being able to articulate the rationale is equally as important as being able to carry out the modification. I suggest something like "Model, document and justify improvements to be made to an engineering design by identifying, evaluating and making tradeoffs."

- Delete D4 and combine with D5 reworded. Improve an engineering design by identifying the positive and negative impacts of the design, making tradeoffs, and explaining the costs and benefits of those tradeoffs.
- no comments - sounds good
- I agree with the use of "improve" rather than "optimize"
- I like the change to improve I agree with the comments on optimize. I think this is something everyone does without knowing they are doing it. If you but are car you now there are things you like and things you do not almost any product you can start a conversation with students about this general concept.
- It's all abut the tradeoffs when you get to design in the real world. Very important for students to understand this in order to become more 'engineering literate'.
- What I am missing here is that tradeoffs are often governed by inherent values.. Engineers need to critically reflect on their values and the values governing their trade-off decisions.
- Understand that this is part of the system approach.
- i agree with some of the comments about breaking it into systems as a means to make optimization easier, and also include benefits

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- This item seems concerned with providing a particular kind of evidence of a certain facet of informed design thinking. It seems smaller in scale to the earlier statements. There are other ways to provide this kind of evidence; e.g., in a portfolio where a design decision is explained with both pros and cons articulated.
- Confusing wording. Should just be "weighing positive and negative impacts and explaining the costs and benefits of those trade-offs" or combine with D4
- Too narrow in scope...could be dropped This knowledge should be evident in process documentation. This skill is inherent in Ques. D6
- It seems to me that D4 requires a student to actually make an improvement, while D5 requires only the justification of an improvement. Since improvements to many systems are beyond the ability of many students, I would suggest that being able to justify changes is more important that actually making those changes. I would also suggest that students should be able to model a suggested improvement through graphical, physical, mathematical means. Perhaps the intent of this one is to hypothesize a rationale for an improvement made by someone else? These two could effectively be combined into one using the wording suggested in D4.
- For the generic high school population, I like the critical thinking required for this competency, but doubt that many could drill down to the level required to do much with costs and benefits. I think most students would gain much simply working at the pro and con level with some supporting rationale.
- A question that required some thought to respond
- Combined with D4.
- Here is my suggestion for this item Please propose and example of engineering design, and through it, describe in which place of the process making decision involves weighing tradeoffs between positive and negative impacts and explain the costs and benefits of those tradeoffs
- Here's an example: In the communications field we are constantly making decisions based on ROI. The cost per megabyte is typically much smaller in densely populated areas than it is in more rural areas. It is more cost effective to run fiber to people's homes in dense areas while it is not in rural areas. So people who live in densely populated areas are getting faster speeds and paying less me megabyte that those in rural area.
- same as comment to D4... The statements itself do not ask engineers to critically reflect their worldviews what govern the values on which we base trade-off decisions.
- Too complex, combine D4 and D5

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).

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- This items seems to combine two separable dimensions of design performance -- sketching and other forms of graphic literacy to model and communicate ideas, and then providing explanations for design decisions.
- Critical piece of the model: articulate (communicate) to yourself or group through iteration...conclude with communicating the "optimized" solution to the larger group ("general public") I prefer "articulate", to me it infers more specificity and analysis...
- I prefer communicate over articulate as well as it is more inclusive of the identified means.
- no comments
- I like this one
- Supporting analytical decision making through appropriate use of technology and communication methods is very important, though may be limited by available resources and time.
- Not only why, but reasons for choosing it -- aka explaining the trade-offs.

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 agricultural, or utilizing renewable energy sources).

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- Important for all sorts of reasons (making students aware of the impact that engineers and technicians have on the world), but not necessary as a standard.
- Research has shown that socially conscious design activity appeals to women and economically disadvantaged groups. These are the demographic groups we are trying to attract to engineering so this is an important emphasis.
- Learning activities are designed with specific objectives, If the objective is "broad" understanding of global problems and designing conceptual solutions and, these topics are very motivating and allow a width stage for INTERDISCIPLINARY learning which is essential to ALL students. If the objective is for engineering students to design an efficient wind turbine this activity may not be the best choice...
- Here is a problem approach that is gender neutral and can easily engage both boys and girls who could apply their solutions to connections with social studies, engineering, ELA, science, and mathematics.
- This is a very important concept for a design challenge, but now agree that it is not a necessary standard requirement. Perhaps it could be included under human values and be re worded to "Identify socially conscious elements ...
- The items above were actives ones, explain, describe, etc that can be explained through the survey. in this case, you would like the survey to explain a little how to engage in ... this is my suggestion Describe the engineering role when engaging in a socially conscious design activity that relates to a community-based need or global issue (such as providing potable water, providing sustainable agricultural, or utilizing renewable energy sources).
- There is evidence (IWITTS/Donna Milgram) that these types of activities attract and retain females in the STEM fields. This is ver important.
- I agree with the comment that this should not just be a separate topic but incorporated into all design and processes. Sustainability is an important concept for engineering. I think the big picture concepts appeal to a greater variety of students and helps them understand the breadth of the field.
- Engaging the student in real-world design issues, including ethics and sustainable design, is a great motivating factor to attract students to

engineering study in college.
- I don't like that it is called "design activity".. this sounds too contrived... I would just say "engage in design"

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.

Round 2 Median was 5 (Moderately agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree ○ Agree ○ Moderately Agree ○ Indifferent ○ Moderately Disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- There is a blending of two dimensions of design work here that seem separable -- doing design to help meet human needs, and using universal design concepts. Not sure to which design model the latter point is referring.
- Should delete. as stated engineering is for everyone not just people with disabilities. technology is there to make all peoples lives better
- Research has shown that socially conscious design activity appeals to women and economally disadvantaged groups. These are the demographic groups we are trying to attract to engineering so this is an important emphasis. This is similar to question D7 but has a different implication. "...people with disabilities" includes those with physical disabilities which we all immediately recognize but it also includes those with intellectual disabilities which most of us don't recognize. This is not those who are mentally handicapped and in special education but those who are intelligent and have great potential but are "learning disabled". This means they have some form of dyslexia the interferes with their ability to learn but if helped can earn advanced college degrees. An example is the development of a "reader" to read printed text allowing students with a reading dyslexia to succeed in school. This type of slight to moderate learning disability affects many many students and most students can relate to this as well as those with severe handicaps. It also creates an awareness of a big educational problem that has only recently been recognized and is correctable if caught early.
- I agree that it is included in D7
- Could D7 and D8 be somehow combined? They are separate idea but both relate to learning through service (LTS).
- I'm guessing the idea of D7 was to specifically address universal design as a concept and D8 was to address the NAE's Grand Challenges. However, both relate to the reviewer's identification of engineering as a "helping profession", which is a novel but critical association. What a great insight! If it is not important to you to identify those concepts (universal design, grand challenges) overtly, the notion of engineering as a helping profession could be used to combine D7 and D8 into something like "Demonstrate the value of engineering as a helping profession by engaging in a socially-conscious design activity to identify and meet a community based need or global issue (such as providing potable water, providing sustainable agriculture, utilizing renewable energy sources) or providing an assistive device or accessible system for a person with a disability" If it is important to keep universal design and grand challenges as separate concepts, it would be great if you could find a way to integrate the notion of engineering as a "helping profession" by including that phrase in both D7 and D8. I would love to have a conversation with that reviewer to thank them for that insight!
- This question could be combined with the thrust and intent of D7
- Reword to "Explain how a design solution ...needs of all people. The most important element of this question is the concept of universal design as defined at http://www.ncsu.edu/ncsu/design/cud/about_ud/udprinciples.htm
- Provide an example and an explanation of how design solutions can integrate universal design concepts to help meet the needs and wants of the community requesting the project, (noy only people with disabilities!!!)
- I think a sentence or two describing/defining what universal design is would help. I also agree with the last comment - a rising tide has a tendency to float all boats.
- I think this is a part of D7. I agree with expanding this concept perhaps aiding humans to live healthy and productive lives-this can go into knee replacements etc. all aspects of how engineering helps human form and function (3-d printing an ear). Maybe ...meet the needs of individuals to improve human health and function.
- There was quite a critique on "universal design concepts' as it can stand in contrast to designing for disabilities or different cognitive styles and functions.. I would rather call it "human-centered design". I would not just limit to "people with disabilities" ... this should include different cognitive styles, people of different cultural backgrounds etc.
- while I think the concept is good, singling out a particular group in a competency is not. perhaps include special needs or disabled in a larger group. What about designing to meet the needs of, children, elderly, people with pets, etc. teach the universal concept and have the teacher apply it/lead a discussion that will be most relevant to the students and their style of life.

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree	Agree	Moderately Agree	Indifferent	Moderately Disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelist's Round 2 responses to the above question:

- I like the emphasis of this item on collaborative work, but would not join it to documenting the process of iterative design, but rather to the process of selecting one design idea out of the many that get generated and then making that idea one that the entire group can commit to and "own." This is a big challenge whenever team work is involved.
- Shouldn't have to require the format as in group work. Documentation should be included in the previous tasks like D1.
- "...and document..." The most important thing in this besides the iteration activity.
- If the discussion (of the iterations) and presentation (communicating the solution) are EMPHASIZED... The analysis and discussion of all the solutions is critical and very effective.....if the analysis is left out the value is lost.
- Does this question intend to address practice in teamwork? if yes, then I suggest a team-based problem-solving activity instead of a group problem-solving activity. "Group" makes me think of large-group, whole-class type activities. As a large group activity, I am indifferent.
- The non-engineering student could gain much from a teamwork activity where some documentation of decisions is recorded. I like this.
- Like it
- Good question; gets at the essence of real world design
- This approach is a great exercise that builds team dynamics, and is an excellent strategy to facilitate out of the box thinking and conceptual blockbusting.
- This is important TE pedagogy, but not necessary as a standard.
- Simplify the statement Engage in a group problem-solving activity to generate several alternative solutions and document the process that resulted in the final design
- Excellent suggestion and one students frequently find difficult. This is also super important ot engineerign design work is often done s a team.
- Although I see this as an integral part of D1 -- design is always a collaborative activity.
- Encourages continuous improvement
- I would not state this question as a "learning activity" ... Engage in group problem solving...
- As crowd-sourcing becomes more common, this may be helpful

D10. Evaluate the effectiveness and appropriateness of the design of common items (such as a can opener, toothbrush, door handle, etc.).

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree	Agree	Moderately Agree	Indifferent	Moderately Disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question:

- Being able to apply ideas that come out of doing engineering design to the comparison of quality and effectiveness of everyday products based on simple experiments and explanations of how they work is critical.
- I know that you are constrained by the length of the question, but I would like to somehow add that the purpose of such exploration is to develop the critical faculties needed to to BOTH evaluate design decisions of others and the resulting outcomes, and designs created by the student following the course of study.
- Could be a useful activity but is not an overarching theme
- This is a good one as it uses items that are low cost and that students have used so they have a familiarity that should allow them to do a detailed analysis.
- Reverse Engineering, the most motivating and effective means of practicing Systems Analysis. West Point has(d) a "Toy" lab to study

mechanical systems. Bell Labs' innovative success has been attributed to the practice of putting scientists, engineers, researchers, and technicians in close proximity and letting them "play" together.. I believe it was Thomas Edison who said, I paraphrase, ...for true innovation to occur, all you need is imagination and a pile of junk.... The presentations to the large groups benefits ALL.

- Sure, but this would be just as good as an introductory activity to achieve one of the earlier objectives.
- Activities like this do not require strong math or science, yet can be very effective introducting engineering concepts.
- looks good
- Great approach to get students seriously thinking about design and practicality with items they can easily relate to.
- This would be an excellent activity to help students meet D4/5/6 etc, but not necessary as a standard.
- I do not see this item fitting the line of queations of the survey. It is interesting by itself but do not add any information about how the student view the design process, looks like a test question and not a survey about their design experiences.
- I would add a software example in the such as - cloud based document sharing.
- I think this is a precursor to D4 or the start of D4. perhaps expand on this for D4.
- Good technique for motivating student learning.
- Must understand existing products in order to develop improvements
- What about: "Functionality of different components" like in assemble/disassemble activities... The effectiveness and appropriateness is one thing... describing function, limitations, different options needs to be included.
- Not sure this needs to be a separate item, could be a suggestion within the benchmark

D11. Provide examples of how psychological factors (e.g., bias, overconfidence, human error) can impact the engineering design process.

Round 2 Median was 5 (Moderately agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree	Agree	Moderately Agree	Indifferent	Moderately Disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelist's Round 2 responses to the above question:

- Sounds like only negative factors are listed. Developing of intuitions and tacit knowledge about mechanisms, brands, etc is part of the process as well.
- This appears to be an extension of D10, and somewhat poorly focused. To that end, it focuses on an arena of design decision making that is very difficult to identify or evaluate without hindsight. Also, the question form implies unsatisfactory or disastrous outcomes: what about the elegant and sophisticated design solution s (such as velcro or the iPod)?
- Too specific to be required of all students
- "Not always right but never in doubt" This question addresses a critical source of design problems and failures. You might also add to this the issue of being too close to a problem that you don't see flaws in your work that fresh eyes might catch.
- Imbedded in D10? To evaluate effectiveness and appropriateness shouldn't one consider the genesis of the design? The "Why was it designed this way?" or "What are the causes of the success or failure of the particular design case study.
- This would lead to a good discussion.
- An excellent method to raise awareness of how psychological factors can impact engineering design and these factors can also be associated with a myriad of other fields of endeavor.
- This should be part of the evaluation process and perhaps a benchmark, but not necessary as a standard.
- The fact taht you placed examples of psychological factors shows that there is a big possibility that the students will not understand what it is that you are asking. You can ask Describe, in your opinion, what are the psychological factors (e.g., bias, overconfidence, human error, etc.) that can have an impact in the engineering design process and how
- I see this as the most important factor for understanding how engineering design can sometimes fail -- can link this to any of a number of current events, thereby potentially enhancing interaction between tech classes and social studies, history, etc.
- Identify as a different verb than "provide examples"
- should be covered in the discussion developed from a lot of the other competencies

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.

Round 2 Median was 5 (Moderately agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree	Agree	Moderately Agree	Indifferent	Moderately Disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelist's Round 2 responses to the above question:

- You have to include safety in the design of good curriculum materials.
- Such factors are often found by extended usage, or exploration of, a solution over time. Rarely can a student engage such activity as part of course of study. Is it worthwhile, yes: can it be accommodated in a standard course, probably not: should they be aware that researchers and industrial organizations use such approaches: yes.
- Too complex to be required of all students
- This is a tricky one because explaining risk and reliability to students without much experience can be difficult
- Isn't this an integral consideration in D9 and 10?
- Seems like we are getting too detailed.
- I would think this would be more of a study and analysis of the role of risk and reliability, how could you demonstrate this in practical terms?
- This too should be part of the evaluation process and perhaps a benchmark, but not necessary as a standard.
- Risk and reliability are two different characteristics that in my opinion do not necessarily need to be linked. I will suggest to separate in two items and use the word describe instead of engage, so the surveyed will have to be active explaining Engage and encourage activities.....
- Risk assessment is often not considered in design courses, though any discussion with industry professionals indicates that it should be. This also provides a great way to build collaboration between tech teachers and math teachers (learning about probabilities, etc.).
- We can succeed through our own as well as through others failures. Important concept in engineering.
- Again, this does not sound a competency... it sounds like a lesson description.... "engaging in an activity" is an instructional mean not the end goal.
- Kind of similar to trade-offs and benefits

Additional Comments Relative to Design:

- You might talk about the need to evaluate failures in detail. This provides insights into flaws in one's reasoning as well as identifies previously unknown influences that can be included in revised models or products. "Failure Analysis" seems to be unique to engineering design and needs to appear somewhere.
- Engage in activities that demonstrate direct applications of Math and Science principles. Create solutions that involve the synthesis of materials, ideas, and academic knowledge. Use Case Study analysis to illustrate the impacts of politics and bias in engineering and design solutions.
- The design standards need to articulate importance of applying the problem solving process to complete a design.
- Applied mathematics is my biggest concern. I see it going away especially in the ICT field with a focus primarily on certification. This is happening both at the high school and community college.
- Emphasize the important of innovative thinking, which can be obtained, for example, by biomimetics.

MODELING:

To demonstrate knowledge of important engineering and technology concepts and skills upon graduation from high school, students will be able to demonstrate modeling capability as follows:

M1. Use representational modeling (e.g., a sketch, drawing, or a simulation) to convey the essence of a design.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- In M1, part of the value of sketching is the ambiguity that the sketch provides, which has a value to allowing the design team's thinking to be more divergent and creative. So I would drop "accurately" in M1.
- Make sure "drawing" is understood to include sketches. The art of sketching seems to be disappearing with a focus on CAD systems. But a sketch is the best way of conveying an idea. New tablet software now suppports engineering sketching so maybe it'll make a come back in K-16 education.
- Modeling exists in many forms and can be connected to many fields of study including engineering.
- ...To accurately depict a design or solution to a problem.
- You could add the term "flow charting" and even "story boarding" depanding on what is being designed.
- I would leave simulation since ti could be a graphic simulation or mockup.
- Great preparation for college engineering coursework!
- The use of model to make decisions is not as well-represented here. Modeling involves as well manipulation of data to have empirical data to guide design decisions.

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- I would say, "Develop a scale model or prototype of a design…"
- Analyzing designs is an integral part of iterative design...awareness of materials, the science, attachments, properties and workability all effect design... Whether the "prototypical model" is real, virtual, or mathematical, it should be age and grade appropriate, to be used as a tool in the communication of the design proposal...but never eliminated or over evaluated.
- May want to emphasize that this is a physical model, if that is the intent.
- Prototype OR scale model
- Much higher level (hands on / minds on) thinking with this approach. This activity engages a wide range of our senses, and enhances students' abilities to become stronger problem solvers, inventors and innovators.
- This is fine
- Seeing a truss finally give way really brings the concepts to life. Having students support books with just index cards really surprises them.
- Can potentially consume a great deal of time and resources.
- I think construction is implied only with the use of prototypical, perhaps change it to Develop a test to analyze a prototype or scale model to determine its strengths and limitations. That way it can study both man-made and natural constructions.

M3. Use mathematical modeling (e.g., using the equation for conductive heat flow, Q=kAΔT/L, to design a shelter) to quantitatively describe and predict the effects of variables on a design.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- As a science ed person who uses design tasks, I have students as elementary students measuring performance outcomes (a key math process) and then comparing how well each design performed.
- The comments imply that higher mathematics is needed and it isn't. The key here is to show that mathematics has a place. One doesn't need calculus to approximate a relationship. And a simple mathematical approximation can identify errors and can eliminate possibilities. This question doesn't imply you have to use calculus. It implies that we need to show students how mathematics is useful. Don't dumb down the curriculum by assuming you will loose students. They just need a reason to use this. If you kill this requirement you have just said to all these students "math is not important so you don't need to learn it" and that is just incorrect. We just spent five years creating a math course for the lower 50% of high school students, those students who won't go to college and won't pursue a STEM degree. It used engineering modeling to teach advanced non-calculus mathematics including probabilistic modeling. These students had no trouble learning the material and doing well with it. Basically, because it focused on the relevance of the mathematics. It's been formally adopted by two states and used in school systems national-wide. It proves these kids can do advanced mathematics if they are provided a context in which to see it's utility and application that is meaningful. Don't dumb down this by removing mathematics use.
- Drop "(e.g., using the equation for conductive heat flow, Q=kAΔT/L, to design a shelter)" and I cannot think of a single instance where some quantitative design is not present...sometimes simple additive dimensions, sometimes sophisticated calculus...Technology and Engineering are based in quantitative solutions that are "predictively repeatable"
- Just because we haven't done it successfully in the past, doesn't mean it should not be included. There are easy ways to mathematically describe loads and other quantitaive properties, that we use even in elementary school engineering.
- An excellent activity for a pre-engineering student but not for students in the general population. However, I do love the approach and the practical connections and relevance this kind of activity can facilitate.
- I will get away to put examples, it can confuse or kimit the surveyed Use mathematical modeling to have a previous idea of the behaviour of the project and, describe and predict the effects of variables on a design.
- I see high school as laying the mathematical foundation. Some simple examples are good at setting that foundation - things like conductive hear flow, Ohm's Law, power equations, etc.
- I have this same problem in my environmental science class-lack of math skills. I am going to try using pre loaded formulas in a spreadsheet so they can at least see the need and impact.
- Again, very good preparation for college.
- Pre-college? That is a giant step for all before graduation
- Collecting, Analyzing of data is missing in this...
- The example is too complex, could be something having to do with simple machine equations or something the student may be familiar with.

M4. Use simulation software to investigate complex systems and issues.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- Simulations can support inquiry into basic phenomena as well as predict performances of specific design configurations.
- Should not be required for all students.

- I reiterate the issue from a comment, complex software shifts the focus to teaching the mechanics of the software and not the critical idea of modeling. In addition, it cost money school systems could better spend on other things.
- Whenever possible, simulation software should be used....
- I tend to agree that simulations are cool and help us understand systems; students already find the free ones online.
- Sometimes the sim software requires substantial insight into engineering to make sense so maybe this does not apply well to all students.
- Simple simulation software, such as the West Point Bridge Design program
- Some schools could provide this simulation experience, but out of the question for many others. I question the time commitment and the benefit of learning this software, while carrying out a senario and drawing conclusions.
- The simulation is an extension of M3
- I like the comment "Simulations seem to facilitate student understanding of complex interactions in systems. I don't want them to just use the software, but be able to explain the dynamic interactions that occur in a common system."
- I find this useful for my students particularly for design of wastewater treatment. I am not sure about the application to high school. Some of the software is easy to use but the concepts are difficult. I have seen some nice app showing simulations of concepts that may be useful. It would need t be an easy to use cheap app or something similar.
- Google sketch-up is free and at least gives the student hands on experience with a 3 D design software
- It doesn't specify what actually to do with the software... "investigate complex systems" is too vague..
- too specific yet too broad, granted you could probably run "simulations" within Excel that most teachers have, but this could be either too simple by using west point bridge builder or too complex by running something within mathmatica.

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- I would say communicate the final model. it could be written or or presented in some way that is not necessarily physically constructed. There is already a construction component in the prototyping task M2
- Without this you don't have engineering. Software is just a refinement step. Students need to learn to build it and learn how to test it. These are important skills. We've had to implement a lower division course in our engineering curriculum becuase students coming into engineering don't know how to use basic tools. They've never built anything so can't tell a screw driver from a hammer.
- Drop or combine with M2
- Could M2, M5 and M6 be combined? Perhaps, "Develop and test a physical or virtual scale model of an artifact, process, or system to analyze its strengths and limitations and how it meets design requirements and constraints."
- This activity is great for pre-engineering classes I would like to see all students have a related experience in order to strengthen their analytical skills as well as have an understanding the range of considerations needed within the modeling process. Virtual modeling is basically 2D and not touchy feely, hence not real world.
- Combine M5 & M6 as suggested.
- I agree with the last comment: I would combine this one and the next one to read "Create and test a physical OR VIRTUAL model of an artifact, process, or system using tools and materials to ensure that a design solution meets given criteria and constraints."
- I think the creativity part is important. I think building is fine but keep the concept simple. Our freshman engineers design a logo for their team and build it -constraints can be materials (foam, clay....)and time allowed. This can be done if you think simple and major concepts.
- The creation of making models does not have to be expensive. With cardboard, a scrap piece of a 1x4, eye screws, welding rod and some plastic wheels you can make a test crash car. Using recycled material and a raw egg, you can model an egg drop package. These can all be done as a group learning activity. Think outside of the box instead of buying the box.
- agree with the combining comment.

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.

Round 2 Median was 5 (Moderately agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately Agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- Students have to evaluate the fidelity of the simulation -- pros and cons.
- The learning overhead to use simulation software tools that reveal the strengths and weakness of models based such design decisions are high. Parametric tools are a wonderful resource, however the complexity of current 3D modeling tools precludes their use in high schools on a regular basis.
- Combine this with M5
- I reiterate a previous comment, "As long as there is the creation of a physical model to test the virtual model predictions. Students need to know that nothing works exactly like the computer simulation and how meticulous one needs to be when building and testing a real artifact. Don't eliminate labs because of computer models."
- See M2 and M5
- m6 very similat to m5
- How readily available and cost friendly will this simulation software be for all schools? Simulation software has many good attributes, but it does not replace real world connections. Modeling a physical model and showing comparisons with a virtual model of the same device or system, would be the best of all worlds. I am not sure if class time, for the general student population, would permit the pursuit of both approaches.
- M1-M6 could all be combined with the previous suggestion "Create and test a physical (and/) OR VIRTUAL model of an artifact, process, or system using tools and materials to ensure that a design solution meets given criteria and constraints." The other items M1-M5 would be benchmarks or indicators.
- 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, before constructing a physical model.
- I agree this can be combined with the physical model and at the high school level there may be issues havingthr right types of software and time.
- Software start-up and cost concerns at the high school level
- There are a number of free simulations on the internet. You just need to find the one that is most suited to your students.
- people are making this over complicated, I did this by using WP bridge builder, then the kids build and test a balsa bridge, then its both virtual and physical, the students know its not perfectly accurate but get the idea.

Additional Comments Relative to Modeling:

- To me, the key competency is choosing the appropriate modeling technique considering availability, complexity, and grade level...

SYSTEMS:

To demonstrate knowledge of important engineering and technology concepts and skills upon graduation from high school, students will be able to demonstrate systems thinking as follows:

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- Systems diagrams are a form of representation that appears often in science ed high-stakes tests: water cycle, rock cycle, life cycles, etc.
- I'm going to disagree with all the items on systems. Systems could just as easily be biological or chemical or anything else in science or economics, it's not only engineering. Feedback and control systems are a topic in engineering, but a very specific one and should not be required for all students.
- Still my top priority
- I like an earlier reviewer's phrase " problem solving for life."
- Systems and sub systems permeate life at every level. Our students need to be able to identify and understand the interconnectedness of systems and become good systems thinkers.
- Label and explain a systems diagram of technological system you are familiar with: describe the specifies inputs, processes, outputs, feedback, and control components
- This is good - understanding a simple system.
- Understanding systems is very important, and provides an excellent way to introduce the multidisciplinary nature of engineering.
- It should not be just "technological system"... systems that span technological, human and social systems are equally important.
- Its up to the teacher to relate tech systems to other systems outside the classroom

S2. Identify and explain the function of the interacting subsystems that comprise a more complex system.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- Is there a better word than interacting?
- Systems thinking is an important skill set for all students to have. Currently, the majority of students lack a strong understanding of systems.
- I am still concern with the choice of complex. Technology is not complex, is composed!!!! - it is in my opinion a philosophical issue, that led people not to be in the technology field.
- I think an example is needed here. Maybe you could use a home water system and hot water heater as an example that combine to produce hot water.
- Understanding how possible unintended interactions between components can lead to failure can be done through case studies.

S3. Explain the differences and effects of negative and positive feedback in a system.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- I like the last reviewer comment.
- How about compare/contrast instead of explain?
- it is a technical item. I will rephrase in state of explain, describe, in your opinion, ...
- Another example would be good here. Maybe a home thermostat - getting too cold, turn hear on. Getting too hot, turn heat off.
- You may want to not limit this to technological systems only.. I t may be easier to approach the concept with a biological or familiar system.
- Why just technological system...?
- Benchmark for ideas for the teacher to to utilize in class

S4. Design, construct, test, and explain the operation of a system composed of several subsystems to accomplish a given goal.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- Designing a system and its rules and interactions is really a challenge -- except perhaps with system software like Stella.
- As long as it is attainable....could be pre-designed, large group project, or attainable individual effort....
- This is a big question. I would change it to three subsystems "Design, construct, test, and explain the operation of a system composed of at least three subsystems to accomplish a given goal."
- This may be limited by available time and resources. If it can be done -- great!
- Use the same language as before "constraints and criteria"... Why here suddenly goal.
- Not as complex as it sounds, can we say Rube Goldberg or the kids game mouse trap

S5. Explain the difference between an open-loop control system and a closed-loop control system and give an example of each.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- This is a particular learning goal that is within the larger category of systems education.
- Agree to "as needed"
- This seems an overreach for the average student.
- Closed and open loop systems are important to understand if students are to truly understand the world around them.
- Again it is technical item, that will give the feeling of a test and not a survey. You can accomplish the same by asking Describe in your opinion, the difference between an open-loop control system and a closed-loop control system and give an example of each.
- I agree with the last comment: The terminology of the question I believe will not be clear for the students in general can be rephrased like ... between system with feedback and without feedback ....
- Terminology may be new, but make them learn it, they need to understand more vocab anyways

S6. NEW QUESTION AS A RESULT OF PANEL SUGGESTIONS. Develop and conduct empirical tests and analyze test data to determine how well actual system results compare with measurable performance criteria.

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Additional Comments Relative to Systems:

- Students should be able to explain what is "big data", and it's relation with cloud computing and cell-phone WIFI technology

RESOURCES:

To demonstrate knowledge of important engineering and technology concepts and skills upon graduation from high school, students will be able to demonstrate capability in selecting and using resources as follows:

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.
Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- This seems to need some focus. It seems way too general to have meaning.
- "Identify people, capital, information, materials, time, and tools as the absolute necessary resources to actualize any engineered system, process, product, or environment. (This is consistent with D1)
- By having a command of the resources for technological systems students can be more adept at visualizing and understanding the big picture as well as its individual parts.
- This was from the older middle school curriculum "blue book" and I think it is still important that students identify and consider each.
- I would also add the word "capacity"
- This is great. Students might list a 2 by 4 but lots went into making just that 2 by 4. Industrial ecology is a very important field and students should be introduced to these concepts as a consumer not just as an engineer.
- I agree that it is a bit difficult to understand the question. This sounds more like a case-study, business-oriented approach to understanding engineering design and implementation of systems and resources. Very valuable if time permits.
- I wouldn't call it technological systems... rather tech-social-human systems. On a minimum we are ignoring biomedical engineering as human problems are part of them.

R2. Select and use appropriate material, energy, and information, tools, and processes to accomplish desired technological results safely, economically, and efficiently.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- The sentiment expressed in the following appears to capture the essence of how this might be better achieved ... "Research and investigation are going to [be the SIC] best resource such decisions. Perhaps that aspect needs to be referenced?"
- How does a student demonstrate they have this knowledge? Seems like it should be part of the M & D sections.
- I suggest dropping. This should be an integral and necessary part of each phase of the design and engineering iterative process;...if not then we are really in trouble!
- Safety, economics, efficiency and ethics should be a basis for all engineering design activities. However, I am not sure that the students have to be able to do this accurately by high school graduation.
- An excellent and needed approach to incorporate and ensure higher order thinking.
- This is what employers expect from their employees.
- to complicated to read and understand. - need to simplify and ask to the point - this will be link with the concept of trade-off when choosing, maybe need to be placed here too
- Maybe Research, select and use.....
- This is becoming more important just a choice of patio furniture can be huge in terms of cost and environmental cost.
- Safely, economically, efficiently -- very important concepts to understand as driving forces in design, operations and maintenance.
- I am missing... the reflection on values in how to determine what is appropriate
- Important of learning from the nature (biotechnology) should be strengthened.

- this should already be covered in the modeling and design competencies

R3. Evaluate technological and scientific information for accuracy, and authenticity of sources.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- This is part of every subject not just an engineering
- Really critical. Are the assumptions used in the model valid? Are the assumptions met by the system being modeled. If the assumptions are violated then why would we still use the model (hint: it gives good predictive results). The issue here is important because there is a tendency to focus on building the model without attention paid to the accuracy of assumptions or data that is used.
- Not sure that high school students are capable of evaluating the information for accuracy. If they see differing viewpoints on a topic, are they capable of determining which is correct ? I have my doubts. (Since the Round 1 median was 7, perhaps I have misinterpreted the question. I guess my problem is with the comma. If the comma were not there and we are talking about the accuracy and authenticity of only the sources, and not the information, then my answer would be a 7.)
- Relate this question more directly to how the authenticity and accuracy of technological and scientific information impacts systems. This question involves a huge research, testing and analytical endeavor that would be difficult to implement at a K-12 level.
- I am fine with this one
- The concept is much broader than tolerances.

R4. Safely and correctly use tools and machines to produce a desired product or system.

Round 1 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- Engineering design can be done on processes, computer applications, etc. and many things that are not physical. We all use computers as tools and machines. I would be careful of defining tools and machines as only hammers, drills, saws and soldering irons.
- By including "correctly" this rightfully includes how to use and file software and electronic files; file formatting between applications such as drawing and .stl files for CNC; and personal files and records for online assignment submission and evaluation.
- I would add in "and processes". .....to produce a desired problem solution, product or system
- Although important, this is already under R2 and could be articulated as an indicator.
- The item is good but what is the link with resources
- I am fine with this one I rated this somewhat lower, not because of the "safely and correctly use" part (I would rate safety as a "strongly agree"), but rather because I don't see machining as a skill that is critical for all students.
- It is way too broad... It should be critically examine which tool is more appropriate in using for a particular problem.

R5. Practice safe, legal, and responsible use of information and communications technology.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- R5 and R6 address appropriate ethical decision making through the lens of ICT: why are limiting ethics to such a narrow subset?
- I don't see how this can be monitored in school as it implies assessment beyond the classroom.
- I do like the inclusion of ethical..... It seems that ethics and ethical thinking need to play a much greater role within engineering and technological problem solving. Reinforcing the consequences of plagiarism is essential?
- Although I understand the intent, should this be limited to information and communication technology? I think that is what the comment "All technological systems are capable of damaging usage: to narrow the list to ICT appears to miss the point." was stating.
- Change to: Practice safe, legal, ethical, responsible and professional use of information and communications technology.

R6. Identify and discuss privacy issues involved in using information resources.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- Most students (and adults) dont' realize that anything put on the web is nearly impossible to remove since you loose control over it completely. R6 is important.
- Good removal of practice
- I am fine with this one
- Ethics plays a big part in engineering.

R7. Identify and discuss environmental, health, and safety issues involved in implementing an engineering project.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- I see this work as being scaffolded by the teacher and not done independently by many students.
- This question is a perfect segway to emphasize the importance of achieving ethical approaches. Discussing environmental, health and safety impacts connected to the implementation of an engineering project hugely important.
- here ... more about trade-offs would be helpful... Many of these are in conflict with each other and need to be reconciled..

Additional Comments Relative to Resources:

- None Provided

HUMAN VALUES:

To demonstrate knowledge of important engineering and technology concepts and skills upon graduation from high school, students will be able to demonstrate consideration of human values in proposing solutions to engineering and technological problems as follows:

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.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- "Identify and explain how intelligent information...
- in today lexicon, what you meant intelligent, is "smart" such as smart grid, smart meters, smart appliances.... i will suggest to change the word intelligent by smart

- I am fine with this one
- Very important concept -- this makes me think that a separate requirement for understanding the broader impacts of technology on society may be needed, which would encompass this area (as well as some of the other areas mentioned in questions here).

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).

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round 2 responses to the above question.

- A very fine activity, but not a requisite for all, I believe.
- Maybe say evaluate and redesign or combine with HV 4
- I like this now that you have narrowed the scope with some explicit examples of sustainability.
- Sort of an extension of the iterations in the Design process...as discussion topic it may be appropriate for everyone, but as a re-design, seems too much for high school
- Again, actually do it or explain how it can be done and provide justification. I would suggest adding "Model the redesign of... and provide justification for the redesign."
- A perfect approach to stimulate the incorporation of student learning and understanding across many schooling exposures and experiences.
- Identify and explain the elements of a socially conscious design related to community or global issues such as sustainability, water quality, energy, or food production. Use D7 as an indicater here. "Engage in a socially conscious design activity that relates to a community-based need or global issue (such as providing potable water, providing sustainable agricultural, or utilizing renewable energy sources).
- the item need to ask if it is needed to redesign all the time, or if it is needed to re-assess the working system and take action after the assessment\
- I like this - it involves collecting and using feedback.
- It's a good item... the category should be part of design and problem solving... If we put it in this category... we make it look like if it is an addon to engineering not core practice... It is core practice when thinking about criteria and constraints.
- The clear definition of sustainability should carefully introduced first. Sustainability is not just "reducing the embodied energy of the product, lowering its energy use, and/or using recycled materials".
- This is covered in another competency.

HV3. Explain and give an example of how different cultures' engineering design solutions vary based upon the desire to satisfy their cultural values.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree | Agree | Moderately agree | Indifferent | Moderately disagree | Disagree | Strongly disagree

Here are panelists' Round w responses to the above question.

- Ending seems narrow -- comparing products from different cultures to satisfy different human needs might make the item a bit broader.
- This activity would require a fair amount of research in order to arrive at cultural understanding and addressing engineering design solutions. How much research would be enough as per an individual student? I believe this activity is too much to ask of the general school population in a K-12 setting and expect realistic comparisons and outcomes.
- This would be more inclusive if reworded to "Identify and explain how various human psychological factors (e.g., culture, bias, overconfidence, human error) can impact the engineering design process. " D11 and HV3 then could be indictors.
- The last gender comment is a good idea.
- I agree with the gender as a means to introduce this topic. No place for a purse in the car....
- I would add a component that targets more the "cultural differences in the process of engineering"
- Just read "The World is Flat".

HV4. Give an example of and investigate the impact of a tradeoff a company might make between profitability and environmental, health, or safety concerns.

Round 2 Median was 6 (agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- Very worthwhile, but very difficult to see how this could be covered in a high school setting without using stereotypes (Pinto fuel tank, for example) which can reinforce the distinction between optimal (engineering) solutions, and practical (accountancy) outcomes.
- In the news almost daily...just another illustration of how technological systems effect our everyday lives
- This could be an indicator of D5.
- Too convoluted for the surveyed. Need to simplify - make two items
- I would use fracking as an example and think a little politics in the classroom is always good!
- See comment above when I discussed why the place here makes it look like an add-on.

HV5. Effectively use social media (e.g., Facebook, Instagram, Twitter) without violating accepted social norms (e.g., not posting personally offensive/rude posts about a person, inappropriate images, or engaging in verbal "fights.")

Round 2 Median was 5 (Moderately agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree	Agree	Moderately agree	Indifferent	Moderately disagree	Disagree	Strongly disagree
○	○	○	○	○	○	○

Here are panelists' Round 2 responses to the above question.

- Appropriate behavior, physical, verbal, written, social, etc. is the foundation of a sound education: it forms the basis of elementary education and is practiced and reinforced throughout a student's school life. To focus on social media within an engineering course is to miss the

point ... appropriate social behavior is part of the climate of schooling. The fact that education is a little late in adding social media to the repertoire of appropriate behavior should be addressed universally, not subject-by-subject.
- Although I strongly agree here, I am not convinced this competency should be related to engineering and technology. Although this skill would not exist without technology, the skill itself is social, not technological.
- I agree with the premise but not with school assessing student use.
- This is a bad one. All public schools ban using social media on their computers because it has caused all sorts of problems. I'd remove this one.
- Agree that all hs students should follow and understand...not sure it can be implanted....cannot even control the distractions caused by the constant use of social media at inappropriate time...(class, testing, etc.)
- Proper and ethical use of Social media needs to be a major concern for ALL teachers and programs. However, many school systems do not allow students to use their internet access for social media purposes.
- Although important, I'm not sure it should be a TE standard.
- High schools are still blocking this content. Students end up learning it on the street (like I learned about sex). That's not the best way to learn anything. It's not going away and is very important.
- I would delete... as this is everywhere and not specific to engineering education.

HV6. Show evidence of considering human factors (ergonomics, safety, matching designs to human and environmental needs) when proposing design solutions.

Round 2 Median was 7 (Strongly agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree ○ Agree ○ Moderately agree ○ Indifferent ○ Moderately disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- These are important disciplines and I like the framing of this item.
- The statement implies that students need to design something that requires human factors. I better phrasing could be to examine a design and deduce human factor consideration.
- Design solutions must address identified constraints, critical human and environmental factors in order for the design to be valid and realistic.
- Would this be a better fit under design, not human values? Or it could be an indicator of universal design.
- Covered in another competency

HV7. Provide examples of how the societal impact of engineering failure may lead to changes in laws, regulations, and design and use of technologies.

Round 2 Median was 6 (Agree)

NOW PLEASE RESPOND TO THIS ITEM IN ROUND 3.

Strongly Agree ○ Agree ○ Moderately Agree ○ Indifferent ○ Moderately Disagree ○ Disagree ○ Strongly disagree ○

Here are panelists' Round 2 responses to the above question.

- Although I see the distinction between this question and HV4 (this DOES focus on the negative outcomes side of the equation), I am concerned that this, once again, tempts students to look at the social aspects of engineering decision at the cost of exploring the underlying design and manufacturing decisions and actions, and their interactions. Do I know how to reword to meet this goal ... I'm not sure I can!
- Good topic but should not be required of all students
- I think the phrase "engineering failure" should be replaced by technological failure. The engineering analysis may have been according to standards, but the standards were not sufficient.
- I'd remove "societal". This broadens it without changing the intent.
- And how even following best practices can have unintended consequences
- Societal impacts, due to engineering failure, are a critical fact of life and students should be made sensitive to the implications of these impacts and also be cognizant to how they can be effectively resolved..
- An indicator of understanding the positive and negative impacts of technology.
- Provide examples of how the societal impact of engineering producs (successes or failures) may lead to changes in laws, regulations, and design and use of technologies.
- I like this as is
- I believe this is very important in enhancing technology literacy -- especially in helping students to understand how the impact of technology (including potential failures) influence the world of technology/societal interactions. The drawback is that this can be a tricky topic to address since people (including students' parents) often have strong opinions on these issues.
- I don't think this is H.S. level material - more appropriate at the college level
- Studying disasters allows for us to look back and better understand their social impact
- Provide examples is not a competency ... what are we asking them to demonstrate as competency in this category?

Additional Comments Relative to Human Values:

- None Provided

In the box below, please be kind enough to add any general comments that you might wish to provide and/or any item-specific suggestions that might inform our findings.

Thank you very sincerely for your participation in this study. Please indicate if you would be willing to have your name and affiliation made public as a study participant.

- ○ Yes
- ○ I'd Prefer Not