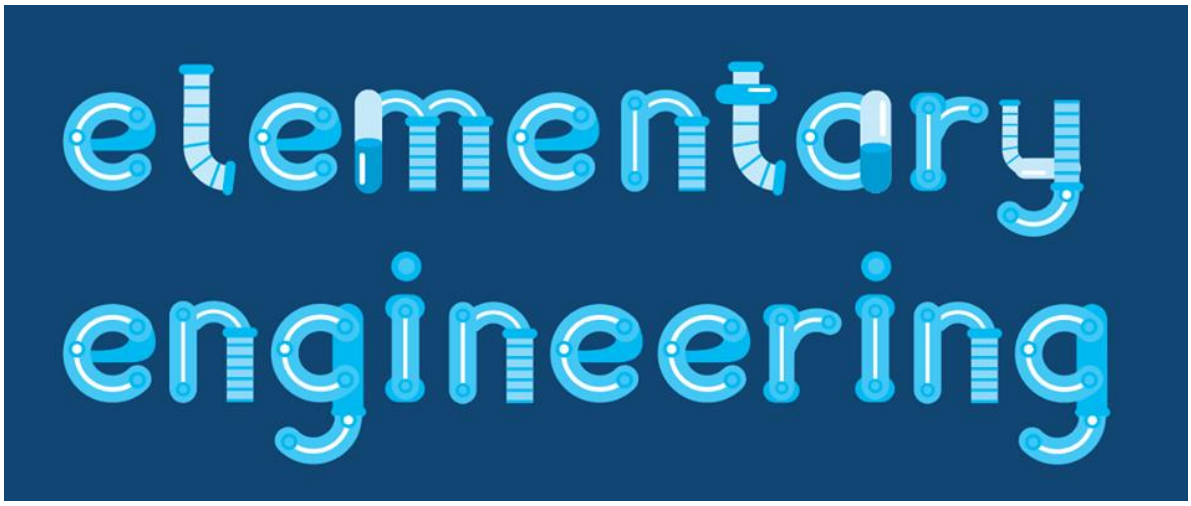

15 Tips
for
Engineering
in the
Elementary Classroom

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Dear Elementary Teacher,

I've written a list of tips because I believe that they will help you with your engineering lessons and, in general, your teaching.

I should tell you that I stumbled upon elementary school education by accident. After nine years in the middle and high school classroom, I was at that "crossroads of life" where I knew that my time in education was going to end soon if I didn't make some type of change. I was becoming increasingly frustrated in how the overwhelming majority of my students had little interest in science. It was a subject most were forced to take as a requirement, something they never ceased to explain to me.

Then by sheer luck in 2001, I got a call from Evergreen School District about a job for an Elementary Science Teacher on Special Assignment. I'd been recommended by a friend of a friend. Although I had no experience in the elementary classroom, I did enough things right at the interview to get the job. The first day I worked with a group of elementary students was teaching a lesson on plants to second graders. I had them gather on the carpet and when I asked a question, all of their hands went up. It was at that moment that I decided my days of working with middle and high school students were over.

Every science lesson I did with elementary students was exciting for them. But nothing gave these students a bigger thrill than building something that moved. That thrill is contagious, so contagious that I decided to start an engineering program for elementary students. In the summer of 2002, I put together my first engineering workshop. That was the beginning of ***Elementary Engineering***. It has become my life's work.

The Value of Engineering at the Elementary Level

I started Elementary Engineering in 2002 because I believed, as I do today, the benefits of doing engineering at the elementary level can have a life long impact on all the students. Here's why:

1. Students get a huge kick out of it.

When something finally works, students get the biggest reward: a thrill. Don't underestimate the power of the thrill. It's something students won't forget. Great memories of school should never be underrated.

2. All students need practice problem-solving.

All your students will encounter problems throughout their lives. Engineering activities are problem-solving activities. The more they do, the better they'll get at problem-solving and that means their lives will be better.

3. Students must learn to work with different people.

One key to success is the ability to work with different people. The more opportunities students have with working with different classmates, the more likely they'll be able to work with different people as adults. That's a good thing☺.

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Sixteen years and about 150,000 students later, I've learned a few things about engineering in the elementary classroom. To all the teachers I've worked with over the years, I finally wrote down what I consider essential tips—you've been telling me I should, so I did☺. I should say that the list has expanded and contracted over the last three months. I finally settled on fifteen. It seems like a reasonable number.

15 Tips for Engineering in the Elementary Classroom

Tip # 1 Positive Energy

The most important thing a teacher needs to lead an engineering lesson is positive energy. I can't emphasize this enough. Check in with yourself and make sure you are in a positive mindset before the lesson begins.

Tip # 2 Challenge to Joy

The best engineering activities begin with a challenge and end in joy.

Here are the key elements to a great engineering lesson:

1. Students are given a challenge that can only be accomplished with a lot of effort.
2. The first idea rarely works. Normally, a minimum of three modifications are needed to get to the end product.
3. With each modification students have to apply physics concepts, work and communicate in teams, employ deductive and inductive reasoning skills, and work their way through the problem-solving process.
4. Students get frustrated, but remain motivated. They see that they can do it, but struggle to figure out how.
5. When they do a trial run and it almost works, the initial disappointment is followed by motivation.
6. When it does finally work, they experience joy.

Tip # 3 Quick Set Up and Quick Break Down

If it takes more than three minutes to distribute the materials and more than three minutes to break the materials down, find another lesson. In elementary school you should be using a few simple materials that are easy to distribute and collect. Your time is precious, so don't waste it.

Tip # 4 90% Non-Intervention and 10% Inquiry/ Encouragement

Non-Intervention

Different lessons demand different pedagogical approaches. With engineering, you should focus on "the non-intervention approach". The non-intervention approach simply means to leave the students alone and let them fend for themselves. At least 90% of the time, they should be working with their team without interference.

Inquiry/Encouragement

The other 10% of the time you should do two things: 1) ask the type of questions that will help students become better problem-solvers (**see tips #5 and #6**) and 2) encourage them.

Tip # 5 First Rule of Problem-Solving

Here is the first thing students need to learn about solving a problem: ***If something doesn't work, you must make a change.***

As an adult this may seem painstakingly obvious that a change is needed if something doesn't work, but that is often not the case with many elementary students. Before they attempt to design and build something, make sure they understand the basic idea that they need to change something if it isn't working.

Tip # 6 Problem-Solving Process

Once the students recognize a change is needed, they need to work through the problem solving process. It's simple, straightforward and after a while, it will become second nature to them.

1. Identify the specific problem.*
2. Suggest a change that would correct the problem.
3. Make the change.
4. Test to see if the change fixed the problem. If the change doesn't fix the problem, go back to step 2.

* The key word here is "specific". Students will often tell you what the general problem is. Here is one of the more common type of exchanges I have had over the years:

Me: What's the problem?
Student: It doesn't work. (General, not specific.)
Me: Tell me specifically what the problem is. What isn't working?
Student: The wheels don't move.
Me: Good, now you've told me the wheels don't move. You've identified the specific problem. Now, talk with your team and suggest a solution that will get the wheels to move.

95% of the time they will come up with a possible solution once they've identified the ***specific*** problem.

Tip # 7 Forces and Energy

You don't need to have a background in astrophysics to lead an engineering lesson. However, it is important that you have a basic understanding of two important concepts: forces and energy. In 2012, I wrote a short 35 page resource book called ***The Brilliant Book of Physics for Elementary Teachers***. It's on the website and you have free access to it.

Tip # 8 Inductive and Deductive Reasoning

Generally speaking, students will use two types of reasoning to solve a problem: inductive and deductive. In order to help your students hone their problem-solving skills, you should have a basic understanding of these two forms of reasoning.

Inductive Reasoning

Inductive reasoning has to do with probability. The basic idea is that if something happens a lot, it's reasonably likely it will happen again. If something happens enough times, you can produce a rule.

Example:

Team A observes that every time they squeeze the wheels against the frame of the car, the wheels don't move. From these observations, they come up with the rule: *Squeezing the wheels up against the frame of the car will prevent the wheels from moving.*

In this case, a series of specific instances led to a general rule.

Deductive Reasoning

Deductive reasoning has to do with using a rule or rules to reach a conclusion.

Example:

1. Friction is the force caused by two surfaces rubbing against each other.
2. When the wheels are squeezed against the frame, the wheels rub against the frame.
3. Since the wheels rub against the frame, there is friction and that slows down the go-cart.

In this case, a general rule—friction is caused by two surfaces rubbing against each other—was used to explain a specific instance.

(Note: I'm intending on doing a short video on deductive and inductive reasoning in the elementary classroom in the future—so stay tuned.)

Tip # 9 Keeping It Student Centered

There are going to be times when students run out of ideas, or just get stuck on an idea that doesn't work. If a team has tried and tried and just can't seem to solve their problem, do the following:

1. Encourage groups to go look at what other groups are doing.
2. Ask another group to take a look at the struggling group's design and suggest a solution.
3. Invite *all* of the students to offer suggestions.

Tip # 10 Simple to Complex -- Building Confidence

If students are going to do it all themselves, they need to have confidence that they can do it. Start with a simple activity and then add complexity. For example, with roller-coasters, I have the students begin with a three track rollercoaster. From there they move on to five tracks, hills, loops, drop-offs, jumps, and kinetic energy transfers. Then they'll merge these different challenges together. The key is to start with a simple challenge.

Tip # 11 Pace – Single Digit Time

Pace is about managing energy. If the lesson is paced well, the students will remain engaged. How do you set the pace in an engineering lesson? Give them a specific amount of time to complete an activity. Students will stay more focused if they feel they are under a time crunch.

I keep the time to a single digit number. For example, I give 8 year-olds four minutes to design and build a three track roller-coaster that works at least five times.

For bigger challenges that require steps, I give the students a single digit amount of time to accomplish each step. For example, there are three steps to building an air-powered go-cart. I give the students seven minutes to finish each step.

Tip # 12 Be Aware of Your Preconceptions

"Aoife is doing great. I'm so surprised, she's quite low in math and language."

I hear something like this four or five times a week. Students aren't tested for spatial ability and how they apply it to a real world situation, so don't be surprised who excels at engineering and who struggles with it. If you find someone who struggles with traditional academic subjects, but is a wiz at engineering, you just found a way to reach another student. Bonus.

It's also important to be aware that high math students don't always make the best engineering students. Some high math students struggle with engineering tasks.

Tip # 13 Randomize Your Teams

This tip could be listed as the second part of tip #12.

When I work with schools, I don't know the students. I randomly pick the teams. At least once a week, a teacher comes up to me and says, "I can't believe how well that team is doing. I thought they would never work well together."

The more practice students get at working with a variety people, the better they'll get at working with a variety of people. Just like problem-solving, students need to practice teamwork. They need to learn how to adapt to each group. In one group, a student might be more of a leader, and in another group that same student may have to learn that there will be co-leaders or no leaders at all.

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Tip # 14 Cover Statistics Through Engineering Lessons

When something moves, there are three types of quantitative data that you can record, analyze, display, and discuss:

1. Distance
2. Time
3. Success rate

When something moves, it moves at a certain speed. Speed is distance per time. That means you can measure how far something moves and/or how long it takes to get from point A to point B. Distance and time are just waiting to be measured. (**Note: You can also measure speed, but that's rather advanced mathematics for elementary students.**)

Another thing that can be recorded is success rate. For example, when I have students design and build rubber-band chair catapults, I have them record how many times out of ten the projectile hits the target.

There's plenty of math embedded in each engineering lesson. Take advantage of it.

Tip # 15 Competitions -- Do Them

I do lots of competitions. Here's why:

1. The level of interest goes up.
2. The level of camaraderie between team members increases.
3. One team wins and the others don't. The team that wins must win with graciousness and the teams that lose must do so with dignity. In Ireland, that's constantly reinforced. After the most fiercely fought competitions, people shake hands and leave it at that.
4. Students who don't get to participate in sports get a chance to compete in something else.
5. If you don't do the competition, the students will start one without you.

For more information about *Elementary Engineering*, please visit:

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