The Teacher-to-Teacher initiative was created by the U.S. Department of Education to provide the latest strategies and research on educational practices that work in the classroom. This series features teachers from across the country presenting techniques that can be used with students of all ages. It's just one way the Department of Education is helping teachers get the support they need so "No Child is Left Behind." (MUSIC)

My name is John Snodgrass. I've taught mathematics in the Cleveland area for about 34 years. I'm currently employed as a math teacher for Fuch Mizrachi Day School. It's a Jewish day school located in University Heights Ohio. The parents who send their students to Mizrachi are committed to quality education for their sons and daughters. I've taught math for about 37 years, and among the courses that I taught was advanced placement statistics. I was a math teacher in a suburb of Clevelend – Beechwood, Ohio. I taught the AP statistics course for a number of years and my presentation has its roots in those classes. I would like to offer an alternative approach for processing and analyzing data that doesn't require complex statistical formulas. Rather, I would like to suggest a graphing approach that will enable us to generate information about what's happening in our classroom. The presentation will begin with about a 15 to 20 minute powerpoint rationale for using this graphing approach. And then we'll spend the rest of the time exploring these techniques and some related concepts, using the packet of worksheets that are in your binders that accompany this – I think its tab 32. If you have questions at any point in time, please, if I don't see your hand, just call out John, please. And if there's something that you might not understand because I've spoken too quickly or I have a tendency to lisp, let me know, please, and I will be glad to repeat it. Educators are constantly asked to turn data into information, and data could come in the form of state proficiency tests, national achievement and ability tests. If you're operating at the middle school or secondary level, you know how important SAT's and ACT's and PSAT's are. I've learned a lot about the national assessment of educational progress. There is a presenter at each of the workshops who has – I've learned a lot from her. It results in a national assessment of skills at the 4^{th}, the 8^{th} grade and at the 12^{th} grade level. We have that data. We have diagnostic tests and assessments, either teacher-prepared or commercially prepared, and, of course, Ohio is now in the process of implementing a high stakes graduation test. So we have to deal with data all the time. And we are also, we collect data through our classroom assessments, discipline records, attendance records, schools look carefully at graduation rates, and then there is a demographic data, like gender and ethnicity. We are inundated with data, but this doesn't mean that we necessarily have information. We're a workshop here. I want to take just a moment to take a step back to where I would start if we were in a course. We will be discussing variables, like how many CD's a student has, and the data would result in numbers. Someone might suggest, I was surprised, 650 CD's for a high school student. One might ask about ask about where one student's grandparents were born. That would be a different type of data – that would be qualitative data. There are really two branches of data. If you start with variables

– things we're interested in like number of siblings a student might have, or the height to which grass might grow in a research plot. Some of the variables will result in numeric data, and some will result in what I would call qualitative data. Gender, ethnicity, color of eyes, the types of trees we have on our school campuses – those are all qualitative data. Now we're going to come back to these. There will be an opportunity for us to discuss these, but most of the data that we collect is numeric in origin. And if we have to report to a department chair, for example, we would summarize our test scores or other types of evaluations with numbers. We'll be dealing basically with numbers, and therefore, if you will allow – although it isn't entirely true – for the purposes of our workshop, data are merely numbers. We're going to turn that data into information. In order to do so, we're going to have to organize the data, describe the data, and perhaps interpret the data. In our school – Beechwood High School – our principal would examine the grade distributions at the end of each semester, and perhaps make some statements about that. If you have a part in establishing the composition of classes for a subsequent year, you might look at the end-of-year assessments in the 4th grade to help the principal, or whoever's in charge, a counselor, devise class lists for the next year. So we do have to organize the data, and when we organize it we'll probably do so with a view toward the number. So we're going to say, for the purposes of our workshop, that data are merely numbers. Would you consider the following? Now over the 37 years or so, I've had students with most of these first names, however, I did take a little bit of license with Zoltan. – I've never had a Zoltan. I've had students whose middle name was Otis, one Iyauna, and Nuran – never had a Nuran as a student – but, typically our data looks like this. Let's suppose these are test scores – and I did manufacture the data. It looks like this basically doesn't it? What's the basic feature of this particular set of data? And it's not individuals, I've anchored it to an individual – individuals are very important in what we do in our life's work. We really have to concentrate on individuals. But, what can you tell me about the data? Pretty typical. Excuse me? I'm sorry? I hope it's not out of a hundred. No, I don't think – we'll say it was out of 40. A wide range, exactly. What are you concentrating on though. The names are alphabetical. The names are alphabetical, but we're looking at the numbers. The minimums and maximums. Exactly, and we are focusing on the numbers. But, typically if you get the results of a state test for your classroom, aren't the scores arranged alphabetically? And you might see, by student name, even if, and they might come to the entire school system organized alphabetically and typically that's the way we organize our gradebooks. But when we summarize the information, we'll generally summarize it with a number. Wouldn't that be a fair statement? So we really should if we're going to organize and describe and interpret, we really should arrive at some numbers. We could compute a mean and a standard deviation of the class. It might be not appropriate however. And of course software does do that automatically, and we could compute it. A mean is a pretty simple number to compute. But, do you remember the formula for the standard deviation? Probably not – probably not. Well, some educators are not comfortable with algebraic operations that would be required to compute these things. And, even if you were, I might find it difficult with a summary set of numbers such as the mean and the standard deviation to discern any real patterns. For example, if you have a class – let's say an algebra class – and you gave a test and the mean were 75, but the standard deviation was 0 – compare with the class where the mean were 75 and the standard deviation were 10. Well, those are nice numbers, but can you get a good picture of what's happened there? Probably some can – some might be comfortable – but others might not be comfortable. So even if we had these summary numbers, we might not be able to interpret the set of numbers. We might find it an abstract, and maybe a not too productive a process. And we would be adding numbers to sets of numbers, which I don't think we want to do. I'm going to suggest that graphical data analysis techniques are a different way to manage data. And, to accommodate the large amounts of data that we get, if we could possibly become comfortable with these concrete and user-friendly data analysis techniques, I think we would be able to organize, describe and interpret data and perhaps it would have an impact on how we organize and what we do in our classes. That's what I'm going to suggest we're aiming for. The techniques, in order to be productive, have to provide the opportunity for educators to gain insight into student performance, and to translate this insight into improvements in educational experience. Again, we don't want to generate numbers if we're not going to use the numbers. And hopefully in our life's work, some of us its been a long life already, for some of you you're just starting, embarking on your careers, but we hopefully want to improve the situation as best we can. And the No Child Left Behind legislation asks us to look at adequate yearly progress. It's a very important concept in the No Child Left Behind legislation. I think it's an important initiative. So if we can use our data to provide for an improved learning situation, I'd say we've really accomplished something. Graphical data analysis methods are ideal for this purpose. They provide us with concrete and clear and powerful exploratory techniques. Now, these are truly exploratory techniques.

These are not designed for us to engage in inferential statistics – these are exploratory techniques that we can use to organize large sets of data, or small sets of data. And once we've organized, we can describe the data and perhaps interpret the data to get meaningful representations of our building and, of course, our classroom realities. And once we've done so – once we've created these visual displays, perhaps we can provide a few summary numbers, such as a mean, if it's appropriate, or a median, or perhaps an interquartile range, and add depth to our analysis – to our understanding of the data. There are some good rules. Do any of you happen to watch – and this might be a regional thing – the New Yankee Workshop, with Norm Abram. Well, Norm always says – and I would like to be able to create some of the things that he does. I'm really, really left-handed. I can't do a lot of that, but I can appreciate what he does. And he says "And before we start on our project, we have to remember shop rules – we have to wear our safety goggles at all times, and we have to read the directions before we operate the machinery." Well there are some good rules to creating visual displays of data, and manipulating data. One – we should organize the data numerically, because our summary numbers will result in ways of communicating what's happened in our classroom to other people. If we are comparing two or more sets of scores, we should put the scores on the same scale. Otherwise, it could be somewhat deceptive, and we should never, ever attempt to distort or engage in deception when we're examining data. And, when graphing test scores, make sure that the visual displays an honest and undistorted representation of numerical test scores. The two strategies that we discuss today are supported by some software. Your electronic grade-books may give you the capability now of clicking on a column and creating a graph of that. They might not support though – some software does not support a stem-and-leaf plot – that's going to be our major focus today. Most educational software packages will compute means and standard deviations, but we're going to look at stem-and-leaf plots, and what I call dot plots. And neither of those graphing techniques, while they're very easy to accomplish by hand, they might not be available on certain software. If you have software available though, if you think that one visual display does not adequately represent your data, you could present your reader with multiple displays and ask your reader to critically look at each of the displays and decide which would be better or perhaps a best representation. And of course if we're creating these visual displays, we want to use them, please make sure that you provide labels and titles and other information that will make the display complete without a narrative, because frequently we'll look through a manual and we'll see a graph and we might not read the narrative, so it should be clear just from what's on the graph. Date everything, if we give a test – I was speaking with a young teacher who works in Southern California – she said at the beginning of the year the 7th grade – and there were several sections in a large middle school. The seventh grade students were given a math test, the scores were recorded for her students – many of whom were students with learning disabilities – and she wanted to, at the end of the year, show some way of providing encouragement to her students because the scores had improved so well. And the stem-and-leaf plot technique that we're going to discuss today she said she was going to go back and immediately create the stem-and-leaf plot, but she would have the original data – you have to date it – for the fall and then the new data, just so that no one is confused by what's being presented – provide your name – if the data are good of course you want to take credit, and if they aren't so good you still have to take responsibility. Identify the source of the data – be as explicit as you can. You could say "John – 7th grade social studies class in such-and-such a school." And whenever possible provide your audience with a context for the data – points of comparison, either with scores from a previous year or from another class, or before-and-after tests because – and this is on the next slide – please note that data should not be viewed in a vacuum. We're going to talk about two graphing techniques. But focus on stem-and-leaf plots. Stem-and-leaf plots are particularly useful and user-friendly data analysis techniques. We can explore the data graphically as opposed to numerically and hopefully make meaningful instructional decisions based upon the information that derives from the data. This technique was developed by John Tukey, worked for Bell Labs, and is promoted by the Quantitative Literacy Movement. And I ought to mention that in

1989 and again in 1991 I was fortunate enough to attend a workshop sponsored by the National Science Foundation. This is one of the books in a four-volume set. It is still available through Dale Seymour Publications. The 1986 publication – at least this one – it might have been updated. And you'll find if you're comfortable with what we do today, you'll find some other techniques that might be appropriate for other sets of information – very readable, very manageable. And we use these same techniques, again, in an advanced placement statistics course. Stem-and-leaf plots have appeared on standardized tests on ACT's, on state tests, they appear in algebra text books, and in elementary school math text books, and perhaps there are graphs in science text books which uses technique – very, very powerful technique. John Tukey developed this. In the same volume, in the preface, to *Exploring Data*, Dale Seymour Publications, Landwehr and Watkins point out that exploratory data analysis techniques like stem-and-leaf plots are designed to help professionals reveal perhaps unexpected "patterns and surprises" within the sets of data. And we're going to start with dot plots – Landwehr and Watkins call them line plots – I call them dot plots because the menu on the software that I use when I pull it down says dot plots and they use a dot to represent each data point. We won't have to do that. Find if you will please in tab 32 the handout packet. We're going to work through – I hope we're going to work through – a series of activities that will allow you to be comfortable with this and perhaps I hope show how powerful these visual techniques can be. Tab 32 – and it seems formidable – there are 22 pages, but it goes rather quickly and we'll be doing this together - activities and discussions that hopefully will allow us to explore two techniques and some other concepts and hopefully convince you of how helpful these can be. Remember that we're going to turn data into information, and we'll do so using a 3-step process of organizing the numbers, describing the numbers, and interpreting the numbers. And if you would find with me page 2 please. Let's suppose that we have this set of numbers and suppose these are the result of a set of test scores, which there were 10 points possible on the test. And providing a little more information – but not much more information – suppose that these numbers represent the items that a student got correct. Not the number wrong – but the number of items correct – and if we wanted to add a little more context to this – what if this were a math test whereby the teacher was trying to determine whether students could compute the circumference of a circle – a little context to this. What can you tell me about the data. Now there are no names attached and remember – I review this in my mind all the time – we're really concerned about students, but when we summarize data, we will do so probably by the numbers. What can you tell me about this 10-point test – not too much else disclosed here, assuming that the scores represent the number correct, what can you tell me about the data? Zero to 9, very good. Only four had 60% or above, very good. There is some variation among the scores. Can you see a pattern at this point? Inaudible. Maureen made a comment, that the students failed and I think that's a comment that would be a natural comment to make – seems to be. Remember that data do not occur in a vacuum however. What we're going to do – we're going to organize this. We're going to use a graph – the graph that we're going to use is called a line plot, or a dot plot – I'm going to call it a dot plot again – that's what my software calls it. Depending upon the textbook that one might consult, or the software that one might use, it could be called a number of things. But I think you'll see that it's so easy to complete by hand. At that bottom of page 2 is this number line. Clearly each of these demarcations represents the score of 0 correct, or 1 correct, or 2, or 3 up to 10. And while we're not going to create the graph on this page, we're going to use the next page. I want to show you something that I think is important. We're going to basically create a vertical scale – notice that there are multiple two's and ones's and in order for our graph to have meaning, I'm going to create a vertical scale – and I've worked with the data a few times before – I know that there was one number where there were four instances of that number, so I'm just going to mark at almost equal intervals, a vertical scale where I could plot a first point, and if there's another zero, a 2nd point, so it will be uniformly placed on the graph. We're actually going to compute the graph on the next page. So if you would turn with me, we're going to construct the graph on page 3. So if you would turn with me to page 3 please, let's construct this graph. In one of the workshops some of the participants were very familiar with the techniques and I don't want to burden anyone with taking too much time with the graph. So what I would like to do here is to ask you to work through this with people at your table and with me and we're going to go – not too quickly – let me show you how I'm going to proceed. I'm going to plot a 9 – a score of 9 – at the one level – I'm going to use a dot. If you prefer using X's or any other character, that is fine. I'm going to proceed down the list, going down each column and I'm going to mark off the number as I go along, so that I won't record a value twice. That's a zero, an eight and a one. We'll do the next column together, because I think in the next column we'll see what that has to do with this one – it's a repeat value, so stack it at the 2nd level. And then we'll complete the graph, if anyone has a question please let me know, and if I've made a mistake, please let me know right away. I'll tell you, and I'll blame it on trifocals, but I probably just will have made a mistake. And there's our dot plot. Of course, software produces things that are a little bit nicer, so if you would look on page 4, there's a software-completed dot plot and it looks very much like the one that we made by hand, and it didn't take a very long time at all. And we've got this visual display. Remember, we're going to organize the data – the numbers, we're going to describe the numbers, and then we're going to interpret the numbers – our descriptive activity. And just as Maureen pointed out, range was from zero to nine – these people would have scored at 60% or above – a lot of students scored in this area. So let's see if we could describe. Now, we've organized. Besides the range being zero to nine, what else can you tell me about the scores? Remember it was a 10-point test. I have a question… you didn't say whether this was the number right or the number wrong. I did mention that it was the number right, but we didn't have a lot of other information. Suppose this were the number of items right on a 10-point test. And you're right – it's very abstract. So we can develop facility just for the, and we'll have more context to some other data sets later. (MUSIC)

(MUSIC) Did any score a perfect score? If you were to guess, if another person were to take the test, what score would you guess that student would earn? 3 – 2 or 3. A lot of students scored a 2 or 3, so there's a pattern here. And we can look now at the data – we've organized it. And I think you've described it very well. Now, Maureen said that four people scored 60% or above, but you might also say – how many people took the test? Twenty-one – 19 out of the 21 scored 6 or less – you could describe it that way as well. We've organized – now we're going to describe. And I think you've mentioned everything. And I sat around with a group of teachers and my wife, who also does teacher training in the city of Cleveland, and we came up with these descriptions. There are 21 scores, the range of numbers from zero to nine, no one had a perfect score – I think you've mentioned everything that we could have to describe it. Now we have to interpret this. And I would like to suggest in an interpretation, because there wasn't a lot of context provided here. What if this represented a pre-test, as opposed to a post-test? It would change things a lot wouldn't it? Now, the 8 and the 9 score – I don't think it would change a lot. But wouldn't you, perhaps in your planning, allow for some enrichment-type activities. And maybe the person who got the 9 was a number fact error – something really trivial. And you'd look at the paper. Perhaps those individuals who scored the zero or the one's, you might do some pre-skill review before you did a large class presentation. But, this context – remember data do not occur in a vacuum. If it's a pre-test, I think we have a little bit of work to do, but we have a plan. If it's a post-test – oh, rats! Then we have to re-teach, revise, find new things, maybe show how one could arrive at an estimate of the answer, just a whole bunch of things – but it does make a difference whether it's a pre-test or a post-test. Let's suppose we could record those here. I think that if you reflect upon this later, I hope you give it a little bit of consideration. You might want to record what happened – how you would interpret these scores if this were a pre-test, as opposed to a post-test set of scores. But let's suppose – on page 7 – that we now confront another situation. The line plot – or the dot plot – is really very helpful for organizing numbers if the range of scores is small. We had a 10-point test, and we created our number line. We had a zero mark, a one through 10 – 11 units long, because there was a possibility of a zero and also a possibility of a 10. What if your test has 20 points on it? Well, a line plot is still pretty good and normal class size is 20 – if we're fortunate between 15 and 20 – but 20, perhaps 25, and if you're some accelerated secondary courses, I wouldn't mind having up to 30 students – it really wouldn't make any difference. And you could plot those scores on a line plot. But now, let's suppose that the test itself has 100 points on it – it might be a unit test. If you're creating a number line to plot those points, I think I estimated that there were 50 characters, including spaces, in this top row, so you're going to have to have a number line that would be twice as long as that top row of text, and if you only had – and we're going to consider this set of scores – if you only had 27 students in a class, then those 27 scores could get lost among those 101 places along that number line, and you might not see any patterns. But we're going to consider our 2nd approach – this is our main focus today for our graphical display. We're going to create a stem-and-leaf plot – a little more context here. Suppose these 27 scores represent 50-point end-of-unit social studies test. And let's further assume that this represents the number of points earned – that is the number of items that the person got right. A 50-point test, again, with 27 scores, the scores – the dots – might get diluted along the line that would be that long. Our stem-and-leaf plot gives us the opportunity of using 10-point intervals. And we're going to explore that, but first we have to define what will be a stem and what will be a leaf. Let's take a look at the data – remember it's a 50-point test. It was an end-of-unit test – there's no ambiguity here. It was a social studies test. We're not given too much more information. Tell me, please, what you note about the data? Are we looking at that or looking at this? Ah, before you get to that. There's some variation in the scores, wouldn't you think? Can you detect any patterns at this point? Probably not. But what can you tell me about the numbers? For example, there was a 29, a 47, a 14 – what can you tell me about those numbers, please? Some very high scores. A perfect score. And just about the numbers themselves – how many digits. Two digits, except for? One. Exactly. Normally – and for those of you who are math teachers – six is a single digit number. It is a single digit number, though a lot of word problems say "Suppose you have this single digit number. Six is a single digit number, but for the purposes of a stem-and-leaf plot, we're going to pad the 0 right here – so we have 2 digits. In a stem-and-leaf plot, the stem will be reserved for, this is sort of backwards. Let's talk about a leaf. The leaf will be the digit in the right-most position. So the leaves in this data will consist of the 5, the 6, the 2, the 3, the 7, the 9, the 6, because it's zero, six and you can see the leaf. The right-most digits. What digits will represent the stems? Okay and what digits occupy the ten's digit for our data? Exactly – 0, 1, 2, 3, 4, 5. And we're going to create a stem-and-leaf plot, using these stems and these leaves, and once we're organized the data, we're going to describe the data and then we're going to interpret the data. Here are the stems, you can see on page 8. Here are the stems. We'll draw a vertical segment to the right of this, we'll draw this vertical segment. And then we're going to begin to code the leaves. And here's how we code the leaves. Now the nice thing about overhead projectors is that I can put this data right here and I'm going to show you – I'm not going to go through the whole thing as such, 'cause it's already done. But, I'm going to show you how you would code the leaves on the appropriate stems – and I'm going to start right here. This is 25 – here's the stem 20, here's the 5. And of course here's 16, there's the one, here's the six. 32, 33, 47, 29 – here's the first 50. Here's the six with that artificial zero padded in ten's place – here's the six and here's the 44. Should I go for another column? Is this clear? Se, we would continue coding the data and here would be our stem-and-leaf plot – takes less than a minute for these 27 pieces of data. I must tell you that when I give a test – and I do teach high school – I have a window by my door. I'll generate the data by hand, because the software on the electronic grade-book doesn't create this and post it. The scores are anonymous. The students will invariably stop by before the end of school and say "I want to look at all these things." And then the next day when I return the tests, the discussion is more contained. Students will locate their scores in the stem-and-leaf plot and perhaps provide me with some explanations as to why – and we always like to see these –they will say I really studied a lot, and perhaps with this score – this is contrived data – I would hope no one would get a six out of 50 on the test, but it is possible perhaps. We get a lot of students who move into our area for a year or so and some come without any English skills. We had one student from Taiwan whose English was so rudimentary that we had an interpreter in the class who was a math major. She took the notes, translated for him and after about 3 months it was remarkable. He was able to participate in class – it was just remarkable. But that might be an explanation for the six. Now, clearly, some of you, I'm sure, would ask "shouldn't we put these in order?" Now this is the first one, and that might be a refinement of our graph if we were then to take the stem-and-leaf plot and put the leaves in order. Clearly in the zero – this is on page 9 – we would have the six as only one score there, we would make this four, six. And that would allow us to perhaps perform other statistical analysis on our data, once the data are in order and it's a very, very simple thing and it doesn't take a very long time and you'll find, if you look on page 11 – not page 10, but on page 11. Some of you have already found it. You'll find the organized stem-and-leaf plot. And on page 11 there is also a suggestion as to how else we might organize our stem-and-leaf plot. Remember by hand this takes less than a minute. A lot of software doesn't support it, but it's a very powerful visual display. For example, and this is what we're going to do soon, we're going to look at this as a distribution, and as you can see I think we will be somewhat encouraged by the scores here. A few people didn't do so well, but as we get toward the high end of the scores, I think our data suggests a pretty good mastery of this material. Here's another way of quoting the very same data. If you have a large number of students – perhaps you're combining several classes or for a whole grade level – these rows in this orientation, or columns if you turn it sideways – could become pretty long. So you might want to break down this data into lower single digits, upper single digits – lower teens, upper teens – lower twenty's, and here you can see because there were very few scores down here. Upper twenty's of 25, 26, 27, 28, 29 – lower thirty's, upper thirty's – lower forty's, upper forty's and of course fifty's. Now it doesn't do too much, and I'm going to use this term, to the overall shape of the graph if we smooth this out. There's a high point here, and again we don't dip down to these valleys here, but the shape of the curve, and we're going to talk about curves, if you're a secondary school teacher you might have students who approach you, either the first day of class or after the first test, and ask "Do you grade on a curve?" and I will say "What curve?", because there are a whole lot of curves that one can choose. I happen to think – do you recall a few years ago there was a rather controversial textbook published – The Bell-Shaped Curve? And we frequently hear about normal distributions. And we're going to talk about distributions. But when students ask me "Do you grade on the curve?" Again, I will ask them what kind of curve. And the stem-and-leaf plots actually allow us to begin to look at curves or distributions. Now distributions, mathematically, have some pretty complex integral formulas. But in terms of visual displays – a synonym for distribution would be shape. And we can look at these shapes – begin to look at these – and begin to discuss a fairly sophisticated statistical concept of a curve, a shape, a distribution – and they have names. But after the first conference in Denver, I learned that I had to make a revision. So, your page ten is going to be replaced by another page ten and we're going to do a couple of things. I went to several workshops in Denver and then in Portland and there's a concept that we have to discuss part of the No Child Left Behind legislation and this gives an opportunity to look at the qualitative data. So if I could ask if you could take a couple and pass those back. One of the first questions that came up, and I hadn't thought of it, because you know I planned this, a teacher asked me, at the end of the first session in Denver, "Will you put something different on the graph paper than you put on the plain paper?" And I explained no, I wouldn't, it's just that I'm really, really left-handed, I wear trifocals, and I don't make numbers or dot that's of uniform size, and it really helps in analysis if you make your numbers of uniform size, so I generally create the stem-and-leaf plots on graph paper – it simply helps me. And, of course, it also gave me an opportunity to remind you that one of the rules – you should provide a title, and we could say here Post-Test Social Studies. And I've traveled a bit this summer – is this the 14th or 13th – 13th of July – this is a little bit of information I need to remind myself about, and I think I'm this person, and you can see I'm really left-handed, and I'm going to say this is 7th grade, 6th period social studies. And, of course, we would begin to graph the data. The data are already graphed for us, but permit me to record this here so that if you review this information later you'll know why there was a piece of graph paper here. Now we're going to use the bottom part. The uniform size of the squares, I think, helps improve my graphs an awful lot. So I generally do stem-and-leaf plots on graph paper, and it'll look like this. Now there's one other thing I want to suggest. The data – you could graph any type of data here – if you had permission from parents, you could take students' temperatures, and you could plot the normal temperature of a student. Someone would make the assumption the students were healthy on a particular day. My normal temperature is 97.6 – a little lower than 98.6 – and other people's normal temperature will be different. And it probably is the case for large populations that normal temperature is normally distributed – it's not the same for everyone – it really isn't. You could graph any type of data on here, but you should provide a key. And I'm going to say I'm going to choose this for the data – I'm going to say 4/4 represents a score of 44, and you could say on a social studies test, because if there were decimals in your data, it wouldn't be clear from the stem-and-leaf plot, but you can easily use decimals in your data for sure. I'm going to suggest that one of the things that you could do as a follow up activity when you return to your workplace in the fall – and this is interesting – I like to learn a lot about the people I work with. You could ask 30 or more colleagues how many miles they commute to work each day, and you could have it in miles and tenths of a mile. And you might be surprised to discover how many people live right around the corner and how many people drive 30 or 40 or 50 miles. Now it depends on where you're from. If you're from Wyoming, perhaps that 50 mile figure wouldn't really be very unusual. If you're from the Cleveland area then it would probably be highly unusual. But you could examine the data. We're going to use the bottom part of a revised page 10 to look at this notion of disaggregating data.

The No Child Left Behind legislation requires us to look at 5 ethnicities qualitative variable. At income level, the way it's described could be quantitative, but probably qualitative, or at least ordinal. Whether a student is a special education student – a qualitative variable. And a stem-and-leaf plot provides us a very convenient way of organizing data and disaggregating it at the very same time. So if you will imagine this – and I made up this set of data – but I provided a gender code, a qualitative descriptor, along with number. B stands for boy and G stands for girl, and let's suppose these are the scores on a 30-point quiz, given at the end of an earth science unit on sources of energy. We come from cold country so I'm always interested in sources of energy. We're going to create a stem-and-leaf plot and we're going to practice now, using intervals of 5. So I'm going to, about right here, draw a vertical segment – I hope you'll do the same – and I'm going to record 0, 0, 1, 1, 2, 2, and 3. We're going to have the lower single digits, the upper single digits, the lower teens, upper teens, lower 20's, upper 20's, and if you scan across here you'll see that there are our 30's. This is a 30-point test, we're going to assume these are the numbers correct. I'm going to use blue for boys – I can keep that straight. Green didn't show up well, and sometimes I can't tell it from blue, so I'm going to use red for girls, and I'm going to code the data – stem-and-leaf plot. Now I might have to say some things out loud to avoid making a mistake, just to reinforce it, so this is 24, lower 20's in blue - upper teens, boy – girl, 24 – girl 23 – girl 28 – boy, blue, 9, that's an upper single digit – boy, 26 – boy 28 – boy 25 – boy 23, oops, wrong place, 25, 23 – girl, 29 – girl, 26 – boy, 30 – girl, 21 – boy, 25, that's upper 20's – girl, 16 – girl, 28 – boy, 24 – girl, 29 – boy, 27 – boy, 29 – girl, 28 – girl, 23 – and girl, 30. It might not show up that clearly because of the distance, but you, perhaps, can see. I'm going to put little asterisks besides the ones that would appear red. This is red, red, red, red, red – these are all red. So the boys and girls do about the same – I think so. I can see a little more clearly here that in the upper teens there is a boy and a girl. In the lower 20's there are 1, 2, 3 boys – 1, 2, 3, 4 girls; in the upper 20's, 1, 2, 3, 4, 5, 6 boys; and 1, 2, 3, 4, 5, 6 girls – and a boy got a 30 and a girl got a 30. So you can disaggregate your data by gender. Now I used gender because I think we really have addressed a lot of those issues. In the early '80's there were significant initiatives at the high school level – I'm not sure about the middle school and elementary school level – there were not enough girls, they said, in physics classes, in upper math classes, but we've addressed those problems, and I find that the classes are really balanced very nicely. Or perhaps there are a few more young ladies in a course than there are gentlemen, but it's pretty well balanced. If you had special education students and regular classroom students, where the special education students might be mainstreamed, you could for yourself – I wouldn't disclose this to the class – but for yourself or perhaps for a supervisor, you could code the regular classroom students and the special classrooms students in different colors and interpret the results. Now remember, we want to organize, we want to describe, and we want to interpret. Now if I were looking at this to interpret how well students have done on this end-of-unit earth science test on sources of energy, I would be pretty pleased with what had happened – 'cause this happens to be the type of curve that I would slide for, if I were going to test for mastery of a particular objective. We know, and if you'll look on page, I think it's page 13 – page 12, pardon me – we know that there are a lot of curves – there really are a lot of curves. This particular distribution, which I'm going to call symmetrical – you could call normal or bell-shaped curve – has received a lot of comment over the past several years. And I – please don't get me wrong – I think there are many situations where for a population under study we should expect to find a symmetric or bell-shaped curve. For example, if you were to measure the life of light bulbs – seems somewhat trivial – but the life of light bulbs is normally distributed. And it makes sense then, if you think about this huge complex, if a single bulb turns out, it would cost a lot of money to write a memo to a building staff and have one person come out with a tall ladder and change one bulb. Probably, and I've heard this described, in large plants like this they'll know how long a bulb is going to last and they'll come around at about this time, if this were the measure of the average life of a light bulb, and change them all, because by that time some already will have died, and some are about to. There might be a few that would stay on a long time, but they would be few in number. So a bell-shaped curve – a normal distribution – makes sense in that. I have a niece who is a lieutenant colonel at the Pentagon and she's involved with logistics and the Army and the other branches of service are great sources of information about waist sizes, neck sizes, shoe sizes, hat sizes for young adults. And, of course, businesses, when they stock inventory, they don't want to have a whole lot of inventory that doesn't sell, they will look at this data and it is the case that the data tend to be normally distributed. If you, and not individual small cases, but if you were to look at the patterns of arrival at classes at your school or at a university, there are a few people who come early, there are a whole lot of people who come just around the time the bell will ring, and then there are those few stragglers. I had this one young lady who likes coffee more than I. The local coffee place is on the other side of town from her home and she invariably would come to school with a very nice and fragrant cup of coffee, but always a little bit late, and we would accommodate her. She was a very, very good student and I could overlook, plus the smell of coffee just revived me anyway. So we can expect this type of curve in some things. Now we're normally dealing with small groups, not large populations, and we're doing exploratory information. But, we could still find, for example, if you were an upper elementary science teacher and you were growing plants – you could say "we're going to grow these plants for 6 weeks." And at the end of that time, 'cause you would have bought packets of seeds, we could say that those seeds were randomly selected, you might find distribution of the heights of your plants, for sure. And you could begin to explain to students that this was a distribution – a shape – of really sophisticated statistical concept. But it's a good opportunity with stem-and-leaf plots to begin to introduce these things. There is a complicated formula for this, but in this approach the shape makes sense. (MUSIC) Panhandle Area Educational Consortium

(MUSIC) Now if you were to review metrics in let's say a 5th and 6th grade class and measure the heights of your students, you might get a curve like this. And I tell a little anecdote in terms of this curve – my youngest sister was in the 99th percentile of the growth chart. She was 5 feet tall in the 1st grade, she is 6'1 ½ now. And her 1st grade teacher was at this end of the heights for adult ladies – she was 4'10", my sister was 5' tall and at the end of the year she was taller than her 1st grade teacher. But, we know that boys and girls mature physically at different rates and you might get a distribution like this. These would be the girls – I was the shortest kid in my class until the 7th grade. And there were a lot of girls who were a lot taller than I was, you know. It might look like this. This is called a bimodal distribution – or some people will call it a U-shaped distribution because of this. I like to use these as a point of contrast. This would be an appropriate place to compute a mean and a standard deviation. A mean and a standard deviation will describe fully a normal distribution. I mentioned a class where the mean was 75 and the standard deviation was 0 – everyone got a 75 – that's the only interpretation. It might not be apparent just from numbers, but that's the only thing that could happen. If you had a mean of 75 and a standard deviation of 10, that would mean, for one normally distributed, 68% of the students would have scored between a 65 and an 85 – it makes sense – those 2 numbers. Now most software computes that immediately, but if you computed a mean here, it would give you this number and it really wouldn't describe a whole heck-of-a-lot, would it? It would be this number, but it really wouldn't describe much. There are a couple of interpretations here. One – the boy and girl interpretation – you're really dealing with 2 populations – they're significantly different. It doesn't make sense to consider them together. And then that mean doesn't really describe either this group or this group. There was a young teacher, retired from the service, who was teaching physics in suburban Virginia. In his school – a pretty large school – there were 5 levels of physics. There was an international baccalaureate sequence, an advanced placement sequence, an honor sequence, a regular physics, and a section called physics concepts for students whose math background wasn't that strong, 'cause physics is really a lot of math. He said, in our discussion, that this is how his grades looked after each test, and we tried to interpret that. And he said – and we've seen this a lot – that there some international baccalaureate students and advanced placement students who were taking advanced placement courses, who were not interested in advanced placement physics, so they dropped back to the regular physics. And then there were some students who, perhaps, were advised to enroll in physics concepts, but wanted to give it a shot, maybe their career plans would have required it, maybe they just wanted to demonstrate to themselves or their parents that they could actually do that, but his grades looked like this. And it really sort of made sense. The students who, perhaps should have been in higher courses were clustered here, and the students who struggled more with the information were about here – but a mean doesn't make a whole lot of sense there. It would be better to look at a range of values and a graph – a graph would tell a lot in a very short amount of time. If you've ridden on a subway – I like to use this example because there have been studies about this – and if this were number of seconds after the subway doors open that people leave. The first second a whole lot of people got off right away, and this is the person whose shopping bag got caught in the doors, but this is how we could describe it. If you were to – and I've not done any hard research on this – but if you were to look at the number of days absent for students. Actually in USA Today in the lower left hand column of the first page, there's a graph that shows % of students who are absent for a certain number of days for a particular school year. And the data for that looked like this. There were students who were absent a few number of days, and a few more days, and then there were some students who were absent a lot of days. But you'll see the graphs and we can interpret those graphs. Now, again, we're doing exploratory data – we are not making inferences about a large population, but it's possible in some of the activities that you do in your classrooms, that you might find normal distributions, you might find U-shaped distributions. If you can encountered this in let's say a 2nd grade with reading scores, it might have some implications on how you arrange your reading groups, how you team up with another teacher, the resources that you might have – a lot of implications. So we would have organized, we could describe this as a U-shaped distribution, and we can interpret that so that it might have some impact on the realities in our classroom. I would hope that if we're teaching for mastering a standard or an objective that we've devised objectives that would be possible for all children. And I tried to – when I would graph the data – always hope to look for a distribution like this. This is called a J shaped distribution. If you're measuring to see whether your class of students that you're responsible for has mastered a particular objective that's manageable for those students, I always like to get something like this, or perhaps like this. I think that if you are a secondary advanced placement teacher, frequently the scores for the nation – not for your individual school because that would interject some bias if you are in a rural school that draws from – and we know there's a relationship between socio-economics and achievement in school – you might not get this type of distribution. But I think that when one takes the 17,000 students who took advanced placement calculus – the AP exam – you could probably look for a distribution something like this. Again we have to – I want to caution you – these distributions would be for a large group if you are making inferential statistics – inferences about the groups. If you're exploring though, they still have some meaning and you can describe the distribution as J-shaped, this represented the number correct, I could easily go, if my principal saw this he might not take issue with my semester exam. We had to look at grades before the semester exam and then semester exam grades to see whether our exam really would be supported by the data for 18 weeks of work – and I think that's a valid thing – I really do. So you could look for this type of distribution for overall achievement for 18 weeks, we assign credit on the semester and I would hope to see something like this for exam grades as well. Now there might be some variations. There might be a student who got a very high for cumulative and only got a next to really high on the exam, but we would also examine those with it's called a sign test, to see where there were too many changes one way or another or whether they were more or less random – so you can analyze that as well. But these distributions, I think, are meaningful ways of interpreting your data. And one can come up with examples of each type of this. Just a note, and I've been in the classroom for a few years. I took statistics probably before many of you were born, and before 1970 – this is called a skewed distribution – before 1970 this distribution was said to be skewed to the left, but now it's skewed to the right, and I'd like to explain why. Here's the high point. Notice – short tail, here's the long tail. The skewness is in the direction of the longer tail, so this distribution is said to be skewed to the right – used to be skewed to the left – and this distribution, if we smooth out the curve, here's the high point, here's the short tail, here's the long tail – this is skewed to the left. It's the direction of the longer tail. And actually these types of questions do appear on ACT's, PSAT's – stem-and-leaf plots are included in some of the information that students have to analyze and if a student hasn't seen a stem-and-leaf plot before they might lose some points that they could easily have secured, and it isn't a difficult graph to interpret once one has a little bit of experience with it. Well, let's suppose – there's another thing we can do with stem-and-leaf – this is on page 13 – oh, good, we have 15 minutes – this is great! Let's suppose these are the pre-test – scores, suppose you wanted to show, as that young lady from a school district in southern California wanted to show to her students, how the pre-test scores and the post-test scores vary. And one can do that very easily using back-to-back stem-and-leafs – this is page 13. I've arranged – and of course these are contrived, I made these up – here are the pre-test scores, but they're in order. And notice we're still going to use the strategy of padding these zeroes on to the left side of single digit numbers so that we would have put these in the appropriate line. I'm going to do just the first 2 rows – it won't take very long, 'cause they're in order – this would be 01, 02 – it's backwards – 03 – for left-handed people it's really nice. We now have an opportunity to show what we can do 'cause I see things backwards a lot. The 10 is the 10 and the 0 and the 1, there's a 12, and a 13, another 13, a 14, a 15, another 15, a 16, 17, 18, 19, of course 20 would go here, 22, 27 and 40, so it takes a very short amount of time. And, of course, because it's nicer to see it commercially prepared, on page 15 you'll see this back to back stem and leaf plot. And I think it shows pretty clearly that initially students scored in the single digits and the teens on the pre-test, and in the post-test, there were a lot of students who scored in the 30's, the 40's and 50's. And we could look at the distributions and it went from being skewed to the left – well, we'd have to look at that differently – but skewed in a different direction and we could see that very clearly. And if you would provide this to parents at open house, it's really powerful – takes a very short amount of time, you can explain so much, the parents pick it up in a flash if they haven't seen it before, if their sons and daughters haven't shown them how this works, and they will often know, 'cause students will have told them what score they got on the test, they say "There's my son or daughter," and it also provides a basis for individual conferences. Take the very same thing and you can say "Yes, here is where Anna scored. She's in the appropriate course. She should take honors physics next year. She seems to be doing well. Do you have any questions, call me." And it really is very, very convenient stem and leaf plot. I think it's fairly clear how one would arrange that. And again we can interpret the 20, the 22 and the 27. But on the bottom part, because disaggregating data is such an important part of the legislation, here is an alternative way of disaggregating data and it only takes a very short amount of time because in this approach we could put the boys on one side and the girls on another. So I'm going to make this vertical double bar right here. I'm going to label this side, boys, and this side, girls. We're going to practice using 5-point intervals, so I'm going to use 0, 0, 1, 1, 2, 2, 3 – this is the same data as on page 10. And I'm going to go through here – you can time me if you want – and I'm going to hopefully not make a mistake, code this data – 'cause it's easy, I can pick out all the boys at once – I don't have to change colors and you don't have to use different colors if you don't want to now. I'm going to code the 24, the 15, the 9, 26, 28, 25, 23, 30, 24, 27, 29, and the boys are done. And then I'm going – actually I'm going to use a different color – I'm going to code the 24 – that's a lower 20's – the 23, 28, 29, 26, 21 – oops there's a boy – glad I didn't cross that out – here's a 25, 16, 28, 29, 28, 23, and 30. And you can see in this back-to-back plot that the boys and girls really do fairly equally in whatever this test represents. So in disaggregating data, you could, again, look ethnicity, you could look at special education status if your school mainstreams students and back-to-back or using different colors, each technique I think will provide the same insights, please. If you were to describe the differences in the pre-test and post-test scores on the back-to-back stem-and-leaf plot that we looked at here, again, you could say most of the students scored in the single digits and the teens on the pre-test – on the post-test the majority of the students scored above – and we would have to count carefully – but clearly you could say scored in the 30's, the 40's and the 50's. You could look at distribution. It would be difficult to track individual students on this particular graph, but you can easily describe the difference in the pre-test and the post-test distributions. It would also enable us to look at programming – if there weren't much movement, we might want to see why there wasn't much movement. If our post-test scores weren't significantly different, perhaps we should review, revise, spend a little more time on that topic. Many times we've looked at stem-and-leaf plots for 2-digit numbers, but frequently our data will include 3-digit numbers. For example, if we were to look at SAT scores, we might have something in the nature of 600 – we'll look at just the math part – 650, 720, 480, 508, 780 – a lot of scores. I'm going to artificially – probably we wouldn't get these odd numbers – but I'm going to make these different values here so that we could examine what would constitute a stem and what would constitute a leaf if we were to code SAT scores for our students to see what the distribution would look like. So suppose these were SAT scores – 3-digit numbers. What would constitute the stems and what would constitute the leaves in case you have to do this. And the rule is the leaf is always which digit? The one to the right. So our stems would consist of 48, 49, 50, 51, 52 – now this might be a long graph. These would be the stems. Or it might be possible, if there weren't great gaps in the scores, it might be possible if you were looking at the entire school, to create a stem-and-leaf plot for this bit of data. What if you were measuring students' heights in centimeters? We have heights in centimeters. And suppose these were upper elementary students, we might have a 96, 123, 142, 85. If you had this data – 3-digit data – what would constitute the stem? What would constitute the leaves? Well, again, the rule is right-most digits would be the leaves, and the stems would consist of perhaps 8, 9, 10, 11, 12, 13 and 14. So you could easily code 3-digit data on using stem-and-leaf plots. And I like to use systolic blood pressure – the end of the year for teachers might be 148, 127, this person 116 – really very calm. But clearly you'd have the stems and the leaves. And you can code decimal data as well. And you can create a stem-and-leaf plot. And of these, if you have a large group, might be a normal distribution, because the test is designed to differentiate among students, not for mastery. If you recorded these, it might be a normal distribution, because things that occur in nature sometimes are normally distributed if you have a large enough group. Blood pressures tend to be, even for individuals. If you're monitoring your own blood pressure, you know it's not the same every day. Systolic and diastolic blood pressures are normally distributed. If you took enough readings, you'd probably see that. That's a nice way of looking at the data and approaching this notion of distribution. On page 18 – these are actually the scores on the Ohio proficiency test – reading scores, city of Cleveland, 4 classes that were selected and totally anonymous, October 2002. And it is the case that a score of 217 at that time would pass. We're going to, just to make sure we can read these properly. Now I counted these ahead of time. In this particular case there were 25 scores. What's the low score for this set, please? 167. What's the high score? 230, very good! For class 2, I counted these before, there were 22 students. What's the low score? 172, oh you're so very good! And the high score? 227. For class 3, there were 22 students, and could you tell me please the low score? 180. And the high score? 243. And I think there were 25 students here, I'm pretty sure there were. What was the low score? 180. And the high score? 268. Now these are all coded on the same scale because we were looking at these together. Started with the stem of 16, went to the stem of 26, notice we didn't use some of the stems here, but we want to use the same scare. And we could look at these. These two distributions – it would be nice if I could have stacked them, the four, this way – these two distributions look pretty much the same. Of these, though, if you look at the graph, which teacher should, perhaps, you think might have the most difficult job here? In terms of preparation time? What's different about four? A lot of range and you can tell that just from the graph – there's a lot of range. And there are a number of students who passed, and a number of students who didn't, but it's about equal. These teachers also have a great task in front of them, of course, because they have to address the issue that a lot of the students didn't pass the test, but the distributions are easy to arrive at. These teachers might be able to share some materials. This teacher might have a difficult task too, because notice the numbers of students here, but clearly the graphs are easy to generate and they're easy to interpret and might add some insight to the range here of scores. You might see that just from the numbers, but you might not. And since the graph is so easy to produce, I think that one can easily take the few minutes it would require and it might add to one's interpretation. I mentioned at the beginning of our talk, I mentioned that we could record the high score, the low score and the middle score. We could add a few numbers and add specificity. Now that middle score might not be a mean. Remember a mean would be useful if the data were more or less symmetrically distributed and that you can tell from the graph. Graphs provide, I think, information as to whether we should use a median, or maybe we should just record the range and find some other way of addressing this notion of a middle number – but it might add some specificity. (MUSIC) For more information or a free online follow-up to this program, log on to www.ed.gov/teacherinitiative. This broadcast and the follow-up are brought to you through a partnership of the U.S. Department of Education and the

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