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                                    Standards Analysis

        The standards that I have chosen to relate to problem solving and engineering design are
the following: "CCSS.MATH.CONTENT.5.MD.C.5 Relate volume to the operations of
multiplication and addition and solve real world and mathematical problems involving volume.
8.1.5.AP.4: Break down problems into smaller, manageable sub-problems to facilitate program
development. 5-PS1-1. Develop a model to describe that matter is made of particles too small to
be seen." The engineering standard to which I am comparing these standards to is, "3-5-ETS1-2.
Generate and compare multiple possible solutions to a problem based on how well each is likely
to meet the criteria and constraints of the problem." All four of these standards relate to my
context as a 5th grade general education science teacher as they are the math, technology,
science and engineering standards used in my state respectively. These standards relate to
engineering and problem solving because they all require metacognition and the ability to break
down a problem in order to arrive at a solution. For example, any of the common core
mathematics standards that mention being able to use the math skill to solve a "real world
problem" requires that students be able to not only tap into their problem solving skill set, but
can also be used to solve an engineering design problem that requires that mathematics skill. As
for the technology standard, being able to break down a problem into smaller, manageable sub-
problems is not only needed for program development, as stated in this standard, but is a
necessary skill in problem solving and engineering design. When students are fluent in their
ability to break down problems into more manageable sub-problems they will not only succeed
in mathematics, engineering, and computing, but will also be able to transfer this skill into
breaking down unknown words in language arts or breaking down long term projects into
smaller short term goals. As for the science standard and its tie to problem solving, any of the
science standards which mention "developing a model" provides a perfect engine for problem
solving and design. This is because it requires that students take their previously learned
scientific knowledge and apply problem solving skills to develop a model that accurately
represents that phenomena and proves it to be true. Each standard connects to engineering in its
own way, but also connects to one another through the medium of problem solving.

        These standards are similar to each other because they each require students to go beyond
their "recall" level of information and into the area of "extending their thinking" (Webb 2006).
In each of these standards students should have declarative knowledge of the concept that they
will use in order to solve a problem that will extend their thinking of the concept. For example,
in the mathematics standard, students should already have a working knowledge of the concept
of volume as a form of measurement previously learned in the 3rd grade standards. They should
also have the ability to use the formula for calculating volume with success. Both of these
aspects of declarative knowledge will be used to "solve a real-world problem", which is
extending their knowledge of volume as no longer an abstract concept, but as something that can
be utilized in the real world. This is similar to the technology standard which requires that
students already have declarative knowledge about a programming language that they are then

able to break down into more manageable parts in order to facilitate program development. Programming itself requires a constant need for problem solving and debugging of the program, therefore students need to extend their thinking in order to develop a problem. Additionally, the science standard also requires that students go beyond their recall knowledge in order to extend their thinking through problem solving. In this standard, students should already have an understanding of the scientific phenomena that matter is made of particles that are too small to be seen. After that has been investigated and proven by the student, only then will they have the declarative knowledge to develop a model that showcases this phenomena to be true. This requires that students extend their knowledge of the phenomena because they need to synthesize the information they've learned in order to design something that will accurately represent the phenomena. Therefore, these three standards are similar to one another in their use of extending on previous knowledge in order to solve a problem.

These standards are different from one another because they require different areas of background knowledge and they meet the requirements for different types of problems. In each standard, although it is required that students have procedural knowledge to solve a problem, they need to have different areas of declarative knowledge. In the mathematics standards students need to know what volume is and how to use the formula for volume. In the technology standard, students need to have used and be comfortable with a specific programming language. Finally, in the science standard, students need to call upon their knowledge of the phenomena that matter is made of particles that are too small to be seen. Additionally, these standards vary in their problem type. As stated in, *Principles for Problem Solving,* there are three types of problems of varying characteristics, "well structured, moderately structured, and ill structured problems." The mathematics standard meets the requirements for a well structured problem because in the case of using the formula for volume in a real-world problem there will only be one correct answer. The skill set for calculating volume is also only limited to similar types of problems in which students are also using the formula to calculate volume. In contrast, the technology standard is a moderately structured problem because there is more than one strategy to break down a problem, but in order to get the program to do what you need it to do there is usually only one correct way to get there. Moderately structured problems also require mental modeling and abstract reasoning, which is needed frequently when coding a program as you need to be able to visualize what various lines of code will yield before attempting to run the code. The science standard differs from the math and technology standards as well as it meets the requirements for an ill structured problem. The science standard, like an ill structured problem, doesn't have a single agreed upon solution and provides the opportunity for divergent practice. This is because the student has the freedom in the development of their model to take it anywhere their imagination sees fit. Not every student will create something exactly the same and the model can vary between using air particles, water particles, and showcasing their movement in varying degrees to show that matter is made of particles that are too small to be seen. I see this is my classroom often when we cover this standard as students ask what the correct model is and we discuss the importance of divergent practice in science and how it is a gateway for creative thinking. Although all three of these standards require problem solving

skills and can be a vehicle for engineering design, they vary in their problem type and require different declarative knowledge.

Engineering design and problem solving can be used as a unifying concept among the STEM fields, in that each field and set of standards requires problem solving as a skill set. In using the standards chosen above an engineering design problem can be constructed in which the constraints require that the students utilize all of the concepts in order to arrive at a solution. In this scenario, the design problem would be to code a model proving that matter is made of particles that are too small to be seen. A constraint of the model was that it had to have a measurable volume. Therefore, they could create a model of a bouncy house filling with air, they could then use the formula for volume to calculate the amount of air that is now filling up the bouncy house. This would be mathematical proof of the scientific phenomena. This problem would also require that the students follow the engineering standard of, "Generating and comparing multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem." Therefore, engineering and problem solving is the perfect way in which the mathematics, technology, and science standards connect in order to make students recall knowledge of each topic and get them to extend their thinking to solve problems.

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