GIFTED EDUCATION NEWS-PAGE (*VOLUME 22, NUMBER 1)*

Published by GIFTED EDUCATION PRESS; 10201 YUMA COURT;
P.O. BOX 1586; MANASSAS, VA 20108; 703-369-5017 **www.giftededpress.com**

Commemorating 9/11: A Special STEM Lesson for Gifted Students

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Introduction

It's still vivid in memory for me, and probably always will be. It was a lively class of high achieving 8th graders at my childhood grammar school. A classic 100-plus year-old red brick city school I grew up in, bringing back many memories, sights, and smells – always a pleasure to go back there. I still visit today and enjoy my time with the children. My mom had gone there too as did some cousins.

Just a few days after the 9/11 tragedy, I had previously been asked by a teacher friend to talk to her science classes. I walked into the classroom to talk about engineering and invention; and something very different happened. I think of it once again as the 11th anniversary of that date approaches…….

"Why didn't the airplanes simply knock-down the World Trade Center buildings upon impact?" asked one of the students.

This question came out of the blue about 15 minutes into my STEM-related talk. I looked around the room and saw the tension on their faces. Clearly they wanted to know about the technicalities of that horrendous incident, maybe something they could relate to, and understand – closure perhaps through an analytic, sterile discussion.

"Wow, what a great question," I said; thus began one of the most interesting and challenging lectures I ever gave. Imagine me speaking as I try and use engineering intuition and years of experience, mixed with science and physics to try and explain to the class what happened – all done in a STEM sort of way……

Analyzing a Tragedy

Think of it this way. If you threw a ping-pong ball as hard as you could at a 16 pound bowling ball…what would happen? The ping-pong ball just bounces off, right? Even if you threw a tennis ball at the bowling ball as hard as you could, the bowling ball is not going to move very much, if at all. The difference in mass is just too great, even if the ball(s) are thrown at great speed. Actually, this is the essence of the science of ballistics.

"Yes, but the airplanes that hit the towers were moving at 500 plus miles an hour," mentioned one of the students.

Anyone know how much one of the towers weighed, or more correctly, what was the mass of one of the towers? It happens to be 500,000 tons. Can anyone relate that to something they are familiar with? Well, a large thing that you have seen on TV or in a movie is a naval aircraft carrier; and one of those big vessels has a mass of 100,000 tons……therefore, one World Trade Center tower (500,000 tons) weighed as much as 5 big aircraft carriers.

Now, about the airplane that hit it – fully loaded with fuel and people and cargo, might weigh in the vicinity 200 tons. What we have is a mass of 200 tons hitting 500,000 tons. And this is not simply two very rigid objects colliding, but two objects that are capable of deforming upon impact, which means a great deal of the speed of the airplane is going to be dissipated in the deformation of the building and the body of the airplane…much like when two cars collide. The cars don't go bouncing off like pool balls, do they? No, they deform and distort and may move around depending upon the angle at which they collide or the speed of collision, but they most certainly are not rigid objects like pool balls or marbles. The same was true for the airplane and the building.

"But didn't the building move at all?" one of the students shouted.

Of course, big buildings like that are designed to move under wind loads, probably as much as 18 inches at the top during very windy conditions. You can bet some of the energy of motion of the airplane shook that building, but not enough to knock it down. Engineers who designed the building take great care to build factors of safety into their designs for a variety of potential accidents that could occur. Unfortunately, an airplane carrying 100 tons of highly flammable jet fuel was not one of them. While its impact did not immediately destroy or knock-down the building, it set into action events that eventually brought the structure down.

The deadly part of the plane was its catastrophic break-up upon impact, disgorging flaming jet fuel throughout the floors. It was the jet fuel and its combustion that did the building in. As fire temperatures neared 1000 degrees, the steel support columns basically lost half of their structural strength, and the collapse of the building ultimately occurred – each floor pan-caking on the one below, and the eventual collapse of the entire building. It was a collapse caused by excessive heat. Overheated steel twisted like candy taffy as supporting loads became too much to bear.

Engineers do design tall buildings against traditional fires with fire-retardant foam sprayed on steel structural members; but when that aircraft exploded on several floors, the blast blew all this protection off and the steel members in the crash areas were then exposed to extreme heat. A great deal of that dust roiling around in the collapse and later covering the streets (that you saw dramatically on TV) was caused by all the fire-retardant material that shook loose as the building collapsed.

Older buildings by the way, like the Empire State Building, have their steel supports buried in brick and cement, which acts to shield heat from reaching the steel members. Newer designs for modern skyscrapers do not use all that building material. In fact, a large military airplane struck the 88th floor of the Empire State Building by accident during the World War II years. The building was simply repaired afterwards.

More Analysis with Math

The physical size of each massive tower was like having a golf course stacked vertically. This produced a "wide-eyed" stare from the children. Anyone know how big a golf course is? About 100-150 acres. Anyone know how big an acre is? It is 208 feet by 208 feet, or 43,264 square feet. Each floor of each World Trade Center tower was one acre in size, so all stacked up, a tower had 120 floors or 120 acres of interior space.

How big is this classroom? Out came the yardsticks and the math was performed. Getting the students out of their seats was a good thing. How many of your classrooms would fit into one floor of the World Trade Center tower? More math was performed and reported upon. By the way, if there were no yardsticks to measure your classroom, how would you estimate its size? Those linoleum tiles on the floor are about 1 foot square, so there is one way…count the tiles over the length and width of the floor. Did you know the distance between the human elbow and the tip of the middle finger is about 18 inches? This is an ancient measurement called the cubit. It is mentioned in the Bible as it discusses the dimensions of Noah's Ark. You could measure the floor in this manner. How else might you do it?

The Tough Part

Now let's consider what this disaster means on the human level. Think about all the valuable lives lost, and the time it will take to replace all that talent. Some companies lost most of their staff!

What about all the records and information lost in the piles of debris littering the streets?

How will this event affect our country down the road? What about national security? Will all this result in war with the country who did this?

Who will care for those families devastated by this catastrophe?

How do we prevent things like this from happening again? Can engineers design better buildings, and how? How about security measures that prevent the use of airplanes as weapons?

On and on the discussions went, largely steered by the students with me as a narrator/guide trying to put things in perspective. I was proud of this class for being brave to ask the questions and try to grapple with the multi-dimensional aspects of what I was trying to convey. It was one of the toughest lectures I ever gave as the students plumbed the depths of my on-hand facts and figures. Always be ready in your STEM classes for something like this to test your skills to explain to young minds that have an urgent need to know about something. I was drained dry after this session, which lasted the entire morning.

Epilog

I watched those towers come down live from my office windows – my engineering mind knowing what was coming next, making it harder to watch as there was nothing I could do. Not a dry eye could be found in my office, and the tears well up as I write this now. Those 8th graders helped me get some closure too. Teaching is like that….you learn very often from the students.