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Integrating Engineering into K-5 Science

1. **Promotes higher-order critical thinking skills.** Meta-cognitive and cognitive skills are multi-leveled and fully integrated into the design process. Analysis, synthesis, and evaluation are sophisticated thinking skills that are naturally embedded in engineering. Sophisticated thinking in one curriculum area promotes increased sophistication in thinking in other areas, and increases overall academic performance. This is a valuable way to expose all learners, including those with special needs, to rich and rigorous higher-order thinking. Also embedded within the engineering design process are many other important higher-order thinking skills, including: differentiating; prioritizing; comparing and contrasting; gathering and organizing information, inductive and deductive reasoning, integrating differing points of view into a consensus decision; determining cause and effect relationships; systems thinking; trade-offs, consequences, and impacts of design decisions; visual representations of systems thinking; hypothesizing; and classification. Meta-cognitive skills commonly used in engineering design projects include self-awareness, self-monitoring, and self-regulating behavior. These meta-cognitive skills are also extended to the group level, as the design team learns to function as a unit and be aware of its progress, above and apart from the functioning of any single member.

2. **Invites incorporation of Instructional Technology into the curriculum.** Excel, Word, and Power Point, along with Smart Board technology, and use of peripheral devices such as scanners and digital photography, are all easy to incorporate into engineering projects. The presentation piece of any engineering project naturally lends itself to formal presentation using IT vehicles. This is invaluable practice in oral communication skills that all students need to develop. It gives students early proficiency with critically important tools that they will need to use throughout their years of education and in the workplace. Engineering is an obvious way to use IT to support and enhance student learning, both in content mastery and thinking skills.

3**. Engineering is differentiated: offers an "in" for learners of all types.** Due to its project-based nature, there are many roles that students can play on a design team. Students with widely differing skill sets and abilities all find a niche. Team-based collaboration and communication skills are strengthened. Students with language-based learning disabilities thrive in engineering environments because engineering is dependent on 2D and 3D spatial thinking and representations – something that many LD students are naturally good at. The visual nature of thinking and problem solving plays to the strengths of many students who struggle in a traditional "paper and pencil" classroom setting: even autistic students can successfully engage in engineering projects and make substantial contributions to their team's success. English Language Learners can also engage with engineering projects because of their "hands-on" nature that emphasizes spatial thinking and doing rather than written English. Because engineering projects typically demonstrate student learning through a finished prototype and presentation, students have a different avenue for showcasing their skill and taking ownership of their learning.

4. **Rich cross-curricular possibilities.** Engineering and technology are always embedded in social contexts. Educators can use the rich social contexts of technology/engineering to tie in meaningful learning in related content areas. Social studies, mathematics, and language arts are

all easy to incorporate into engineering projects. For example, students could engage in engineering/technology projects related to social studies units having to do with the ancient Egyptians, Mesoamericans (Aztecs and Incas), Native North Americans, Colonial Americans, European Explorers, etc. Any social studies unit examining a particular time and place can include a project centering on the engineering and technology that people developed at that time. Engineering is simply the process of humans meeting their needs and solving perceived problems – this process has occurred throughout human history. Language arts are easily included in engineering projects, particularly communication standards having to do with oral communication and writing for presentations. Mathematics is essential to the design process and cannot be left out. The economic impact of engineering/technology designs leads to deeper understanding of real-world considerations that affect societies. The failure of New Orleans' levee designs and early warning/public safety systems contributed to the horrific loss of life and property with Hurricane Katrina. Students can gain a rich understanding of how engineering and communication systems can help mitigate loss of life and property in severe weather situations. The arts can be incorporated into engineering, particularly art and music. Music is inherently dependent on technology, science, and engineering. Students who investigate the engineering dimension of sound and instruments learn to appreciate music on a new level. Health, physical education, and the science of the human body are also highly connected to engineering on many levels. Students can build working human joints, design assistive technology to help disabled people with daily living needs, design new games or toys to be used for physical education and improved physical fitness, or design playscapes for school playgrounds or community parks. Students can investigate how technology has impacted sports, including the Olympics, biking, professional football, baseball, and basketball. They can investigate how the technology of sports and recreation has evolved over the centuries. The list is literally endless.

The cross-curricular possibilities for technology/engineering are so rich and plentiful that one could easily conceive of a K-12 charter school organized around this very idea.

5. **Integration with math is important way to show students how and why math is relevant and useful in the world.** Engineering counteracts the "Why do we need to learn this?" question that students always complain about. Using math in a meaningful, real-world context strengthens mathematics skills for all students, especially those struggling to pass the MCAS. If curriculum directors take the time to analyze MCAS data to identify specific standards or strands that students are struggling with, they can then plan engineering projects that incorporate these standards or strands, thus giving students meaningful "real-world" practice using those skills. This, coupled with higher-order critical thinking skills, presents a rich and rigorous learning opportunity for increased achievement in mathematics. This can only mean good things for districts struggling to make AYP in math.

6. **Directly connected with improvement of living conditions/safety/health and welfare of people.** Engineering can provide relevance to students' lives and the world outside the classroom. Students can explore authentic problems and issues, connect their learning to real issues in their local community, tap the knowledge and resources of local experts, and make a meaningful contribution to their school or town. Research shows that girls are more attracted to fields of endeavor that provide opportunities for helping others. Research also shows that many children have decided what they want to do in life as early as grade 3. By engaging students

with authentic and meaningful problems, engineering can open up a career path for young learners who are developing early and lifelong interests. If young learners have an opportunity to do engineering at an early age, it will stimulate their interest and engagement. Early interest and success in a field of endeavor will promote lifelong engagement with that field. This also speaks to differentiated learning: engineering is a way to reach and engage a large number of learners who are not necessarily excited or turned on by "traditional" learning settings and subjects.