The Engineering Design Process and other Standards in the STEM Learning

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To address the question "Which technology education, mathematics, and science standards relate to problem solving or engineering design? "I decided to start by using the core ideas of engineering design from the NGSS standards in the Framework and from there find the commonality in the definition of the standards and practices from the Math, ITEEA, NGSS and NCTM. For my own clarity, those criteria are listed on *Table 1*.

The visual representation in Figure 1, reflects my intention to find the purpose and goal of each silo to support the engineering design and the commonality/difference of language and approach to find a solution to a problem.

- **Defining and delimiting engineering problems:** All four standards considered (1-4*) the importance of reasoning and understanding the problem to solve by evaluating the problem from different perspectives.

- **Designing solutions to engineering problems begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.** This core of engineering design is supported by the considered standards by applying the core of each subject reinforcing the concept of strategy, creativity, questioning, investigating, evaluating, and establishing connections between concepts learned in each discipline. Teamwork, communication, critical thinking, and explanation of solutions in a collaborative setting support the goals desired in the engineering design learning.

- **Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.** Optimization of solutions, I believe is achieved by consideration of the core and practices of all standards, which in many cases will require revisiting initial steps, like reconsideration of the problem or approaches take, new planning and development of new solutions from initial methodologies or thinking.

- How are these standards similar to each other?

The standards considered for this comparison in general have the same goal from its own angle of integration. Some of the commonalities are

a. Understanding of what's being taught/learned.
b. Integration and connection to understand and solve a problem/question
c. Freedom to explore the curriculum instead of fixed checklist material
d. Teaching/learning through hands-on material
e. Relatable/realistic lessons that can be visualizes in our society.

Standards like communication, teamwork, ethics are not explicit in the engineering design, however they are an intrinsic part of the engineering design core as fundamental basis.

COMMON CORE STANDARDS/MATH

3 Construct viable arguments and critique the reasoning of others.

ITEEA Standards for Technological and Engineering Literacy

7. Communication

8. Attention to Ethics

Next Generation Science Standards

7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

NCTM

- Communication

- How are they different from each other?

Each standard approach goals and practices that can be integrated into the engineering design process, and perhaps the use of specific model with mathematics (4), is the only one that requires specific knowledge and approach but still requires the deep reasoning and understanding advocated by all other standards.

- What are your thoughts on engineering design problem solving as a "unifying" concept/skill?

In general, all standards aim towards similar goals and are presented very descriptive with a sense of freedom for application. The engineering design in the other hand is a more visual approach that can be adapted and integrated. In my opinion, the engineering design problem can be a unifying concept when the acknowledgement of all other standards is considered starting with the most basic skill that is simply understanding the problem. Every aspect of learning provides important aspects in the development of deep learning, the engineering design perhaps acts as the glue of all integrating deep reasoning, exploration of solutions using prior and new knowledge and the implementation of the solutions by systematic and effective approach.

Standards considered:

1) Common Core Math Standards http://www.corestandards.org/Math/
2) ITEEA Standards for Technological and Engineering Literacy (Located in Resources Folder and Lessons area of OLS)
3) Next Generation Science Standards http://www.nextgenscience.org/overview-dci
4) NCTM http://standards.nctm.org/

Table 1. Main Core Ideas from Math Core, ITEEA, NGSS and NCTM and the Engineering Design Process

CORE COMPONENTS OF THE ENGINEERING DESIGN (Appendix 1 – Engineering Design in NGSS)	**COMMON CORE STANDARDS/MATH**	**ITEEA Standards for Technological and Engineering Literacy**	**Next Generation Science Standards**	**NCTM**
A. Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits. B. Designing solutions to engineering problems begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem. C. Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by	~~1 Make sense of problems and persevere in solving them~~ ~~2 Reason abstractly and quantitatively~~ ~~3 Construct viable arguments and critique the reasoning of others.~~ 4 Model with mathematics. ~~5 Use appropriate tools strategically~~ ~~6 Attend to precision~~ ~~7 Look for and make use of structure~~ ~~8 Look for and express regularity in repeated reasoning.~~	Core Disciplinary Standards The eight core disciplinary standards presented in *STEL* are described in Chapter 3 . The standards include: 1. Nature and Characteristics of Technology and Engineering 2. Core Concepts of Technology and Engineering 3. Integration of Knowledge, Technologies, and Practices 4. Impacts of Technology 5. Influence of Society on Technological	The Framework identifies eight science and engineering practices that mirror the practices of professional scientists and engineers. Listed below are the science and engineering practices from the Framework: 1~~. Asking questions and defining problems~~ ~~2.Developing and using models~~ ~~3. Planning and carrying out investigations~~ ~~4. Analyzing and interpreting data~~ ~~5. Using mathematics and computational thinking~~ ~~6. Constructing explanations and designing solutions~~ 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information	The Standards for school mathematics describe the mathematical understanding, knowledge, and skills that students should acquire from prekindergarten through grade 12. Each Standard consists of two to four specific goals that apply across all the grades. The five Content Standards each encompass specific expectations, organized by grade bands: • Number & Operations • Algebra • Geometry • Measurement • Data Analysis & Probability The five Process Standards are described through examples that demonstrate what each standard looks like and what the teacher's role is in achieving it: • ~~Problem Solving~~ • ~~Reasoning & Proof~~ • Communication

trading off less important features for those that are more important.		Development 6. History of Technology 7. Design in Technology and Engineering Education 8. Applying, Maintaining, and Assessing Technological Products and Systems The eight Technology and Engineering Practices, as covered in Chapter 4, are: 1. ~~Systems Thinking~~ ~~2. Creativity~~ 3. ~~Making and Doing~~ ~~4. Critical Thinking~~ ~~5. Optimism~~ ~~6. Collaboration~~ 7. Communication 8. Attention to Ethics		• ~~Connections~~ • ~~Representation~~

		The eight technology and engineering contexts are: 1. Computation, Automation, Artificial Intelligence, and Robotics 2. Material Conversion and Processing 3. Transportation and Logistics 4. Energy and Power 5. Information and Communication 6. The Built Environment 7. Medical and Health-Related Technologies 8. Agricultural and Biological Technologies		

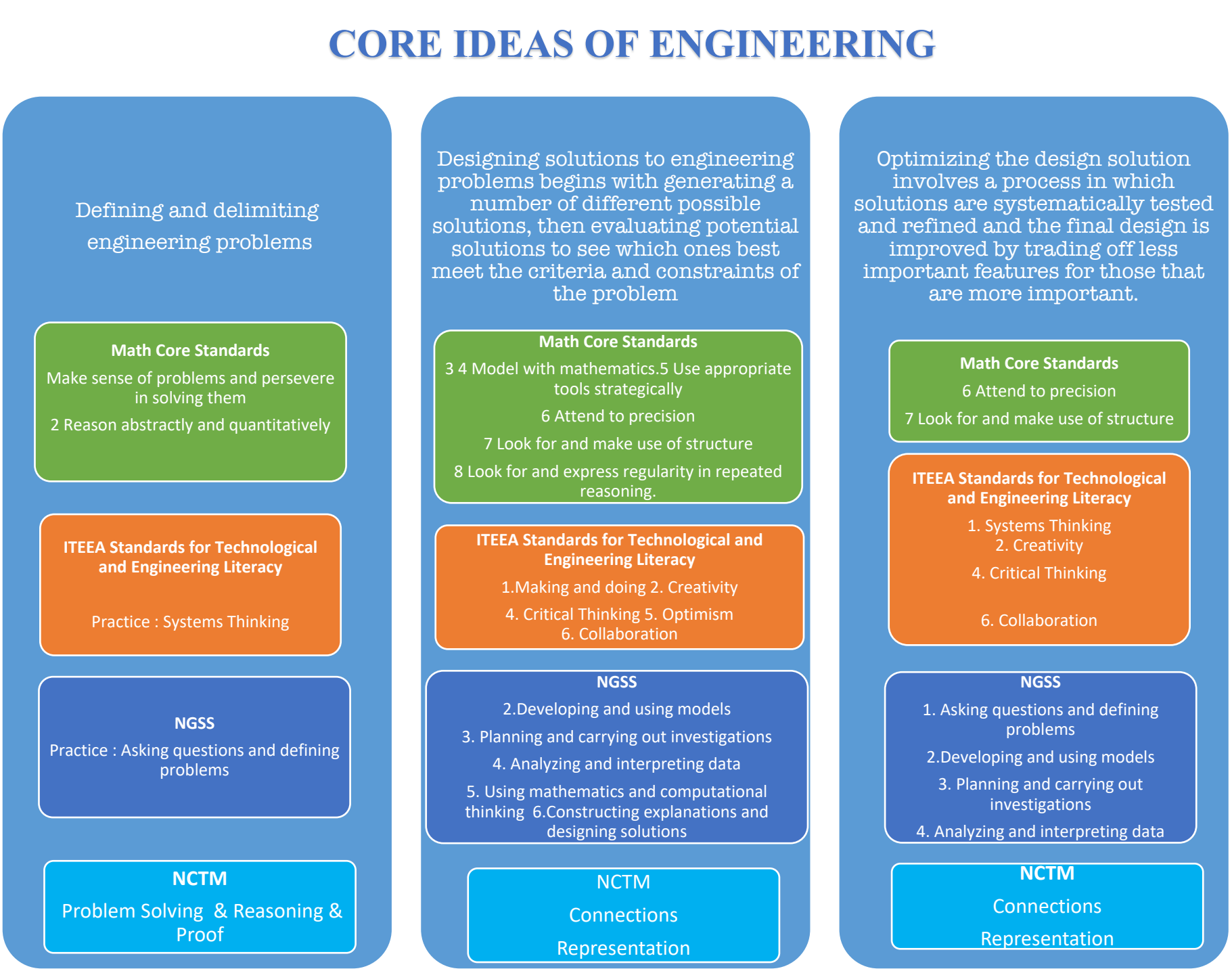

Figure 1. Personal Interpretation of alignment among the Math Core, ITEEA, NGSS and NCTM standards with the Engineering Design Process.