ANNALISA L. WEIGEL: Tools and topics-- this is really the first part of two modules. The following module's going to be Six Sigma basics, and what I'm going to talk about in the quality tools and topics is going to flow in from the foundation for what Earl is going to talk to you about in the Six Sigma basics module.

So at the end of this module, we expect you to be able to describe how quality is essential to lean in achieving customer satisfaction. And secondly, we want you to be able to use some basic quality tools, and we're going to spend about half of the lecture exploring these different kinds of tools.

So why do we care about quality? Always have to start with that-- a lot of times the cost, of poor quality is directly measured in items like this. It's, how much scrap or rework do I have on a project? How many service calls do I have to make to fix something that's broken? What are the costs of fulfilling a warranty or other concessions that you have to make to customers when your product doesn't work?

But it turns out that the hidden costs or the indirect costs of quality can be 2 to 3 times as large as your direct measured costs. So if you think the direct measured costs are large, really, what your organization is spending on poor quality is enormous, because it's much, much bigger than that.

And they show up in terms of the excess inventory that you might need to keep around, because your processes, your quality is so poor over time for employees to deal with those poor quality issues-- all the non-value added and wasted steps, and queues, and delays that happen and cost money. And not the least bit is the reputation or image of the organization for having poor quality. And sometimes the cost of that is really quite immeasurable.

So let's start with-- one of the common ways that people think about adding quality is with inspection. But we've already talked a little bit about inspection in the course, and how non-value added inspection really is. So if you're buying a car and you have lots of people who are inspecting it, does inspections make your car go faster? Does inspection make your car get better fuel economy? What else is important to you about a car?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: Safety-- does inspection make your car safer? Some of you are nodding. OK, so some of your saying no, so there's some disagreement about if inspection increases safety. I think, after the next three slides, I will convince you that inspection does not make your car safer. Anything else you value in your car?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: Gas mileage-- so does inspection make your gas mileage get better? Probably not-- the takeaway is inspection doesn't typically add to what you, the customer, value. It may help to make sure that a bad product doesn't come out of a factory, out of a service to get to a customer, but inspection doesn't help you actually build in quality in the first time, because inspection is subject to a lot of problems.

There's different varying skills of inspectors and their attention span at any given point in time. There's measurement capability of humans-- varies widely. And there's environmental factors as well that contribute to inspection having widely performing characteristics. Yes?

AUDIENCE: [INAUDIBLE] inspection from the point of view of the owner of a car, where really, inspection is part of a system of the quality of the safety of our communities. We are stakeholders because we own a car and we have to have it inspected, but it's not-- it wasn't necessary there. The inspection--

ANNALISA L. WEIGEL: Are you talking about the state-mandated inspections?

AUDIENCE: Yeah.

ANNALISA L. WEIGEL: Oh, I'm sorry. I should have clarified. So I'm thinking about inspection like you're at the Ford or the GM plant, and they're manufacturing a car. Yep. So I'll note that for the future. Maybe that example's not the best one to take, but yes-- or think about a factory making a television. The fact that there are inspectors all along the assembly line doesn't mean you get a better picture quality on your TV, for example. Or it doesn't mean that it costs less. Cost might be a value that you have for your TV.

Yeah, state inspections-- we'll talk about that in a little bit. And it turns out, when state inspections are done, they're actually not visually inspecting much. They're actually doing inspections that have instrumentations that are taking quantitative data. We do call that inspection, but what we mean here is really visual inspection, eyeballs on some kind of part of the process to make sure that the product is turned out right.

So just to demonstrate to you some of the challenges involved with inspections, we have an exercise. So if you can take out your folders, there's an inspection exercise in there, and it's a bunch of prose. So it looks like this. It is entitled inspection exercise. So if you can take it out and turn it face down in front of you-- so take your text, flip it over face down so you don't see it, and take your pen in your hand, and get ready.

So the exercise is going to be in two 30-second sessions. So your first task is to find all of the lowercase or uppercase Fs on a page of text. So you are an inspector. You are the F inspector. So take out that inspection exercise. Turn it face down. When I say go, you are going to circle all the lower and uppercase Fs that you find. On stop, I want you to turn your sheet over, OK? And we're going to pass it to the right.

So everybody clear? I say go, you flip your page over, you circle-- it's important that you circle. Circle all the Fs, lower and uppercase. Ready? Go. And stop. Turn your paper over. Pass the sheet to the person on your right. Yeah, turn it face down.

All right, this is the second inspection. So now on the paper, when you turn it over, you're going to mark Xs on all the other Fs you find that were not found the first time. So ready? You have 30 seconds. On your mark, get set, go.

And stop. All right, now, take the page that you have, and I want you to count all of the Fs that you placed an X or a circle around. So tally up all the Fs that you found on the sheet-- both you and the person previous to you. And please make sure you tally separately the circles and the Xs.

All right, when you have tallied your Xs, I'd like to get the number of Fs that were circled. And we're going to just go around the room and just shout out the number of circled Fs that you have in turn. I'm going to take them down here on the computer when you do this. And the next one?

AUDIENCE: 31--

ANNALISA L. WEIGEL: 31-- oh, that's a record now. Go ahead.

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: 36?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: So 36 is a data point you'd like to add? Well, that's a pretty high-quality inspector. That one definitely wins. All right, let's go on past two. So now what I'd like to know is the number of Xs that were caught. 10? 10-- OK, great. All right, so let's take a look. So this is a graph that shows us how many Fs we caught on our first pass on our second pass. The average is in the red.

And then we also have the standard deviation that's shown, so you can see the kind of variation that we have between all of you highly-qualified inspectors in the room. There are still some significant variation in the number of Fs that we can catch. And then the blue column, which you see displayed in pass 2, is the projected average of Fs that might be caught based on the percentage of Fs that was caught on the first pass and the second pass. And we could keep calculating that, if we made third and fourth passes, and so on.

AUDIENCE: Is that average the total number of Fs that would be caught within two passes-- so [INAUDIBLE]? Or is that--

ANNALISA L. WEIGEL: That's total, yes. So that's not this-- the number caught on the second. That's the total. All right, so now let's go ahead and look at our summaries here. So our inspector efficiency is running around 68%. All right, so let's take that inspector efficiency and then return back to our graphs here. So there's our inspection exercise.

This is a graph that shows you the impact of inspector efficiency on escaped quality. So here on the y-axis, we have escape defects per million, and down here on the x-axis is the number of consecutive inspectors. So we had just did an example with two consecutive inspectors.

And then here, our different color lines represent different levels of Inspector efficiency. So 70% is with the red line, so that's about the line that our class was on-- 68% efficiency-- let's call it 70. So if we wanted to inspect-- visually inspect our product down to one escaped defect per million, we have to have more than 11 consecutive inspectors examining each product.

Do you start to see how that adds up to a lot of time for maybe not the biggest payoff? You need to have lots and lots of inspections, and what did we say about inspection? It's non-value added. It's really a waste in the process to do visual inspection. You want to be able to build in your quality up front. You want to have consistent processes that deliver the kind of quality you want, and not try to inspect it in later.

So that's just a motivation for why we need to think about quality tools, and building them into all the processes that we use to accomplish our tasks. And lean uses a number of them. They came out of the foundation of total quality management, which became really big in the 1980s, and also emerged from Japan.

And TQM, as it was called, was built on the notion of customer satisfaction, and we achieved that through employee involvement and continuous improvement. And then those were all enabled by focusing on some problem solving tools, designing processes, purchasing efficiently, and thinking about your product service design, as well as benchmarking-- going out and looking at how you're doing relative to your peers.

But lean, on the concepts we've looked at in class, are very much related to all of these. We talked about value stream mapping analysis as really analyzing the process design part of it. We talked, at least yesterday in the enterprise [INAUDIBLE], about lean supply chains as being the way that we're looking at purchasing-- and lean product development or lean health care deployment as a focus on the product and service design.

And today, in the module here, we're going to talk about seven very common quality tools that help you address the problem of troublesome quality. So the seven basic quality tools are these. We'll start with flowcharts. Then there's some cause and effect diagrams-- example of which is shown here on the chart. Then there's check sheets or checklists, histograms, Pareto charts, scatter diagrams. And then control charts we won't cover in this module, but Earl will be covering it in the next module on Six Sigma basics.

So stepping right into our first tool, flowcharts, examples of these are the process maps that we've already done, the value stream maps. A flow chart is which activities are taking place in sequence, and the inputs of one flow into the process become outputs, which are inputs into another part of the flow chart. You also see these commonly as describing software program flows, and sometimes [INAUDIBLE] algorithms are also described with a process and a flow chart.

So why are these a quality tool? There are a number of reasons why we think about these is helping to improve the product or service quality. This kind of visual description that a flow chart gives you really helps to improve comprehension among a large group of people, because it's laying out there visually those steps of the process takes.

And in addition, it becomes a flow, and it helps us make sure that we are doing each step of the process that's required in the order it's required and when it's required. So it becomes that tool for us to make sure that we've done the right thing. It also helps to tie our outputs to the inputs of different steps in the flow chart, and it can also assist us with data collection by helping us understand where in the process flow we need to collect and add data.

The second basic quality tool are cause and effect diagrams. These are also called fishbone diagrams, or Ishikawa diagrams after the gentleman, Mr. Ishikawa, who invented these. And they look a lot like a fishbone. And it's a tool for root cause analysis, and it's often supported by using the five Ys exercise. And this is really to help you with brainstorming all the potential causes or things that might affect a problem.

So we think about the problem as being represented on this horizontal line here, and then there are usually six categories of causes to help with your brainstorming to try to fill those in. So you want to think about causes related to materials, or causes related to personnel, or to measurements, or to methods, or to the environment-- or external factors-- or to machines. Now, not every discipline uses these exact same six, but they're a great starting point for most. And some organizations and disciplines have determined their own particular veining structure that they like for their fishbone diagrams.

And then, as you see the examples I'll show you next, there are some primary causes that relate to materials, which are typically shown on the horizontal axes feeding into these spines. And then there are sometimes secondary causes that feed into a primary cause. So let me show you an example. I think that's easier way to understand how these are used.

So this is an example from the Institute for Health Care Improvement, and it's a cause and effect diagram about why tests take so long to get results. And they've used the categories for the main causes of people, environment, equipment, methods, and materials. And so if we wanted to ask, well, why might materials make test times take so long, it might be because there are lab supplies as part of materials, and those lab supplies-- this is a secondary cause illustration may be unavailable or they may be spoiled and no longer good.

We may think about the methods of why tests take too long. So what is it about the method that I'm doing with the test? Maybe there are too many people involved. Maybe there are unnecessary steps in my method. So it's not a definitive answer. This is the brainstorming tool that you use to get all of your thoughts flowing about, what might be all the potential causes that contribute to a particular problem?

All right, another tool are check sheets, or a simplified version of these are checklists. But a check sheet is just a structured tool for collecting data. So we'll put up for you this purely hypothetical example of keeping track of the instances of quality problems in our lean academy courses. So we've identified these various problems here, on the column under problem, and then we're trying to keep track of all the instances we see on Monday, on Tuesday, on Wednesday, and we're totaling them for each of the days and for each of the instances.

So this helps us know what kind of data to collect so we can monitor the quality of the process and understand where we might want to make some improvements. So I said a simplified version of this is just a checklist. Pilots often use these when they're getting ready to fly. It's a structured list of exactly what you're supposed to be doing, and each time you accomplish the item, you check that you've done it, and then you place another check on the other activity.

When my first child was born and I found myself in a sleep-deprived state, like most parents do, my husband and I were trying to get out the door with our son, and we kept forgetting things. And of course, we were tired and we really didn't have the mental capacity to remember everything, but both being trained in lean, we said, you know, we need a checklist.

And we made a checklist of all the items he needed-- diapers, wipes, toys, sippy cups, food-- whatever-- and we kept them right next to our door, and every time we left, we picked up a checklist-- being brain-dead parents-- and all I had to do was read it, and say, did I have it in my bag? And I checked it off. And after that, we were happier, happier families-- so yet another instance of how lean in the home is very helpful.

All right, next tool is a histogram. So histograms are typically showing the frequency of occurrence of a particular activity or item. And from this, you can start to understand a little bit more about the frequency distribution that you're seeing-- is this a normally distributed event, is it randomly distributed, and so on.

So we can also use it to see how a distribution is spread out-- whether it's very concentrated or very spread. We can also use histograms to see changes over time. We can look at inputs and outputs in a quantitative way, and we can also use histograms to help us compare what we need to be doing to what the customer requires us to be doing.

And here's where we get to the sweet part of the lecture, or about midway through. And we're going to do an exercise involving some M&M's. And I'll ask Q if you can start to distribute the packages of M&Ms.

AUDIENCE: It's already done.

ANNALISA L. WEIGEL: Oh, excellent-- they're here-- great.

AUDIENCE: I hope nobody's actually eaten them already.

[INTERPOSING VOICES]

ANNALISA L. WEIGEL: All right, so what we'd like you to do is your bag of M&Ms, but don't eat them yet. We want you to count the number of M&Ms in your bag, and we'd like you to do that by color. So arrange all the reds, and the blues, and the greens, and the yellows, and the browns all in different categories, and then count them up.

And what you want to do then is take the data sheet that is on your table-- did everybody find the data sheet underneath your M&M packages? Once you have your M&M bag tallied, please fill in the data on the data sheet. So go to it. Once your table has filled in that sheet, please bring it up from.

All right, if you can direct your attention up to the front of the class, so this is a histogram of the number of M&Ms that are in all of your bags. So we have the quantity of M&Ms that were found in your bags, and we have the frequency of occurrence of those particular M&Ms in your bag.

So let me also ask you to look around at your table and look at the color distributions that you see. What do you hazard about those? What do you learn from looking around at the distributions?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: People are shaking their heads. What does that mean?

[INTERPOSING VOICES]

Not many reds? So maybe red is expensive to produce. All right. What else?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: Do you see an even number of colors?

AUDIENCE: No.

ANNALISA L. WEIGEL: Not within your bag? Even if you took a big sample on your table?

AUDIENCE: No.

ANNALISA L. WEIGEL: Still not the same?

AUDIENCE: [INAUDIBLE]

ANNALISA L. WEIGEL: And then, what about the number of M&Ms that are in a bag-- the same, variable?

[INTERPOSING VOICES]

ANNALISA L. WEIGEL: Kind of variable-- so if we're thinking about quality and we're thinking about the M&M attribute that you think Mars company-- which is [INAUDIBLE] the company that makes M&Ms-- what attribute do you think that they're applying quality principles to control the variation of? So do you think they're controlling the variation of the total M&Ms in a bag?

Not with that big a variation-- how about the color distribution? Not that-- so is it something else? I won't accept that as an answer. What do you think it might be?

AUDIENCE: Weight--

ANNALISA L. WEIGEL: Weight-- what does say in your bags?

AUDIENCE: 1.69 ounces--

ANNALISA L. WEIGEL: 1.69 ounces-- yeah, and that's exactly what they're controlling. They're not only saying, you get about an ounce or about an ounce and a half. They're saying, you get exactly 1.69 ounces of M&Ms in your bag. So that's a variable that they're controlling for. So we can use a histogram to learn a lot about the variations and about the distributions that we can see in our process, in our data. All right, so let's continue with another example, a Pareto chart.

[INTERPOSING VOICES]

AUDIENCE: Can we now have it?

ANNALISA L. WEIGEL: Yes, you may now eat. I forgot to give you the go-ahead. Yes, munch away on your M&Ms. We want the sugar level to raise up so that you stay active and functioning for the rest of the afternoon. So just to give you maybe a more serious example of a Pareto chart, these are causes leading to emergency department admissions.

So we start here. And this is called a Pareto, because we have the tallest bar starting in the front, and working our way down to lower bars. And what Pareto charts do are call our attention to the things that are happening the most. So what this chart says is pneumonia, in this particular emergency department, is a leading cause of admissions, and accounts for almost 25% of those admissions. And UTIs are next, urinary tract infections.

So if you wanted to think about addressing some of the causes of admissions, then you might really look at these leading categories. So you might not want to think so much about cellulitis or hypertension, because those aren't your leading folks who are coming into the ER-- ED. Maybe you want to think about these areas.

And similarly, this line up here tells you the cumulative percentage, as you add in each of the columns as you go along your Pareto chart. So your pneumonia and UTI account for a total percentage of about 75% of your cases.

Just another example from the aerospace world-- this is a similar kind of Pareto chart, but done for the root cause of various discrepancies on satellites. This actually comes from research that I did as a master's student. And we were trying to understand exactly what this kind of chart tells us, which is, if I wanted to eliminate the waste in my testing, where do I start?

And we found that the biggest problems involved employees or operators. So there may be issues of training or skills here, and that was the non-satellite-related causes. And then we called a category of satellite-related causes, and it turned out that this basic design of the satellite was at fault most of the time. So if you wanted to try to eliminate some of those causes, you might start with perhaps training, and then thinking about design that might ensure more robust performance under the testing conditions.

Next quality tool, scatter diagrams-- these are just plots of x, y pairs of numerical data. And what we can see from here is whether there's any kind of correlation or pattern-- because correlation and pattern are not the same thing. Correlation indicates whether they're following some kind of straight line, like they are here.

So this type of data is correlated data. We can say that x varies with y in some relationship that we can estimate from the scatterplot. Or we can look at scatterplots here and say, well, there's really not a terribly strong correlation between our x and our y-axis. The patterns are not very strong.

It's a very good starting point for root cause analysis. If two variables are related, you want to think about them in terms of which one might be causing the other one. Keep in mind, correlation is not causation, but there's some kind of link between those two variables.

All right, just to sum up and try to get ourselves back on schedule, so first thing we hope to prove to you-- that inspection is just a very ineffective way to produce high-quality products and services. Sometimes you're going to have inspections. Sometimes you're going to do it, but it's not really the most effective way.

We then talked about total quality management and lean thinking, and tried to show you how they're closely related to each other, and that they both utilize some simple structured quantitative and qualitative tools to help achieve quality as a result of applying the different processes. We covered seven-- well, actually, covered six basic quality tools in this module. We'll cover one more in the next module.

But we want you to remember that capable people are the most important factor in achieving quality. So it's not just having a better testing machine, or having a better design, or other factors, but it's capable people.