How to Be Successful in the Lab

Presenter: Donna Milgram, Executive Director, Institute for Women in Trades, Technology & Science (Donna's Bio)

Presentation Transcript: Hello and welcome to the *STEM Success for Women Telesummit*. We are going to have an amazing week together where my guests and I are going to share with you our top strategies and best practices so that you can increase the number of female students in your STEM classrooms. That's my intention for you for this Telesummit. I'm your host, Donna Milgram, Executive Director of the Institute for Women in Trades, Technology and Science (IWITTS). I have to say it's such an honor for me to be the host of these ten experts and expert practitioners from around the country. Each and every one of my guests has either personally increased female enrollment in STEM or retention, or both. We're really looking forward to sharing with you in as much detail as possible our best practices, our strategies, our secrets, everything that we can to help you have the kind of success that we've had in your own STEM classrooms.

Now this session is about an hour and at the end, I'm going to have question-and-answer session.

I decided to start with the lab and how to ensure female students are successful in the lab because this is such an important part of STEM education. Really, it can make or break your success in the lab. It's an area that overall as a group, female students tend to have more difficulty with. I'll talk about why that is in a little bit.

In this session, I only have time to go into the **top three strategies** but I talk about all of my strategies in more depth in the WomenTech Educators Online Training, which I'll go into a bit later. So the three things that I'm going to address in this session are:

1. First, appealing to female interests in STEM in the lab;
2. Two, having structured activities in the lab; and,
3. Three, making sure that female students have building block skills so that they're not feeling behind from day one.

Okay, so let's go ahead and get started.

A lot of female students will express that they are feeling bored in a STEM lab. They're not excited by the curriculum or what they're doing. There's a lot of research that shows that overall as a group, men are very excited about the features of technology and science. They care most about how the big the hard drive is, how fast the engine goes, how fast the processor goes, overall as a group. Women, on the other hand, as a group, care more about how STEM will be used to help others. That might look like developing computer-controlled toys for children with disabilities or developing an environmental monitoring system for an art museum to preserve exhibits. But they care about how the technology is going to be used.

Figure 1. Lego MINDSTORM™ R3PTAR

So one of the things that is going to engage your female students is when you can make a connection between what you're teaching and how it's going to help others. Often, that's not what most STEM classes look like. I'm going to give you an example. I'm guessing that most of our listeners are familiar with Lego MINDSTORMS™. They were developed by the MIT Education Lab and they teach robotics, computer programming, and engineering principles.

If you go to the home page of the Lego MINDSTORMS™ website, you see what look like monsters. I want to just describe to you the two characters on the home page. One is EV3RSTORM, leader of the Lego MINDSTORM™ robots, superior intelligence and fighting power with blasting bazooka and spinning tri-blades and R3PTAR, strikes at incredible cobra-like speed with fearsome fangs. I'm going to tell you something that might shock you: a lot of female students are not that attracted to Lego MINDSTORMS™. They are widely used to teach robotics throughout the education system.

Figure 2. SciGirls Robots to the Rescue Video

I know some of you are saying, "Ah, I know girls that love Lego MINDSTORMS™," but if we ever want to interest the majority of girls and women in robotics, then we need to teach it in a different way that will be more appealing to the large group of female students who are just not engaged by STEM education in its current form. So what that looks like is, for example, SciGirls has Robots to the Rescue. There are middle school girls who learn how to program robots that are being used for disaster relief with human emotions. There's actually a video and it starts out by showing the girls going to the area in which they have pretend disasters, seeing what that looks like then seeing what they need to do and learning actually how to do the programming after they have seen what the impact will be. Actually, it's amazing because here you see these middle school girls very engaged with computer programming.

Do you see the difference between using Lego MINDSTORMS and Robots to the Rescue? Huge difference. Teaching the same skills but with a really different perspective. I just want to be clear I'm not saying that you want to get rid of Lego MINDSTORMS™ but what I'm saying is that you want to add Robots to the Rescue. So again, appealing to how this part of STEM is going to help others and making that connection for your students.

I want to give you another example. We actually have a set of posters that are of women engineers, and there are inspirational quotes. There's one from a woman who actually services manufacturing equipment that is used for manufacturing food. What she talks about in her inspirational quote is that she feels really good being part of a manufacturing facility in which they're making sure that food is safe when delivered to the consumer. I'm hoping that you see that connection again with helping others. If you want to look for some other really good examples, I suggest you go to PBS Kids and Design Squad. They have lots of the kinds of engaging engineering examples that I'm talking about.

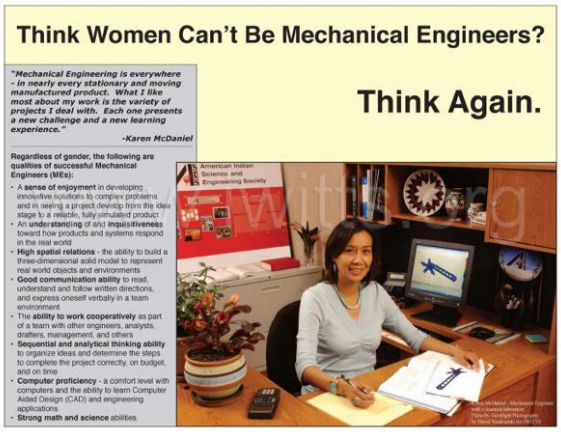

Figure 3. IWITTS Female Role Model Engineering Poster

Carnegie-Mellon University did a big study of female students in computer science. One of the things that they found was that it was really important to provide upfront the context for computer programming and the practical application as the first thing. For example, when it came to computer programming, how it has traditionally been taught was that the students did coding right away and there was no context of practical application. When they reversed the order and they gave the bigger picture and then had them do the coding, things went much better for the female students. If you have done any coding, you know that initially you could have like one little period off and the whole thing doesn't work. The female students were much more likely to persist with coding when they understood the difference it was going to make and how it was going to be used.

I have to say that Carnegie-Mellon really did some amazing research. The chair of the computer science department and the chair of the women's studies department actually got together and they figured out what things were most engaging to female students, how to support them the most. They greatly increased female enrollment and also retention. If you want to read more about that, I would suggest you look at the book that they co-authored, *Unlocking the Clubhouse: Women in Computing*, a really excellent book.

Now let me give you some more examples of appealing to female interests in STEM in the lab. There is another amazing book called *Gender Inclusive Engineering Education* and it was written by two female engineers who actually teach out of Australia. I was fortunate enough to meet them at an American Society for Engineering Education conference in Vancouver where they were speaking. I was speaking. I learned about their book and I was like, "Wow, this is fantastic. This is exactly what I've been looking for."

They have examples in their book of gender-friendly engineering as they describe it. A lot of them, by the way, are from the United States. What's interesting is that they actually make the case that this will help male students as well as female students and that also having context right up front is female-friendly but this also helps males as well. The example from the book that I want to share with you that I actually like the most is from a course on engineering materials. It's a compulsory first-year engineering course that often has a high failure rate.

Before they changed around this course, only 54% of the students actually made it through to the end of the course. What they then did was they started the course the very first day by having case studies from the industry about disasters that happened when there were failures in engineering materials. They gave practical demonstrations and displays of the failed material components and really, right from the first day, there was a connection between the theory and the real-life situation. They then had students, again, in that very first day and week actually, work on case studies together as a team and that actually totally transformed the retention rate in the course. It went **from only 54% to an average of 80%** over a six-year time period.

So, again, having the context right upfront really makes a huge difference for female students in particular, but it also helps male students with retention as well. Appealing to female interests in STEM in the lab is one of the important ways to ensure their success. You've just heard a few ways to do that.

Okay, so let's go on to number two. I'm going to talk with you about structuring activities in the lab and why that's important. First of all, research shows that if you pair a male and a female student together in the lab, what's going to happen? Often, the men are going to take over the equipment and the female student is going to end up taking notes. It's really important that professors structure their labs and monitor them to make sure that this doesn't happen. I want to give you a personal anecdote as to why this is so important because I know sometimes that professors, especially at the college level, will say, "You know, female students need to learn how to handle themselves in the classroom and they're not really thinking they need to do the structuring." So I want to just describe how strong this dynamic can be.

Recently, I decided to take a bike repair class at my local bike shop. I'm pretty lucky. I've never had a flat tire but just in case I ever would, I wanted to learn how to do it myself. It was a small class and I think there were six of us in the class. I had brought my bike and first, we got the lecture. There were a lot of terms I was not familiar with. I had never done anything like this before. There was actually a male student in the class and he seemed to know quite a lot. He was sort of translating the terminology for me.

Then it came time for the lab. Actually, he was paired up with me. He did not have his own bike. We turned my bike over and it was now time to pull off the tire and change it. He had done this before. I'm not sure why he was taking the class, maybe for a refresher. What I found was that even though it was my turn, he was actually trying to do it for me. He was well-intentioned but I really wanted to learn how to do it myself.

So it took three tries of saying to him as diplomatically as possible, "I really need to do this myself." Finally, I just said to him, "I appreciate your help. Do you think maybe that you could act as my coach, not say anything but just let me do it on my own but be there as a backup if I'm not able to do it? Because I really feel I need to actually try to do this all on my own or I won't learn how to do it." It took until that third try until he let me do it.

I have to say as the Executive Director of the Institute for Women in Trades, Technology and Science – I am the founder of 20 years – I'm not exactly a shrinking violet here. Can you imagine for the average female student if they were to encounter that, how hard it might be for them to change that dynamic that I just described that I experienced in that bike class? That's why I really want to say it's very, very important to structure your activities so that we are sure that female students are not going to be over-

helped and that they're going to actually get their turn. I'm going to talk with you about some ways to do that.

One method of doing that is initially, if you have a few female students in the class, you have more than one and I'm hoping that will be the case you might want to pair them together initially. Then as they master it more, then you could also integrate them with the male students in the class. Not everybody's going to want to do that but that is one strategy. Another strategy is called the **driver/navigator technique**. If you have two students working together, the student actually touching the computer is taking directions from the navigator who is not touching the computer or any other piece of lab equipment. Then you switch.

It's important as a teacher or professor to monitor that process and make sure that the switch is actually happening. I know that one instructor, Barbara DuFrain, would actually use student helpers to help with monitoring that process. Generally, they're the students who already got it. So the driver/navigator technique is also a technique that's used in industry as well. That's another way to do it.

Then the other thing you can do is call time and then switch when you have students that are working in pairs. Again, similarly, you want to monitor it. When you're having teamwork, you can have different roles for each member of the team assigned different roles and then have them rotate. The key here is not simply letting the students go out on their own and not monitor the process, not call time because not only are the female students less likely to be able to do the hands-on work but then you're going to have some male students who come maybe with less experience, less background, less confidence and they also will need that kind of structured pairing and teamwork in order to ensure that they are learning everything that they can in the all-important lab.

Now the third area that I want to talk about is making sure that female students have building block skills so they're not feeling behind in the classroom from day one. In the WomenTech Educators Training, I go into a lot of detail about why overall as a group female students come to the STEM classroom with less hands-on experience and informal STEM experience. It really makes a difference because it is assumed often in STEM classes, even those that are introductory and don't have prerequisites that the students will know how to tinker, problem-solve, have some basic hands-on experience, experience with tools, have spatial reasoning skills, be able to do some applied math. If you can't do those things because you have no experience, then you're going to feel like you don't belong or you're behind.

One of the things that I recommend is figuring out how to incorporate those building block skills so that your female students and some of your male students aren't struggling. I'm going to talk about the number of ways that I've seen that it can be done. When I do the full WomenTech Educators Training, I also go into detail on each of the building block skills which again are tinkering, problem-solving, hands-on experience in the lab, spatial reasoning, tool identification and use and applied math.

Here are some models for incorporating those building block or bridge skills. One is to have a summer program. This is actually a very popular way of providing bridge skills. Not every student is able to spend the whole summer learning bridge skills. Also, it means that they can't work. It can be expensive to do these programs and it can be hard to get students to attend in the summer. But that's a popular model and when you are able to do it, it can be very effective.

There are also models in which you provide the bridge skills in the very beginning of the semester. That actually is my preferred method because that makes sure that every student has the opportunity to learn those skills. It doesn't expect that they'll do that on their own and especially if you're behind, you may not want to do that on your own. Incorporating it right in the beginning of the class is my personal bias. I know a lot of instructors will tell me, "It's not possible. We have so many things we need to cover." **So another way to do it is via supplementary content.**

City College of San Francisco actually did this. They identified that binary numbers was an area that their female students and some of their male students had a lot of difficulty with and it's really critical in computer networking. They developed some You Tube videos and they not only were helpful to their own students but the videos actually now have thousands of comments from students around the country and around the world thanking them because now, they can understand binary numbers. By the way, they actually decided to share a Google Doc and share supplementary content among the instructors to push out to the students that would help them in different areas that they needed additional skills in. So supplementary content, sort of along the lines of what you might do with the flipped classroom is another model.

Also, you can have a parallel program. Cañada College has a program in 3D animation, game development required good spatial reasoning skills. They provided actually a short mini-course in spatial reasoning to help their students with the 3D aspect. By the way, teaching a short mini-course in spatial reasoning has become a popular way to do this including in four-year engineering schools. Later on in the week, we're going to actually hear from the international expert in this area, Dr. Sheryl Sorby, in a lot more detail about the building block of spatial reasoning. Overall as a group, research shows that female students have less spatial reasoning skills but the great news is that they can be taught.

So providing the short parallel mini-course is one way to do it. **Another thing that can be done is providing additional open lab time.** Because female students have less hands-on experience, additional open lab time gives them the opportunity to practice. You might want to do what City College of San Francisco did. They staffed the lab with female teaching assistants who were students and also students of color so that the students would feel more comfortable coming to the lab and asking questions. Additional open lab time is another way to provide the building block skills. Some professors will do individual assessments of students and then direct them towards supplementary material that will help them.

Another way to do it is what Carnegie-Mellon ultimately did. They said (paraphrase), **"Okay, even though we're one of the top computer science programs in the country, there are some students who need more materials than others. So we're going to have different entry points into the program."** They purposefully did not actually frame it as “students who need additional help, start here”. Instead, they framed it as “different entry points” because they didn't want students to feel like they were starting out in a deficit model. Speaking of that, I think that's very important. If you have a really significant portion of your students that are missing certain STEM building block skills, then I don't think the way to go is for them to have individual tutoring as a solution. Instead, there should be a bigger picture solution that incorporates those skills either in the classroom or with different entry points as Carnegie-Mellon did.

There are some types of models for providing additional building block skills into your STEM programs. The reason that this is so critical for the lab in particular is because research shows that confidence is a

big predictor for success for women in STEM. If you're coming to that classroom on day one with less experience and you don't know the terminology and you've never pulled something apart and put it back together, then you're going to feel a lack of confidence. The research shows that for female students, if you are feeling behind and lacking confidence from day one, it is really a de-motivator in a STEM classroom. Again, the great news is these types of bridge strategies not only help female students but help male students as well. So these are just some of the strategies that can help improve success of female students in the lab and will also help male students as well.

So if you have any questions for me and I hope you do because this is my favorite part. I get to hear from you. I'm going to try to get to all of the questions.

We already have some. **The first one is from Deb Struble. She says, "What if you have only one female in your lab course?** This is our technology institution's problem." First of all, Deb, I want to let you know that we actually have many sessions coming up that are on recruitment. I hope that you'll attend so that you can have more than one female. If you have only one female, again, appealing to female interests is still going to be important and that's probably going to also help some of your male students. The structured activities are going to be really, really key there as well so that you can make sure that she is getting her turn.

The other thing that I'm going to recommend and this is not specifically about the lab but this is about overall, if you are in a situation where you have only one female student, it's also important to connect her with other females in other courses, potentially a female instructor like yourself, making sure that she has support. That goes above and beyond success in the lab. I actually talk in some detail about how to do this in our WomenTech Educators Training because the support piece is really important as well. Thank you for that question.

Next question is from Bradley Layton in Missoula, Montana. He says, "Great explanation on how to motivate robots for women." Oh well, thank you. He indicates that they're going to build a robotic recycling system. That sounds really interesting. Of course, that also has that value in terms of helping. So that's great to know.

The next question is, "Can you spell the SciGirls website?" I'm going to tell you where to go. First of all, we are a reseller of SciGirls DVDs. So if you actually want them in a DVD format, you can go to our website, www.iwitts.org/store. In addition, you can go to PBSKids.org and if you search within PBSKids.org, you'll come to SciGirls and their website and clips that they have. I don't know if they specifically have Robots to the Rescue. We do have it on our website but they have a lot of rich, good content that you can take a look at.

So okay, next question is from Peggy from Bloomington, Minnesota. She asks, "What is the alternative option to MINDSTORMS for girls?" Ah, okay. So this hurts my heart to have to tell you this. MIT Lab actually developed an alternative that taught the exact same things as Lego MINDSTORMS and it was called PicoCrickets. We actually used to be a reseller for PicoCrickets. Instead of the monsters that I described, you could make a birthday cake sing, you could make a cat purr, things that appealed more to females overall. Actually, if you go to our Proven Practices Collection on our website of mostly journal articles that we've gotten permission to use and some case studies that we've developed, we actually have studies on the success of PicoCrickets.

Unfortunately, they discontinued PicoCrickets so that's why it hurts my heart to tell you this. Now having said that, I know that we do have a bibliography which I mentioned earlier with STEM resources for the classroom and I know that we do have some things. They're not like the complete equivalent to Lego MINDSTORMS or to what actually PicoCrickets were, the complete equivalent, but they do elements of that. One is not coming to mind off the top of my head right as we speak but I know there are some options that we've identified. They're not as complete, but of course as I mentioned Robots to the Rescue. That's a video but nonetheless, SciGirls has lots of goods ideas and they're in their videos which again you can go to www.iwitts.org as well as www.PBSKids.org.

Okay, the next question is from Jill Rogers in Tucson. She asks, "Context upfront for any lab task seems like common sense to me as a woman. Why do you think labs in the past were or not always structured that way? Can you say the name of the book you mentioned again?" Sure. So I believe the reason why context has not been traditionally how it is taught is that, again, the research shows that overall as a group, males are most excited by the features of the technology as opposed to how it's applied. That's what ends up coming up front because overall as a group, mostly male professors are teaching these courses. That's the majority of who teaches. So that is my guess as to why they're structured that way.

Of course, it doesn't mean that they can't do it differently or that they aren't willing to do it differently. In fact in my experience, they're totally willing to do that when they learn that that will help engage their female students as well as their male students and it certainly doesn't harm the male students. I can tell you from our own National Science Foundation projects, our external evaluators have found that wherever we're improved retention of female students, we've improved retention of male students because we have primarily focused on classroom strategies that impact both genders and they help males as well. The book is called *Gender Inclusive Science and Engineering* and they make the exact same point in their book that our external evaluators found which is that when you use these strategies they not only help female students but they also help male students who, for example, are not totally interested exclusively in the features of the technology and also care about context. For example, there are male students who I mentioned earlier that need building block skills and this is helpful to them as well.

These are great questions. Keep them coming. This is my favorite part when I get to hear from you. **Okay, so Helen from Athens asks, "Would you please repeat the bridge skills that you listed earlier such as applied math?"** Okay, what I personally have identified as the areas that I see women and girls having less skills in and I go into depth in our WomenTech Educators Training about why this is and talk about each of them but they are the following: tinkering and problem-solving; two, having hands-on experience in a lab or with equipment whether that be an auto lab or a computer lab or a biotech lab. So that's number two.

The third area is spatial reasoning, having less spatial reasoning skills. The fourth is tool identification and use. Again, whether that's auto tools or the tools that you use in computer networking. The fifth is applied math. Those are the five areas that I have found in my years of working in this area that overall as a group because of less informal STEM experience and, again, I got into detail as to why that is, etc. but these are the five. I got into some detail on each of these. But I'm also going to let you know that we have other speakers that are going to talk about these in some depth.

So for example, on Thursday at noon PST, 3:00 ET Sheryl Sorby is the international expert on spatial reasoning and has significantly improved the retention of female students in engineering by teaching spatial reasoning. She developed a course and then it became actually some software, etc. and 12 contact hours. She'll talk in depth about spatial reasoning. I'm pretty sure on Wednesday Carmen Lamha at noon will be talking about tool identification and use in computer networking. I know that that was one of her strategies. I'm not sure about the others but I think they're threaded through. I know the lab is quite important in a number of the speakers' topics. I think you'll get to hear more about them throughout the week as well as I talk about them in the WomenTech Educators Online Training. These are great questions.

Okay, so the next question is from Deborah in Hampton, Virginia. She asks, "Can I ask what age group was evaluated for these studies on males versus females?" It depends on the studies that I talked about but I can tell you that for *Gender in Science and Engineering*, those are four-year college students. So they're going to be a traditional four-year college age. For *Unlocking the Clubhouse: Women in Computing,* that's also a four-year college.

I also referenced additional supplemental content as being a bridge skill and that came from work that I did with two-year college students at City College of San Francisco. So that really varies. The average age of a community college student nationally is 29 and City College of San Francisco probably pretty similar to other colleges in that there's a range in ages and that's probably about the average. A lot of older students, both two-year colleges and four-year colleges represented. Then I mentioned the PicoCrickets Study. That study is I believe with middle school students if I remember correctly. Actually, these kinds of strategies really apply at all grade levels.

It looks like we are coming to the end of our questions. Thank you all so much.