Module 4: Designing Improvements and Sustaining Changes

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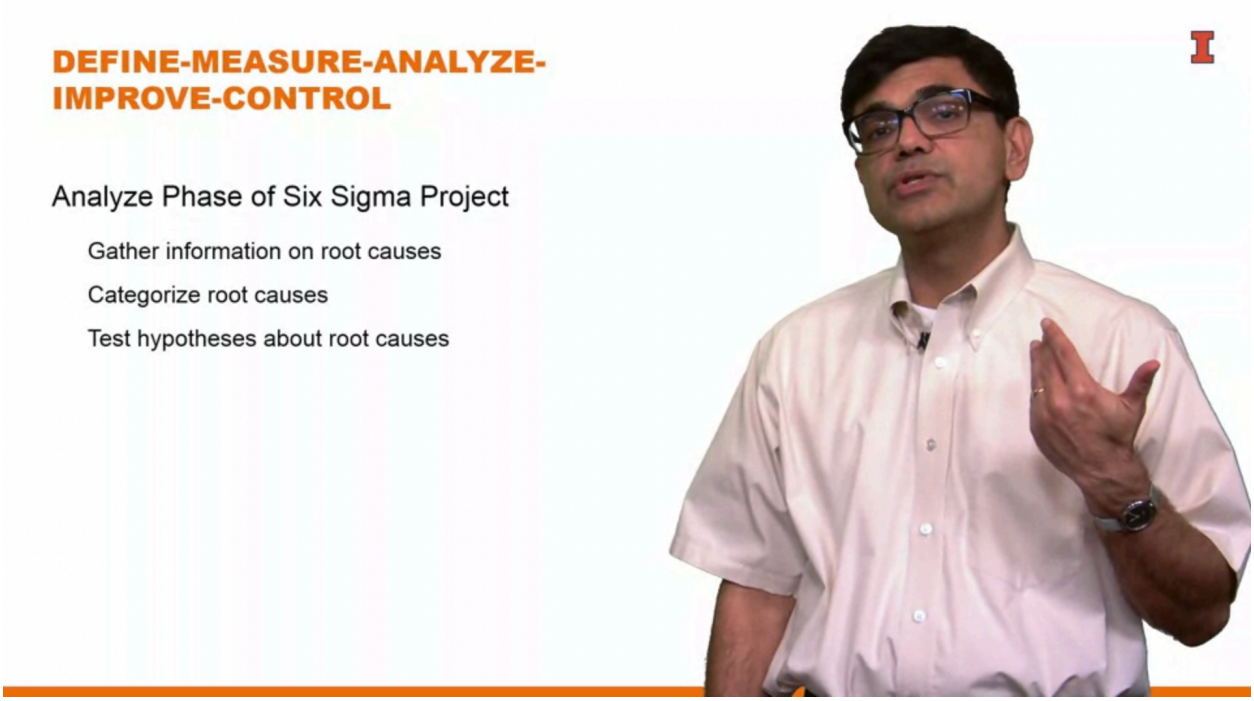
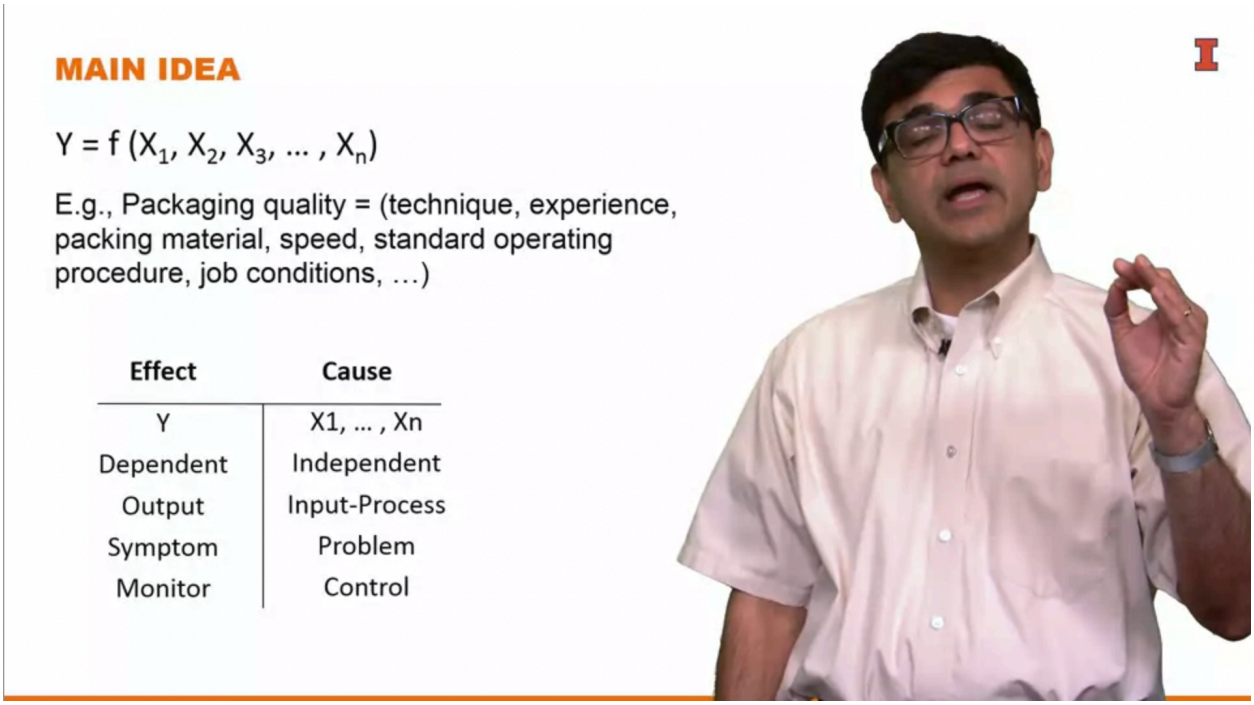
Lesson 4-1: Identifying Potential Causes

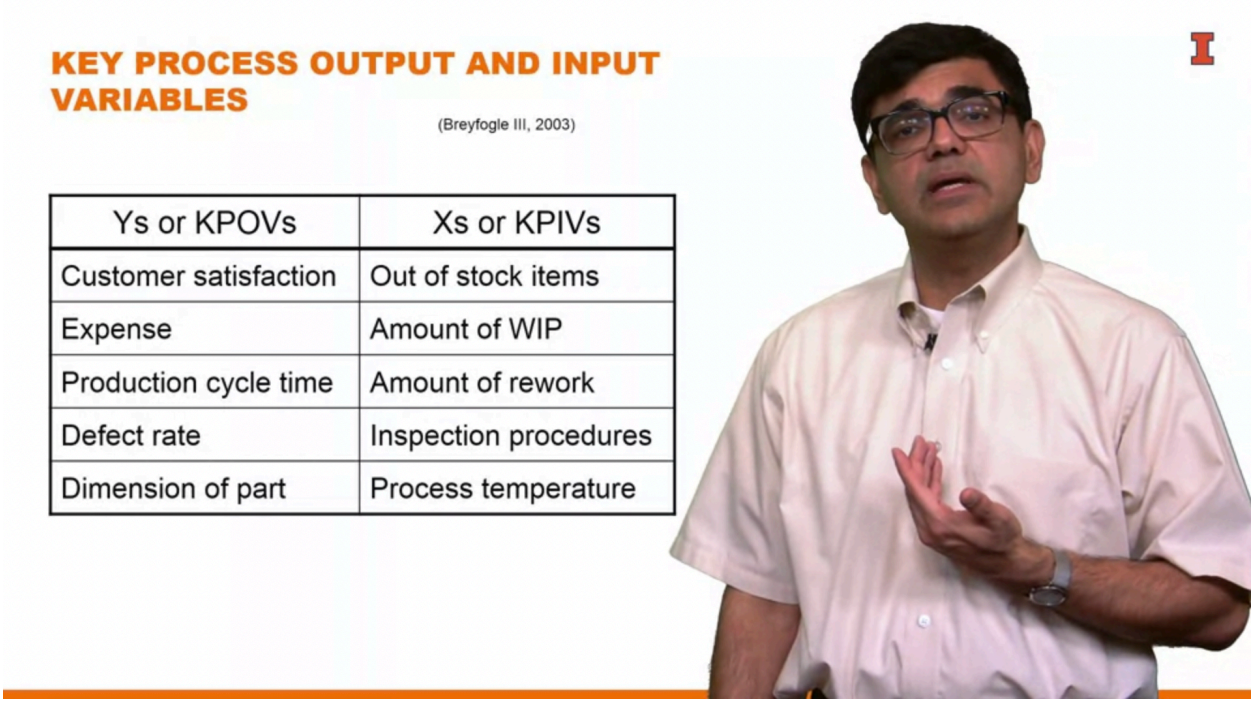
Module 4.1.1: Analyze Phase in DMAIC



In this session, you're going to look at the first part of root cause analysis. The first part of root cause analysis is trying to formulate hypothesis. What are the things that we should be testing in terms of being the causes of the effects that we're seeing in terms of something that a process customer cares about? How do we go about coming up with the idea that something might be affecting the output that we care about? That's the idea of formulating hypotheses. That's what happens in the analyze phase of a Six Sigma project. In the analyze phase of a Six Sigma project, you try to get information about what may be some of the things that we may want to change in the way we do things so that we get better results for the process customer. If you think about Six Sigma projects, they are made up of cross-functional teams. You're trying to get people from different functions, from different levels of expertise, from different areas of expertise together. We're trying to get all of their knowledge to come together and come up with informed hypotheses on what might be things that might be related to each other and that they should be looking at. Then you want to take all of that information and next go into testing those root cause analysis and cause-effect relationships in the form of statistical tests, hypotheses tests, or even doing experiments and seeing if something is what you were expecting it to be based on your analysis. In this session, we're going to look at some techniques that are used in order to gather that data from the experts. Gather that data from a bunch of people who are coming from different areas, who have different perspectives.

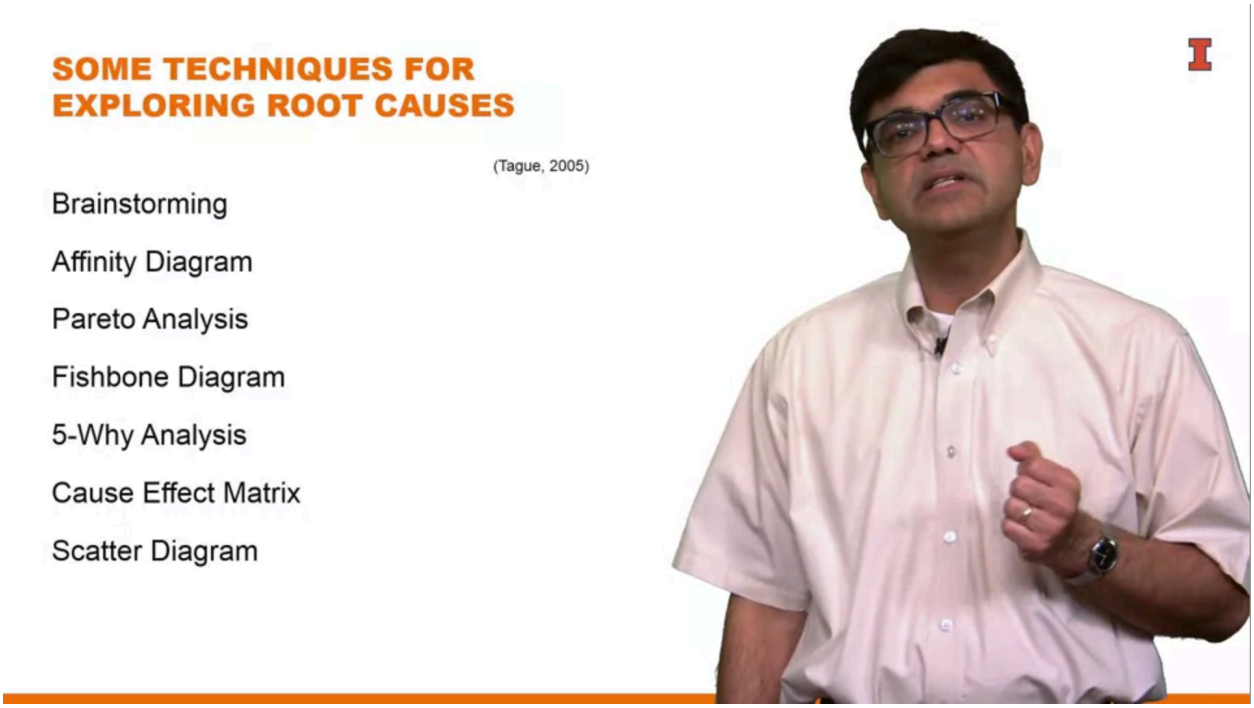


What is the main idea? The main idea is that there is a Y value or a Y, which is the effect that is caused by certain causes. Those might be the different Xs and they might be many Xs and there might be interactions among those Xs and that's what we want to try and parse out. We want to be able to say, how is the Y affected by the different Xs. If you think about Six Sigma projects, if you think about process improvement projects, you can think about it from the point of view of here's the Y, here's the main X that is causing that Y, and then you could start breaking it down. You can have cascading sets of Y as a function of X equations where the Y is a function of X as the top equation. Those Xs becomes the Y for the next level, so you're basically doing some sort of a 5-Why Analysis in terms of drilling down to the Xs that you want to control so that you affect the Y. If you think about Y and X, you can be thinking about this Y as the dependent variable, X as the independent variable. Y as the outcome, X as what you're doing in terms of trying to create that outcome. Y as a symptom of a problem. Y is the number of defects that we see, and you could be looking at the causes in terms of what are the problems in the process itself that are causing those defects. Finally, you could be thinking about in terms of, Y is something that you monitor. It's already the effect. It's too late when you get that Y to make a change to it. It should be the Xs that you should be controlling and the Ys that you should be monitoring. You should be constantly testing the relationship between the Xs and Ys in order to have your process working at a certain level. But that's the main idea of root cause analysis, Y is a function of many Xs.

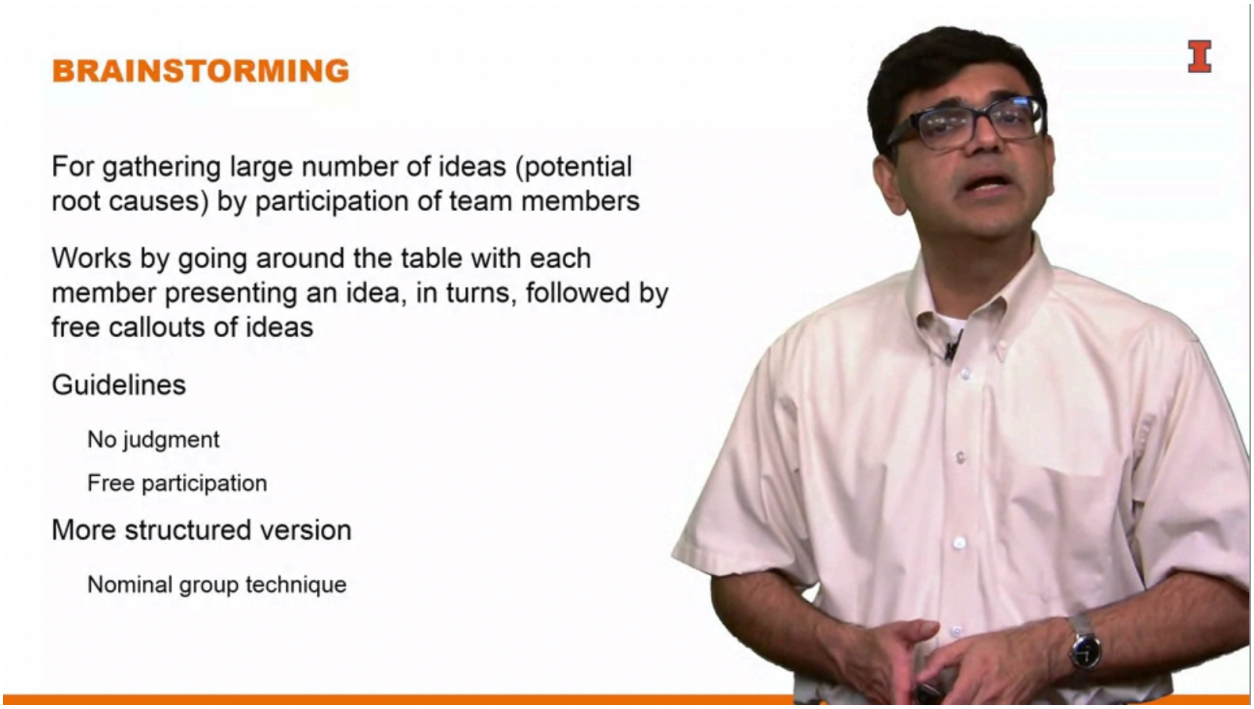


Some standard things to think about when you are thinking about different types of Y. Here you see a set of Ys and the corresponding big Xs that you may be considering. Just to get some sense of what are we talking about as Ys and Xs here, Y could be customer satisfaction that is affected by out-of-stock items. When you have a lot of out-of-stock items, your customers are going to be dissatisfied. Y could be the expense in terms of how much you have to spend on stuff that is waiting, stuff that is being kept in storage, and the X could be the amount of work in process which stands for the work-in-process inventory. Production cycle time could be the Y that you care about and that will be affected by the amount of rework. Because as you have to do something over and over again, if you don't do it right the first time, it affects your production cycle time. It increases your production cycle time because you're using up your capacity for other things. That's an X that you try to reduce in order to get a better level of Y. Defect rate as the Y being affected by inspection procedures. If you're thinking about lean as a philosophy, there would be saying that, hey, you shouldn't be thinking about inspection procedures in the first place. But, if you do have to have inspection because you don't have perfect processes yet, or it's a new process, and you still have inspection procedures, that's something that you might want to focus on in order to have less defects or a smaller defect rate. Process temperature affecting the dimension of a part. These could be environmental things that you may want to control. Right now you're just saying that there might be an effect of process temperature on dimension of part, you figured out if there is, then that's something in the environment that you need to control in order to get better quality outputs for your customers.

Module 4.1.2: Techniques for Exploring Root Causes

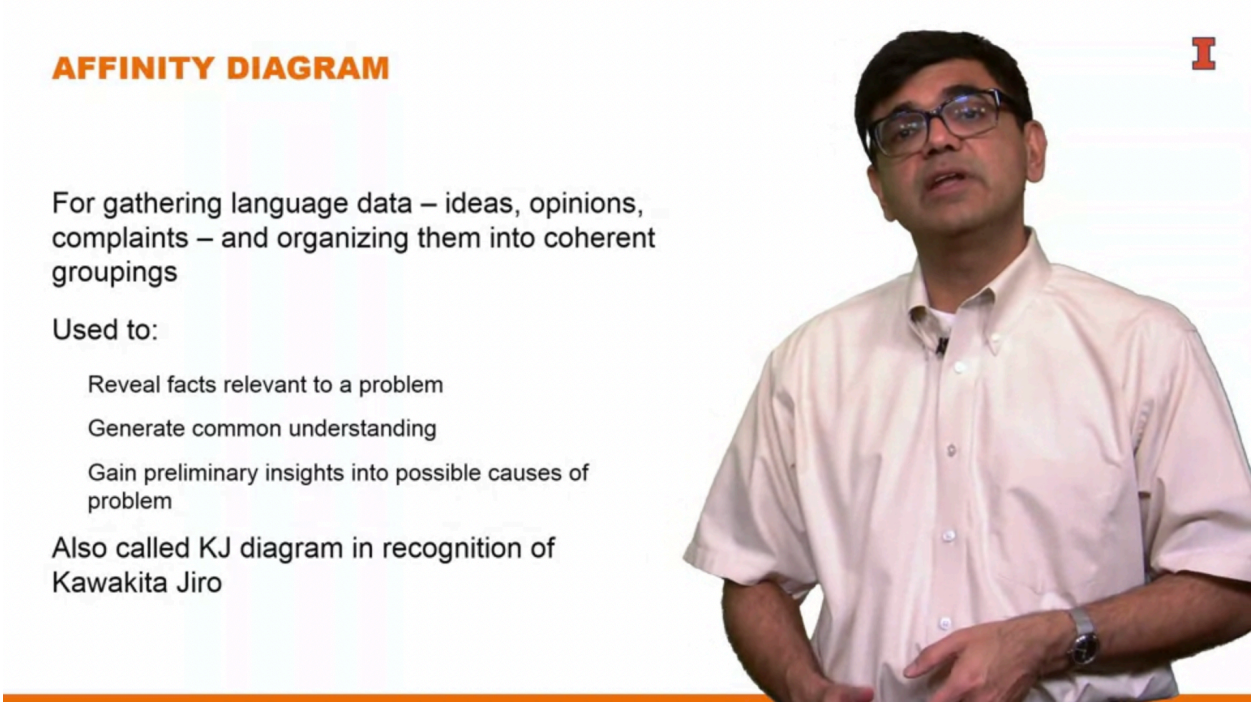


Let's take a look at some techniques that are popular for getting into the idea of what are the root causes. Here's a list that will be going through in this session: brainstorming; affinity diagram; Pareto analysis; fishbone, what is also called the Ishikawa diagram; 5-Why Analysis or what I like to think of, my five-year-old's asking five whys and many more whys than five because they keep asking why for every response that you give them for the previous why. You say, "Don't put your hands in the socket." "Why shouldn't I do that?" "Because you might get a shock." "Why will I get a shock?" Those kinds of things are what we are talking about, more from a process perspective when we're talking about a 5-Why analysis. Just going through the rest of the list. The things that you'll be seeing in this session, cause effect matrix and scatter diagram. Scatter diagram is where we start bleeding into from the idea of exploring root causes to starting to test them. Scatter diagram is already starting to test the relationships based on doing an x-y analysis on a graph and saying, "Does it look like there's a relationship?" There we're on the border of formulating hypotheses and starting to test them when you're thinking of a scatter diagram.



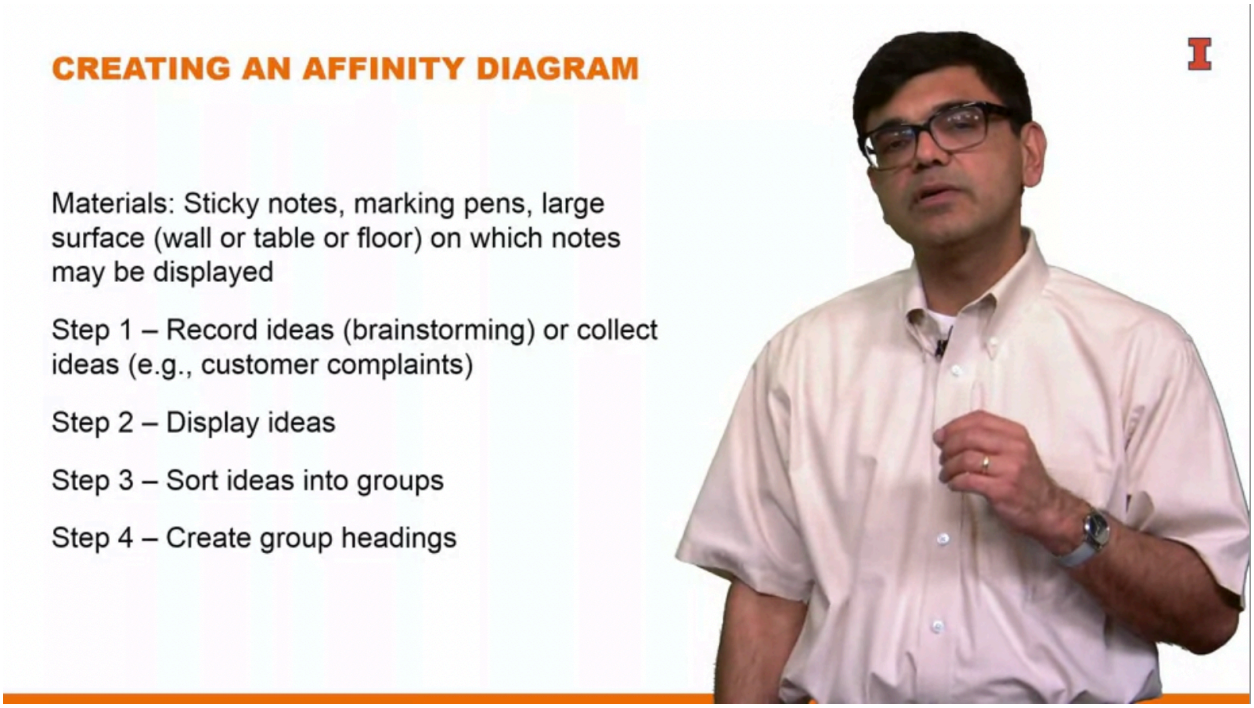
Let's take a look at the first technique here, and this you may be familiar with. You may have heard this term being thrown around quite a bit, brainstorming. This is what we do in teams in terms of, "Let's brainstorm to come up with a way of doing something." That's exactly the idea when you're using it for a process improvement project. What are you doing when you're brainstorming? You're getting people who may be from different levels of expertise, who may be from different areas of expertise into a room, and you are trying to get their ideas together. Now, the important thing when you're doing this in a commercial setting, is that when you do have people who have diverse views, there can be problems. There can be problems of somebody might be more dominant in terms of not letting others speak or there might be some people who don't speak up. In terms of trying to find a way of having an effective brainstorming session, you can structure the brainstorming session in many ways. You can have rules or you can have ways in which people can give their anonymous opinions or anonymous ideas before you start discussing them. You can have rules as to every person has to speak once and you take that down and then you open it up for everybody else. Or you can say there can be a way of giving your opinion, giving your assessment of the situation, giving your best judgment in terms of anonymous pieces of paper or on software in a survey and then using that in some way to collect the information. The idea being that you want to be able to get all the diverse points of view. You want to be able to get that idea that's way out there and somebody should not be afraid to give that idea that's way out there. When you're thinking of innovative ideas, sometimes we think about them as being laughable ideas and laughable ideas are to some extent good when you're talking about a brainstorming session. The idea of somebody simply coming up and saying, "What if we could do this?" This brings to example, a particular instance of

brainstorming in health care where somebody said, "How about if we have a drive-through flu clinic?" It was laughable idea at that time but it ultimately became a reality for hospitals to do drive-through clinics. Again, the idea of brainstorming is to get a free flow from ideas without there being any judgment of those ideas at that point in time but trying to get everybody to discuss those ideas.

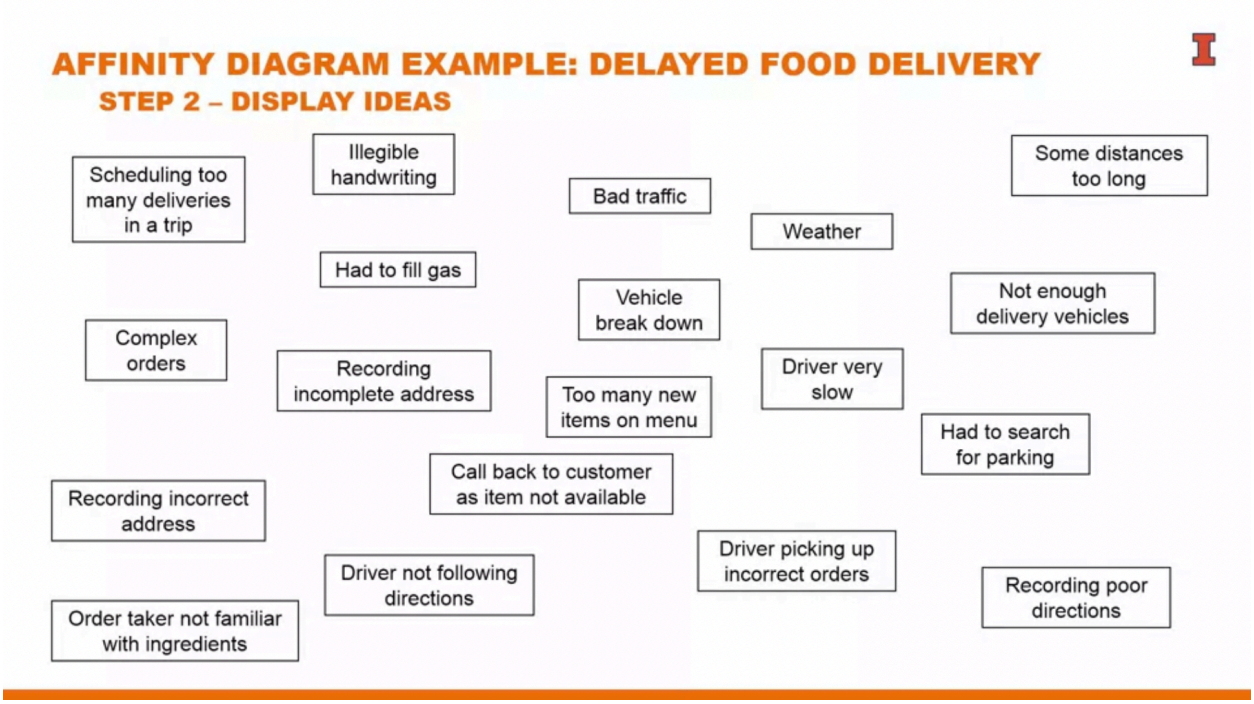


In the same way as brainstorming, there's the idea of affinity diagram. This is a little more systematic than an affinity diagram. Brainstorming can be made systematic based on an affinity diagram. It can also be based on another technique. It can be also be made systematic based on another technique called a nominal group technique. That's another technique that gets used in order to get people's ideas and get them together so that you can do something about them. But what is the affinity diagram? Affinity diagram is basically an idea of categorizing different reasons for a problem, so not only collecting the data but also categorizing it. Having people give their opinions, having people give their ideas, and then categorizing them into different categories, putting them in different clusters, putting them in different groups, so that they can be more manageable in terms of doing something about them. Now these could be ideas that are coming from people, or these could be a list of customer complaints. You could be taking those lists, that list of customer complaints and saying, these are really about our drivers who are delivering things to our customers. These are really about our food quality and what we're making in terms of our take-out service. These are really about the service level in terms of our order takers and how they are taking the order. You could take customer complaints of some number and start to categorize those and have people categorize those. Have people who know about these things categorize those.

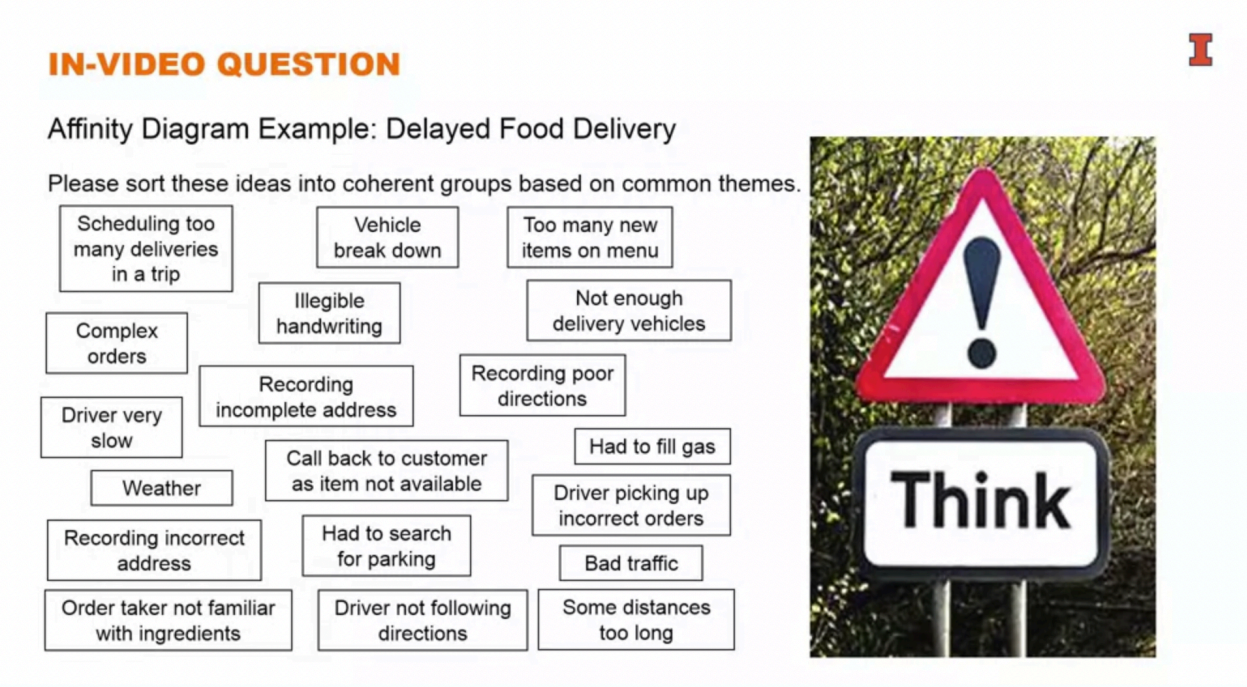
Now, for any of these kinds of people involved, categorization or data collection kinds of exercises, when you have people from the process, you are getting an additional benefit in terms of involving the people that are working in the process. You are also serving that purpose of getting buy-in from the very people who are going to be taking the changes that you might get from this project, from this initiative, and using them. That's also a bonus if you can call it that on top of you being able to speculate on root causes.



But let's move further into the affinity diagram and see how you would create one, get into the specifics of it. There are four steps that we talk about when we say come up with an affinity diagram. For these, you need materials like sticky notes. If I may use a brand we talk about Post-its and Post-its are what we use in order to collect people's ideas. So sticky notes, marking pens, you need a large surface like a table. If it's going to be a flat table or it can be a wall, or where you can put different Post-its and start to group them together. What I have done for these kinds of exercises usually is I use an easel board and the big chart paper that you get from the easel board. Those are the ones that you can actually paste on the wall. The advantage that you get from that is that you can take those with you and then codify them, put them into an Excel spreadsheet in terms of codifying them as data for future use. That's something that you can do. But what are the steps for an affinity diagram? You get the ideas from people or you collect complaints from people. You display the ideas so that people can see them. Then you start sorting them into groups and then you create group headings. How does this actually work in terms of a real example?



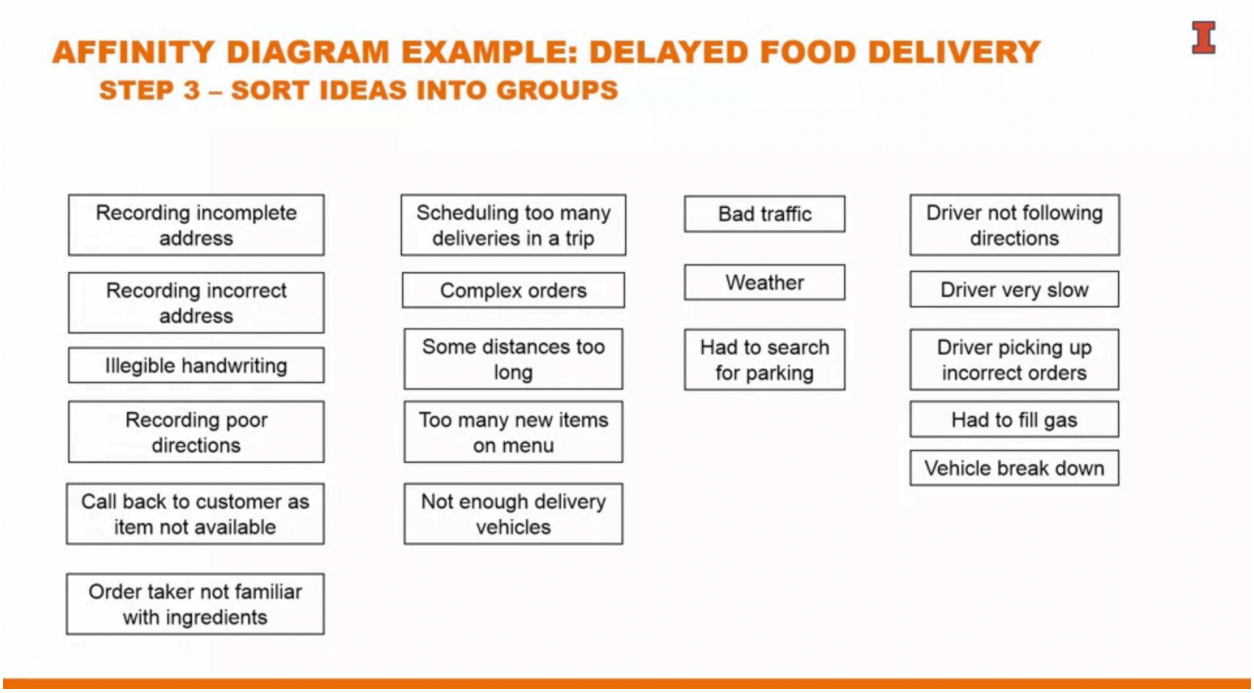
Here we have an example of delayed food delivery that I made up and here are different reasons for why that food delivery might be delayed. Your Y is, the outcome is the delayed food delivery. The X's maybe all of these different things or some kind of grouping of these different things. So this would be step 2 in terms of displaying the ideas. Step 1 would have been collecting the ideas and you didn't see that happening here. But step 2 is displaying the ideas on a wall or on a table. Now next, what I'd like you to do is take these very ideas that you see on this slide, and use them to categorize it.



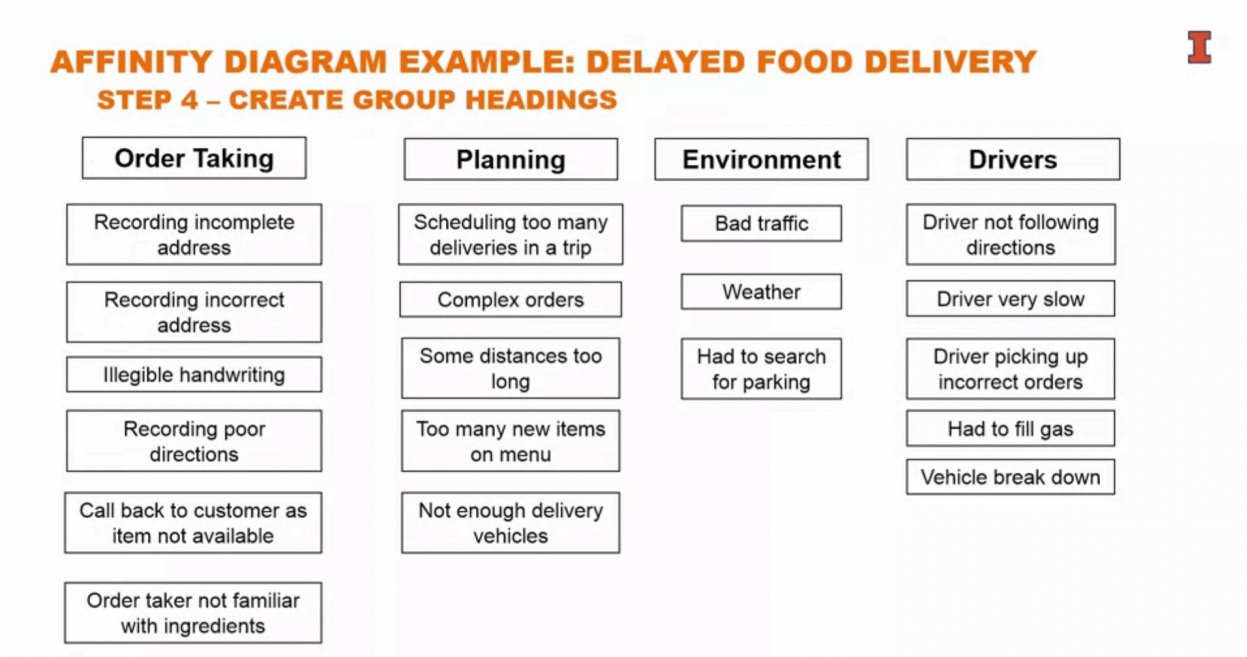
What I'd like you to do is think about categorization of these different reasons for delayed food delivery. Something that you should be able to relate to. Try to put them in categories. Think of 3,4,5 categories that you would put them in and see what you find and then I'll show you my categorization and we'll see how that matches up.

You had a chance to think about this and put those different reasons into different categories. What I did was I put them in four different teams. One team was order taking, one was planning the resources, one was factors affecting drive, the

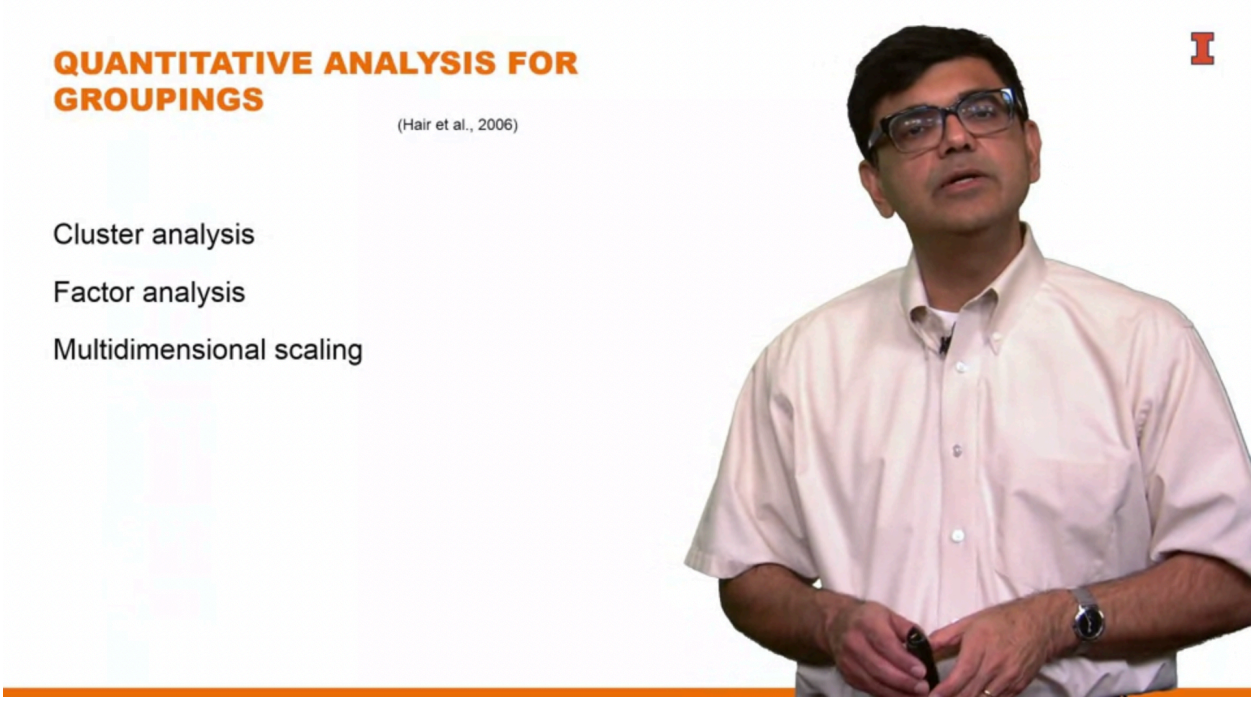
environmental conditions affecting the drive, and one was driver capabilities. Those are the four areas in which I clustered the different reasons that you saw on the previous slide.



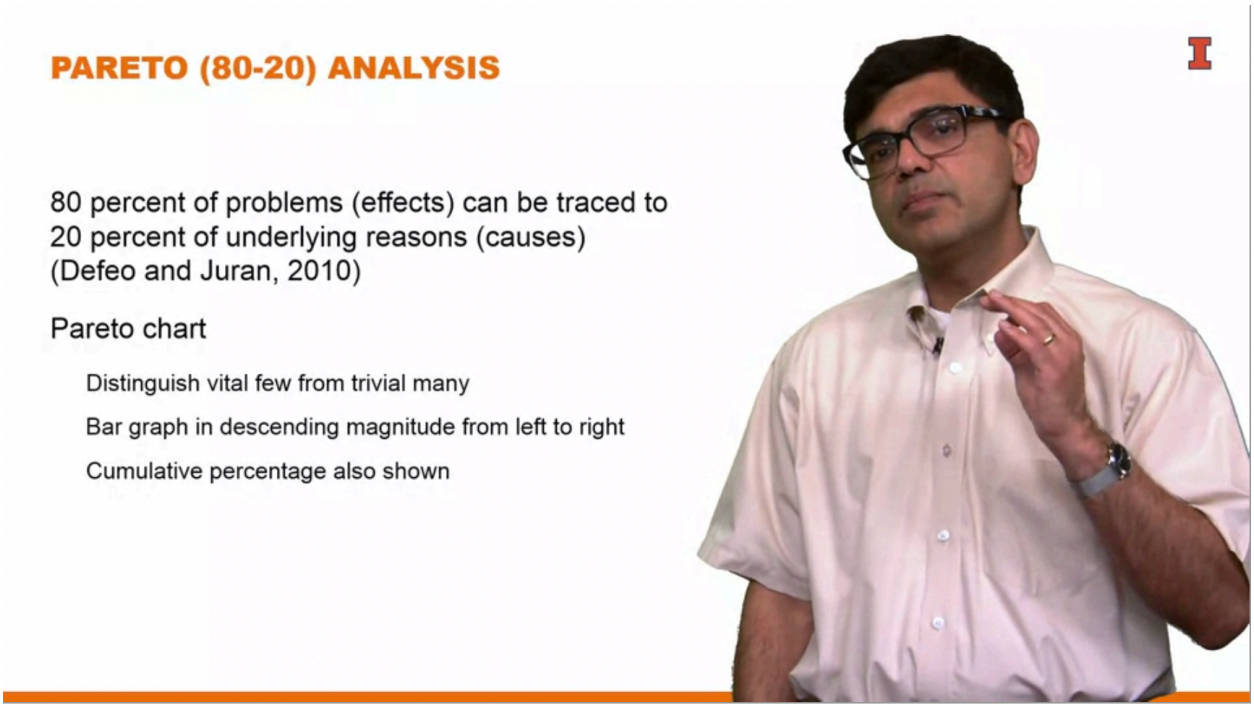
Let's take a look at how I clustered them. Here are the four categorizations, the groups that I have formed. Then I gave them those four names that you saw earlier. You might recognize those four names simply by looking at this but here are the four names.



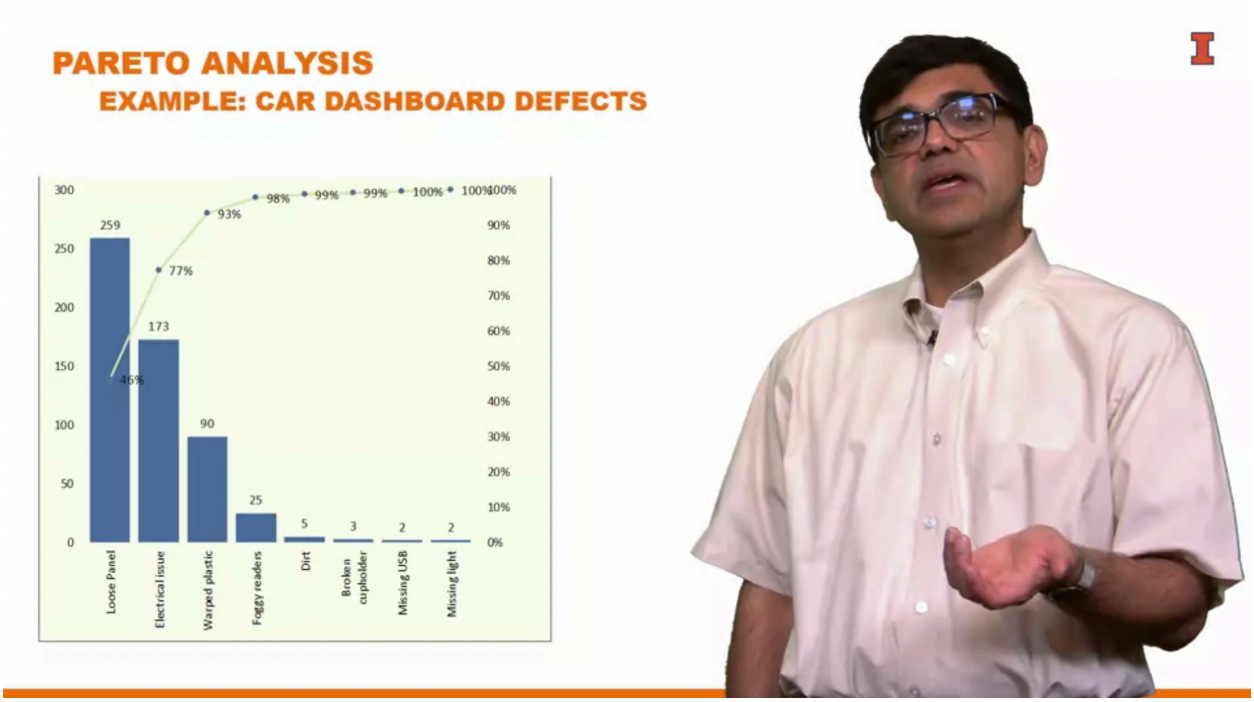
The order taking was made up of the six reasons. Then you had planning made up of five reasons. You had environment made up of three and drivers made up of- A couple of points of caution when you're trying to do something like this. You are obviously going to or you are probably going to have some disagreements on what goes where. You may have some disagreements of what to call what category, and there may also be this temptation of creating a miscellaneous category where you put things that don't fit anywhere else. Similarly, there might also be the temptation of taking something and putting it in two categories. The last one is not that bad, I guess if you had to take something and put it in two categories, it's saying that there might be two ways of thinking about that particular cause for the effect that you're getting, so that might not entirely be a bad thing. These would be the four group headings that I would have used if I was doing this. Like I said, you may not have gotten the same, so there's no right answer here, but this is how you would start using the affinity diagram.



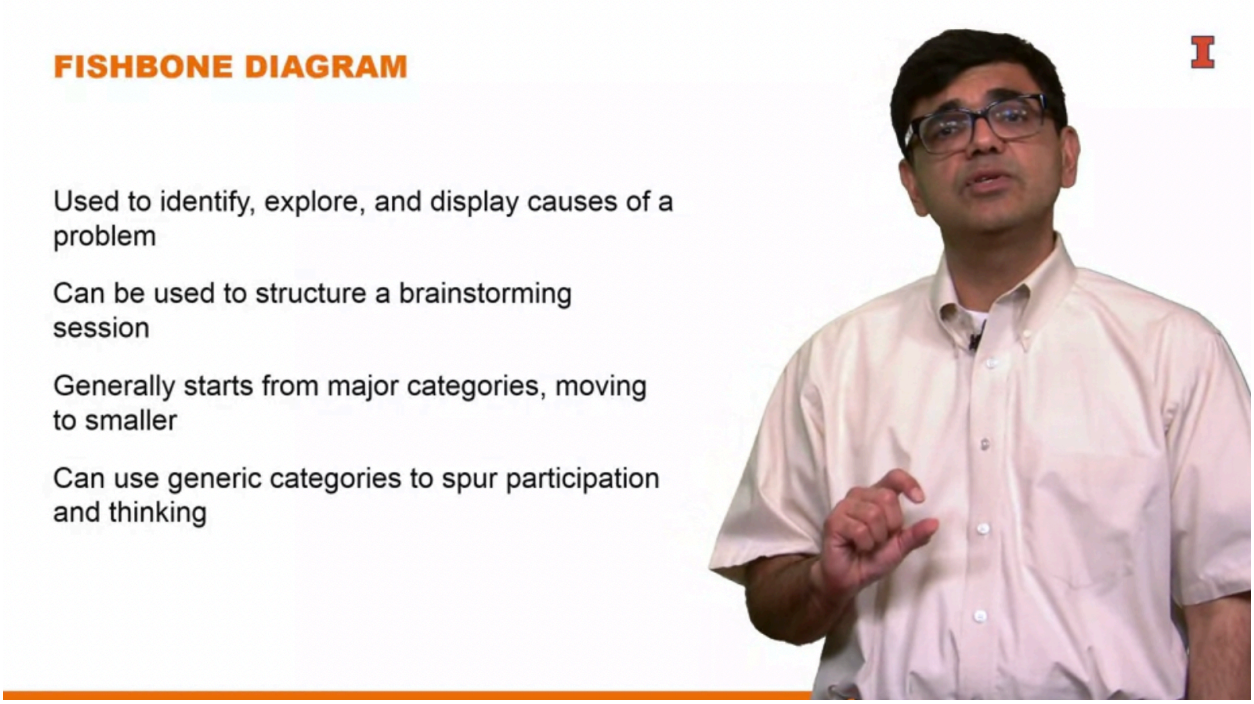
Let's take a look at some other techniques that can be used for something similar, and these are quantitative techniques. The quantitative techniques that I point out here are cluster analysis; which is a way of taking data and trying to put it in groups based on similarities, based on different variables that might be assessed for that particular product or process that you're looking at. That's cluster analysis. Factor analysis is another quantitative technique, another statistics based technique. Then multidimensional scaling, which is used very commonly in marketing circles to figure out customer segments, and what are the different aspects of a particular product that customers like? If we can segment customers based on similarities or things that they prefer from a particular product. All the winners and all the qualifiers or the Kano characteristics that customers might prefer from a particular product. Those you can cluster them together on the basis of this technique of multidimensional scaling.



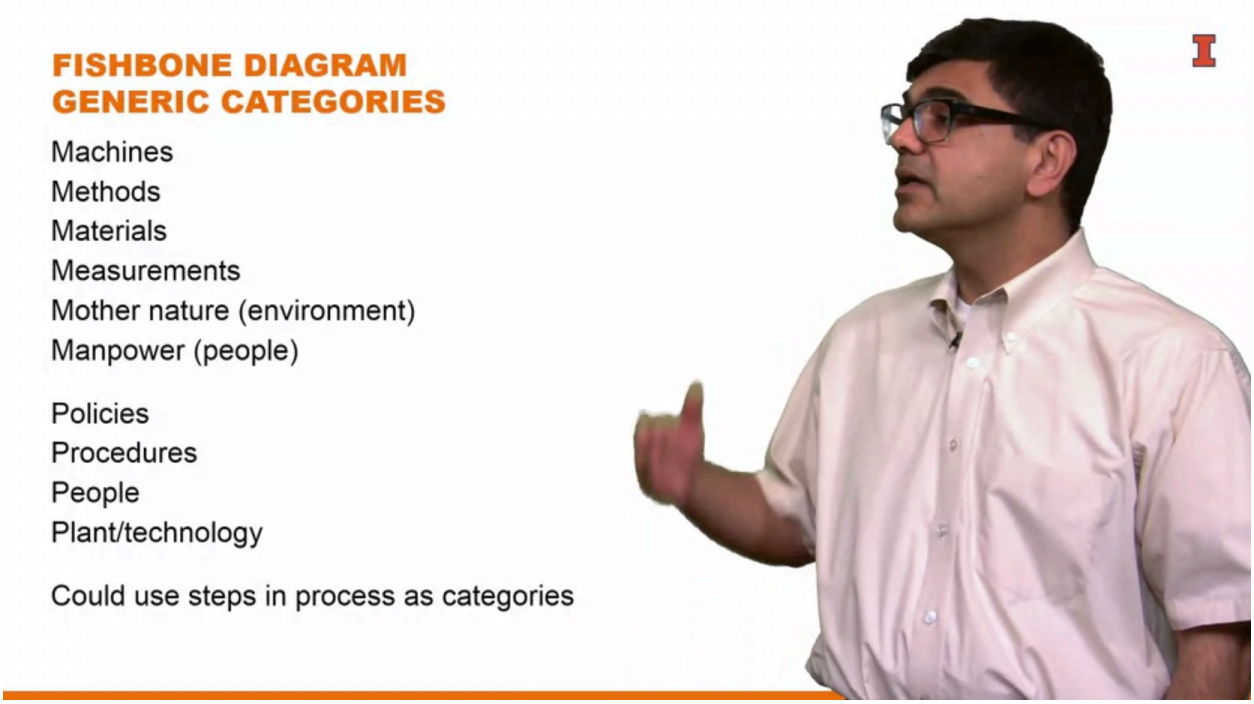
Moving on to a different technique here, this is called the Pareto analysis. The Pareto analysis is something that get used in many different contexts, it's what is popularly known as the 80-20 rule. You may have heard of this as the 80-20 rule. The origins of this interestingly came from an Italian philosopher who simply made the observation that the 80 percent of the wealth was owned by 20 percent of the people. That 20 percent of the wealthiest people owned 80 percent of the wealth. That's where the 80-20 rule came from, and nowadays it's used in many different contexts. We think about it in terms of inventory and how we should be thinking about important inventory that we should be focusing on. Here you see an application of it that was popularized by Juran, the idea that 80 percent of problems can be traced to 20 percent causes. That's why we should be focusing on those 20 percent causes, on those trivial, on those vital few that are causing most of the effects. You shouldn't be worrying about the trivial ones, there may be the many trivial that you can actually ignore or not pay that much attention to in terms of causing the defect. What does the Pareto analysis look like? How is it done?



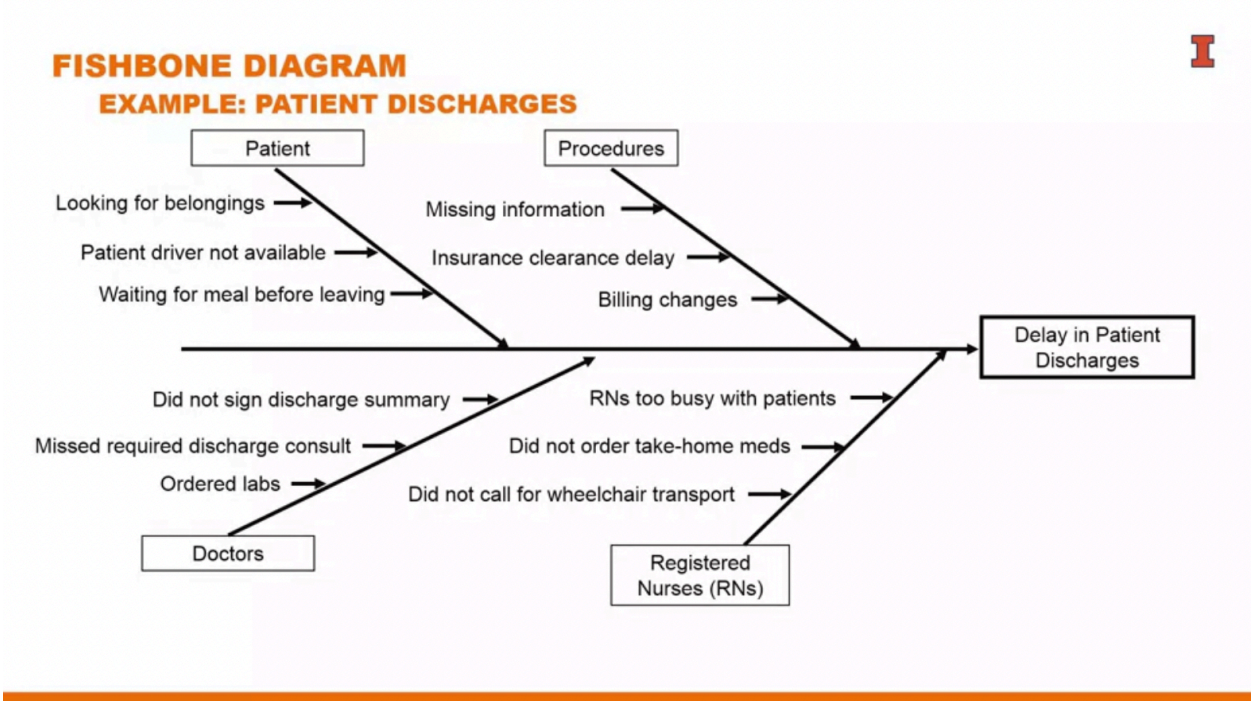
You basically take the frequencies of different things, and you go with the frequency going from left to right, highest frequency to lowest frequency. What you have here in this chart is an example of defects that were found on a car dashboard. Again, data that I made up but it's simply giving you an example of saying that there is a high number of defects that came from loose panels, which is the first area, and those account for a high percentage. If you combine the first and the second, that gets you to that 77 percent number. If you take care of those two types of defects, what you're getting is 77 percent of the problems are being taken care of if you take care of those kinds of defects. Then you can move on and you see that there are many trivial ones. You can see the hundreds getting all clustered together up there because it's not even making a tiny difference to the cumulative percentage. Just to describe what you see in this Pareto chart, you have the bars that are describing the actual number of defects in each category, and then you have this line that's going from left to right which is the cumulative percentage. You're starting with 44 percent, you're getting to 77, you're going on and on until you get to 99 and then it stays at 100 percent, so it's basically 99.98. 99.99, so it's staying at 100 percent as you're going on and on from there. That's the idea of a pareto chart. How do you use this? Well, it's telling you where you should be focusing your attention first, and then maybe you can prioritize based on these what you should be focusing on.



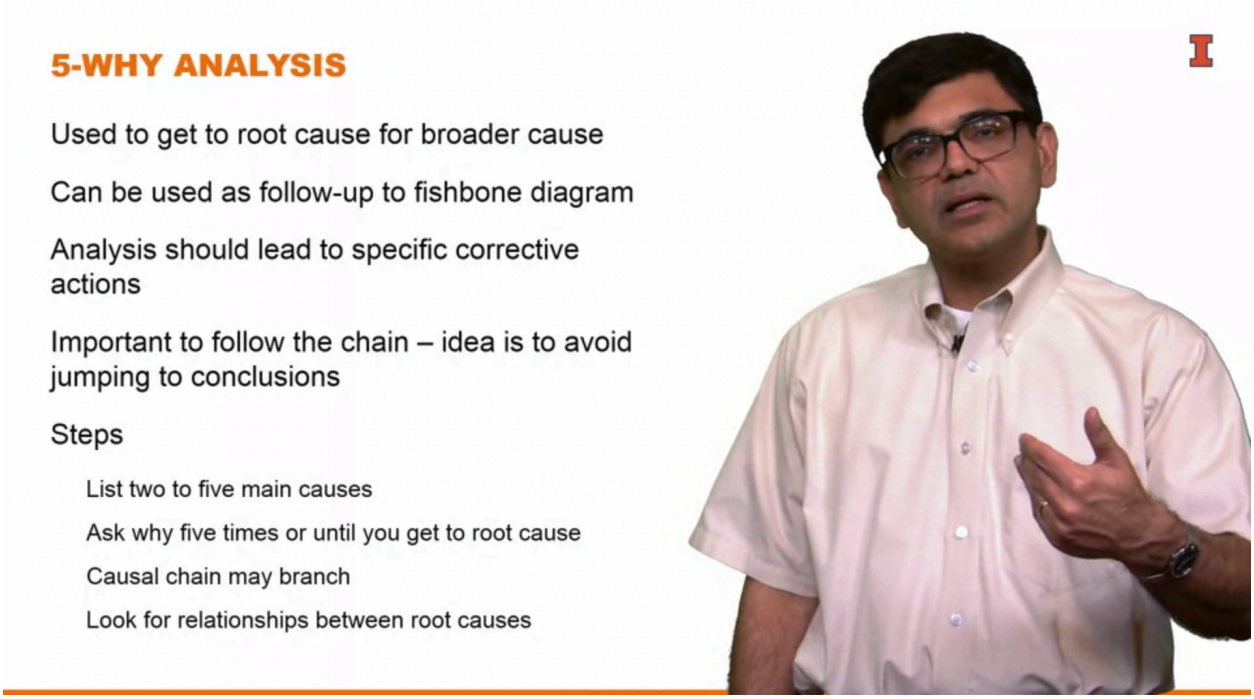
Next is the idea of a fishbone diagram. In some ways, this is very closely related to the idea of an affinity diagram. How is it related? Well, in an affinity diagram, what you're doing is you're taking many ideas and you are trying to group them into small groups. In the case of the fishbone diagram, what you're doing is you're taking a big idea and you're trying to break it down into smaller ones in some way. You start with an effect and you start looking at the causes. The reason it's called a fishbone diagram is it's shaped like a fishbone. You start on one end with the main effect, and you start looking at the main causes, and then you divide it up among the different sub-causes, the sub-bones, so to speak of that. Again, it can be done in both directions, I said you can start from the bigger ones and break it down into smaller causes, or you can go the opposite direction. You can say, we started off with the smaller ones, we started grouping them into these particular areas. Similar to an affinity diagram, this can be done using sticky notes, getting ideas from people, and starting to group them in some way. What you can use in terms of spurring some conversation, or if people are not talking in that fishbone diagram exercise when they're all together in a room, you can use some generic categories. The problem with generic categories is then people try to force things into those categories. If you can use generic categories without forcing the team to have certain things in those categories, these categories can be helpful in terms of thinking about where the problems might be coming from or thinking about areas that we should be considering. Here are some generic categories.



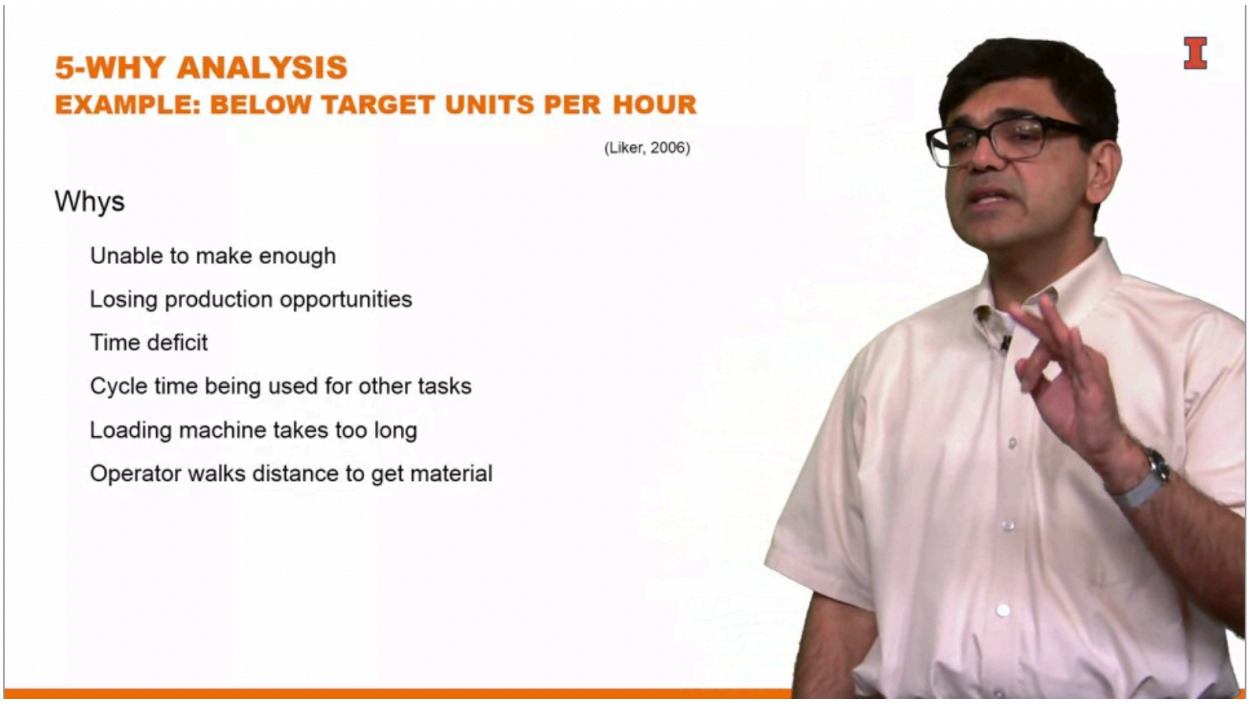
In marketing, we popularly talk about the four Ps of marketing. Here we have the six Ms if we can call them that of process improvement of the fishbone diagram. You have machines, methods, materials, measurements, and because we wanted to force this into Ms, we're calling environment, mother nature, and because we wanted to force it into Ms, we are being politically incorrect and calling people as manpower. These are the six Ms that could be generic categories that you could be thinking about when you're trying to get people to think about fishbone diagram categories. The other one that you can have is policies, procedures, people, plant, and technology. If you're thinking more from a service perspective, these might be more applicable. In the service industry when we do a fishbone diagram, these are more readily applicable if you're thinking of generic categories. Finally, what you can do is you can think about each of the steps in the process as categories. Here's a defect here's an effect, and I want to think about the causes, you can have each of the steps in the process as being the main bones and then you can start thinking about the different sub-bones in there.



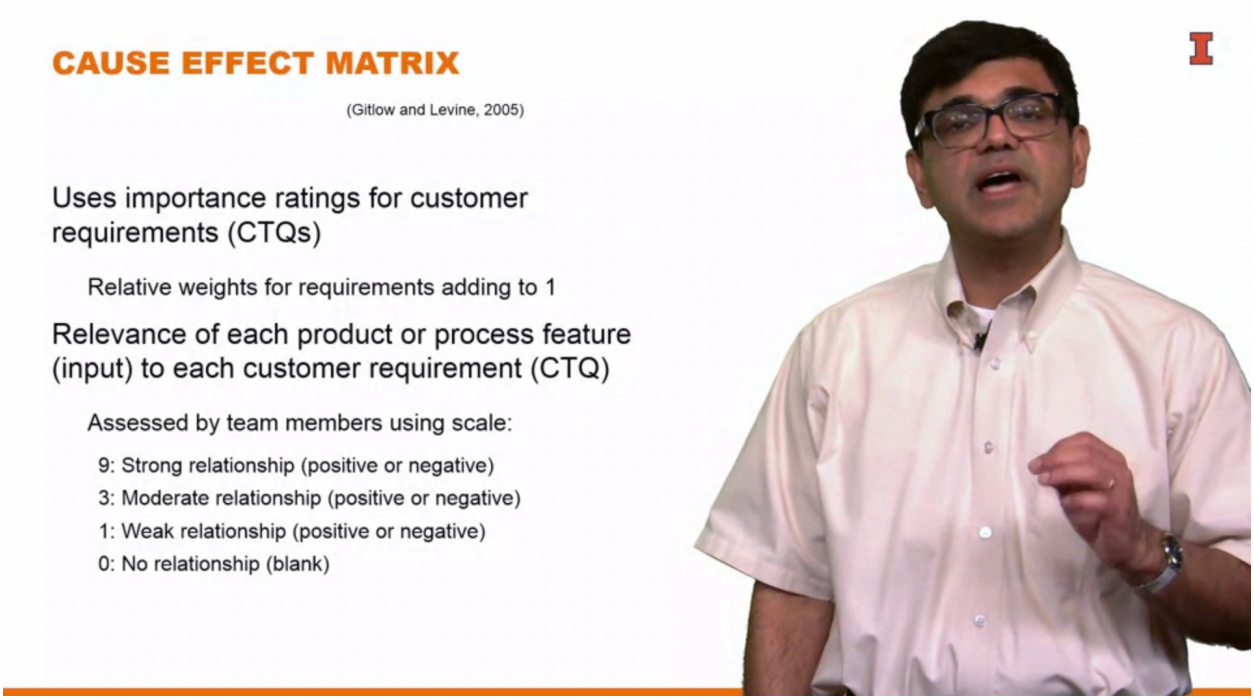
Here's a made-up example of a technique, so a fishbone diagram that I put together for delay inpatient discharges. Here I'm using an example from health care. There's a delay in inpatient discharges that they're thinking about, why does this happen? There are four different big reasons. It could be the patient not being ready in some way, so you have three sub reasons there. Procedures, you could have missing information, insurance could be causing some delays, there might be some changes in billing toward the end. On the bottom half of this, you have doctors and registered nurses. It's something that they did with the procedure or did not do with the procedure for that to take place, that's why there was a delay. That's why the patient had to wait in order to get discharged. This would be how you would be thinking about a fishbone diagram. Next, let's take a look at a related technique that you can take from the fishbone diagram and go even deeper, and that's the idea of the 5-Why Analysis.



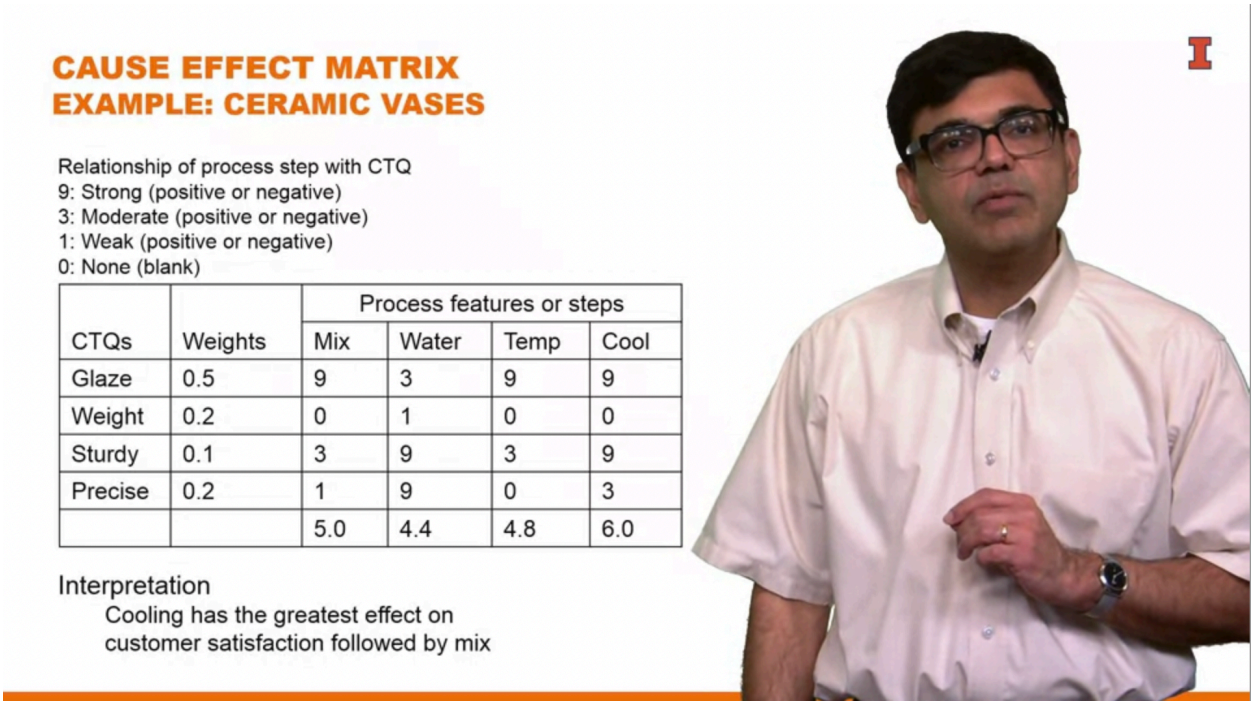
The 5-Why Analysis, the one that I referred to as being that toddler, that four or five-year-old who keeps on asking the question, why? It's the same idea when you're thinking about it for process improvement. You can start off with the causes that you find from the fishbone diagram. You can use this as a follow-up to the fishbone diagram and start asking the question why. The important thing about using the 5-Why Analysis, and this is very popular with Toyota. They use this all the time when they're thinking about root cause analysis, when they're thinking about systematic going after root cause analysis. The point that is emphasized when you think about Toyota using the 5-Why Analysis, and these points are from Jeff Liker's book, The Toyota Way. The point that Toyota emphasizes is that we should follow the chain. We shouldn't be jumping to conclusions, that we should be slow in going towards the root cause and not jumping to conclusions. It's not only that you want to get to the root cause, but you want to make sure that you don't miss any cause that you might not have thought about. What Jeff Liker also talks about Toyota as doing with the 5-Why Analysis is branching off from within the 5-Why Analysis. Toyota thinks about this as there may be a causal chain of reasons that may branch off and go into different branches off multiple 5-Whys that you might be thinking about. Those are the things that you might want to think about when you use a 5-Why Analysis to systematically get to the root causes, to think about root causes that might be giving you the problems or maybe giving you opportunities for improvement.



Here's an example of a 5-Why Analysis. Now, this is not made up. This is from Jeff Liker's book. It's an example of the below target production from a particular assembly line, from a particular task. If it is falling below target all the time, it means that they're not able to make enough. Why are they not able to make enough? Because they were losing production opportunities. Why were they losing production opportunities? Because there was a deficit within the cycle time. Why was the cycle time not enough? Why was there a deficit? Because the cycle time was used for other tasks. Why was the cycle time used for other tasks? Because loading machine was taking too long. Why was loading machines taking too long? Because the operator was walking a long distance. What does this get to? This gets to an actionable item, something that can be done in order to take care of this problem of below target units per hour. Like I said earlier, this could branch off into multiple reasonings. This might be one way of taking care of this particular problem, but there might be other ways that are branched off from any of the previous whys that you may have looked at and you may be thinking about going more in-depth into why those things are happening. Next, let's take a look at another technique called the cause effect matrix.

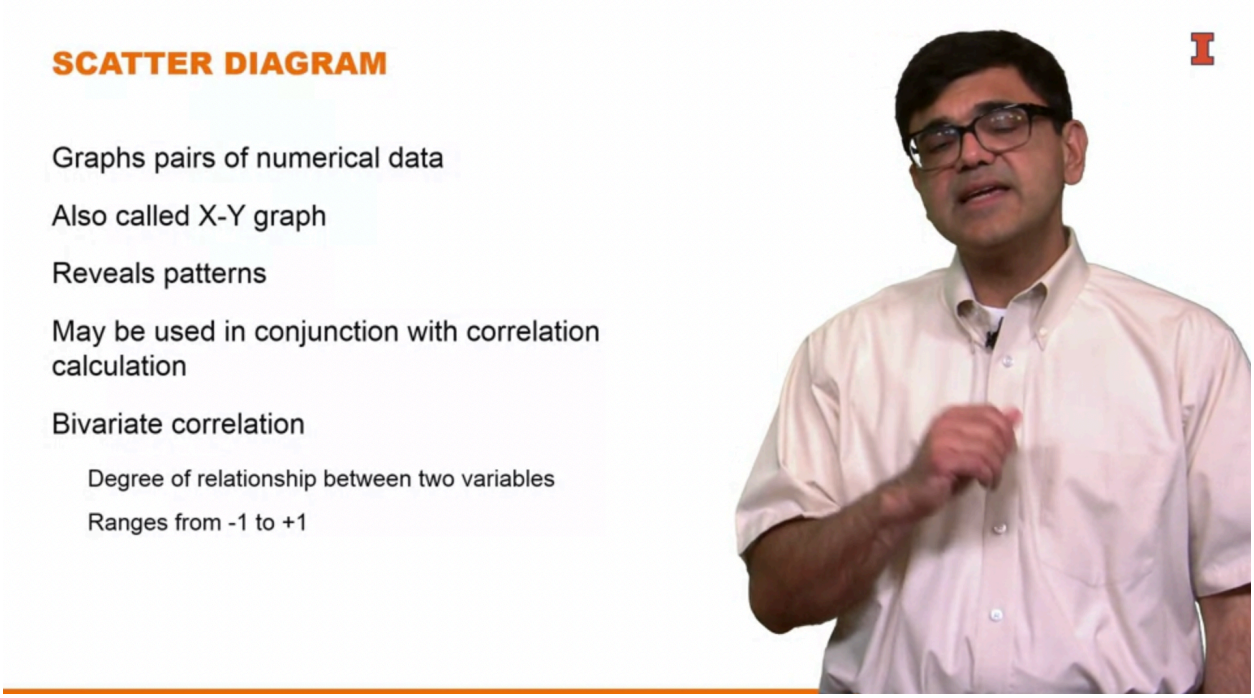


Now you looked at the fishbone diagram as a way of looking at one effect and the many causes. The cause effect matrix gives you a matrix of many different effects and then looking at the causes simultaneously and thinking about it in that way. It's used to get some sense of what may be the different things that customers care about, and then go back to the idea of how do things that we do in the process affect what customers care about. You start off with getting critical to quality characteristics from customers, and you get weights for those critical to quality characteristics. Those weights add up to 1. This may sound familiar to you. We use something like this for project selection. It's something similar to that. The idea here is you get weights from customers for our critical to quality characteristics, and then you try to co-relate things that you're doing in the process. You try to find a relationship or you try to get information from people who know about the process, about the relationship between different things that are being done in the process with the different critical to quality characteristics. I think this can be best seen with an example so let's take a look at an example here.

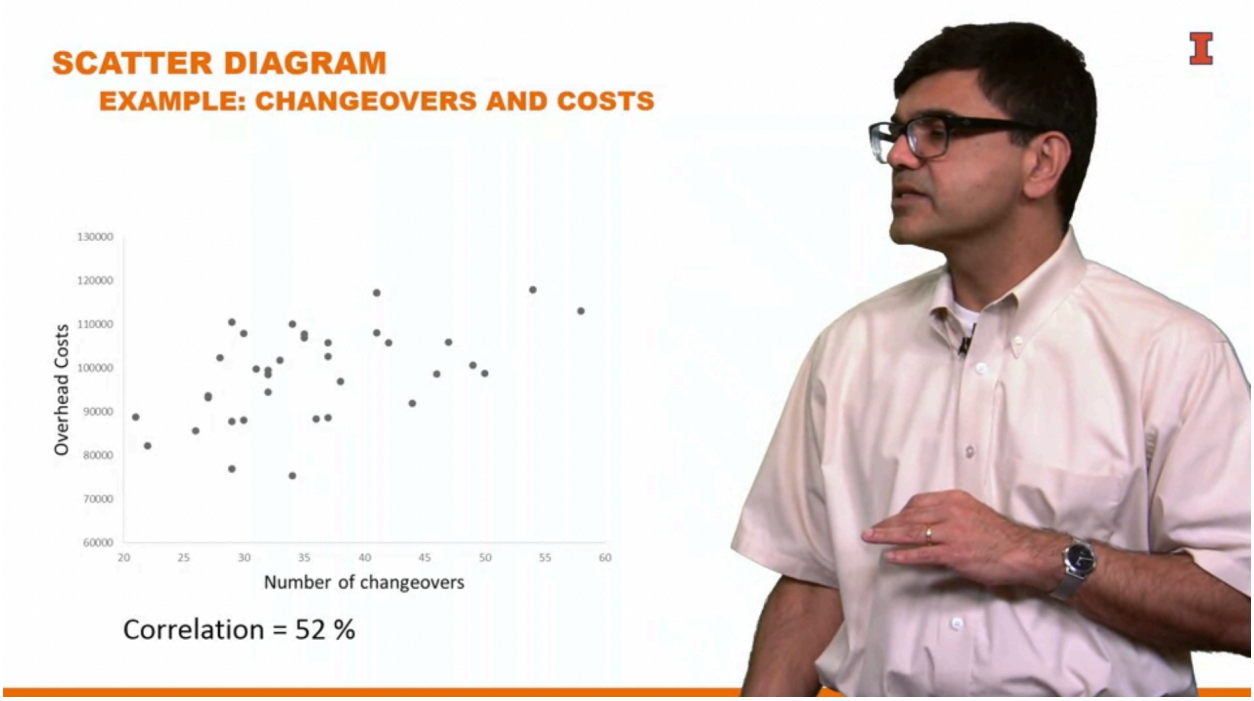


Here's a cause effect matrix for ceramic vases. What are our customers caring about in ceramic vases? They are caring about glaze, weight, whether it's sturdy or not, and whether it's precisely made. Those are the things that customers care about. You see the weights, those would have come from some kind of customer analysis, and those weights add up to 1, so we have 0.5, 0.21, and 0.2. Those weights adding up to one tell us what is relatively more important for the customer, and here you can clearly see that for the customer, the glaze is much more important for the customer. That's what they care about when they're looking at ceramic vases. They are the different features of the process that are on the top row and they're talking about what mix to be used in order to make those ceramic vases? What are the different kinds of materials that we've put in? How much water has been put in? What is the temperature at which the kernel was when these were fired? Then how was the cooling done? Whether it was rapid cooling, whether it was slow cooling, whether it was natural cooling, how was it done? Those are based on people who know about this process, experts on this process, we have a rating going from 0-9. Here's the key for that rating. Zero, meaning no relationship, to nine meaning a strong relationship between what we're doing. That can be a positive or a negative relationship when you're thinking about what is being done in the process, what are the different inputs to the process in terms of the mix of things and things like that and how is that affecting each of those critical to quality characteristics. Whether it's affecting it at a nine, which is a strong relationship, or whether it's a zero with no relationship, or it's a three, with some relationship. What you can do with this is, you can come up with a total weighted average for each of those features or each of those things that you're doing in the process and what this is telling us is that cooling has the highest effect on customer satisfaction. A cooling has an effect on glaze, cooling has an

effect on sturdiness. Glaze happens to be very important, so 9 times 0.5 gives you 4.5 and then 9 times 0.1 gives you 0.9. So 4.5 plus 0.9 plus 3 times 0.2 gives you 0.6. That adds up to six. That becomes the most important thing to focus on when you want to get more customer satisfaction. Cooling would be the first thing that you should be paying attention to based on this cause effect matrix.



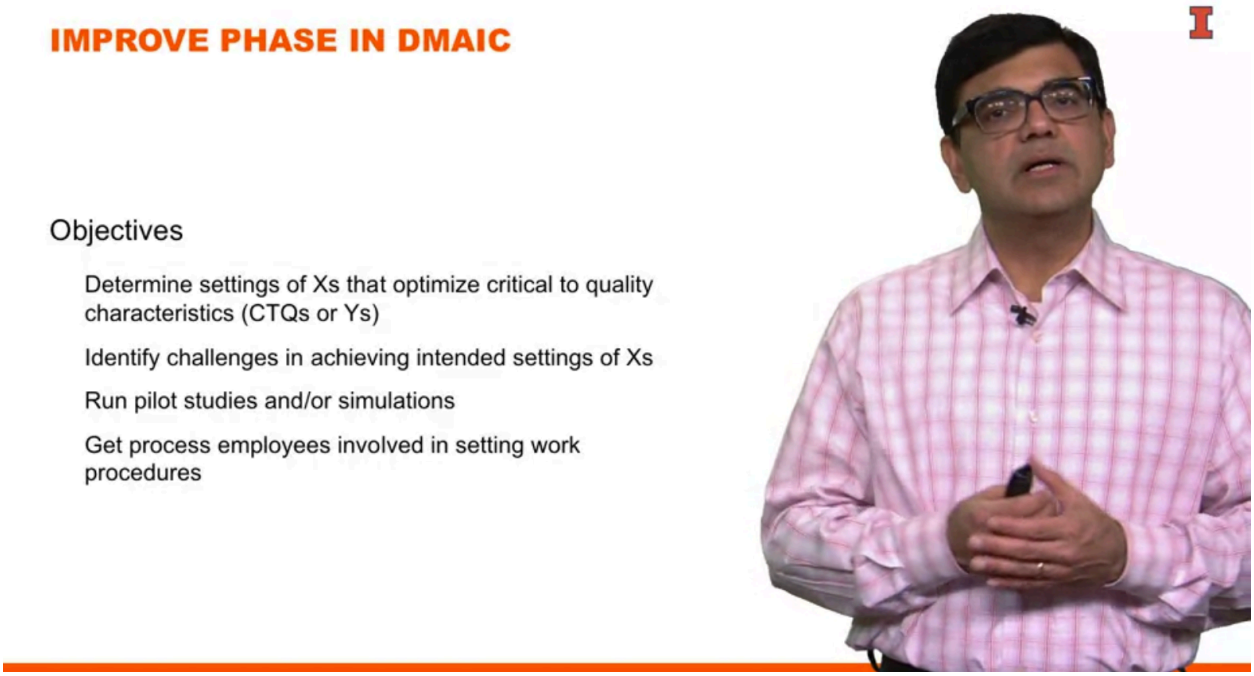
Let's take a look at this technique, which is the last technique that we'll talk about in terms of speculating about what might be the relationship. As I said earlier, the scatter diagram is bordering on the idea of you're formulating hypothesis, but you're also starting to test the hypothesis. What is a scatter diagram? It's a basic X-Y kind of a chart. It has one aspect on the X and one aspect on the y. We usually like to think about Y as being the outcome and X as being the input for that outcome. Y as being the dependent variable and X as being the independent variable. But when you're doing a bivariate analysis, it doesn't really matter where you put it, what you're trying to look for or what you're looking for from a scatter diagram is, is there any relationship when we put this on an X-Y chart, doesn't reveal any pattern when we put something on an X-Y chart. Now, you can get the same information from simply looking at a bivariate correlation, or you can get at least some of the similar information. From a scatter diagram, you'll be looking at all different patterns from a bivariate correlation. You can look at the relationship between two variables from a correlation perspective, going from minus one to positive one, whether it's when one increases the other goes down, or whether it's when one increases, the other also increases.



Let's take a look an example here to see what a scatter diagram looks like. Here you see the number of changeovers and then you see the overhead costs and what do you see from here? You can see some pattern here. As the number of changeovers goes higher, the overhead costs are getting higher and higher. Now it's not going to be perfect, but there's some pattern here in terms of the relationship between them. The advantage of the scatter diagram is it can show you a linear relationship, it can show a nonlinear relationship, it can show you an inverse U relationship, U relationship or any other kind of an S curve relationship simply by looking at the picture of the X-Y kind of a graph, simple graph over here. Finally, you can also talk about this from a correlation perspective that there's a 52 percent correlation between number of changeovers and overhead costs. These are all the techniques that you can use in order to hypothesize about cause effect relationship.

Lesson 4-2: Techniques

Module 4.2.1: Improve Phase in DMAIC

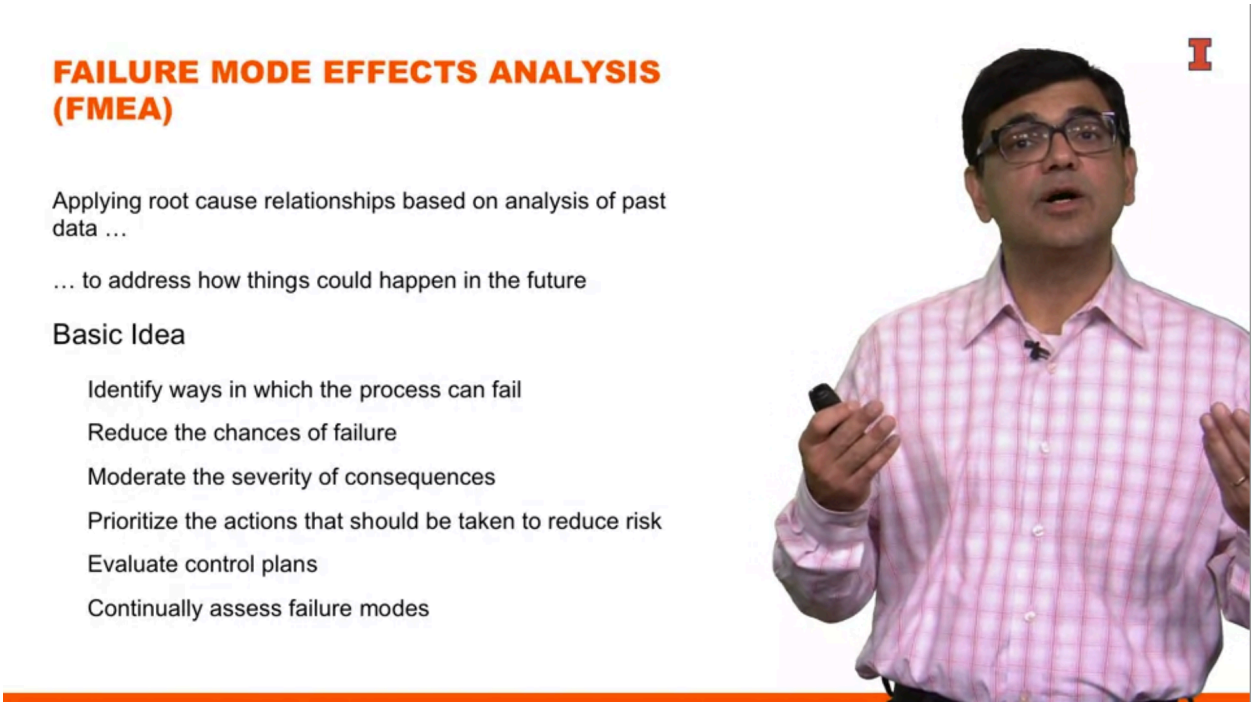


In this session you're going to look at some techniques that are mainly used in the improve phase of a Six Sigma project, or if you're thinking about a lean project, you're mainly using these kinds of techniques when you have figured out some changes, some improvements to processes, and now you are trying to put them in place. You are trying to institute them in the organization. You're trying to institute them in the process. If you're thinking about the improved phase in DMAIC, if you're doing a structured Six Sigma project, a DMAIC Six Sigma project, then what are the objectives of the improved phase? The objectives are, you figured out the Y equals function of X relationships. Now you are determining the settings of the Xs, the settings of the causes, the settings of the steps in the process that will give you good results of Y. You're trying to optimize the process based on putting in place those settings of Xs. Then what you're trying to do is that, you may have some resistance from people or you may have some challenges in trying to implement those changes. Even other than resistance of people, there might be issues in terms of trying to take two different processes and trying to optimize them. Then you are having some tension between them. You're trying to take care of those challenges and trying to figure out a way out of those challenges, whether it's resistance from people or whether it's sub-optimizing one process when you're trying to improve another. In the improve phase, what you do is you run pilot studies and simulations. As you'll see when we talk about pilot studies in detail later, the idea is not only to get a sense of what would happen if you try a certain change, but also to get buy-in from

people based on doing pilot studies and simulations. Getting those people who are doubtful about the results of the change, getting them to be enthusiastic about that change. That's one thing that gets achieved by doing pilot studies and simulations. Then you definitely want to get enthusiasm of people in whatever way you can in terms of getting them enthusiastic about implementing the new standard operating procedures. What will happen at the end of the improved phase is you'll come up with new ways of doing work on a day-to-day basis. That's something that the people who are working on the process need to adopt, need to buy into, need to believe in if they're going to do that on a day-to-day basis. Remember that the Six Sigma project or the project team, if you're talking about a lean project, are going to come up with improvements and then they are going to be leaving to do their other tasks. The team is going to get disbanded once the improvement project is over. Therefore, it becomes very important for this last step, for the idea of handing off the changes to the process owner so that they can put those changes in place and make sure that the changes stay in place, which is the idea of the next phase, the control phase of domain.

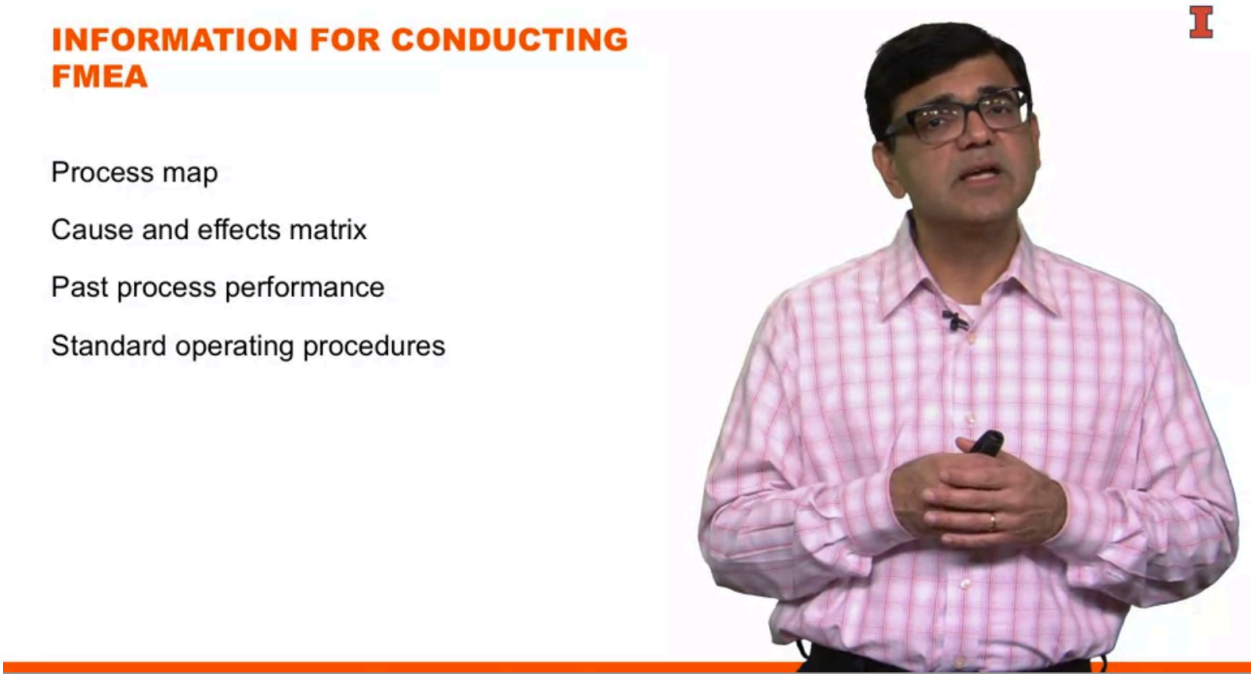
If you think about lean or Six Sigma, both of those process improvement initiatives have a few techniques that are commonly used for this kind of thing, for putting in place these changes. Some of these techniques that we'll look at in this session are FMEA, simulation, pilot cells, standard work, and visual workplace. Now, standard work and visual workplace, you might remember from us talking about the DNA of the Toyota production system are very important aspects of lean, of the Toyota Production System. Putting them in places, it becomes very important especially if you're talking about a lean implementation.

Module 4.2.2: Failure Mode and Effect Analysis (FMEA)



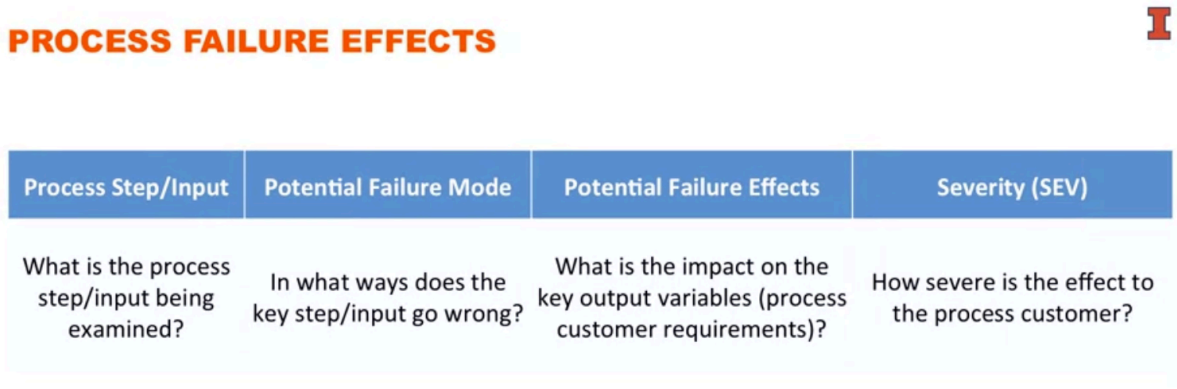
All right, so let's take a look at the FMEA, Failure Mode Effect Analysis. What is the idea here? The main idea of FMEA is that you've done in the analyze phase, you've done the task of figuring out the relationships between Ys and Xs. So you figured out the root cause relationships between Ys and Xs and what you're doing with the FMEA is that how to take those relationships and translate them in the future. So in a sense The root cause analysis was based on models that were checked based on past data. So you modeled past performance of the process and you figured out Y equals function of X relationships, cause effect relationships. And now you want to take those relationships and and take them into the future and say if I want to implement this change in the X, how difficult is it going to be? And if I do implement this change in the X, if I do implement this change in the process, what kind of results can I expect in terms of the outcomes for this process? So you're trying to control the Xs to have an impact on the Y and Y is something that you simply measure. That's something that is a critical to quality characteristic for the customer and X is something that you can actually do something about. It's the input to the process. It's part of creating that critical to quality characteristic for the customer. So that's what you want to focus on and that's what the FMEA technique helps you do. So what's the basic idea? You identify ways in which the process can fail. You're basically figuring out failure modes you're saying where can this process fail? Where are the critical places where this process can fail and you're giving these things scores. So you'll see there will be a scoring mechanism. There be an objective scoring mechanism that will be using as part of the FMEA. You want to reduce the chances of failure ad and if you can reduce the chances of failure by putting in place some aspects into the process, some checks and balances in place in the process, then that's something you'll be thinking about as part of the FMEA. You want to moderate the severity of consequences. So in cases where there will be failure, you'll be measuring as part of the FMEA the chances of failure and in case that there will be failure, what do you want to do? You want to make sure that the result of that failure is minimized on the

customer, on the process customers. So that x even if it fails, you want to make sure that it does not have a very severe impact on the critical to quality characteristic for the customer. And then you want to say what what are the things that we need to do? What are the things that we need to do in order for these things to happen in order to prevent the consequences from being very severe or if we can make it even better to prevent these errors from happening in the first place? So you will think of ways of making those improvements and and just as we talk about and continuous improvement, everything is an iterative process. You'll have control plans in place but you'll be continually evaluating this control plans to see how well is this working. And then you'll continually go back and try to make improvements to the control plans in order to ultimately have a better control mechanism in place for the inputs that are having an impact on the output. So the basic idea becomes how can we continually improve how we're controlling the excess that have big impacts on the Ys? So that's the basic idea of the FMEA.

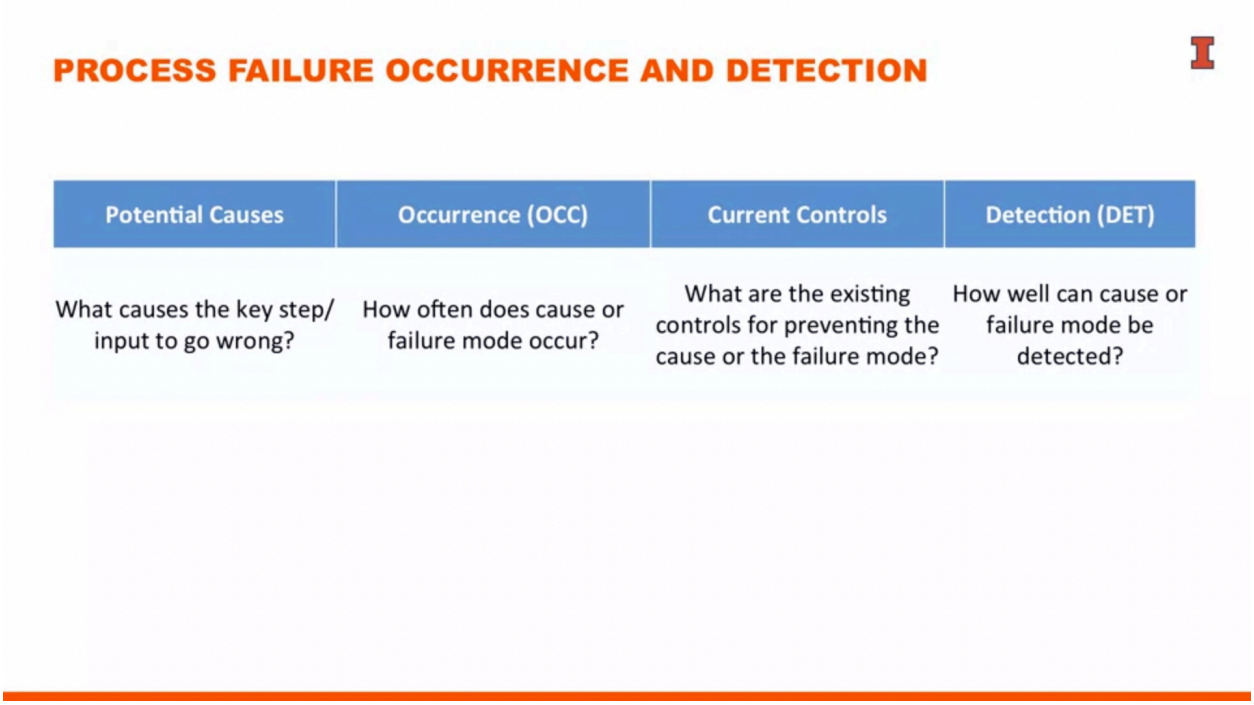


How do you start doing in FMEA? What is the information that you would collect if you were doing an FMEA? The information that you would collect would be a process map. So you would start with the basic process map. It could be a value stream map, it could be a flow chart, you could be using and then you would also have a cause effects matrix. So you're going from figuring out the process steps to looking at a cause effects matrix. That is saying, what are the process steps that have impacts on critical to quality characteristics? So you may remember the cause and effect matrix as as looking at multiple objectives for the customer and then multiple causes that are having impact on those objectives for the customers. So it's a matrix that tells you what are the excess that are that you should be prioritizing on. So this gives you an idea for FMEA as to what you should be prioritizing on. You have some sense of past performance, historical performance data of the process. So you know how well the previous control plans have worked and then you're trying to improve on the standard operating procedures. So you will have the previous standard operating procedure that is being used currently and that's in place. So you'll have that as well as the starting point for your FMEA as you will take all these

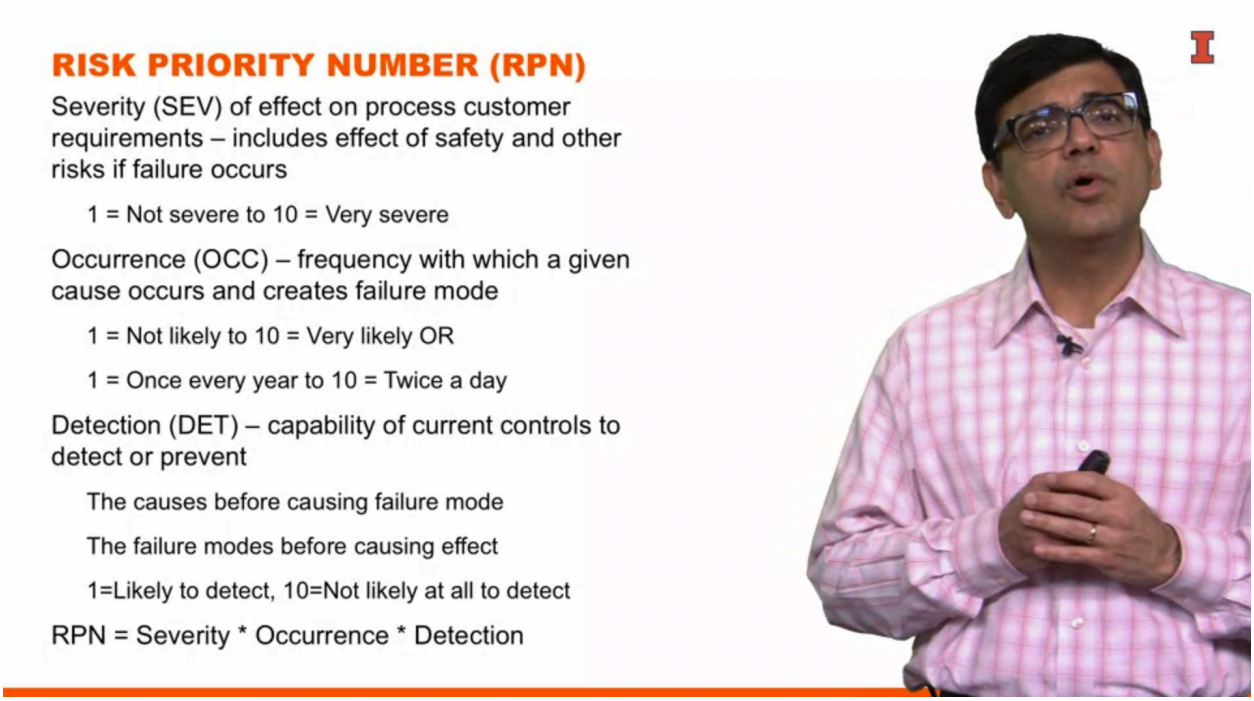
things and start looking at how well these things are working and what is it that you can do in order to improve this aspect of the process?



So what would you be doing next is like we said earlier, you're going to try to make things objective for an FMEA. How do we make things objective? The first step is you figure out what is the step that we are examining and in what ways can this step go wrong? The first objective number that you will get is how severe is the effect going to be on the process customers? So if something does go wrong in this process, in this X that we are measuring in this process step that we're looking at if something does go wrong, how severe is the impact to the process customer? And later on we'll look at the example of a specific skill that you can use. Basically you're saying one through 10 if the task, if the mistake is going to have a huge impact on whatever customers are going to get from this, then it's going to get a number of attempts to, the severity number would be 10. And if it's not going to be a very big impact, it would be a number of 1. So you can use a scale of 1 to 10 which is typical for when you do an FMEA. So severity is the first objective number that you're going to get in terms of doing the FMEA, in terms of doing the failure mode effect analysis.



And the next number that you're going to look for is if something does go wrong, how often does it happen? So when things do go wrong, how often does that happen? And this could be simply a frequency number. It could be a number that says it happens once every 10 years, and it happens once every day or once every hour. And that's the sense you're getting about the occurrence of this kind of problem from your process. And finally you want to assess the detection procedures that are in place. So what what are the current controls and how good are they at either preventing the problem from happening or if the problem does happen, how good are they are detecting? So we use a common number here. We could use a common indicator here for looking at how good is the detection as part of the process in terms of either preventing the problem from happening or if the problem does happen, how quickly does it get detected? How easily does it get detected? How quickly does it emerge?



So let's take a look at the scales that you can use for coming up with with a number that will use as part of the failure mode effect analysis. So this number, as you can see here is called the risk priority number. And the risk priority number is made up of the three indicators that we've just seen. So the severity, the occurrence and the detection. The three indicators that that we just saw as being part of the FMEA. So the severity could be a scale of 1 being, it's not going to have a very severe impact on, critical to quality characteristics for the customer to 10 being, it's going to have a very severe impact. Occurrence could be looked at in two different ways that this is not very likely to occur, so would be a low score and 10 being, it's very likely to occur or it happens very often. So the second way of thinking about it is it happens very often to it doesn't, it happens very rarely. So here you see the example of a scale which says 1 equals once every year to 10 equals twice a day if it's happening very frequently and and these skills would be based on the context, whatever the context is and how often these problems occur. That's how you'd be thinking about constructing these scales. And finally, the third part of the scale is detection where we're talking about, how easy is it for the problem to be detected if it has happened or how easy can be, is it for you to catch it even before the, the failure happens? So you would get a sense of if it's an easy detection, it's a low score, if it's a tough detection, it's a high score. So what you can see with these three objective numbers is 10 is bad versus 1 is very good. That's how you want to keep the direction of the scales, It has to be in the same way because ultimately you're going to use in multiplication Index based on these three things. Three things being severity occurrence and detection.

BEFORE AND AFTER RPN

RPN	Actions	Responsibility	Actions Taken	SEV	OCC	DET	RPN
	For reducing the severity and occurrence of the cause or improving detection	For the recommended action	And when?				

So how is this useful when you're trying to make improvements to how the process is being currently implemented? So the way this gets used in a practical sense is that you assess the the RPN the risk priority number for the Xs that are important. And then what you do is you come up with an improvement plan and saying here's the RPN that we have, it's it's 3 times 10 times 3. So it's 30 times 3, which is 90. Can we make this better? So can we make improvements to this? So you come up with an action plan that says these are the things that we're going to do in order to make an improvement to the risk of any failure of this X which has an impact on Y? So you come up with a plan and you say whose responsibility is this plan going to be? Who is going to make these changes? When are these changes going to be made by? So always when you make plans in continuous improvement you're thinking of making them specific in terms of responsibilities and dates in terms of who's going to do them. So once you have that plan in place what you can do is that you can continually assess the risk priority number. So here what you see is there's a before RPN and after RPN and the idea being that you should get better at the RPN. Your RPN numbers should get smaller and smaller as you are getting better at the detection of the error if it happens or reducing the occurrence of how frequently it happens or if it does happen the severity of the impact on the customer is being reduced. So those three aspects are being reduced from the actions that you're taking.

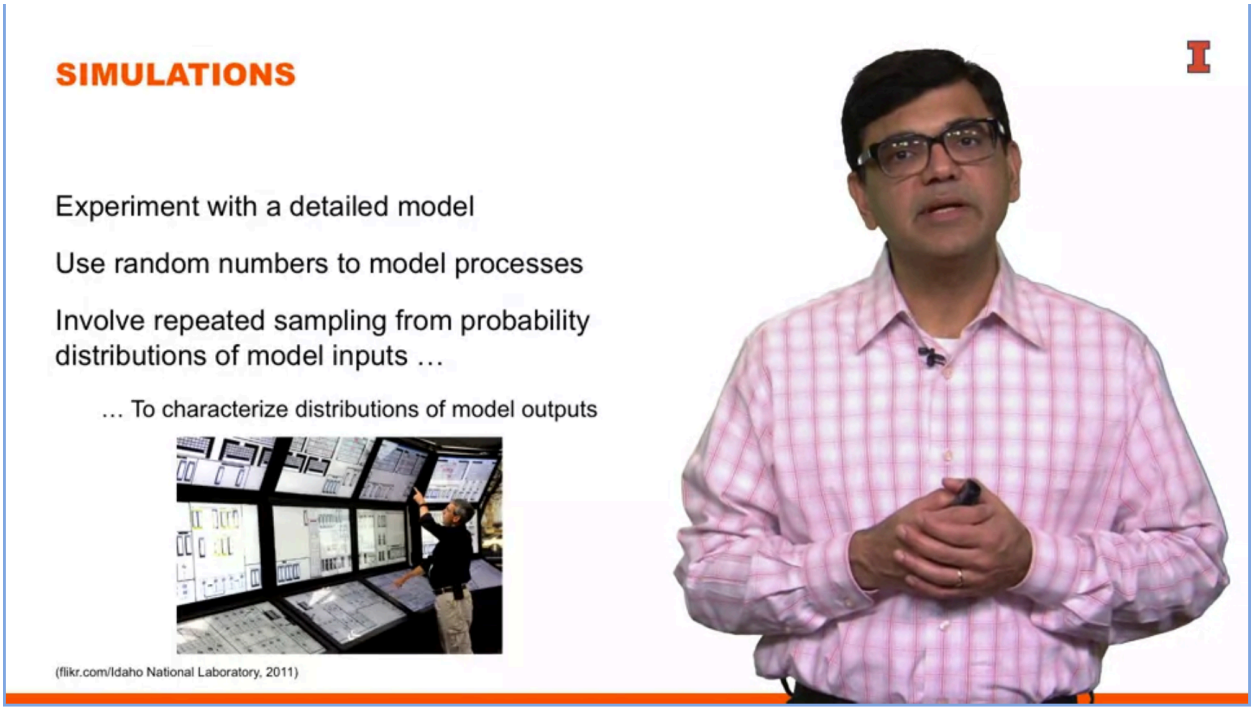
FMEA EXAMPLE
MEDICINE LABELS

Failure Modes	Causes	Effects	SEV	OCC	DET	RPN	Actions
Error in label	Error in order entry	Wrong dose, wrong route	3	3	3	27	Improved entry process, error detection
Label not printed	Printer or computer failure	Missed dose, disrupted treatment	3	3	1	9	Printer and computer testing and maintenance

Let's take a look at a specific example here of a situation where you would use an FMEA. So here's an example of labels on medicines, labels on bottles of medicines or labels on packets of medicines. And the editors that you're seeing over here are there's an error in the label which is the first failure mode. And the second failure mode you're seeing are is that that the label is not printed. So those are two failure modes that are being studied In this particular FMEA. Let's take the first one. The error in label could be caused by an error in order entry. The effect is that the patient gets a wrong dose or gets an intra muscular dose when it's supposed to be an IV and and that's going to be an issue. So that's the problem that can occur. So then you have the numbers given on there. So I'm not an expert in medicine and and I made up these numbers so I may not be accurate in terms of the severity number of such an error but I just put in there as the severity being 3, the occurrence of it being 3and the detection being 3. So they're not very bad in terms of a scale of 1 to 10 and the product of it becomes 27. So what you can see on the right most column is what are the actions in terms of trying to make this better trying to get this to be at a lower level than 27. And that's the idea of this going forward. Now what you can also do with this particular example is that you may be able to use this based on the value that you're getting from this FMEA. You may be able to Use this technique which simply just two parts of this multiplicative number, the multiplicative RPN. You might just be looking at severity and occurrence and focusing on that and and looking at how you're trying to improve that and detection is something that you might not have or it might not be worth it for you to calculate. So depending on the context, you could change this technique to using it as just simply severity and occurrence and and looking at a multiplicative index of that. The second example is label not printed, and this can happen if the printer is not working or if the computer has failed or the connection between the printer and the computer has failed. So those might be the reasons for the label not getting printed. The effect of it would be that the patient has a missed dose or the treatment is disrupted in some way and and of course the the effects of it are that the patient is staying sick longer. If it's if It's a pain control medication, they're not getting adequate pain

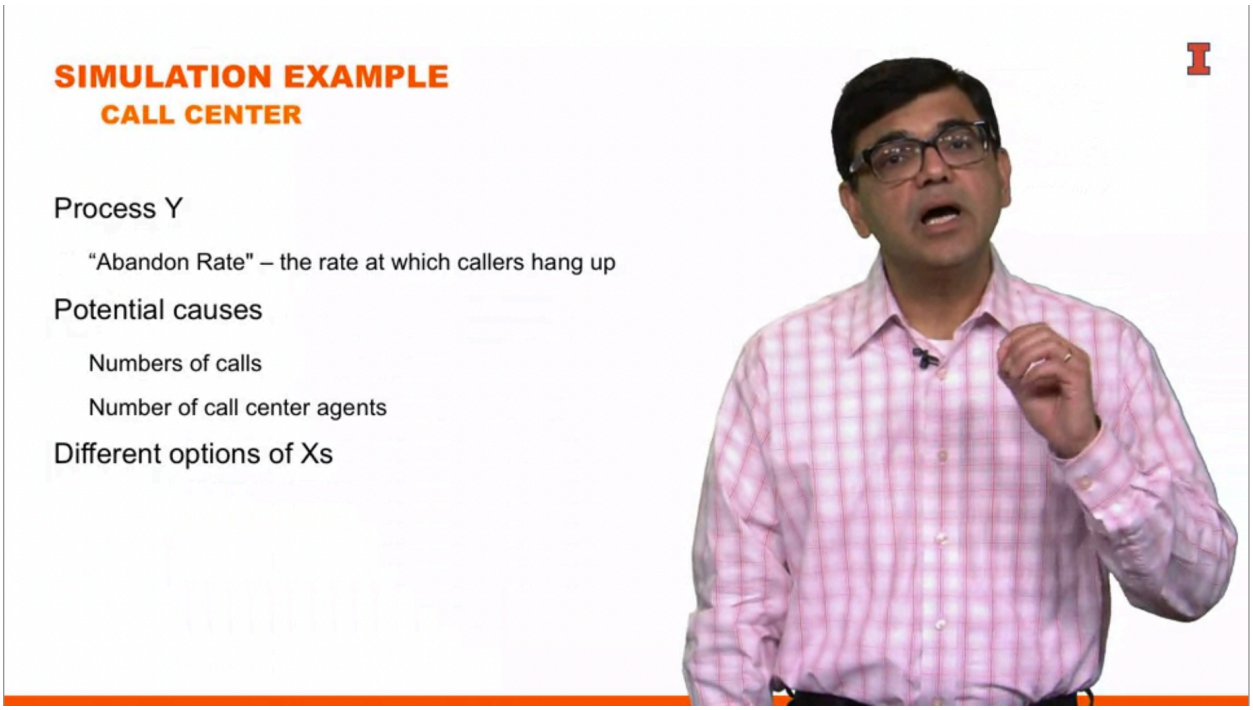
control. So the severity is 3 here, the occurrence is 3, and here I put the detection as being very quick that if it's not printed, you would know that pretty quickly. So The RPN works to be a 9. So here you get a sense of the comparative RPNs of different failure modes. That's one way in which you can think about using an FMEA. And the other way in which you can think about using an FMEA is of course using at the before and after. So after these actions are put in place, what happens to the RPN? And if these actions are as they are intended, they're making an improvement to the steps in the process, then the RPN should be trending downwards, it should be going downwards.

Module 4.2.3: Simulations and Pilot Cells



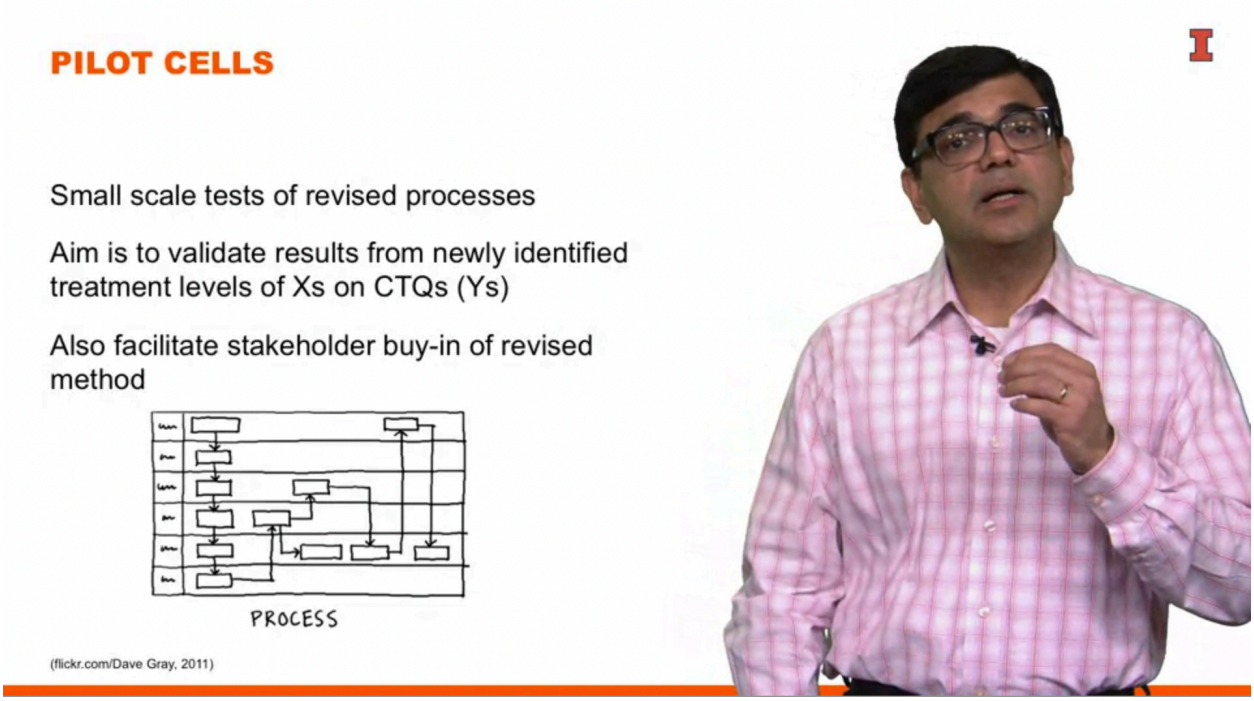
When you think of simulations, the first thing that comes to mind are flight simulators, typically. You think of flight simulators as somewhere where you sit in a box and it simulates a flight and you're learning to fly a plane based on the conditions being replicated. The same idea is used when you're thinking about process simulations. The idea of process simulations is that you want to experiment with the changes that you want to make in a process. You want to change some settings in the process and see what impact it would have. When you are trying to think of using simulation, first of all, there's going to be a lot of software that's going to be available for you to run the simulation. The user interfaces have become really good with the different software where you can take a simple process map. It looks like a simple process map with condition boxes and boxes for actions and things like that. You can put in different probabilities of things happening and you can put in different distributions into the simulation and then let it run and give you the results and it can replicate a long period of time by running very quickly at very high speed. You can run the simulation for thousands of iterations, tens of thousands of iterations to see what would be an impact and what would be the average time taken for something? What would be the average number of times it might run out of something? What would be the average wait time for a customer? Those are the things that you could use a simulation to look at. They're going to be many software that you can use for doing that. What is important for you to think about when you're thinking about process improvement and using simulation for that. What's important for you to think about is how are you going to set up the simulation? What are the different factors that you want to include in the simulation? Now, this is where you have to strike a balance. It shouldn't be a very complex simulation you want. You don't want it to be so complex that you have no idea how to make a change based on what the simulation is telling you. You don't want it to be that complex either. At the same time, you want it to be realistic. You want some of the things that might interact with each other to be in that simulation because you want to be able to see the impact of all those different things from

making a change in the process so you want to include those. You'll have to balance out complexity and it being not very realistic. Those are the things that you would have to balance out when you're setting up the simulation. When you do set up a simulation, you want to validate the simulation. What that means is you run the simulation and you take real data, and you take simulated data. If you give it to an expert who knows about that process, they simply should not be able to tell the difference between those two. They should not be able to recognize the simulated data from the data that you have that is real data. If you do have real data on that particular process and you've built a simulation for that particular process, they should not be able to tell the difference. That's the best way of validating whether your simulation is going to be a valid simulation in the sense that you are going to be able to see the impact of things that you're trying to change. Then you run the simulation using some software, you should be able to interpret the results. That's nowadays, like I said, it's become very easy to run the simulation once you have the flowchart in place of all the steps that you are taking through the simulation. Then you'll look at the results and you say if I change a particular variable in this process from it being two workers to three workers. From it being one cashier in the grocery store to being two cashiers in the grocery store, or if I change the rules that we have for the lines in the grocery store for it being a single line versus multiple lines, what is the impact that I'm going to see? You should be able to see that with the results of the simulation. That gives you an idea of what are the outcomes that will change if you make a change to some Xs in that process.



Just to give you a quick example of a simulation here, you can have a simulation that's a call center and a Y variable that you might be looking at is, what are the number of customers that go away without getting their call taken or their problem resolved, then you could define it either way. You might be looking at the different causes of it. It might be the number of calls. There might be a distribution of the number of calls that you have from data in the past, or you could

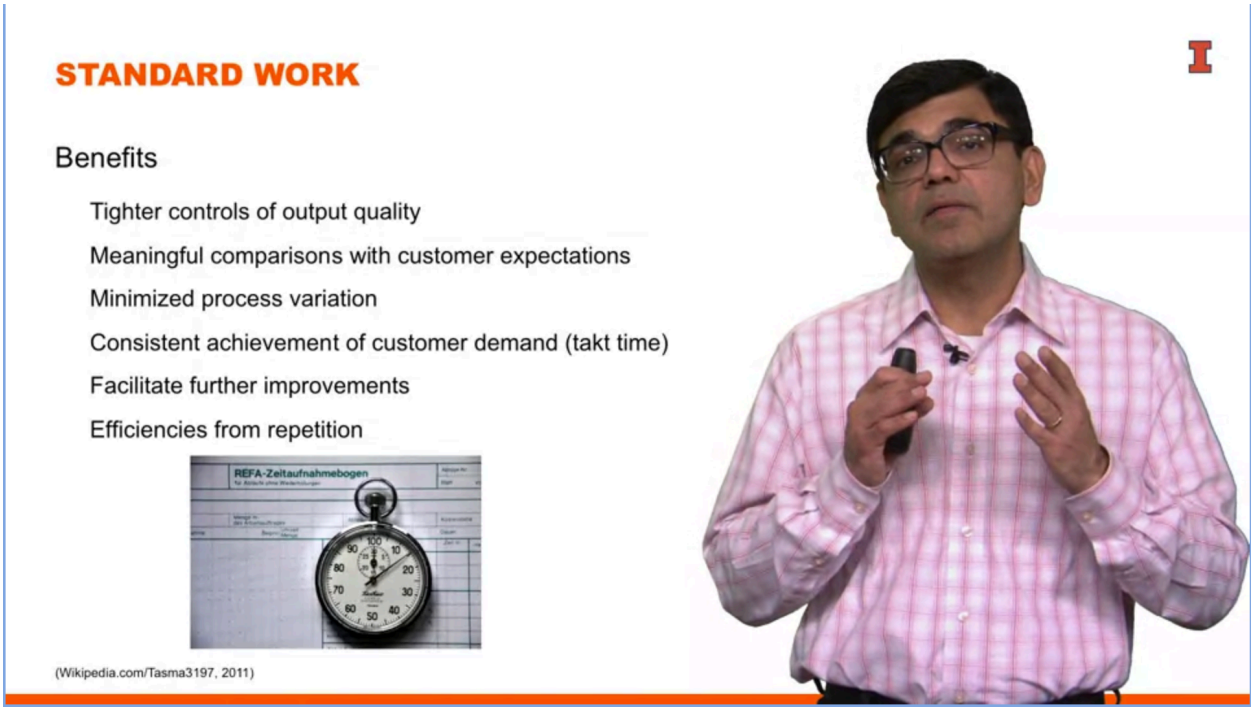
be using any kind of a standard distribution for it. If you had the mean and the standard deviation, you want be using that in order to run your simulation. You would have the number of call center agents in order to look at what is the impact of this on the abandon rate. Then you can manipulate these different Xs. You can have different call center agents. You can have different ways of having customers wait when they are placed on hold so that the abandon rate gets better. That's what you're trying to achieve, is you're trying to get a lower rate of abandonment. What are the different things that you can do in order for that abandonment rate to get better? That's the idea of a simulation.



Next, let's take a look at another technique called pilot cells. When you think about implementation of a change, the best way to get buy-in for that change is to demonstrate it. You want to show people, this is the change. You want to make believers out of people in that change. You want them to come to you and say, whatever is that change that you made in that particular cell or in that particular manufacturing line or a service process, we want you to replicate that in our manufacturing line or in our service process as well because we see the improvements that they are getting over there. A pilot cell in that sense gets you to two different objectives. One is it lets you try out the change. Now you can try out the change in a small area of your organization. You don't want to have a full rollout before you try it out in a small area. They might be some cause-effect relationships that you might have overlooked. You want to be able to see that and the best way to see that is to do it in a pilot cell and to do it in a small place where you're trying to replicate the exact environment that you would find in the rest of the places where this change in the process is going to get implemented. What you're doing is you are trying to validate the results and you're also trying to get the buy-in of the people based on making that change in a small place and trying to roll it out after that. Now again, as we said in simulation, there's going to be a trade off between whether you want to do a pilot cell that's large enough for you to be able to replicate the context in which it's going to get changed or was is it going to be a small one? Is it going to be a very visible one so that everybody can see the

impact of that change right away, or do you want to try it out in a discrete small cell in case the changes don't work out? Those are decisions that you would have to make. Other than that, this is a very simple technique in terms of trying out the things that you think might work in a small place before having a full-scale rollout.

Module 4.2.4: Standard Work and Visual Workplace



So when you're thinking about lean and the Toyota production system a big part of lean in Toyota production system is standard work. If you remember, if you go back to the article, the DNA of the Toyota production system by Steve Spear and ken Bowen. What we're talking about there is that the work content must be highly specified. They're they're talking about three aspects of work content. The content itself or what are the different steps that need to be done for any piece of work to be to be completed? The sequence of the work in which it should be done and the timing, how quickly should a frontline employee be able to do that work. And if you think about the Toyota assembly line where this idea is implemented in a very real sense, they're taking these three aspects to heart. So they have assembly lines in place where the timing of every person's task is fixed. They know that what are the different things that they need to accomplish in the one minute in which that assembly or that car is going to pass through their particular work area. Because it's moving assembly line, it might be parts that are passing through, it might be cars that are passing through. And they have a tack time that is given to them that they have to get it done within that time. So the timing is very much specified, the work is of course very much specified in terms of what they're going to do. And what results they should get when they do that work and then the sequence is also very specified. So if you think about the Toyota production system, there they're talking about four bolts that have to be placed into a particular part, have to be placed in a particular order. It goes in a particular order, going left bottom to left top to right top to right bottom, and it has to be in that order and the torque is specified and so on and so forth, so it's highly specified. Now, the idea of standard work being highly specified is that you want to be able to get all these benefits cited, controls of output quality. You want to be able to make comparisons with customer specifications. So if you reflect back onto the idea of process control charts, they are also getting at the same idea. You figure out how your process is doing, you cannot do that. If you don't have standard work, if you have standard work, you can say my process performs at this level. Because I know everyone

who works on this or every time the step is done, this is the kind of results that I can expect. So it helps you in terms of comparing your process performance with customer expectations, it minimizes process variation. So if you're thinking from a six sigma perspective, it minimizes the variation so that you get consistent results. And it also helps keep up with tact time, so the idea of matching the cycle time of the, of the task to the attack time of what the customer is asking for. It facilitates further improvements, gives you a baseline for you to make further improvements. And also as employees are doing the same thing over and over again, they're getting more efficient from a repetition. So these are the benefits that you get from standard work. Now, how do you go about implementing standard work? The important thing there is for you to sell the idea of standard work to your employees first. They should know that it's important for them to follow standard work, so how do you do that? Well, you involve them in designing the standard work, that's an important part of Toyota. The idea of respect for people, so you involve them and coming up with the standard work, instead of just imposing it on them, you involve them. You tell them or you have them know what is the impact of that small piece of work that they're doing on the larger picture on the product that is being made. So for example, if they're working on a small part, it could be a sensor that is used in cars for stopping the window from going up. If a child puts their hand through that, window through that car window. So it could be a simple sensor like that they're working on, it's a small part of the car that they're working on. So they might not see the impact of that when they're thinking about what they're making. But if you can display to them, if you can show to them, if you can tell them that you know what? If this part fails, the consequences can be very severe if it's a child that's putting their hand out the window. And the window is going up and the sensor fails from it, from stopping the consequences can be really awful. So that's an example of of showing them why it's important for them to focus on the standard operating procedure that's been given to them for even a simple small part for a car. Because that's going to have an impact on the performance of the whole product, so that's why standard work becomes important. It's the important part for you to think about an implementing standard work is to convince the people to to implement that standard work. The idea that the effectiveness of the solution is going to come from the quality of the solution. But also the acceptance of that solution from the people who are actually going to implement it. So they should know the importance of standard work.

VISUAL WORKPLACE

- Labels
  - Color codes
- Lines on floor or table
  - Kanban
- Warning signs
  - Andon
- Mistake prevention
  - Poka yoke

Top: (Wikipedia/Jeff.Iasovski, 2011) Bottom: (Wikimedia.org/lexcie, 2012)

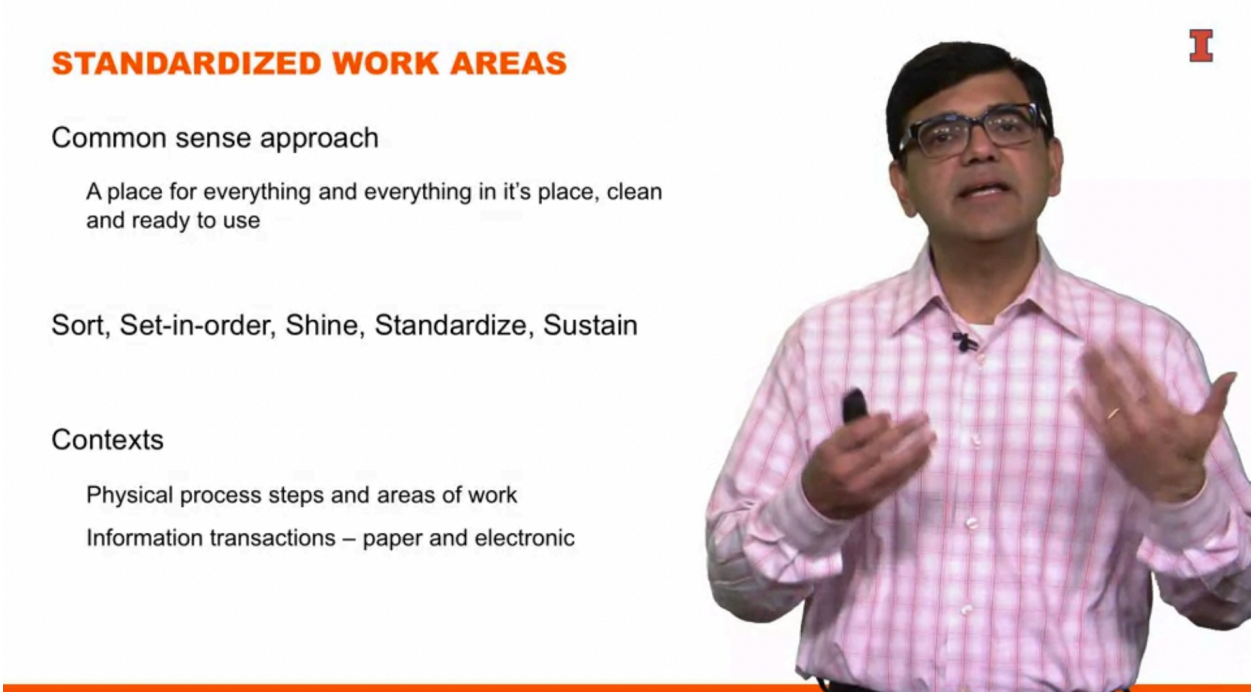
And finally, the idea that is also very popular in lean or very much a part of lean is the idea of a visual workplace. And you see in plants that Arlene in workplaces, that Arlene in hospitals, that Arlene that these are being practiced very widely. So what is the idea of a visual workplace? Well, the idea of a visual workplaces that you should be able to simply from walking around the workplace, be able to see how things are. And you can think about this in terms of how things are on a day to day basis. So if you're thinking about doctor's clinic, they should be colored signs, colored flags. You may have seen these in some doctors clinics that tell people outside if the room is being used for a patient at this time, at the current time. If it's has been used and needs to be ready for the next patient, if it needs to be cleaned or if it's clean and ready to go for the next patient. Or if it's clean and ready and it's been allocated to the next patient. So you could have four different colors of flags that are telling people the status of that particular rule, a quick glance at at that flag will tell you whether that room is available or not. And you don't have to go look at the computer, or check the timing, or anything like that because you get a quick glance of it right from looking at the workplace itself. The other way in which you can use color codes or labels is the idea of cautioning things about things being low. So the idea that here's the level up to which the inventory should be. If you're thinking about printer paper, you can have the idea of here's the level at which this printer paper should be. And here's the red level and here is the yellow level and here's the green level. So if it goes below this, you better place in order because otherwise we're going to run short. Now the same idea of of labels flows into the idea of having lines on the floor or on the table. And here I use a Japanese term from the Toyota production system from lean management practices called Con bond. Now, what is the idea of con bond? It's a very simple idea. The idea is that a con bond is a signal for the previous step to provide you more parts, or to send the next patient to you, or to do something in order to fill my requirement as a process customer. So if you're thinking about this in terms of physical parts that you require in order to work on your task. This is a container that when it's emptied and you send it back to the previous step, they know that there's something required by the next

step and they start filling it up based on that. And in addition to it being a signal for what is the quantity that's needed by the next step. It also becomes a very good inventory control mechanism because then you are you can control the inventory based on the number of compound containers that you have. And each con bond container is filled with just a fixed number of items that are going to be used. So con bond containers can be replaced by lines. You can have lines on the table that tell you that this is this area needs to be filled up with parts or needs to have parts over here. If you're talking about big physical parts in a warehouse, you could have a line on the floor that indicates that this area is in the is for these particular part. And these need to be filled up when you're talking about parts being needed by the next step. And so you could be using a con bond as lines or on the floor on the table. And in fact you can even use it as a order card, It could be an order card, it could be an electronic signal. So when you think about Toyota ordering parts for their cars from their suppliers. A con bond is a signal that says to the seat supplier, please send me these seats in this sequence and in this quantity. Because that's what's needed for today's production or the next hours production because they usually keep just in time inventory. So that's the idea of a con bond in terms of making it a visual workplace, so visual can be physical visual or even can be electronic visual in the sense that there is a signal that pops up. The other way that the lean management system or the Toyota production system uses the visual workplace. The idea of a visual workplace is this other Japanese term that you see on the slide, which is the Andon cord. And the Andon is basically the literal meaning I'm told is a lantern. It's a light that gives a sign that says that there is some some problem in this particular area. So here is the idea of saying that when there is a problem with the process, there should be a quick visual signal. That tells people that tells, the team members, that tells the superiors that there is a problem with this particular task. So the idea of Andon signal, the lantern is that it's green when everything is okay, it becomes yellow when there is a caution sign and the team members need to come and health that particular area. And it becomes red when it's an absolute stopping of the line or saying that we really cannot take any more orders here. Because we we have reached a stage where there's a larger problem that needs to be solved with the root cause analysis with the PDCA cycle. When you think about lean, you think about PDA cycle. So that's what you'd be doing if they Andon color was red. So again a use of a visual signal to say what's going on. And last is the idea of mistake prevention, the idea of poka yoke and we'll see some examples of poka yoke later. But the idea there is better prevention to make sure that there's a visual for the person who is working on that process to say there's a mistake here. That we need to stop and and correct that mistake to to make a change so that the arrow gets eliminated before we move forward. And and sometimes the idea is is even more proactive in the sense of preventing the person from making mistakes, giving a signal that you need to be cautious, this is not how it should be. This could be an example of medicines that may interact with each other. So if it's a pharmacy that is filling a prescription for a patient and there are two medicines that are supposed to not be given together to a patient. The system pops up a warning that says you shouldn't be adding this to the prescription for this patient because these are the other things that that the patient is taking. So the idea of a visual workplace is that when a manager, a supervisor or anybody who is working in their workplace walks around, they get a sense of how that process is doing, how that value stream is operating. They get a sense of whether the work is keeping up with the pace at which customers are expecting, so is there is the timing of the work, okay. And they also

get a sense of where is the process in terms of improvements? What are the current quality levels? What are the current defect rates? What is the current cycle time? How is it compared to to attack time? They get a quick visual just by simply walking around. So it's taking management by walking around to its most extreme when you're talking about a visual workplace. And that's a very effective technique when you're trying to put improvements in place.

Lesson 4-3: 5S

Module 4.3.1: "Five S" for Standardized Work Areas



In this session, you are looking at 5S. 5S is a technique that although you're seeing it as part of implementing improvements, it's a technique that can be used at any stage of a process improvement initiative. The basic idea of this technique is very simple. It's the idea that you should have an organized workplace. It's a very common-sense approach and it's following the principle of a place for everything and everything in its place. You can use 5S and it's originally five Japanese words that happened to start with an S. But if you think about those 5S's in Japanese, they work out to be very similar to sort, set in order, shine, standardize, and sustain. You can use the 5S exercise when you're thinking about a particular work area, or you can think about it as a particular process. When you're thinking about a process, you could be thinking about not just a physical process, but you could also be thinking about paperwork, you could also be thinking about places where it's electronic information because keeping everything in order when you're thinking about files and folders that you're maintaining on your computer or when you're talking about files and folders that you're maintaining in a physical paper that becomes very important for you to be able to run the process in a standardized way and then make improvements to that process. The basic idea of 5S is to make sure that your place is completely stabilized for you to be able to assess how the process is doing and to make improvements to it.

SORT (SEIRI)
SEGREGATE AND ELIMINATE

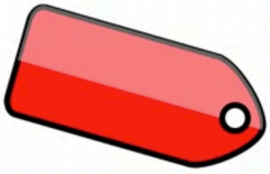
Arrange

- Often-used items at the work area
- Infrequently used items away from the work area

Dispose of items that are not needed

Steps

- Start in one area, then sort through everything
- Discuss removal of items with all persons involved
- Items that cannot be removed immediately should be red tagged



Top: (flickr/Cynthia Donovan, 2006) Bottom: (pixbay.com, 2013)

Let's take a quick look at what are the different aspects of 5S, what are the different 5S's? The first S here is the idea of sorting. The idea that when you take a look at your workplace, when you take a look at your process tasks, what you probably have is a lot of stuff that you don't need. The general rule that we like to talk about when you're 5S'sing a particular workplace is that you're thinking about things that I have not touched in the last six months. Things that I have not touched in the last 90 days. The idea being that those are going to be things that should be completely eliminated from that workplace. When we look at our workplaces, quite often we find things like that. We find things that we've put there just in case we might need them and we've actually never needed them. This can happen with paperwork, this can happen with tools, this can happen with parts, and this can happen with electronic information that you keep there just in case. Getting into the specifics of the sort step when you're doing a 5S exercise. You can do this in your workplace and you can do this even at home in order to keep your things arranged. You can go through the 5S's, the first S being sort. What you're doing there is you're taking the things that you want to retain, that you want to keep, and arranging them in such a way that you are keeping the often-used items at the particular work area, and then you are taking the infrequently used items and you're keeping them away from the work area. That's your idea of the sorting of items. You want to dispose of the items that are not needed. How do you start doing this? Well, you start in a particular area of the process of the workplace, and you start sorting through everything that's in the workplace. You want to make sure that people are involved, the people who are working on that process are involved. If you're doing this at, let's say a nurse's workstation at a hospital, you want at least some of the nurses from each of the shifts, the three shifts that might be working there to be involved in making those changes. You don't want to alienate people and make changes that they may not like or that they may actually believe are going to be detrimental to the performance of that process. You want to make sure that those steps are taken in conjunction with the people that are working on that process.

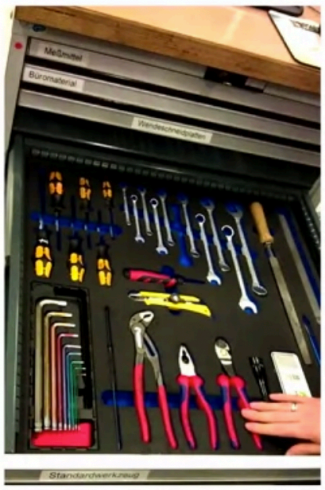
STABILIZE (SEITON)
SET IN ORDER

Put essential items in order so that there is easy and ready access

Have a designated place for everything

Use labels, tape, floor markings, signs, shadow boards

Shared items (eliminate excess) should be kept at a central location



(wikipedia.org/Tasma3197, 2011)

The next step, when you're doing a 5S is stabilize, which is setting in order. Once you've sorted out the things that you don't need, you've kept them out from that place, you do want to keep the things that are there in order. You want to put them in a particular order. You want to have a designated place for everything and here the idea of a visual workplace also comes in. You may know what a visual workplace is all about, it's the idea that you have labels for everything. You have tape markings on the floor in order to tell people where they should place something, or also to give an indication of when something is missing from a certain place. Again, a healthcare example, if you're thinking about a floor in a hospital where there are nurses' workstations and there's place for them to keep the equipment. Where should the wheelchair for patient transportation be? It should be in a particular place. It shouldn't just be sitting in the hallway, it should be at a particular place. Where should all the equipment before taking vitals? It should be in a particular place. When you're thinking about a room in which there are patients, they should be things that are kept in place, and that should be the same regardless of which room that you go to. When you think of nurse's workstations, there should be things that are kept in the same place regardless of which workstation that you go to. When you think about different employees working in different shifts in that same work area, or if you think about different employees going into a particular patient's room, they don't even have to think twice because everything has a place and it's neatly labeled. They know where it's supposed to be. If it's not there, they know that it needs to be replaced, that it needs to be found and put back in that place. That becomes the idea there. When you're setting the place in order, you also want to make sure that you are looking for things that can be shared across the location. It doesn't mean that you duplicate everything in every possible area. Lean is all about eliminating waste and excess of anything is also a waste. When you're thinking about setting a place in order, you want to make the judgment that there are some things that can be shared and maybe putting them in a central location. That might be a solution for some particular items, while it might not

be for some particular items. You'll have to use some judgment when you're setting the place in order, when you're putting things in the right places that they should be found.

Then you have the idea of shine. Here, I have a picture of a fire truck. Because if you think about fire trucks, they don't get used on a very regular basis. However, they have to be kept in impeccable shape for when they actually need them. They cannot have situations where something is not working, so everything needs to be checked, everything needs to be cleaned and polished. Typically when you look at fire trucks, they are shining, and gleaming, and it's not because those people have free time to be cleaning their fire trucks all the time, it's because it's very important for when it is that critical time for when they need to use that equipment. That it should be working and it should be quick to use when they're needing to use this. That's why you think about the shine idea of keeping the workplace clean. Just as you do in the case of the fire truck, you want to do the same thing with the tools and the equipment that you're using in your workplace.

Then you have the idea of standardized. This S is talking about standardizing the workplace in the sense of, the content, the sequence, and the timing of work. How is the work going to be done? At the same time standardizing how things are going to be placed. You're standardizing the work as well as the workplace in that sense. Here, you have ideas like checklists. The example that you see on the screen is a pilot going through a checklist, a DC-10 pilot going through a checklist before flying that plane. The idea is that in the same way, there should be a checklist at every workstation, at every process step for the important thing. In medicine now, the idea is being used even in surgeries. The idea of using checklists when you're talking about doing surgeries. These are highly accomplished surgeons and surgical teams that are doing these surgeries, but you don't want to miss out on certain things when you are trying to do those high pressure tasks. Having standardized work practices in place is important for that to be done. When you think about any kind of workplace, it's important for this thing to be in place.

SUSTAIN (SHITSUKE)
USE SELF-DISCIPLINE

Make 5S a part of daily work

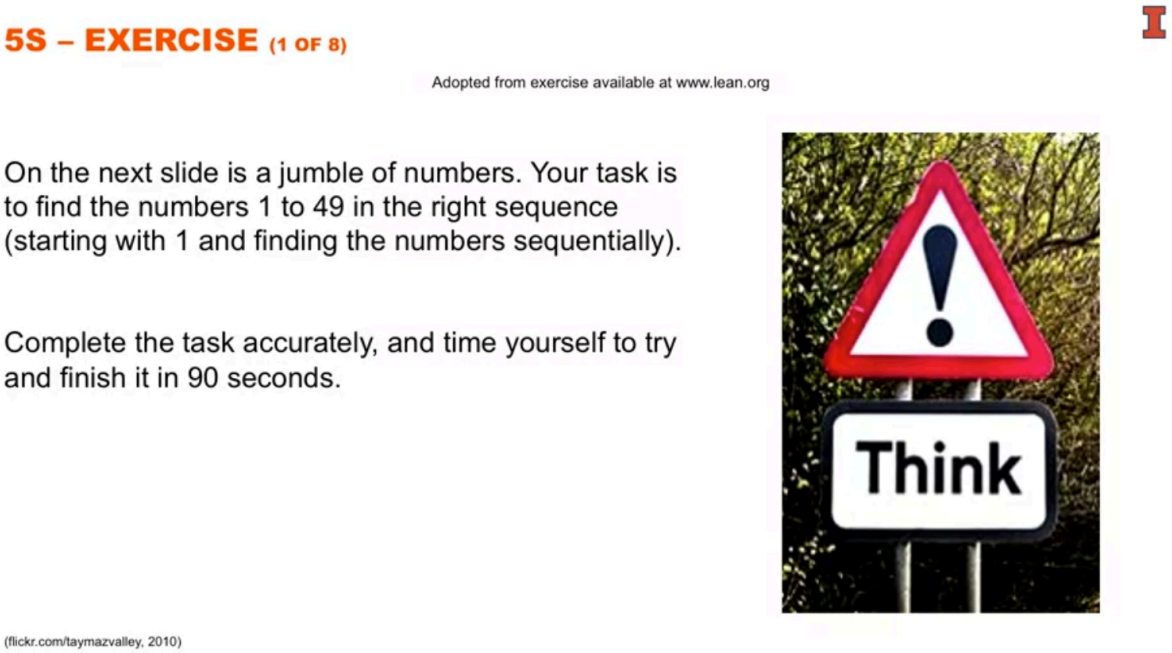
Practice to make it a way of life

(flikr.com/Jurgen Appelo, 2012)

	Sort	Simplify	Sweep	Standardize	Sustain
Level 5	100%	100%	100%	100%	100%
Level 4	75%	75%	75%	75%	75%
Level 3	50%	50%	50%	50%	50%
Level 2	25%	25%	25%	25%	25%
Level 1	None	None	None	None	None

Finally, the idea of sustaining or using self-discipline. Taking the idea of standardizing, taking the idea of having a clean workplace and using it on the 5S concept itself. Keeping track of how much a particular process step is 5S. Keeping track of how much a particular work area has been 5s and how can it be improved. So continually thinking about getting to a higher level of 5S is important, and therefore, the last step in this. As we say in continuous improvement, everything is iterative. You don't rest by saying, this place has been 5S. You say, what is the next level of 5S that we can take this to? What is the next level of mistake proofing in this particular process, in this particular workplace that we can take it to? How can we make it more efficient and more effective for the kind of work that's being done over here? The last S in the 5Ss is the sustain idea.

Module 4.3.2: Practicing "Five s" with an application



Let's do an exercise here in order to take this idea of 5S and try it out with something that you might be familiar with. Work with me through this exercise as it's going to have many different steps on it. You'll see that they relate to the S's that you see in the 5S. What's the first step of this exercise? What you'll see on the next slide. Now, I'll show you the next slide briefly and then I'll come back to this slide. The next slide you'll see a bunch of numbers. There's a huge jumble of numbers on this slide. Going back to the instructions here, what you're going to see is this big jumble of numbers. Your task is to go through the numbers. Go through this big jumble of numbers and find the numbers one through 49. Start with one, go to two, go to three. Do this visually and find them in order. You don't want to be skipping numbers. You find them in order. You can start writing them down as you find them so you've checked off in that sense whatever you found. You go from 1-49 in that sequence and find all the numbers. In order to complete this task, you have 90 seconds. When we show you the next slide, you're going to get 90 seconds and you'll have 90 seconds for you to complete that task of finding the numbers from 1-49. Ready, set, go.

5S – EXERCISE (3 OF 8)

On the next slide is a jumble of numbers from 1 to 49 (the numbers 50 and above have been deleted).

Your task is to find the numbers 1 to 49 in the right sequence (starting with 1 and finding the numbers sequentially).

Complete the task accurately, and time yourself.

(flickr.com/taymazvalley, 2010)

We don't know how you did, but you probably found it hard to go through and find those numbers, especially because there were numbers that were beyond 49 that were in that big jumble of numbers. You had numbers that were above 49, 50 and above, within that set of numbers and that made it difficult. What we're going to do is we're going to do the first step of 5S which is to sort. In terms of sorting, we're going to take stuff that we don't need, material that we don't need, which is the numbers 50 and above, and we're going to delete them from that big jumble of numbers. Your task next is going to be to take that same set that you had earlier without the numbers 50 and above from it. You'll see that jumble and it's going to be a reduced jumble. Now, you can try this out. Go through and find the numbers one through 49 in sequence. Of course there might be some learning that might have happened from you simply doing this exercise in that big jumble, but that's okay. Do this task. For this particular iteration, you're just going to time yourself. We're not going to give you a time in terms of you had 90 seconds earlier. This time you just going to time yourself. Go ahead and do this starting with now.

5S – EXERCISE (5 OF 8)

Now the numbers 1 to 49 have been set in order in "shelves" so that the sequence goes from left bottom, to left middle, to left top, to middle bottom, and so on, ending with right top.

Repeat the same exercise and time yourself.

(flickr.com/taymazvalley, 2010)

For the previous step, we had already sorted out the numbers that were 50 and higher. Next, what we're going to do is we're going to set them in order. What we're going to do is we have these shelves that are available to us to put these numbers. What you'll see in the shells and I'll give you a brief glance of what you're going to see here. You're going to see these nine shelves that we've put these numbers in. Your task is going to be to go in these nine shelves and find the numbers 1-49, same tasks that you had earlier, except now it's been set in order for you. There's a particular arrangement for it. It's like we've put the tools in their particular places in that toolbox. I'll tell you the sequence here. The sequence is going from the left bottom to the left middle, to the left top, to the middle bottom and so on. What you'll find is the Number 1 is going to be in the left bottom. The Number 2 is going to be in the left middle. Go to the left top, you'll find the Number 3, and then you'll go to the middle bottom, that'll be the Number 4. You keep going that way and you should be able to find the numbers 1-49. You can time yourself again and see how much time you take. Get your pencils and your timer ready. When I say go, you can start going, so go.

5S – EXERCISE (7 OF 8)

With placement of numbers 1 to 49 “standardized,” repeat the same exercise.

(flickr.com/taymazvalley, 2010)

Now we've gone through set in order. First, the numbers 50 and above were sorted out. We had deleted the numbers 50 and above. We set it in order in those nine shelves and now we're going to stabilize the system. We're going to skip the shine step. We're simply going to stabilize the system. What you'll see is that you will find these that are being put in a standardized fashion in a particular way and you'll be able to go through them and find the numbers from 1-49. What's the standardized way in which you're going to see this? This is the way in which you're going to see them. Obviously, this is going to be much easier for completion. You can time yourself and see what happens, but hopefully this exercise has given you an idea of what it means for a place to be 5S. What you saw in this particular exercise is that you can gain a lot of efficiency from having things in their place and kept in that particular place with some meaning to why they're being kept in that particular place. When you have them in sequence like this in their particular boxes, it's very easy for you to find them and go from 1-49.

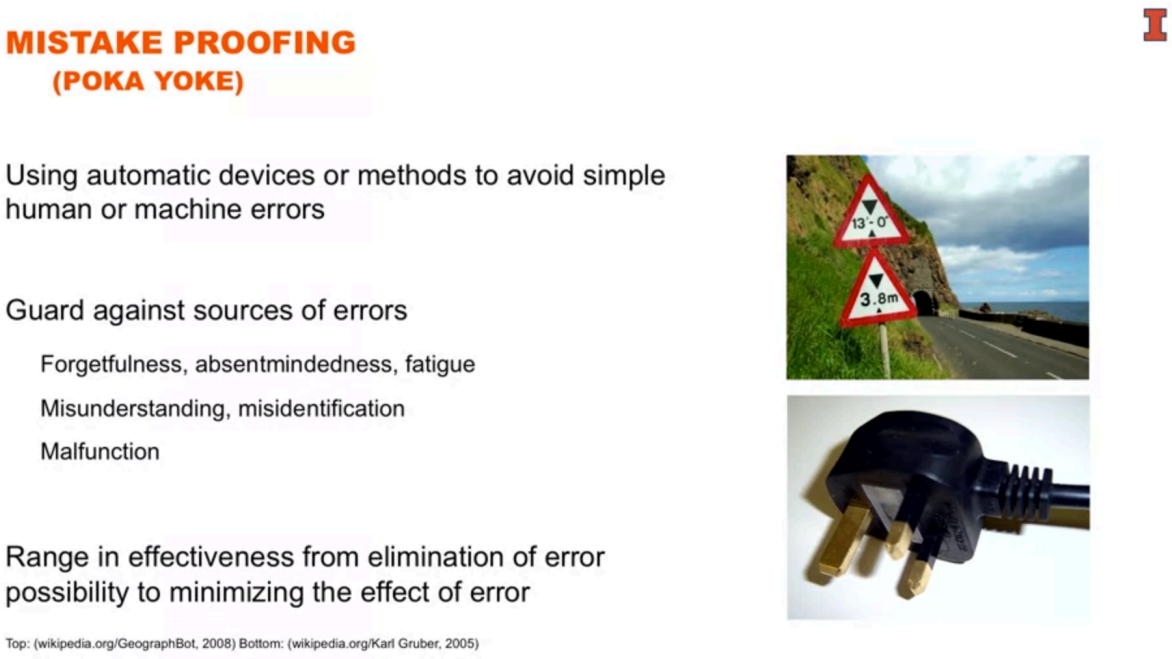
Lesson 4-4: Confirming Process Improvements

Module 4.4.1: Control Phase in DMAIC

If you're doing a Six Sigma project or DMAIC project, you've gone through define, measure, analyze, improve, and now you've reached the control stage. This is the stage where you're saying, "We put the improvements in place, and we want to make sure that they stay at that level, that the process improvement stay at that level." The objectives that you have in the control phase are that you want to make sure that the intended changes are in place, the intended Xs are in place so that they have the desired effects on customer, critical to quality customer characteristics. You want to make sure that whatever standardized procedures you have in place stay at that level, that there's no deterioration in their level of standardization in how people are following those standardized practices. This is important. It's critical in fact, from the point of view of lean. If you're thinking about implementing a lean process improvement initiative. But in Six Sigma also, you want these things to stay in place. You're going to maintain a particular Sigma level of a process and improve from there. You better make sure that that is being maintained before you can jump to the next level. Roll out the new procedures throughout the organization, so you want to get buy-in. If you figured out some best practices for doing certain things a certain way, and if you have many locations at which those things are being done, you want to make sure that that is being implemented in the same way across many different locations, many different places where that same work is being done. Two reasons for that, one, is that you want to be able to communicate across different places that are doing the same thing and make comparisons. By doing it the same way, by following the standard operating procedures, that helps everyone stay on the same page. The second reason for doing a worldwide rollout of a particular process is to make sure that you're getting an advantage. You're getting advantages of the best practices that you spent time figuring out. That's why you

want to have a rollout of the best practices that you found from doing a process improvement in a particular area. You want to complete the handoff at the stage. In the control stage, it's the project team, it's the project Black Belt if you're talking about a Six Sigma project, handing off things to the process owner and the people who are working on the frontline. That handoff has to be complete. Then, you want to put in place a schedule, a systematic schedule that says, these things are not going to be implemented overnight. The results are not going to show overnight, so we want to do a check after three months, six months, a year, and be able to see whether the improvements that were expected have actually been achieved and whether they can be used as the baseline for the next set of improvement. That's the idea of the control phase in DMAIC. Now, you've come to realize by now that Six Sigma talks about this, and in particular stages, and define, measure, analyze, improve, control. If you're thinking about lean process improvement, the lines around these stages are very fuzzy. They're continually thinking of improvement. That's the principle behind lean. That's the principle behind the thorough production system, is that we're not doing this in the form of structured projects. It's a way of life, and this is how we always think about improvement. We always think about PDCA cycles all the time.

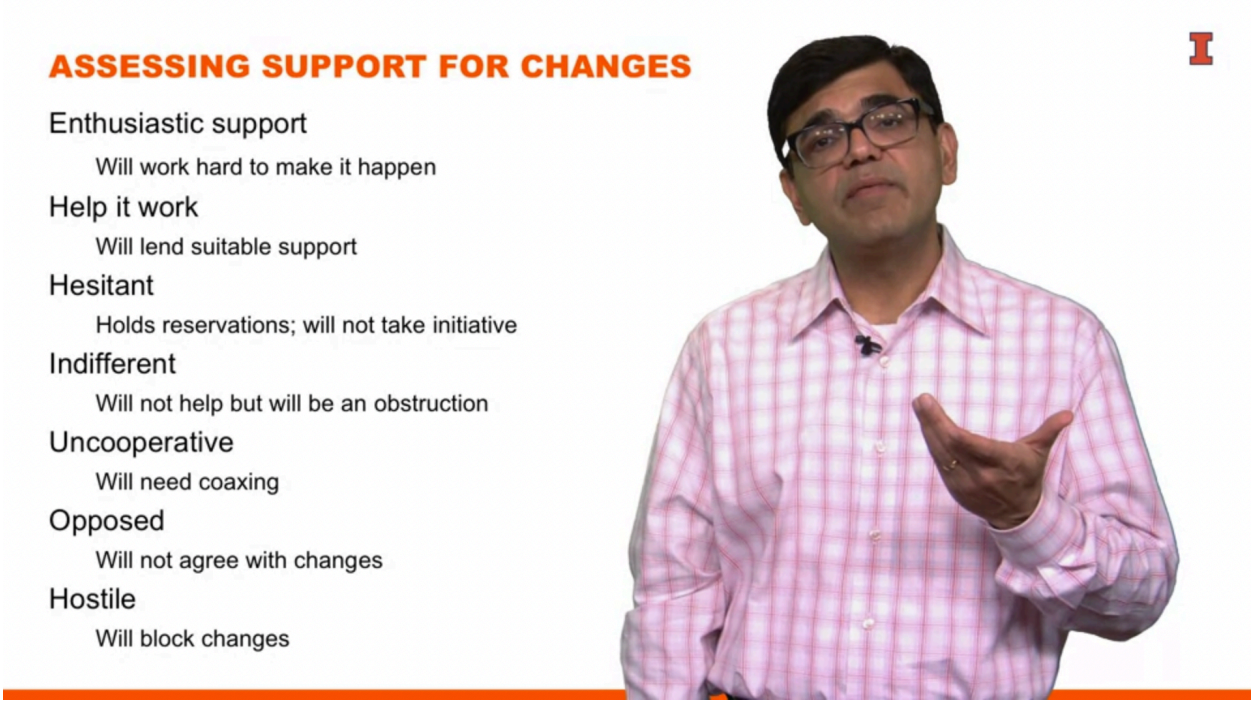
Module 4.3.2: Preventing Errors and Sustaining Improvements



A technique that that is used in lean implementations is called poka-yoke. And the idea of this is all around you, actually, if you think about it, you see poka-yoke examples mistake proofing mechanisms all around you. So what's the idea of mistake proofing? Well, it's using any kind of device that avoids errors. That helps you prevent errors before they're happening or if the errors do happen, it helps you catch the errors very quickly. So the two pictures that you see over here are examples of poka-yoke devices that we see when we are traveling and we see that we're going underneath a bridge or if we're going through a tunnel. Sometimes you see that there is a bar that's placed that is just before you enter that tunnel, or that is just before you go underneath that bridge when you're traveling on a road. And the idea of that is that it is trying to prevent a vehicle of a particular height, of being above a particular height to go underneath that bridge. Because it will have very bad consequences if it actually it's too high for going underneath that bridge and it's going to crash and it's going to cause damage to the bridge. So, having that bar before that is to tell the people that they need to think about the height of the vehicle before they go through it. And also, if they actually do try to go through it when they are not going to be able to make it because the height of the car is too much or the vehicle is too much, they're going to crash into that metal bar that is placed at the exact height of the bridge. Similarly, the second example that you have here, the picture that you have here is a power plug and you put it in a socket. In some countries, there are only certain ways that you can put a plug in a socket and that's an example of a mistake proofing mechanisms. And if you think about more examples, you can come across these. So, when you go into a hospital, if you are being treated and if you're staying over in the hospital, you notice that whenever there's medication being given to a patient, they scan the band that are on the wrist of the patient. And that a mistake proofing mechanism to make sure that the medicine is not being given to the incorrect patient, that the medicine is being given at the right time. So there may be any number of things that it might be checking when they're scanning that band on the patient's wrist. If you

notice when you go to put gas in the gas tank in your car, there are usually different sized nozzles for putting diesel versus putting petrol. And the reason there is that you don't want people to make mistakes of switching from one to the other. When we travel on airplanes and you are told to check the size of the cabin baggage that you're going to take into that airplane. The idea there is that you're giving a mistake proofing device. You're given a device at the check-in counter to say, if you have cabin baggage, place it in this device, place it in this crate that we have placed over here to see if it's actually going to fit in that overhead bin. And that's a way of mistake proofing so that you don't take that further. The another example is an example is that of the ATM card. An ATM card, before we had this feature of people having to swipe and take it out before they run the transaction, people used to forget their ATM cards in the machine. And the reason to have them swipe and take it out is to prevent that error from happening. So, what you see here is the kind of examples, kind of things that you can do and you can do the same kind of things for work processes. You can have the same kinds of things for preventing people from making errors in their work processes so that they don't go forward. If you think about software-based warnings that you get for any kind of form that you're filling out. Saying, you haven't filled out the necessary fields or you put in a date that doesn't make sense, it comes back and it tells you that you'll be making an error if you proceed further. Now, mistake proofing can be done at different levels. It can be to prevent an error from happening or to give a signal when the errors happened. The idea of coming up with a mistake proofing mechanism is that it should be simple, it should not be very expensive. It shouldn't be adding to the cost, it shouldn't be adding to the time that a customer is going to take or a worker is going to take with that particular product or process. So if that's the case, if it gets too expensive, or it's too time consuming, then it's not going to be very helpful in terms of being used. So, that's why you should be thinking of those aspects when you're thinking of building in mistake proofing mechanisms into your product or process.

So finally, let's talk about the action plans for implementing improvements. So, as you saw that there are not too many techniques we're talking about here in the improved phase. It's because what is happening in the improved phase is the basic handoff and you're giving people a set of things that they need to check. So, what is the action plan for any implementation of improvement? It's what actions are going to be taken in order to put the new things in place, the changes that are going to be in place? Who is going to be responsible for making those changes, and who is going to be responsible going and checking whether those changes have been put in place? What kind of effort are we expecting to be put? What kind of improvements are we expecting in terms of the effort being put? We may not be able to make a change overnight. It might be too sudden so we might make that change in a gradual fashion. In which case who's going to put in the effort and when is that effort going to be put in also needs to be given. And that's why you have the data as well as to by when are we expecting a certain change to take place? And then by when are we expecting the results of this to materialize or when are we going to check the results and see whether the results of materialized or not? So that's the idea of a control phase.



And finally, we've been talking about this a bit, but you want to check whether the people who are going to be making the change are enthusiastic about it. So, here you have a list of seven levels of attitude that people might have towards the change. And depending on whether they're enthusiastic or not. They might be very enthusiastic about the change going all the way to they may be hostile and they may be wanting to block the change if they're completely against that change. And you can see the gradual change, gradual difference between going from enthusiastic to being completely hostile. So the idea of making controlling the improvements or putting them in place and sustaining them is the idea that the the quality of change is going to be important, but also the acceptance of the change. So the effectiveness is going to be based on the quality of the change, as well as the acceptance of the change by the people who are going to put that change in place.

Lesson 4-5: Leadership for Continuous Improvement Initiatives

Module 4.5.1: Leadership for Continuous Improvement Initiatives

When you think about sustaining a process improvement initiative, a continuous improvement initiative, leadership plays a very big role. Whether you are thinking about Six Sigma, whether you're thinking about lean, whether you're thinking about any continuous improvement initiative, leadership has a big role, and there's no substitute for leadership. When you think about leadership for process improvement, you can think about it at three different levels. The three different levels are organizational initiative, project teams, and day-to-day work. When you think about the organizational initiative, it's at that top-level, thinking of continuous improvement as part of being the strategy for the business, as part of being the strategy for the corporation, and trying to implement it all the way at the front lines. At the project team's level, leadership is important for project leaders to be able to gather the team, bring them together, especially when it's a cross-functional team, especially when they're going to be disagreements about things. It's being able to balance this idea of getting diversity in the team, diverse views in the team, and at the same time getting them unified behind certain ideas. Project team leaders need to be good at doing that. Day-to-day work, when you have supervisors that are supervising front-line workers, when you have any kind of middle management that is supervising people who are doing their day-to-day tasks in a business, in any kind of manufacturing or service business, the day-to-day leadership is also important. There has to be a way of solving problems when there are day-to-day problems. There have to be a sense for frontline employees to feel safe when they have to bring up problems, when they see opportunities for improvement, when they see a defect in a process to bring that up. The three levels of leadership become important, although we're going to study leadership in this session, typically more from organizational initiative perspective, from that top leadership perspective.

When you think about leadership at that level, leadership is about management and leadership. We can break leadership up into the idea that part of the job for top management is to control resources, coordinate activities, make sure that the operation strategy, the business strategy, the process improvement strategy, they're all aligned and going towards the same direction, that there is buy-in across the organization for the process improvement initiative. Both of those things, management and leadership have to be combined for there to be a good execution of continuous improvement that's sustained over time. What we're saying here is that managers and leaders are not necessarily different people, especially when you think about continuous improvement, they have to be the same people. They have to be people who can get stuff done from a more structural perspective, getting things administratively done, but at the same time they should also be inspirational leaders in the sense of inspiring change, and getting people to think about change.

Why is leadership or management of a continuous improvement initiative difficult? Why is it challenging? What are the challenges that are faced? There are some things that have to be balanced when you're thinking about a continuous improvement initiative that make leadership of continuous improvement initiative that much more difficult. Let's take a look at a few of these. You can think of these as paradoxes. Academics like to call them paradoxes, but you can also think of these as things that have to be balanced, that are going to pull in two directions, that if you do too much of one, then there's going to be a problem, so you need to have a balance of both of those. One is being too fast versus too slow. You're talking about it being whether it's the changes that are being made are being done too quickly. If they're done too quickly, then what's going to happen is that we're not going to be able to sustain it for a long period of time, and you're not going to be able to see the improvements happen over a long period of time and people are going to get tired. On the other hand, if it's too slow, that's not going to be good either in the sense of, you are not going to be able to keep up with the best practices and with competition, and not be able to sustain performance in a particular area. Too big versus too small, making in conjunction but too fast versus too slow. Are we going to make sweeping changes very quickly or is it going to be slow? Are we going to wait for buy-in? That's attention there has to be maintained. Top-down versus bottom-up. When do you give direction to the next level down from you as a leader, and when do you say, give me your contributions, or you go discover what the problem is? When is it more Socratic and when is it more dictatorial? If we can think about it from two completely different examples, the idea of Jack Welch in GE, making it a top-down initiative when Six Sigma was implemented, versus the idea of the Toyota production system, where it's all organic, it's from the front lines, it's from giving loose direction to the front lines, but then they going out and coming up with improvement ideas and implementing them. Again, that's a balance, and sometimes depending on the culture of the company, you may have to go toward one direction or the other when you're talking about these extremes that we're seeing listed over here. Delegated and imposed. Is process improvement

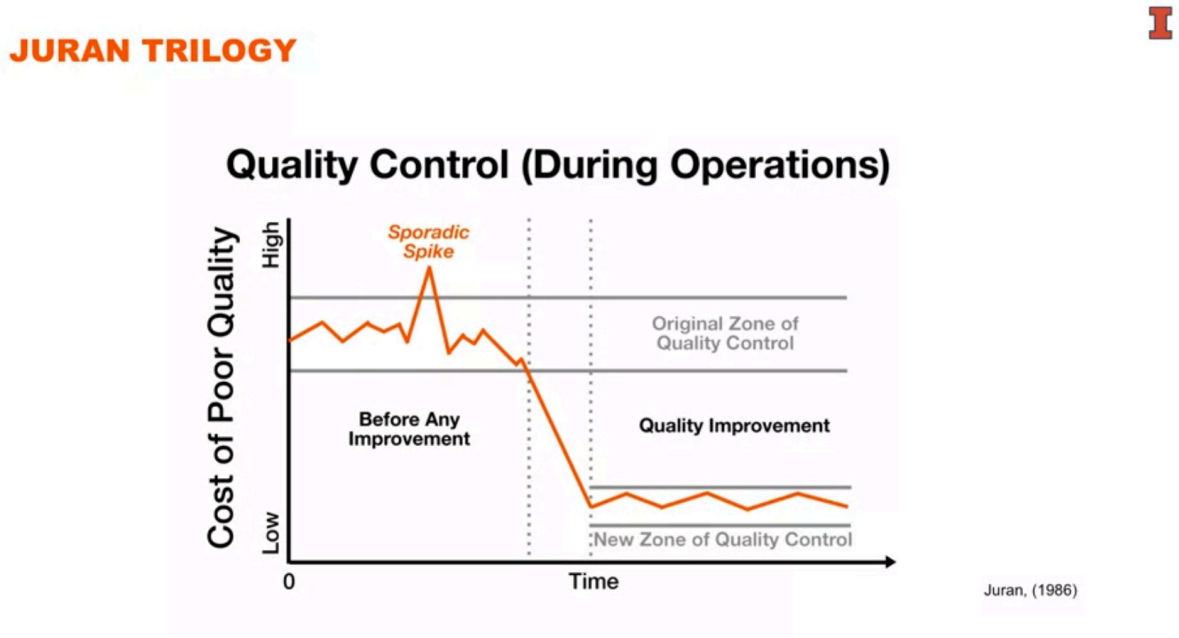
something that is going to be given to people in terms of participatory environment, more autonomous environment? Which is where most of process improvement is today. We're talking about it as being more delegated to the people and involving the people versus imposed, which is what we've moved away from mostly in terms of getting things done, in terms of improvement. Informal versus structured. Here, you can see a very clear example of, at least on the face of it, the Toyota Production System seeming to be more informal, seeming to be, I should say, more organic, not informal rather, and Six Sigma as being more structured. You can even call it more bureaucratic. It has got a lot of procedures that have to be done when you're starting to do a project. In the define phase, there are certain check boxes that have to be checked off, but before you can move on, and so on and so forth with every stage of a DMAIC project versus when you're thinking about a Toyota Production System, Kaizen event, or a improvement project, or a PDCA project, you're not thinking about it in such rigid terms. There, it's more informal. Although you have the idea of using the A3 and the PDCA cycle, it's not a rigid structure in terms of a reporting structure, and tollgates for each stage of the process improvement project. Finally, this paradox that gets discussed quite a bit and that if you think about the Toyota production system from a principles perspective, it does take care of this paradox in a nice way. But when you talk to people about making improvements and when you talk to people about process control. Process control and process improvement are seen as being anti innovation, they're seen as being anti creativity. That if you're going to tell me to only make incremental improvements to a process, or if you're going to tell me to focus on standardizing a process and having process control, that you're going to move away from creativity, that you're going to move away from innovation, that is in some ways, attention that has to be managed by leadership. They're the ones that have to make the decision of the kind of push that is being made toward each of these aspects of the company, whether it's going to be more innovative, or whether it's going to be more focused on simply improvements, and there's some balance that has to be maintained there. Not to say that every company can be like Toyota and manage this organically, sometimes you need two different types of initiatives that are working in parallel going toward improvement as well as innovation, and hopefully, there's some connection between these initiatives.

Lesson 4-6: Cycles of Knowledge Creation

Module 4.6.1: Iterations of Improvements

You've been hearing me talk about continuous improvement as being these continuous cycles of improvement. That it's iterative that you start from a certain spot, you do some things, then you go back to that spot and start again. That there's some kind of either a PDCA. And then you go back to PDCA, and you go back to PDCA. Or it's to make and then you have a certain level of process execution that you've achieved. And then you go back and say how am I going to make an improvement on that? So it's always been the cycle of improvement that we've been talking about. So let's take a look at some some underlying theory behind this whole idea of cycle of improvement. So Juran, Joseph Juran, this quality philosopher that you may have heard me talk about earlier, gave this idea of the trilogy of quality improvement or what we have been calling process improvement, continuous improvement in all the different sessions. So what is this idea? The idea is that you start off with identifying what the customers are, what their needs are and then you develop products to fulfill those customer needs. And so you develop products to fulfill those customer needs. And from a process perspective, you have to come up with processes that are able to deliver those products. To manufacture these products or deliver the services based on the customer needs. And next what you need to do is, have standard operating procedures in place. Standard work in place. We've been talking about standard work quite a bit. Standard work needs to be put in place and make sure that the process stays in control. You can think about this from the statistical process control perspective, you can also think about it from the point of view of poka-yoke, or mistake proofing mechanisms. Or things that need to be put in place to make sure that the process is performed exactly the same way whenever it's being performed and whoever is performing it. So that's the idea of quality control. That's the idea of process control. That's the idea of standard work and

being able to implement standard work exactly the same way. Therefore idea of improvement is to use the standard work as a baseline. And then make improvements to the process is to deliver critical to quality characteristics to customers in a better way. And then finally when you get through the idea of improvement, you go back to making further improvements. So you plan for additional things that customers expect, you can think of this as cumulative capabilities. You can think of this as new order winners that you want to give customers. So you've reached a certain level of performance, now what? Well, now you go and find out what else can you do for the customer or what else is the customer expecting? What are competitors doing that you want to offer to the customers that you haven't been able to offer yet. So those are things that you do from point of view of going back to planning and saying, what else can we give the customer? What next, what else can we give the customer? How can we get better at cost, quality, delivery, flexibility? And all of those order winners and qualifiers that you can think of. All of those canon needs that you can think of, dissatisfiers and satisfiers and things that customers might become excited about, that can excite customers. So you can offer more when you've reached a certain level of performance.



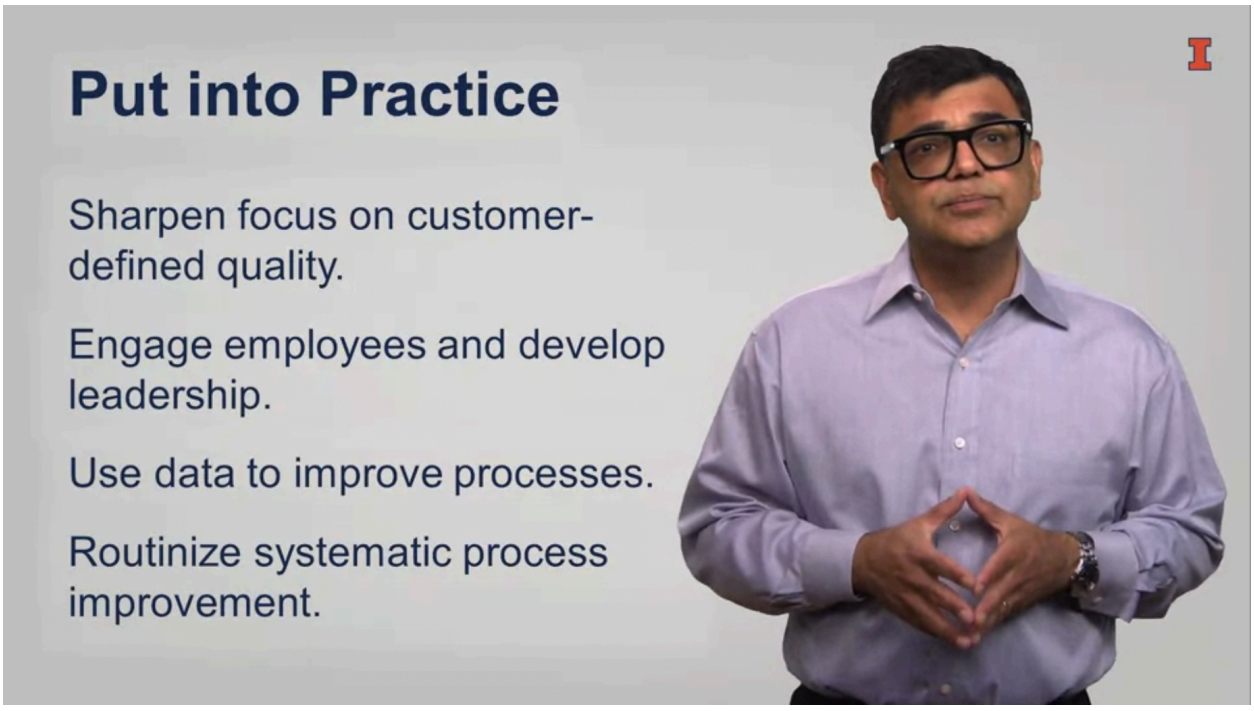
Putting this in the form of a picture, this whole idea of the Juran trilogy, here you can see the idea of process control. So on top you see this band of original zone of quality control. And there the notion of statistical process control. So you have an upper control limit and lower control limit and you try to control the process over time within those. That's the capability of your process at this current time when you haven't made the improvement yet. And what you're doing there is you're saying I'm going to look out for these what are called sporadic spikes in this case. So if there's something that is unusual, you'll try and find out what is the root cause for it and and try to make sure that doesn't occur again. But what you're trying to do in that idea of process control is you're trying to minimize the occurrences of such sporadic spikes. When you have established that level and you're able to maintain it over time, you start to think of improvement, you make an improvement and you reach a new zone of quality control. So when

you see at the bottom is this band of new zone of quality control. And what we're talking about there is not just that it has moved to a lower level of defects, but also that the variation has gone. There's meaning to the idea of that band becoming more narrow, of that band becoming narrower. The variation in the process has actually gone down when you've made an improvement and that should be the idea. So this is just a schematic of what you should be thinking about. And then if you can draw an arrow from the new zone of quality control, going back to the idea of improvement. So now you go back to saying this is our new level of of quality with additional features that we're offering customers. With additional thinking things that we're offering customers then that becomes our new current quality level. But now we're offering other things, so we can make improvements for those. So here we have this notion of a trilogy of managing quality, controlling quality and then improving quality. And the three steps being done in an iterative fashion.

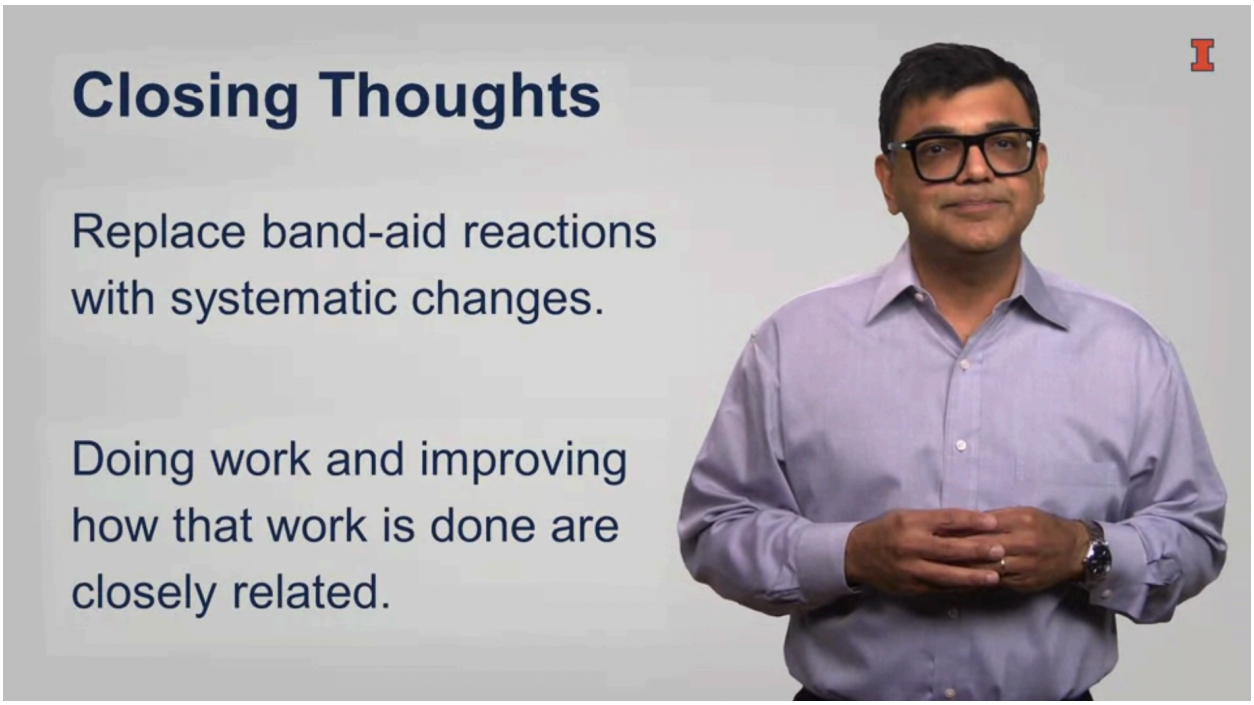
Lesson 4-7: Course Conclusion

Module 4.7.1: Course Conclusion

In this course, we focused on organization level initiatives for continuous improvement, mainly Lean and Six Sigma on tools for program level decisions such as project selection, and on process, and project level techniques such as fishbone diagram and statistical process control. The four modules, in this course we're on the principles of quality management, continuous improvement programs or initiatives, measurement and analysis using quantitative data, and discovery of improvements and implementation of changes.



By going through the four modules in this course, you are now equipped with frameworks and techniques that you can apply in your own work and in your organizations. You can work to elevate the importance of good quality and focusing on quality at source, affecting decisions for purchasing materials, selecting suppliers, training employees, and treating errors as learning opportunities. You can help create an infrastructure for a process improvement initiative based on templates offered by programs such as Lean and Six Sigma that you have learned about. Such an Infrastructure will give employees a path to engage in improvement efforts and provide them with opportunities to develop their leadership skills, by leading process improvement projects. You should be more comfortable with the use of Data to assess processes. You will find that you can have more informed conversations with data analysts. Speak their language and make them understand yours. You will recognize, even anticipate the challenges in implementing improvements and managing change. On a side note, for those of you who are already engaged in process improvement initiatives, who are applying the things we have talked about in their daily jobs. I hope this course has provided you with a more systematic perspective to do the things you already do.



In closing, I would like to leave you with two ideas. Move away from band-aid reactions and ad hoc changes. Instead, adopt root cause analysis and systematic changes. Remember that doing work and improving how that work is done are closely related. Thank you.