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ABSTRACT

One of the consequences of Ohio's educational accountability efforts mandated under Ohio Senate Bill 55 (SB 55) and the traditional testing programs of Ohio school districts is the generation of huge amounts of data. In order for school-based educators to organize and explore these voluminous amounts of information, they need exposure to user-friendly data analysis techniques. Two particularly useful approaches developed by J. Tukey (1977) are stem-and-leaf plots and box-and-whisker plots. The first section of this paper shows how both these types of graphical representation can be used to help educators understand student test performance and the distribution of test scores. The second section shows how a scatter plot can be used to illustrate how fifth graders' 1995-1996 Iowa Tests of Basic Skills reading scores and the same students' 1996-1997 scores on the Ohio Sixth Grade Reading Proficiency Test can be segmented into intervals that indicate each student's relative chance of passing the Ohio Sixth Grade Proficiency Tests. The scatter plot also shows the probably impact that higher Ohio 1998-99 standards will have on students' ability to pass the sixth grade reading proficiency test. (Contains 4 tables, 10 figures, and 6 references.) (SLD)

Graphical Representations of Data:

Iowa Tests of Basic Skills, Ohio Sixth Grade Proficiency Tests, and SB 55

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Exploratory data analysis can never be the whole story, but nothing else can serve as the foundation stone--as the first step.

John W. Tukey (1977)

As part of its school accountability effort, Ohio, like numerous other states, has mandated that a variety of tests be administered at selected grade levels. Ohio proficiency tests, which are state developed instruments, are given at grades four, six, nine, and twelve in the areas of *reading, writing, mathematics, citizenship,* and *science*. Competency tests, also mandated by the State, are administered at grades one through eight in the areas of *reading, composition, mathematics, social studies,* and *science*. Although competency tests are required in the State of Ohio, competency tests are developed or selected locally with the intent of measuring those curricular objectives towards which the district perceives itself to be moving. In addition, many districts, like the one in this study, administer nationally normed achievement and ability batteries at selected grade levels. In this district, the *Iowa Tests of Basic Skills (*ITBS) and the *Cognitive Abilities Tests* (CogAT) are administered at grades three, five, and seven.

The Ohio Legislature has taken the position that a frequent and comprehensive proficiency testing program is the single most relevant component of holding school districts accountable for higher levels of student achievement. Beginning in the 1998/99 school year, as a result of Ohio Senate Bill 55, each Ohio school district will be rated on eighteen criteria to determine the effectiveness of their schools. Sixteen of those eighteen criteria are based on the district's student performance on the *Fourth, Ninth,* and *Twelfth Grade Proficiency Tests*. (There will be twenty-seven criteria in the future.) In a lighter moment at a regional State testing meeting, Roger Trent, the Ohio Department of Education's Director of Assessment joked that Ohio's license tags might read, "*Ohio, The Testing State*". However, the tests themselves are no joking matter, as students must pass the Ohio Ninth Grade Proficiency Tests to obtain an Ohio diploma. Moreover, in the 2001/02 school year fourth graders will have to pass the *reading* section of the *Ohio Fourth Grade Proficiency Tests* to be promoted to fifth grade (Ohio Senate Bill 55).

One of the consequences of the Ohio's accountability efforts and districts' traditional testing programs, is the generation of huge amounts of test data. In the 1997/98 school year alone, our district of approximately 4,400 students, generated over 85,000 separate standardized test scores. Unfortunately, the typical school administrator or teacher has had little training in making meaning of the steady stream of test scores with which they are regularly confronted. Typically, university classes in educational research and statistics are of little practical value in helping educators organize and explore data sets, as these courses focus on abstract and confirmatory statistical techniques like t-tests and ANOVAs. Confirmatory data analysis techniques, grounded in algebraic computations, are generally foreign and not particularly useful to school-based educators.

Worthen and Sanders (1987) emphasize that for those who are responsible at the district or building levels for evaluating educational programming, it is important that they tailor their reports to their specific audience. In order to be heard by and to make a difference with those whom they impact, Weiss and Bucuvalas (1980) note that the reports must meet two criteria. They must have both truth value and utility value for the recipients. Reports must be fashioned in a way that allow the audience, in this case educators, to find useful representation of their own reality. Educators must recognize their own experiences and expectations in the reports, as well as be able to employ the reports to improve the educational situation for their students. Clagett (1990) states that "*the challenge is to present research results in formats and at a level of sophistication accessible to top management*". He goes on to say, that "*The researcher or planning professional must devise ways of improving the odds that study insights and findings will be assimilated into the decision makers' frame of reference.(p 3).*"

In order for school-based educators to meaningfully organize and explore the voluminous amounts of data they are presented with each year, they need exposure to *user-friendly data analysis techniques*. For the results of the data analysis techniques to be valuable, they must enhance the chances that educators gain insight into reality and can translate this insight into improved educational experiences for children. Graphical data analysis methods like those developed by John Tukey (1977) are ideal for these purposes. Tukey's methods provide school-based educators with clear and powerful exploratory graphical techniques around which they can organize large and small sets of test scores into meaningful representations of reality. Two particularly useful data analysis techniques developed by Tukey (1977) are *stem-and-leaf plots* and *box-and-whisker plots*. Stem-and-leaf and box-and-whisker plots help educators graphically, rather than mathematically, explore data in ways that can assist them in making meaningful educational decisions based on factual information. Landwehr and Watkins (1986) point out that stem-and-leaf and the box-and-whisker plots are designed to help professionals reveal unexpected *patterns and surprises* within sets of data.

The first section of this paper shows how stem-and-leaf and box-and-whisker plots can be employed by classroom teachers and building administrators to better understand student test performance and the distribution of test scores, both within and between classrooms. The second section of this paper demonstrates how a scatter plot can be used to graphically illustrate how *fifth graders' 1995/96 Iowa Tests of Basic Skills reading scores* and these same students' 1996/97 *Ohio Sixth Grade Reading Proficiency Test scores* can be segmented into intervals that indicate each student's *relative chance of passing* the Ohio Sixth Grade Proficiency Tests, interval by interval. The scatter plot model also reveals the probable impact that higher Ohio 1998/99 standards will have on students' ability to pass the sixth grade reading proficiency test.

SECTION I

Stem-and-Leaf Plots

Stem-and-Leaf Plots are particularly useful to educators because they have the following characteristics:

1. They can be drawn quickly by hand.
2. They require no computations.
3. They use and retain each subject's exact score.
4. They can be used with small sets of numbers, such as the number of students in a typical classroom.
5. They show the shape of a distribution of scores.
6. They show clusters in the scores.
7. They show gaps in the scores.
8. They show extremely high or low scores (outliers).
9. They can be used to compare one set of scores to another set of scores.

To construct stem-and-leaf plots a person need only be able to engage in the following quantitative activities:

1. Users must be able to read numbers.
2. Users must be able to identify place value.
3. Users must be able order numbers from the lowest to the highest value.

The set of test scores in *Table 1* are a set of ITBS Reading percentile scores obtained from Ms. Jones' class of twenty-five fifth graders during the 1995/96 school year. As is generally the case with test scores which are returned from the scoring service or test scores which are placed in a grade book, these scores are organized alphabetically. Alphabetically organized data rarely reveals any patterns within the data set. If there is a pattern embedded in these scores it is difficult to determine what the pattern is by visual inspection.

Figure 1 shows these same twenty-five ITBS Reading National Percentile Rank (NPR) scores reorganized into a stem-and-leaf plot. (The numbers in the stem of the stem-and-leaf plot represent the values form the ten's place of each ITBS NPR score. The leaves represent the values from the one's place of each of the ITBS NPR scores.) Even an uneducated and cursory glance at the stem-and-leaf plot suggests there is a shape or pattern to the test scores which was hidden in the alphabetically organized data set.

TABLE 1

ITBS National Percentile Rank Reading Scores From Ms. Jones's Class Which Are Listed Alphabetically

Adams	68	Jackson	36	Randell	74
Baxter	67	Jenkins	69	Ross	13
Billings	89	Klein	60	Smith	78
Carter	87	Long	51	Thompson	47
Dawson	73	Marshall	69	Turner	79
Edwards	79	Moore	26	West	47
Franklin	53	Newman	86	Wilson	69
Goldsmith	57	O'Neil	18		
Herman	9	Patterson	60		

N = 25

FIGURE 1

ITBS National Percentile Rank Reading Scores From Ms. Jones's Class in a Stem-and-Leaf Plot

Stem	Leaves	
0	9	
1	38	
2	6	
3	6	
4	77	
5	137	
6	0078999	← *cluster of higher scores*
7	34899	←
8	679	

N = 25

Scores organized into the stem-and-leaf plot in *Figure 1* reveal that within this data set, scores are more clustered at the higher end of the numerical distribution. Specifically, the scores are clustered in the sixtieth and seventieth national percentile range. This pattern of score is not readily seen in the list in *Table 1.*

Scores organized as stem-and-leaf plots have three other positive attributes. First, stem-and-leaf plots are a quick and organized method to order a set of scores from their lowest to highest value. Second, the value of each child's score is retained on the plot in a way that allows a non-mathematically oriented user to discover embedded patterns. Finally, turned on their side, stem-and-leaf plots quickly become frequency distributions. *Figure 2* illustrates how the stem-and-leaf plot in *Figure 1* can be rotated 90 degrees counterclockwise to create a frequency distribution. By rotating the stem-and-leaf plot into a frequency distribution, as in *Figure 2*, it easy to see that there are seven scores in the sixtieth percentile range and that they are the most frequently obtained subset of scores. Another set of fifth grade 1995/96 ITBS reading scores, from Mr. Smith's class, are presented in *Figure 3*, are organized into second stem-and-leaf plot. This stem-and-leaf plot reveals that a different pattern or distribution of student reading scores occur in Mr. Smith's class than in Ms. Jones' class.

FIGURE 2

ITBS Reading Scores From Ms. Jones' Class Presented as a Frequency Distribution

Frequency of Scores

7							9			
6							9			
5							9	9		
4							8	9		
3						7	7	8	9	**← leaves**
2		8		6	7	3	0	4	7	
1	9	3	6	3	7	1	0	3	6	
stem →	0	1	2	3	4	5	6	7	8	

Percentile Ranges

N = 25

Figure 3

ITBS Reading Scores From Mr. Smith's Class

Stem	Leaves	
0	489	
1	02222357	← *cluster of lower scores*
2	56666	
3	123	
4	446	
5	3	
6	0	
7		
8	7	← *outlier*

N = 25

Unlike the scores from Ms. Jones' class, the reading scores from the twenty-five students in Mr. Smith's class tend to cluster around the lower end of the numerical distribution, specifically in the ten's and twenties. An initial inspection of the scores reveals that there is a single student with an outlying score at the 87th NPR in this distribution of reading scores. The next closest score to this outlying score is a score at the 60th percentile rank. The 27 percentile point difference between these 87th and 60th NPR scores creates a noticeable gap on the stem-and-leaf plot, and may be an accurate indication of a real difference in the ability of the child with the outlying score to the other students in the class.

Back -to-Back Stem-and-Leaf Plots

Another method of constructing stem-and-leaf plots is to place two sets of leaves back-to-back on the same stem. Back-to-back stem-and-leaf plot allows a more direct comparison between the two classes. In *Figure 4*, the two sets of test scores from Ms. Jones' class and Mr. Smith's class are used to illustrate the value of back-to-back stem-and-leaf plots. Individual analysis of each set of scores in *Figure 4*, as well as a comparison of the two sets of scores on the back-to-back stem-and-leaf plot can provide educators with grist for instructional discussions. For example, one might ask:

- How might Mr. Smith approach the instruction of his single student with a score in the eighth percentile range (the outlier) differently than Ms. Jones will approach the instruction of her group of three students who scored in the eightieth percentile range? What can their principal do to support their efforts?
- Or, how might Ms. Jones and Mr. Smith differentially prepare their respective children for the *Sixth Grade Proficiency Tests* given the different ability levels of their students. How might the content and instructional activities differ in the two classes, based on the two different distributions of ITBS reading scores?

Hand Drawn Stem-and-Leaf Plots

Stem-and-leaf plots are easily hand-drawn in a matter of minutes. However, when creating stem-and-leaf plots by hand, graph paper should be used. By placing each number on the graph in an individual box on the graph paper, one retains the integrity of the scaling from number to number, both between and among the stem and leaves. For example, a cluster on the graph should always reflect a greater frequency in scores in that particular area on the graph and not numbers that are written in larger and smaller print. Distortions in scaling can lead to distorted conclusions about the patterns in the data. Tufte (1983) stresses the importance of maintaining visual integrity when engaging in any type of graphing. To ensure the visual integrity, he states, that the graphical representation of the set of numbers must always reflects the numerical relationship between the numbers in the set and not visual distortions.

FIGURE 4

A Comparison of NPR Reading Scores of Jones' and Smith's Classes Using Back-to-Back *Stem-and Leaf Plots*

Jones' Leaves	STEM	Smith's Leaves
9	0	489
38	1	02222357
6	2	56666
6	3	123
77	4	446
137	5	3
0078999	6	0
34899	7	
679	8	7

Box-and-Whisker Plots

Box-and-whisker plots are useful because they have the following characteristics:

1. They require no algebraic computations.
2. They show the exact middle score (or point) of a set of scores. *(Other names for the exact middle score are the median or the 50th percentile score.)*
3. They show the lower quartile score, or the 25th percentile score.
4. They show the upper quartile score, or the 75th percentile score.
5. They show the range of scores between quartiles.

To construct a box-and-whisker plot a person must be able to perform the following quantitative tasks.

1. Users must be able to count.
2. Users must be able to order a set of scores from the lowest to the highest score.
3. Users must be able to locate the exact middle score of a set of ordered numbers.
4. Users must be able to calculate the average of 2 scores.

Five Number Summaries

Box-and-whisker plots are graphical representations of a five number summary. Five number summaries are frequently employed by researchers to statistically describe a set of numbers, both in terms of the set's most typical score and in terms of the variability of the scores in the set. The five number summary includes the following information about a set of scores:

Five Summary Scores	Synonyms
highest score	*maximum score*
upper quartile score	*75th percentile score*
median	*50th percentile or exact middle score*
lower quartile score	*25th percentile score*
lowest score	*minimum score*

The five summary scores which represent Ms. Jones' classes' ITBS Reading scores have been identified and are listed *Table 2.*

Table 2

Five Summary Numbers Reading Scores for Ms. Jones' Class

89	highest score
76	upper quartile score
67	median
47	lower quartile score
9	lowest score

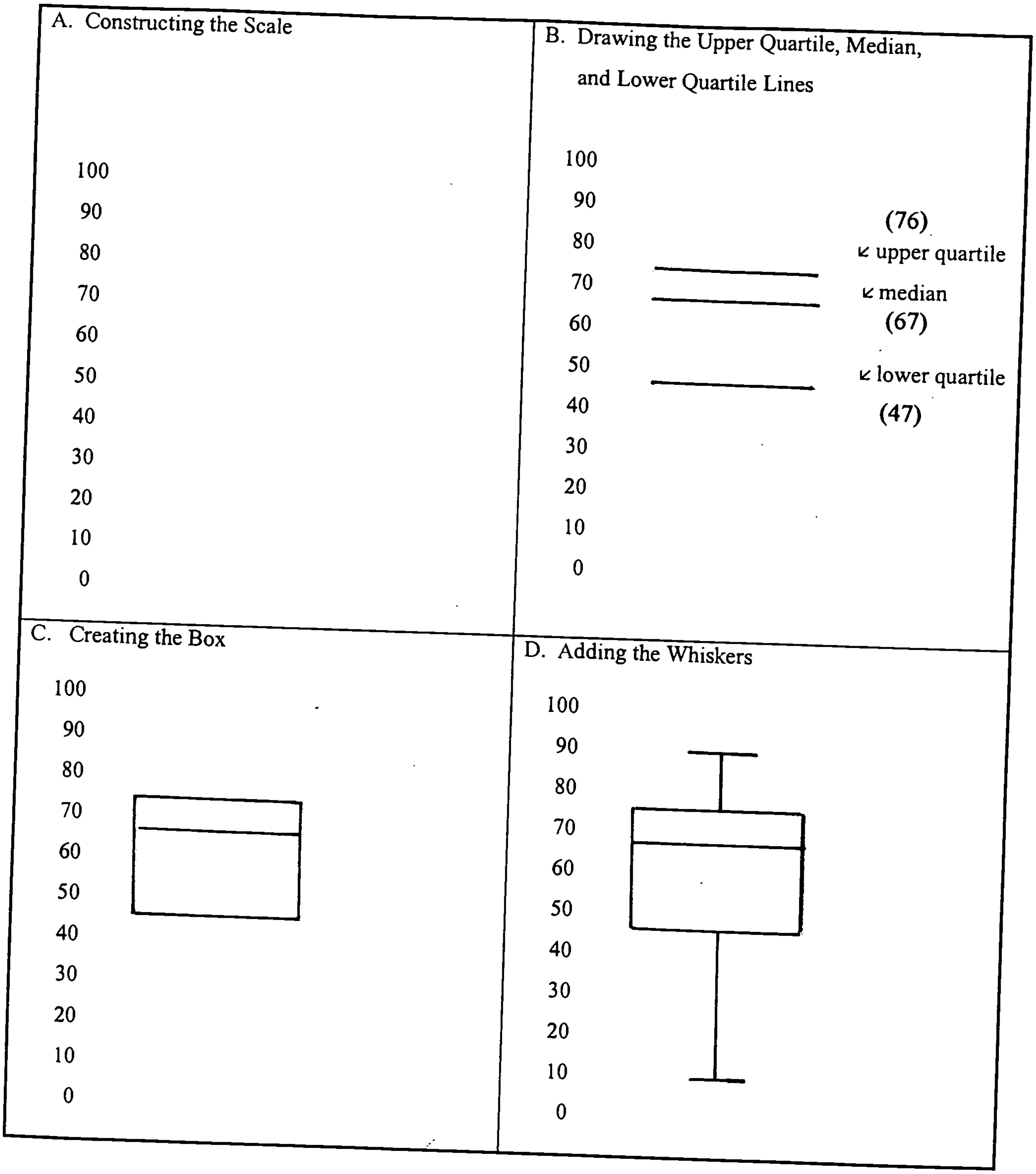
Figure 5 presents four simple steps (**A-D**) required to draw a box-and-whisker plot. In step **A.** a scale is developed. The scale should be large enough to encompass the range of scores in the given set of scores. The natural scale of percentile scores goes from the 1st percentile to the 99th percentile scores. However, a scale of 1 to 100 was selected for this box-and-whisker plot, because it encompasses the range of scores in Ms. Jones' set of scores of 9 to 89, while retaining the visual integrity of the scale by maintaining 10 point intervals along the entire scale.

The three horizontal lines, drawn in step **B** in Figure 5, represent the upper quartile score (76), the median score (67), and the lower quartile scores (47) of Ms. Jones' class. Notice that these three lines are placed on their appropriate places on the scale to the left of the lines.

In step **C** in *Figure 5*, two vertical lines are drawn which connect the three horizontal lines, creating the box of the box-and-whisker plot. Fifty percent of the students' scores from Ms. Jones's class fall within the range of this box, running from the 47th percentile to the 76th percentile. Twenty-five percent of Ms. Jones' students scored in the upper range of the box (from the upper quartile to the median) and 25% of her students scored in the lower range of the box (from the median to the lower quartile score). A quick inspection of the box indicates that

FIGURE 5

The Steps in Constructing a Box-and-Whisker Plot



the scores of the 25% of the students below the median (from the median to the lower quartile) are more variable than scores of the 25% of the students above the median (from the median to the upper quartile). The spread of the scores in the upper part of the box is 11 percentile points (from the 67th percentile to the 76th percentile). The spread of the scores in the lower part of the box is 20 points (from the 67th percentile to the 47th percentile).

The whiskers are added in step **D** of *Figure 5*, by drawing horizontal lines at the points on the scale of the highest and lowest students' scores and then attaching those lines to the box. The respective length of the two whiskers indicates the spread of scores of the 25% of the students above the upper quartile in Ms. Jones' class and the 25% of students below the lower quartile in Ms. Jones' class. The top 25% of the students' scores in Ms. Jones' class are less varied than the 25% of students' scores in the lowest ability level. As a result of the information presented in this box-and-whisker plot Ms. Jones might anticipate the need to employ more varied instructional material and methods when teaching reading to her lowest ability children than when teaching reading to her upper most ability children.

The two computer generated box-and-whiskers plots in *Figure 6* compare the relationship between Ms. Jones' student ITBS reading scores and Mr. Smith's students ITBS reading scores. Notice, that both box-and-whisker plots employ the same scale. Only when two or more box-and-whisker plots employ the same scaling can the data from one box-and-whisker plot be compared to the data from another box-and-whisker plot. Also notice how the outlying score (of 87) from the one high scoring student in Mr. Smith's class is represented by a "°". This notation is commonly employed on box-and-whisker plots to indicate an extremely high or low score. Outliers are often presented on box-and-whisker plots in this manner, as a warning that a singular high or low score exists. Of course, if one chooses to include the outlying score in the box-and-whisker plot, all that needs to be done is to extend the whisker to the position of the outlying score.

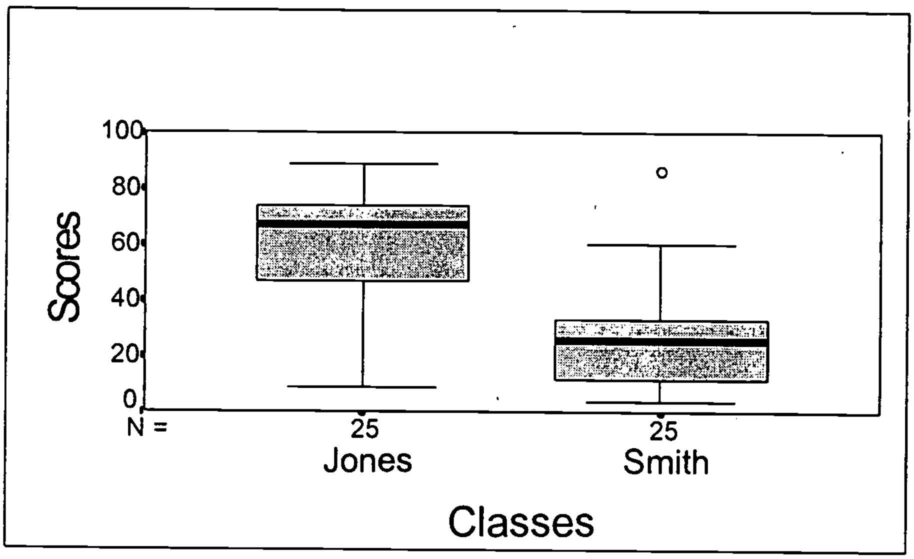
Now that the scores are plotted, a number of interesting comparisons can be made between Ms. Jones' and Mr. Smith's classes box-and-whisker plots. For example:

- With one exception, no student in Mr. Smith's class scored above the median performance of students in Ms. Jones' class.

- The upper quartile score of Mr. Smith's class is below the lower quartile score in Ms. Jones class. This indicates that at least 75% of the children in Mr. Smith's class scored like the lowest 25% of the children in Ms. Jones' class.

FIGURE 6

Comparison of Jones' and Smith's Classes
1995/96 National Percentile Rank ITBS
Reading Scores



SECTION II

Employing Fifth Grade ITBS Scores to Predict Sixth Grade Proficiency Performance As a Function of Changing State of Ohio Standards

In sixth grade classroom after sixth grade classroom, teachers are reviewing and instructing students in the same proficiency related concepts, as if all sixth grade students were in need of the same material and method of delivery. With limited funds and ever increasing student needs, Ohio school districts will have to find ways to work smarter, and not just harder. In part, the solution for our district has been to learn to make more objective, systematic, and defensible decisions about where money and time can be most efficiently spent to meet the specific needs of all children. Scatter plot, as well other types of graphical data analysis methods, can provide teachers and administrators with a mechanism for recognizing the patterns of student performance within their classrooms, which can translate into meaningful and defensible instructional interventions.

The following descriptive study is an example of how graphical data analysis techniques can be employed to understand the degree to which fifth grade ITBS scores can be used to estimate student performance on the Ohio Sixth Grade Proficiency Tests. These results can be employed to target children who are in need of differential programming in order to pass the proficiency test.

METHODOLOGY

SUBJECTS

The performance of two-hundred students from an inner ring suburban school system near Cleveland, Ohio are used in this descriptive study. The intersect of the students' 1995/96 fifth grade performance on the Iowa Tests of Basic Skills (ITBS) Reading Test and the same students' 1996/97 scores on the Ohio Sixth Grade Proficiency Reading Test are graphically presented and analyzed based on scatter plot data.

The ITBS Reading Test was administered to the students in October 1995 of their fifth grade year. The Ohio Sixth Grade Proficiency Tests were administered to these same to students approximately seventeen months later in March, in 1997 of their sixth grade year. Only students who took both tests were included in this study. Students omitted from the study included handicapped students who were exempted from one or more of the tests, students transferring in or out of the district during the seventeen month period of time, students who were ill, during either of testing periods, and students of limited English proficiency.

PROCEDURES

Students' ITBS NPR reading scores and students' scale scores (SS) on the Ohio Sixth Grade Reading Proficiency Test were the two measurements used in this study. In 1996/97, when the reading proficiency test was administered to this cohort of students, the standard for passing the reading test was a SS of 200. In the 1998/99 school year, the passing SS in reading will be 222. The study investigates the differential impact these two SS standards have on students' ability to pass the sixth grade reading proficiency test. Graphical data analysis of the usefulness of fifth grade ITBS NPR reading scores to estimate students' performance on the Ohio Sixth Grade Reading Proficiency, under both the higher standard (222) and the lower standard (200), form the basis of this investigation.

The data in this study is also being employed as a means to demonstrate how graphical data analysis techniques can help non-statistically oriented school-based educators make more objective and systematic decisions about where and how limited district resources should be employed.

RESULTS AND DISCUSSION

1996/97 Standards and Student Performance on the Ohio Sixth Grade Proficiency Test

Figure 7 is a scatter plot designed in our district last year to illustrate graphically the intersect of the *fifth graders'* 1995/96 ITBS reading scores and these same students' 1996/97 *Ohio Sixth Grade Reading Proficiency Test scores*. Each dot on the scatter plot represents the intersect of an individual child's performance on both tests. The bold horizontal line in the body of the graph represents the 1996/97 State of Ohio standard for passing Ohio Sixth Grade Proficiency Test in Reading, specifically, a scale score (SS) of 200. Any dot on or above the bold line indicates a sixth grader who passed the reading proficiency test in 1996/97. Any dot below the line indicates a sixth grader who failed the reading proficiency test that school year. The State of Ohio standard for passing the sixth grade reading proficiency test was raised to 211 in the 1997/98 school year, and will be raised again from 211 to 222 in the 1998/99 school year.

FIGURE 7

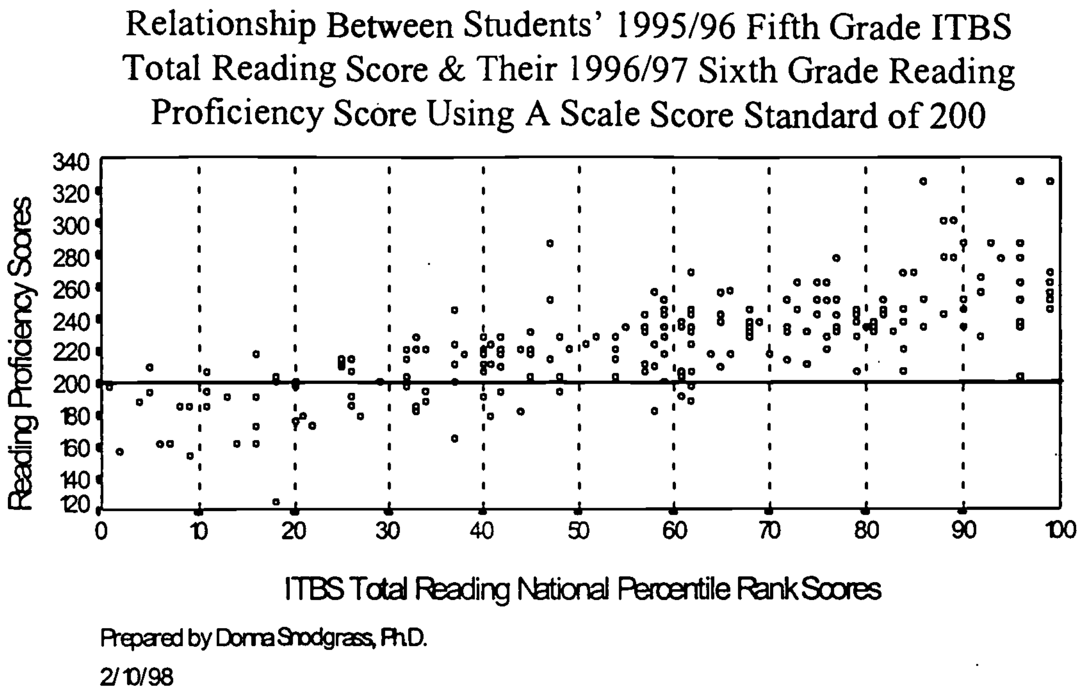


Figure 7, illustrates that there is a positive relationship between children's performance on both tests. Not surprisingly, as children's fifth grade ITBS NPR reading scores increase, so too, do their sixth grade reading proficiency test scores. This relationship is graphically depicted by increasingly more and more dots falling on or above the bold line as children's ITBS NPR scores increase.

A series of dashes form nine vertical lines, dividing the scatter plot into ten intervals. These ten intervals, segment ITBS NPR scores into a series of ten percentile point interval ranges (1^{st}-10^{th}, 11^{th}-20th, 21^{st}-30^{th}, etc.). Only the final interval contains nine percentile points (90^{th}-99^{th} NPR). One interesting way to explore the scatter plot, in search of *patterns and surprises*, is to calculate the proportion of students who pass the proficiency test interval by interval. The proportion of children who passed the Sixth Grade Proficiency Test for each ITBS NPR interval can be easily calculated by dividing the number of dots on or above the horizontal line by the total number of dots in the interval, remembering to include the dots on the vertical line to the right of the interval (10^{th}, 20^{th}, 30^{th}, etc.).

Consider the first interval (1st -10th) in *Figure 7*; there are ten dots in this first interval. This shows that ten fifth grade students obtained ITBS reading scores in the 1st to 10th NPR range. However, only one of the ten children who scored in the first interval on the ITBS fifth grade reading test, passed the sixth grade reading proficiency test. Only one dot is on or above the line on the scatter plot in the first interval in *Figure 7*. Thus, the proportion of students that passed the Ohio Sixth Grade Reading Proficiency Test in the first interval was only one child out of ten, or 10%.

Conversely, examination of the proficiency scores of students with ITBS NPR scores in the three highest NPR intervals (71st-80th, 81st -90th and 91st-99th) reveals that every student whose score fell in these three intervals passed the reading proficiency test, based on the 1996/97 standards. Moreover, closer examination of *Figure 7* reveals no student with a fifth grade ITBS national percentile rank score above the 62nd NPR failed the sixth grade proficiency test, based on the 1996/97 standards. One might hypothesize, that children who score somewhere around the mid-sixtieth NPR on the ITBS reading test have mastered enough reading skills to be able to generalize these skills to multiple settings and tasks, at least at the standards set in Ohio in 1996/97. Another hypothesis might be that both tests are measuring an underlying construct, such as reading aptitude or intelligence; and that a score in the mid-sixtieth NPR range on the ITBS is a measure of the point at which children have enough aptitude for reading that they can readily adapt what they have learned about reading from one test to another test. These are issues which warrant further investigation.

Table 3 converts the graphical data in *Figure 7* into numerical data. The graphical scatter plot helps teachers and administrators conceptualize the relationship between the performance of students on these two tests. *Table 3* converts the graphical picture into numbers which allow administrators and teachers to speak with more precision about the data on the scatter plot. The line, *Total Number of Students Per NPR Interval*, in *Table 3*, reports the total number of students who scored in each of the ten NPR intervals on the ITBS reading test. The next row, *Number Of Students Who Passed Per NPR Interval*, lists the number of students who passed the reading proficiency test with at least a scale score (SS) of 200 or more in each of the ten ITBS intervals. The next row, *Proportion Passing With SS of 200*, gives the proportion of students in each of the ten ITBS interval who passed the reading proficiency test with a scaled score of at least 200. Notice on this

TABLE 3

Number and Proportion of Two-Hundred Sixth Graders Who Passed the Ohio Sixth Grade Reading Proficiency Test Based on the Students' Fifth Grade ITBS National Percentile Scores in Reading Using the 1996/97 Standards

	Fifth Grade ITBS Reading Scores Segmented into Ten Intervals of Ten NPRs									
	1st-10th NPRs	11th-20th NPRs	21st-30th NPRs	31st-40th NPRs	41st-50th NPRs	51st-60th NPRs	61st-70th NPRs	71st 8 0th NPRs	81st -90th NPRs	91st-99th NPRs
Proficiency Status By NPR Interval										
Total Number of Students Per NPR Interval	10	15	10	23	21	23	28	26	25	19
Number Of Students Who Passed Per NPR Interval	1	3	4	15	17	21	25	26	25	19
Proportion passing with SS of 200 Per NPR Interval	10%	20%	40%	65.22%	80.95%	91.3%	89.29%	100%	100%	100%

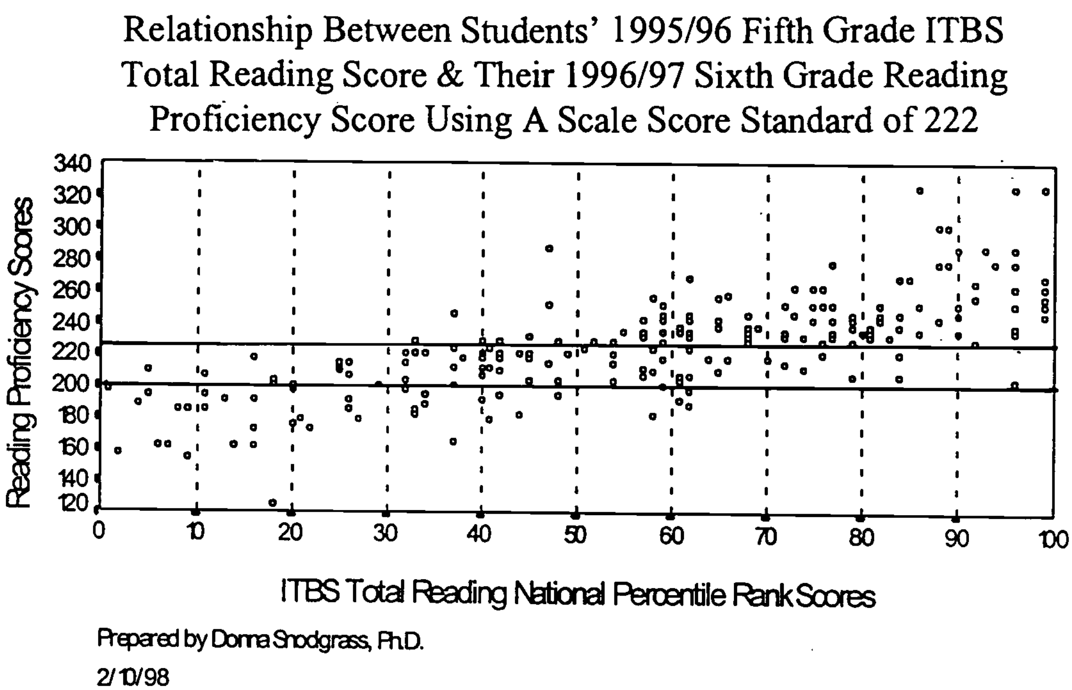
row, *Proportion Passing With SS of 200*, how the proportion of students who pass the reading proficiency in their sixth grade year tends to increase, as the interval scores increase: 10%, 20%, 40%, 65.22%, 80.95%, 91.3%, 89.29%, 100%, 100%, and 100%. There is a single exceptions. There is a small, seemingly insignificant, inversion between the sixth and seventh intervals (91.3% and 89.28%, respectively). This suggests that students whose NPR ITBS scores that fall in the sixth and seventh intervals should pass the reading proficiency test in the same proportions and require the same types of intervention.

1998/99 Standards and Student Performance on the Ohio Sixth Grade Proficiency Test

As previously stated, the State standards on the Ohio Sixth Grade Proficiency Test in Reading are increasing. By the 1998/99 school year, the passing scale score on the sixth grade reading proficiency test will increase to 222. The state refers to this increase, as, *raising the bar*. The scatter plot technique employed in this article is ideal for illustrating the concept of *raising the bar*. Moreover, the scatter plot technique is an excellent device for illustrating the impact that *raising the bar* will have on the number of sixth grade students who are able to pass the sixth grade reading proficiency test in the 1998/99 school year. *Figure 8* illustrates the concept of *raising the bar* by adding a second and higher horizontal line at the scale score of 222. The bottom line on *Figure 8* still represents the 1996/97 passing score of 200 on the sixth grade reading proficiency test, and the top line represents the 1998/99 passing score of 222 on the sixth grade reading proficiency test.

Teachers can readily visualize, by looking at the scatter plot, the additional number of students who are likely to fail the sixth grade reading proficiency test when the bar is raised in the 1998/99 school year. These are the students who fall in the band between the bottom horizontal line (SS 200) and the top horizontal lines (SS of 222). This strategy also gives a district a rough estimate of how many children in their district are likely to pass the reading proficiency test when the new standards actually take effect in the 1998/99 school year, and, in which intervals the district should expect the greatest drop in the absolute number and proportion of students passing the sixth grade reading proficiency test. By applying the higher 222 standard to 1996/97 test scores, it is revealed that not a single student in the first three intervals (1^{st} - 30^{th} NPR), would have passed the sixth grade reading proficiency test. As a matter of fact, data from *Figure 8* suggests that few, if any, of these fifth grade students, who score in the first five intervals of the ITBS reading test would have passed the Sixth Grade Proficiency Test, if we

FIGURE 8



were to have employed the 1998/99 standards. The data also suggests that only a moderate percentage of children (52.17% to 67.86%) in the sixth and seventh interval (61st to 70th NPR) would have passed if the higher standards were employed. Only students scoring in the eighth, ninth and tenth intervals (71st to 99th NPR) have a good chance, on average, of passing the sixth grade reading proficiency test without seemly aggressive intervention.

TABLE 4

Number and Proportion of Two-Hundred Sixth Graders Who Passed the Ohio Sixth Grade Reading Proficiency Test Based on the Students' Fifth Grade ITBS National Percentile Scores in Reading Using the 1998/99 Standards

	Fifth Grade ITBS Reading Scores Presented in Intervals of Ten NPRs									
Proficiency Status By NPR Interval	1st-10th NPRs	11th-20th NPRs	21st-30th NPRs	31st-40th NPRs	41st-50th NPRs	51st-60th NPRs	61st-70th NPRs	71st 8 0th NPRs	81st -90th NPRs	91st-99th NPRs
Total Number of Students Per NPR Interval	10	15	10	23	21	23	28	26	25	19
Number Of Students Who Passed Per NPR Interval	0	0	0	4	6	12	19	22	23	18
Proportion passing with SS of 222 Per NPR Interval	0%	0%	0%	17.39%	28.57%	52.17%	67.86%	84.62%	92%	94.74%

A second way to analyze *Figure 8*, is to locate those specific NPR intervals in which the changing standards would have the greatest impact on children's ability to pass the sixth grade proficiency test. As it appears, raising the standards to 222 would have a relatively small effect on the number of students who were able to pass the sixth grade reading proficiency test in the first three intervals. Few of these students were able to pass the test, even with the lower standards.

Conversely, higher standards would have a marginal impact on the number of failures on the proficiency test in the highest three intervals (71st-99th NPR). Only seven of the sixty-five students who passed the test with a SS of 200, would fail the reading test if the bar were raised to 222. Students in these three intervals tended to score above the 222 standard, even when lower standards were in place. Thus, a change to the higher standards for students in these intervals would have a relatively small impact on the number of students' able to pass the reading proficiency test.

If one analyzes the data, either graphically or numerically, the increase in standards has the greatest impact on those students in the medial area, children in the fourth through the seventh intervals (31st to the 70th NPR). Thirty-seven of the seventy-eight students in the medial area, who passed the reading proficiency test using a SS standard of 200, would have failed the test using the higher SS standard of 222. This substantial increase in the number of failures appears to be is due to two factors. First, as in any relatively normally distributed population, more students tend to score in the medial area, than in the extremes. Second, a large proportion of students in the medial area on the fifth grade ITBS reading test tend to score in the 200 to 221 SS range on the sixth grade proficiency test. Districts might anticipate that if a large number of their students scored in the 31st to 70th NPRs range on the fifth grade ITBS reading test, that there will be a noticeably laarge increase in the number of students failing the sixth grade reading proficiency test in 1998/99, unless effective intervention programs are implemented.

Obviously many factors come into play when a child passes or fails the proficiency test, and therefore our data cannot predict with certainty which specific children in any interval will pass or fail the proficiency test. But certainly these graphic data analysis techniques reveal patterns and trends within the scores that can assist educators in making objective, efficient, and systematic decisions when preparing students to take the Ohio Sixth Grade Reading Proficiency Tests.

With finite human and financial resources, and ever increasing student needs, districts will have to find ways to work smarter. Hard work is not enough. In part, the solution will be to make more objective and defensible decisions about where money and time should be spent to meet the specific and differential needs of all children. Our data indicates that not all of the children require the same services. To this end, and with the use of various exploratory data analysis techniques at hand, our district educators are asking questions like the following:

- Which children are most in need of the regular small group or individualized daily intervention in order to pass the Ohio Sixth grade Proficiency Test in reading? For us, these are the children that our graphs show are at serious risk of failing the sixth grade reading proficiency tests using the 1998/99 standards (ITBS intervals 1-3). Most of these students' dots are substantially below the 222 point of passing. Many are below the SS of 200.
- Which children will benefit the most from tutoring in order to pass the proficiency test? Which of these children will require tutoring daily, twice a week, etc.? For us, these are children who appear to be a moderate risk of failing the sixth grade proficiency test using the 1998/99 standards (ITBS intervals 4, 5 6, and perhaps the lower part of the 7th interval). Most of the dots of the students who failed the proficiency test in these intervals are above the SS of 200 and are approaching the 222 bar.
- Which of our children have a good chance of passing the reading proficiency test and are just in need of cyclical and regular review of the proficiency concepts in their classrooms and a pep talk just before the test in order to pass the proficiency test? For us, these are students in the ITBS intervals 8, 9 and 10, and perhaps the upper part of the 7th interval.

Coming Full Circle Back to Stem-and-Leaf Plots

The final section of this paper takes the reader full circle, back to the discussion of stem-and-leaf plots, and suggest how teachers can use scatter plots and stem-and-leaf plots in tandem to target children in their classes who are in need of different types of interventions to pass the sixth grade reading proficiency test. Recall the stem-and-leaf plot that was constructed earlier in this paper to represent Ms. Jones' fifth grade class' ITBS NPR reading scores. For easy access, this stem-and-leaf plot is presented once more *in Figure 9*. If Ms. Jones wants to estimate how many of her children are at serious risk of not passing the sixth grade reading proficiency test, she could first look at the scatter plot on *Figure 8*. She should recall, that not a single student with a NPR score of less than the 30th on the ITBS reading test would have passed the reading proficiency test using the 1998/99 standards. Ms. Jones could then look at the stem-and-leaf plot illustrating the performance of students in her class and count the number of students that scored at or below the 30th NPR on the ITBS fifth grade reading test. She would find that four of her students scored below the 30th NPR. Based on the data in this study, she might conclude that four of her twenty-five students are at serious risk of failing the reading proficiency in the sixth grade. Ms. Jones would also see that eight of her twenty-five students scored in the higher three intervals (71st to 99th NPR).. Based on data from this study, at least eight of her students have a good to excellent chance of passing the sixth grade reading proficiency test, even with the higher standards. She might also hypothesis that the five students that scored in the upper part of the 7th interval in Ms. Jones' class (67, 68, 69, 69, and 69) could be included in the low risk category on a case by case basis. Given the students' different levels of risk of not passing the reading proficiency test, Ms. Jones would be wise to use this information to implement different instructional strategies and/or delivery strategies for these two groups of children, as well as the third group of students in the medial area.

FIGURE 9

ITBS National Percentile Rank Reading Scores From Ms. Jones's Class in a Stem-and-Leaf Plot

0	9
1	38
2	6
3	6
4	77
5	137
6	0078999
7	34899
8	679

N =25

The stem-and-leaf plot for Mr. Smith's class is presented again, this time in *Figure 10*. The data *in Figure 10* illustrates that sixteen of Mr. Smith's twenty-five students (more than half of his students) are in the three bottom NPR intervals; and based on our data, they are at serious risk of not passing the reading proficiency test. Recall, only sixteen percent, or four students, in Ms. Jones' class are at serious risk of not passing the test. One of Mr. Smith's students scored in the top three intervals and has a good to excellent chance of passing the reading proficiency test, based on our data. Conversely, thirty-two percent of Ms. Jones' class (8 out 25 students) scored in these top three intervals, and have a good to excellent chance of passing the proficiency test based on our data. Principals, supervisors, directors of curriculum, and superintendents might want to factor this type of information into their decisions about which classes are in most need of resources, when planning student interventions.

FIGURE 10

<u>ITBS National Percentile Rank Reading Scores From Mr. Smith's Class in a Stem-and-Leaf Plot</u>

0	489
1	02222357
2	56666
3	123
4	446
5	3
6	0
7	
8	7

N = 25

Principals often believe they are randomly assigning students to classrooms in their buildings, and therefore assume, that students in any classrooms at any given grade level, are relatively equivalent in ability, this is not necessarily the case. When one's selection pool is small, which is often the class in elementary schools, then the chances of random sampling errors increase. Random sampling errors heighten the chances that characteristics, like reading ability, of children in different classrooms in the same building and at the same grade level do not represent each other. Stem-and-leaf plots, like those in Figures 9 and 10, are a good way to illustrate these differences. (Box-and-whisker plots, as shown earlier in this report, are an even better way to compare classes for equivalence of variability on any given measure, than are stem-and-leaf plots.)

IMPLICATIONS

All of the data and graphical techniques presented within this paper can be easily created by hand on graph paper and do not require the use of any statistical experts, computerized statistical software, or graphical software. These techniques are *user-friendly* to any educator in any district in the State of Ohio, and beyond. The extent to which these graphical data analysis techniques can be used by other teachers and administrators to predict children who are at varying degrees of risk of not passing the proficiency can only be determined by replicating these methods with other students and with other nationally normed achievement tests. As for our district, these methods have helped building principals and teachers employ appropriate interventions and delivery services to their diverse student bodies, as well as employ their limited financial and human resources in more systematic and defensible manners.

In no way does this article cover the breadth and depth of exploratory data analysis techniques for school based-educators. We have merely scratched the surface of the value of graphical techniques to educators. Obviously, one can apply these same techniques to other tests, and at other grade levels. We have done it. We have also employed exploratory data analysis techniques to summarize the results of self-report inventories, as well as track district trends over time. The value in these graphical techniques is that they allows educators, who lack the sophistication to interpret algebraic data, to see themselves and their children in the patterns revealed by graphical presentations. These patterns provide teachers and administrators with a wealth of powerful information, which allows them to more objectively, systematically, and defensibly improve upon their students' educational experiences.

We offer the following three rules as a guide to those educators who plan to use graphical data analysis techniques to find useful and valid information in a set of test scores.

Three Rules for Graphing Scores

1. *When confronted with a set of scores, organize them numerically.*
2. *When comparing two sets of scores, place them on the same scale.*
3. *When graphing test scores, make sure the visual picture is a honest and undistorted representation of the numerical test scores.*

If the reader finds graphical data analysis techniques, like stem-and-leaf and box-and-whisker plots, a meaningful method of data analysis, two excellent sources are Landwehr and Watkins (1986) and Tukey, (1977). Landwehr and Watkins (1986) guide their readers though simple and basic techniques like stem-and-leaf and box-and-whisker plot construction. The ideas and techniques which they present are as appropriate and challenging for building administrators and teachers, as they are scientists and managers. Landwehr and Watkins (1986) work is perfect for the less mathematically oriented professional who wants a practical guide to graphical data analysis techniques. For the reader who is interested in the theoretical underpinning of graphical data analysis techniques, like stem-and-leaf plots, box-and-whisker plots, as well as more sophisticated graphical data analysis techniques, Tukey (1977) is a more challenging source.

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