



Math for Girls through Fun Experiments

Marsha Tufft
Engineer & Author, GE Aviation

EPISODE 41

[Quote]

“Engineers are problem solvers; you’re really learning **how** to learn”

[Description]

Many students don’t even consider STEM fields because they lack confidence in their own math skills. For Marsha, it was not grades, but all the hobbies and creative projects she dreamed up, that kept her on course.



She now creates fun experiments that show the magic and power of math. Marsha spent 35 years at GE Aviation, and has a PhD in engineering. In this episode, we talk to Marsha, about why how you can help set your kids up for success in Math, build resilience that comes from learning from failure, and empower them to follow their dreams, even when it gets tough.

[Intro]

Jaison Dolvane: Math is a critical skill for children to make sense of the world around them. It starts early with play, observing patterns and shapes, looking at and counting objects.

Math then becomes an important component of education and a requirement, if a student is to have any success in STEM, which stands for Science, Technology, Math, Engineering. Many students don’t even consider STEM fields because they lack confidence in their own math skills.

For Marsha, it was not grades, but all the hobbies and creative projects... things that she dreamed up, problem-solved, and figured out on her own that kept her on course.

Math is so important to success in STEM fields, and Marsha has created fun experiments that show the magic and power of math. She also encourages girls in STEM and enjoys developing experiments to give girls fun experiences with science, engineering, and math.

Marsha spent 35 years at GE Aviation, and has a PhD in engineering. Today, her passion, as an engineer and an author, is to help students survive and thrive in STEM.

In this episode, we talk to Marsha, about how you can help set your kids up for success in Math, build the resilience that comes from learning from failure, and empower them to follow their dreams, even when it gets tough.

[Episode]

JAISON DOLVANE: Welcome Marsha.

MARSH TUFFT: Welcome. Thanks for having me, Jaison. I love your podcast and your whole theme helping parents with their kids and their education.

JAISON DOLVANE: Oh, awesome. Thank you. Yeah. You know, hopefully our parents see a lot of value in it also. So Marsha why don't you tell me a little bit about yourself and just some of your background and what's kind of created this passion that you have around math and stem?

MARSH TUFFT: Well so I was one of the earlier women engineers. So I graduated from Purdue university in 1981 in mechanical engineering, and there were only about 10% of my graduating class for women. I went on to GE, got my master's and later my PhD there and while working full time. And in more recent years, I've been volunteering with girl Scouts year of the girls stem program. So an afterschool program, and we also have stem summer camp. And I just love working with girls, especially middle grade age, because I feel like that was a period of time in me, a period of time for me, that really helped me when I got my first D ever in physics, electricity, and magnetism sophomore year at Purdue. And I was like, holy crap. I've never gotten a D before, Cs were not that common, a little bit more common in college than high school.

And it's like, well, do I tough it out? I didn't want to be a quitter, but I didn't know if I had what it took to succeed. And when I dug down deep, it wasn't the [01:50 inaudible] my high school physics project had one that helped me to stay the course. It was all the crazy things I dreamed up, problem solved and figured out on my own as a kid in elementary school. And so I have a real passion for trying to empower the engineering everyone and help kids develop problem solving skills, help them learn from failing, help them build their self-esteem and their confidence so that they can pursue their dreams no matter what that is.

JAISON DOLVANE: So take us back to sort of elementary school. And what were some of those kind of cool creative projects that you dreamed up?

MARSH TUFFT: Well, okay. So my sister and I always liked designing our dream houses. So we'd go to Homearama and Cincinnati. At one point we were in California looking at houses and we take all the floor plans. And so we would build our dream houses and kind of to scale. So we'd measure it out, but we'd figure out, you know, how big do we want the master bedroom? We always had a fit, an Olympic size swimming pool in. So we would do layouts like that. I loved art. So drawing and painting were hobbies. I would have this map project where, you know, we traveled here, I wanted to create this old map. So I [03:04 inaudible], and then I burn the edges with a candle to kind of age it and give it that aged effect.

I also did a lot of sewing and that's something that I've found that a lot of women of my age, So obviously if I graduated from Purdue in 81, I'm in my early sixties now, but a lot of the women engineer of my generation, a lot of us grew up sewing. And I don't think it's a coincidence because you don't learn to sew without ripping. So you make mistakes, you rip it out, you figure out how to put it together, but you're learning how to build clothes. And now in elementary school, that's making doll clothes. Okay, But you'll learn all the pieces. You learn how things go together. I was learning industrial engineering, how to set up my workstation efficiently. So I had my seam ripper, my scissors at hand. I could change my thread easily or my needle. I figured out my process for laying out fabric and cutting it out. I was learning program management because I was figuring out, okay, how long does it take me to do this? How much material do I need to buy, all these things and then you don't even get classes in all of that at school, but you need it on the job. So it was like, I was always get project management because I've been managing my own projects.

My dad was a woodworker, so I got to watch him build stuff. And I designed like in high school, I designed a custom built desk that my dad made for me, but I designed, you know, what I wanted the surface to be. And I had a site extension instead of drawers on one side, I wanted stuff from my art supplies and I wanted a typing table, extension, and more room for art supplies in that. And he would make adjustments based on what he needed to be able to put the desk together. It's was like, well, I can't quite do this because I need to be able to assemble it here. And by the way, it's got to fit through the doorway. So we've got to be able to assemble and disassemble.

So I was learning all these things by doing, and working with my dad and working on my own. And I think that's where I really learned great problem solving skills was just, you know, when you're in the driver's seat with your own hobbies, the motivations built in, so your success in learning is greatly, Your odds are greatly increased because you're motivated. And problem solving is all about the learner being in control. So you have, you have a problem or a challenge. You make a choice, how are you going to solve that problem? Then you get feedback and then you make course corrections. And it's one of the more difficult skills to teach, but it's the most transferable of all the content you're going to get in school.

So you can learn it on your hobbies. It's a lot harder for a girl scout troop leader to teach a bunch of girls in an hour and a half session school, how to solve a problem than it is for those girls to go think of a real project that they want to tackle and start taking it on their own.

JAISON DOLVANE: Yeah. Cause they'll figure it out themselves.

MARSH TUFFT: So I had a lot of free time in elementary school. My, my mom was a stay at home mom. So I had summers that I got to play and create and invent and try stuff. And it was wonderful.

JAISON DOLVANE: Yeah. No, that's cool. So what do you tell, I mean, you know, a little girls or little kids, you know, obviously, you know, in hindsight you understand that these things were program management or project management or even problem solving. I mean, these words are kind of foreign to kids, so how do we break it down for them and sort of keep them interested? Because I feel like if you start using these kinds of words, we'll lose them.

MARSH TUFFT: Well, so there are so many great afterschool programs and stem activities that organizations have. So there's lots of opportunity to engage. And I think that for girls it's like, and for parents in particular, I would say, give your kids the creative space to just try stuff on their own and encourage them to have hobbies and to tinker. And they don't have to tinker with bikes. So you don't have, there's not just one path to engineering, but to recognize, help them recognize the problem solving that they are doing in their hobbies and help them to see that, Hey, you didn't just create a model Barbie store, something like this, or you didn't just do a racetrack, but look, you know, you're learning something about modeling or program management or engineering.

And one of the things I've seen, some of the experiments I've led for girl Scouts. So I have a golden retriever. So one of my favorite all time activities was this cardboard boat race that I organized for our preliminary design group at GE when we had a Christmas in February. So the budget at the end of the year was tight, got cut off. So we've got to have our Christmas party in February, and we're looking for a team building event. And I came across this build a boat thing. It was like they wanted like 5,000 bucks, I thought, heck no, you know, we just moved. We got a stack of cardboard boxes. What do you need to build a cardboard boat? You need cardboard, you need duct tape, you need plastic tablecloths and a pull to test it in. And the GE fitness center had called them. They said, they'd already checked it out for another group. We could use the pool for free.

The materials were dirt cheap. My manager agreed to, you know, half a day off work on a Friday afternoon. And I pulled together a table that would let you size a boat based on volume of water displaced and how much weight you wanted to carry. So I help with the design decisions and we drew MacGyver style for that. So I've done since then, I've done, I've led several years of buoyancy, cardboard boat experiments in summer camp. And I've also done a school visit that was really, really successful where the kids learn about buoyancy. And then I show them, okay, once you understand how to predict whether something's going to float or not, okay, now you can use it to design something.

So now you've got a math model and it's the cheapest model you're ever going to have because before you even cut cardboard or duct tape or anything, you can size it and make some decisions. And so I take them through a real simple process from, you know, here's volume of water

displaced. Okay. Here's the volume of a rectangle. Okay. Now here's some options for, if you want to carry a hundred pounds, 150-250 pounds, here's some sizing options.

And then I show a picture of my golden retriever surfing on a surf boat in the ocean, which is actually what our team's solution was for the cardboard boat race, because there was going to be this paddle boats challenge I was afraid of, and I didn't want to get sunk. So we were unsinkable. We went all the races and I had so much fun with it. I had to build an over-designed system that I took my dogs surfing in the ocean at Hilton head. And then later I improved the design. I made it lighter weight, simple waterproofing, my first design, I actually had to design a beach cart to haul it to the beach. It was a little too heavy to carry from our place, which is about a 10 minute walk. But, you know, so I take pictures of my dogs on the surf goal and the girls are like, I could do that. I had a girl talk to me. I was like, I could design a surfboard, you know, and they see that, Hey, this is something you could use right now. And if, you know, just basic math, you know, two times, three times four, okay. You substitute length times, width, times depth. So, you know, you have basic multiplication division, we just substitute letters and you can come up with some cool designs.

JAISON DOLVANE: I mean, obviously when kids start to learn math in school they're just learning the math. Right. They're not learning the application of the math. And so it strikes me almost like a, you know, like as you're talking, you know, obviously I have an engineering background too, so I kind of get excited about some of this stuff. Right. But I mean, it's exciting just to see like build real things and put them in water and, you know, they're actually working. So I just wonder, I mean, you know, what age should you be starting to kind of like help make that connection. But we math an application of math because, you know, for parents, they probably struggled to do that at early ages.

MARSH TUFFT: Well, so, okay. Yeah. And okay. Full disclosure, we weren't able to have kids. Okay. So I don't have all the experience of, you know, taking a kid from, you know, birth to high school and everything with girl Scouts, I've worked with kindergarten cadet through, so like kindergarten through like eighth grade and certainly middle grade, this is dead within their wheelhouse. You don't have to have algebra to, in fact, I like to get them exposed to this way before they get to algebra. So that algebra will not be scary and irrelevant to them when they reach it, they'll be like, oh yeah, bring on the algebra.

It's just, that's just numbers with secret, you know, secret identities, A or B or C or V or W or this funky upside down T.

JAISON DOLVANE: What are some of those things that we could do to actually, that parents can do to kind of you know, tie that math together, the applications before they get to algebra?

MARSH TUFFT: Well, so the, the cardboard boat experiment, and these are all on my website. In fact, I also have a series of middle-grade books that I write stories about to try and change attitudes and get kids excited about the fun side of math, the fun side of science and engineering. So I've got experiments on my website, [www. Putneydesigns.com](http://www.Putneydesigns.com). So I'd say the younger age that they if they don't have basic multiplication. So if they can't do two times three equals six, that's maybe a little bit early then, but if they can do two times three is six. I mean, one of the things I did for was it fourth or fifth grade, the after-school program, we were supposed to give them advice on what classes to take.

And so I gave them a simple beam bending experiment, and I was figuring this out. So I took a plastic knife, and I did like three pages of, you know, just, you know, 11 by 17, you know, wrote down the beam, bending stuff and said, okay, if you can do two times three times four, okay, you can take this and you can predict that this knife, if I hold it. So the I-beam way. So the skinny side in the middle and the narrow edge on top, so the flat stuff is on the side. So I beam way. That this is not going to deflect hardly at all. And if I turn it, so it looks like a diving board, I'm going to get quite a lot more deflection. So that from a few simple equations, I can plug some numbers in and show that I'm going to get at least 10 X more bending deflection with this flat side down, as opposed to if I have the flat side vertical.

JAISON DOLVANE: Yeah, yeah. The skinny side up kind of thing. So, I mean you know, maybe we can kind of just like try to switch it to, you know, we talk about sort of math and math really being important. And, you know, I hope I answered the question for parents in terms of like, how can they get their kids set up for success in math? So what would you recommend? Like if we broke this down, like baby steps, right? You just take a kid that's kind of a middle grade, you know, how do we get them interested in this and how do we sort of like, help them be successful?

MARSH TUFFT: Well, if I can, I always like to start with your interest or something that is interesting to the kid. So like with the girls, I found out that I had a really cute golden retriever and they would just drool at pictures of my golden retriever on a surf boat. So it's like, okay, if I start with, you know, Hey, cute dog on a surf boat, and wouldn't you like to take your dog into a pool and have them serve, take them to the ocean and Hey, you can build this and here's how we're going to, how we're going to approach it. So that would be one way.

If they are sewing or woodworking any of those projects where you're building stuff, you got to figure out what materials do you need? How am I going to lay it out? What do I need to buy? So anything that is, you know, figuring out you know, what dimensions are needed. Okay, how much is this going to cost? How big do I really need it to be? In my first book, I do a rapid prototyping process on a set upon. So the kids are at this new experimental stem steam school, and their art teacher wants some to make a suit upon so that they can go sketching. They can go the ocean and sketch up the ocean or go to a lagoon. And the challenge is to do it using stuff that they have at home. So the first challenge there is, what size does it need to be?

Okay. If you want to sit down, cross-legged how much padding do you need? Do you need padding? But those are things you can grab an Ikea bag and a tape measure, and a piece of paper and pencil and write down, okay, how big does this need to be? What materials needs to be water resistant? What materials can you choose? Then you challenge yourself. Well, do you really need this padding? In the book I discovered bubble wrap doesn't really pop when you plop down on it. So that's lighter weight than the 1960s girl Scouts sit upon that we're, you know, woven newspaper and dead heavy and covered with oil cloth.

So, you know, just look at what you have on hand, figure out what you can do with it. And then, you know, show them, Hey, you know, this is a simple math model. Do you want it to carry a sketch pad? What size is your sketch pad? Okay. 9 by 12, eight and a half by 11. Okay. It needs to be at least this big. So just coming up with simple projects and doing some problem solving.

JAISON DOLVANE: Got it. And so do you have a list of some of these projects?

MARSH TUFFT: Yeah, they're on my website. So if you go to www.putneydesigns.com under the stem menu and in fact from last year, a girl scout summer camp was virtual. Yup. So I led five experiments last year.

JAISON DOLVANE: And what were those?

MARSH TUFFT: So we did egg drop. That was okay. So my egg drop is not like egg drop. So I get into some of the physics behind it so that you can see, you know, the effect of mass and velocity and, you know, do you have a dummy that you can use? So I actually look at the fracture pattern on the eggshell and look at a hard-boiled egg versus fresh egg. And I begged the egg. So it's not messy. So if you crush your fresh egg, it's in a plastic bag and you don't have a lot of mess to clean up. And then give a couple challenges, like, okay, so inside the box. So if you in a container, think outside the box, or even if you want to try and do a hang glider thing. So I kind of have three categories if you want to get really, really wonky.

And then I look at mass Springs and dampers, and what element is going to help you most in an egg drop system. So I've got some great videos and handouts for that. So that was the first one. Cardboard catapult, The first experiment I helped with in girl Scouts the afterschool program was a would catapult and I had such a blast. I had to go in and look at the physics and derive the equations for, okay, what's the trajectory and what's the optimum angle and how can you predict all this?

And then we have problems getting the kits. So I was working on a non-fiction book at one point for some experiments, and I wanted things that you could build at home. And I came up with the design for a cardboard catapult so on, I've got a bunch of, so I've got videos on the cardboard, catapult making it, and then we did a separate one on the testing it and predicting how far it's going to go and looking at, okay, it's a kinetic, well, it's an energy storage device. You change potential energy into kinetic energy. And so you've got the rubber band and, you know, you've got a frame that supports the lever arm, and I just use some Woodster stick and a little condiment cup to carry the projectile. And then it's just cardboard and duct tape.

And I actually have a design that loop lets you change the incidence angle so that you can have multiple lever, arm angles.

JAISON DOLVANE: So what else you got?

MARSH TUFFT: So those two, then I did the cardboard boat. Which is kind of, it's kind of a two-part experiment. So there's the buoyancy piece and then the build the cardboard boat. So if you already understand what poignancy is, then you're ready to do the cardboard boat, but you can break that down to two.

JAISON DOLVANE: Like these Four experiments that you've done on your website and what do you think the age group is for people to try those?

MARSH TUFFT: I would say, well, you could try them at any age. I would say probably second grade on certainly by fourth grade. And some of them, you know, it's like if you get into and you can do these experiments on different levels too. So you can do it as, Hey, let's just, you know, rapid prototyping. You can do that at any age. Just pick something you want to make and here's feedback. And here's how you learn.

JAISON DOLVANE: So it seems like you [20:46 inaudible] information on your website today. So what would your advice be to kind of like parents you know, should they be doing what I'm hearing from you is like, obviously there's a formal kind of school education around math, but what I'm kind of hearing or reading between the lines is that pick experiments and try to make it more applicable to make what they're learning more applicable with the help of experiments.

MARSH TUFFT: I would go one step further in that the greater Cincinnati stem collaborative did a conference a few years ago and the math thing is a big thing for kids. Some kids just have this math phobia and a lot of times parents have bad attitudes about math or they have attitudes. So you're never going to use this. So I'm guessing the people on your podcast are being proactive and they're not going to be in that category. But the first thing I would say as a parent is present a positive attitude about math. Because your attitudes shape your kids' attitudes.

And so if you can help support them and be excited about, oh yeah, math is cool. Algebra is super cool. It's not just the word problems. You can do so much with it. Just shaping those attitudes and encouraging them that yeah. Okay. Memorizing the multiplication tables maybe isn't a lot of fun, but that's the foundation for all this other cool stuff you're going to be able to do.

JAISON DOLVANE: Yeah. Yeah. No, absolutely. So, what's been some of the challenges that you've kind of faced you know, trying to get your message out?

MARSH TUFFT: Well, okay. So as an indie author is just, you know, getting the word out there and, you know, connecting with other people and, you know, I've been especially active in the last year. Well, actually my first book came out when COVID hit. So it's like trying to do school visits during COVID. It's like, it's just tough. So part of that is just, you know, getting on podcasts, getting the word out there trying to do some in-person events and really work with the kids.

JAISON DOLVANE: Got it. Okay. Sounds good. So what would be your hope for your audience?

MARSH TUFFT: So my hope for my audience would be that regardless of whether a girl or a boy goes into a stem field, that they come away from some of my books and experiments with an attitude of, oh, I can do this. And what I do today matters. So I can do cool stuff today. I can learn problem solving skills while playing and having fun. And that's going to help me later on in other courses I take, right?

Because really the best thing you learn at, you know, engineers are problem solvers and, and you can look at that as you're really learning how to learn, because going to be solving problems that maybe, you know, in the future that exists, that you didn't have a course on. So you're going to be solving problems that we don't even know about yet. And regardless of whether you go into engineering or not, trust me, you know, life is messy.

So, you know, when your mom's condo floods and you got to figure out, okay, what do I need to do? And I got to price this and I got to get this done. I got to get the place for it out. And I got to change carpeting. And I got, you know, when things hit and you're able to solve tough problems, then the hard stuff doesn't, isn't so hard anymore. It's like, okay, I know how to manage projects. I can deal with this. And it just sets you up for success in so many other ways.

JAISON DOLVANE: So, you know, there is a question that I ask my audience usually, which is, you know is there one feeling that they have as a parent that they would rather not feel, but you don't have kids.

MARSH TUFFT: I had dogs, I had furry kids.

JAISON DOLVANE: Right. So, you know, is there a feeling that you, whether it's, you know, not having kids or whether it's having sort of you know, your pets as kids that you have, that you would rock the feeling that you would rather not have?

MARSH TUFFT: I guess, I'm not sure if I'm going to answer this question the way that you intended. But let me share this insight. One of the things that I've learned actually is, so we've had dogs since like 1987 and I couldn't teach Tiser how to heel off lead to pass a test [25:26 inaudible], because he only learned jerk and pull. So he only learned what he was doing wrong. And I think one thing I've learned with clicker training with dogs is the cool problem solving skills that unlocks because clicker training focuses on positive reinforcement. So it's like, I don't have to correct Harry, my golden retriever for everything he does wrong. I'm more effective if I notice the things he's doing right and I reinforced that. So with dogs that might be with treats or a game, and if he's doing something I don't like if it's not a safety issue, if I just kind of ignore it, that behavior's not going to get stronger, unless it's self-rewarding.

So I'd say, you know, from a parent's perspective, I would say, figure out what your kid's doing well right now that you can reinforce them and recognize them for, and don't split all the small stuff, build them up because especially for girls, I feel like we tend to be perfectionist. And there's, one of the statistics is, you know, over half of college students are women, but fewer than 25% are in stem fields, especially engineering.

So in my own personal experience you know, my roommate was acing aerospace engineering and she dropped it and changed into languages. So women, if we can't be perfect, we're more likely to change into something that we can be perfect and guys are more resilient with failure. So just anything you can do to build that grit and problem-solving resiliency.

JAISON DOLVANE: That is an excellent point because, you know, as parents, we have such busy lives and we tend to focus on all the things that we don't want our kids to do versus sort of, you know, focusing on, on making sure that they understand the things that they're doing well and rewarding them for them. That's

great. So you talked earlier about where people can reach you. Maybe just repeat that again for the audience before we close.

MARSH TUFFT: Okay. My website is www.Putneydesigns.com. And so I use it as a noun and a verb, so, yup. And you can see my design projects. Some of my quilts as a hobby, I've got a cool millennium falcon quilt that I did for my two great nephews. And then all of the stem experiments and projects, and then information about my books.

JAISON DOLVANE: Awesome. That's so good. Well, good to have you here, Marsha. Thanks for being on.

MARSH TUFFT: So happy to be on your podcast, Jaison, thanks for inviting me.

[Outro]

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[Resources & Links]

Marsha's Website

<https://putneydesigns.com>

Home STEM experiments

<https://putneydesigns.com/stem/>

Middle grade fiction book series, Putney and the Magic eyePad.

<https://putneydesigns.com/books/>

YouTube Channel for My STEM experiment videos

<https://www.youtube.com/channel/UCPA9hiqwQJExem5WXaQhu6g/>