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USING ASSESSMENT ITEMS TO STUDY STUDENTS' DIFFICULTY READING AND INTERPRETING GRAPHICAL REPRESENTATIONS OF DISTRIBUTIONS

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SUMMARY

This paper describes the analysis of assessment items used in a large scale class testing of high school and college students to learn how students reason about graphical representations of distribution. We focus on the use of items that reveal some consistent errors and misconceptions students exhibit when presented with graphical representations of data. We find that perhaps because of students' early exposure to bar graphs and time plots, they tend to confuse bar graphs and time plots with histograms. In addition, students have difficulty correctly reading information from histograms and identifying what the horizontal and vertical scales represent. We offer some reasons for why it is important for students to be able to correctly read and interpret histograms, and offer suggestions for how to help develop this type of reasoning.

Keywords
Distribution; graphical display; assessment

1. INTRODUCTION

Constructing graphs of data and interpreting graphs is an important part of the k-12 Statistics curriculum (see NCTM 2000) and something that all high school students are supposed to be able to do. In introductory college courses, students learn how to graph distributions of data typically using dot plots, histograms, and boxplots. These skills are not considered to be difficult for students, as compared to the more difficult topics of probability, sampling, and inference. However, recent research in statistics education documents difficulties students have learning to reason about distributions and graphical representations of distributions (e.g., Bakker & Gravemeijer, 2004; Ben-Zvi 2004; Biehler, 1997; Hammerman & Rubin, 2004; Konold, 2003; McClain, Cobb, & Gravemeijer, 2000). Results from these studies indicate that:

1. Students tend to see a data set as individual points (local reasoning) rather than as a graph or a data set as an entity (global reasoning). They tend to focus on particular values such as high and low ones or outliers.
2. It is not intuitive to understand that area (of a bar) represents frequency as opposed to length (as in a bar graph).
3. Understanding data as an entity in a graph such as a histogram involves coordinating ideas of center, spread, density and skewness.
4. Students are most familiar with bar graphs or case value graphs where each case or data point is represented by a bar or a line, and the ordering of these is arbitrary. It is important to build on this conception in moving to other forms of representation such as dotplot, so that students can map one form of graph to the other.

5. Even when making comparisons of distributions, novices tend to compare slices of data or points, rather than comparing entire entities, taking into consideration overall center and spread.

It is important to note a shift in current research from earlier research on understanding graphical representations. These earlier studies focused more on "graph sense", "graphicacy" and "graphical comprehension" than on distributional reasoning about graphs (e.g., Friel, Bright & Curcio, 1997; Friel, Curcio & Bright, 2001). Graphicacy is the ability to read and interpret graphs (Friel & Bright, 1996). Graph sense is the ability to recognize components of graphs, speak the language of graphs, understanding relationships between tables and graphs, respond to questions about graphs, recognize better graphs, and contextual awareness of graphs. Graph comprehension has been defined as being able to translate between graphs or a table and a graph and being able to interpret relationships or important factors in a graph. Extrapolation and interpolation behaviors require noting trends and extensions to and within information in a graph.

While many tasks and questions about graphs have been used in research studies on understanding and reasoning about distribution, there has not been an effort to develop and collect assessment items to evaluate this type of learning. The authors of this paper have been collecting, modifying, and creating items to assess students' understanding and reasoning about distribution, and have collected data on how high school and college students perform on these items, as part of a larger project on assessment in statistics (Garfield, delMas, & Chance, 2002). One of the most interesting result of the item analysis is the difficulty students have understanding and reasoning about graphical representations of distributions, in particular, histograms. After a brief description of the assessment project, details of the assessments and their results will be shared.

2. THE ARTIST PROJECT

2.1 ASSESSMENT DEVELOPMENT

Over the past three years we have focused our work on assessing learning outcomes in a first statistics course through the NSF-funded *Assessment Resource Tools for Improving Statistical Thinking* (ARTIST) project. ARTIST was designed to address the assessment challenge in statistics education as outlined by Garfield and Gal (1999), who called for the need to develop reliable, valid, practical, and accessible assessment instruments to use in the assessment of students' statistical literacy, reasoning, and thinking. As part of the set of outcomes designed to meet this challenge, ARTIST has developed both an online searchable data base of test items as well as individual online tests on different topics, called topic scales.

The topic scales were developed through a process that took over one-year. One of the major influences in the development came from the ARTIST advisory group, which consisted of faculty members from United States higher education institutions who have expertise in at least one of the following areas: statistics, statistics education, measurement, and evaluation. ARTIST assessment items were developed primarily for a United States audience using graphing conventions and statistical nomenclature typically used in college statistics courses in the United States.

The ARTIST advisory group first helped to identify eleven major topic areas for a first course in statistics: Data Collection, Data Representation, Measures of Center, Measures of Spread, Normal Distribution, Probability, Bivariate Quantitative Data, Bivariate Categorical Data, Sampling Distributions, Confidence Intervals, and Significance Tests. For each topic area, around eight to twelve multiple choice, context-based items were identified from the ARTIST item database that were thought to assess literacy and reasoning for the topic. The advisory group met in March, 2004 to evaluate each topic scale. The advisers judged whether each item for a scale fit the particular topic, rated how essential each item was to assessing understanding of the topic, suggested rewordings or other changes, and identified important aspects of the topic that were not assessed. The ARTIST project team used this feedback during summer 2004 to revise items, and to identify or generate new items to cover missing topic areas. Online versions of each topic scale were created, and the advisers engaged in another round of validation in early August of 2004. During this second evaluation, advisers judged the validity of each item (i.e., whether or not an item fit the topic area), and used a rating scale to indicate how essential each item was to assessing students' understanding of a topic. This feedback was then used to produce final versions of each topic scale, which were used in pilot studies with introductory statistics students during fall 2004. Each scale was revised further based on analyses of the pilot study data.

In addition to the eleven topic scales, an overall Comprehensive Assessment of Outcomes in Statistics (CAOS) was developed by the ARTIST project team. The advisory group met in August 2003 to discuss the nature and content of such a test. Discussion led to the decision to focus on an understanding of variability as the primary outcome of a first course in statistics. The ARTIST project team initially identified a large set of multiple choice items that appeared to assess students understanding and reasoning about variability when describing distributions, making comparisons, reasoning about sampling variability, and making statistical inference. CAOS went through a validation process similar to the one described above for the topic tests. The final version of CAOS consisted of 37 multiple choice items.

2.2 CLASS TESTING

A large scale class testing of the online instruments was conducted during spring 2005. Students for the study were obtained through invitations sent to high school Advanced Placement (AP) and college statistics instructors through email lists of major Unites States organizations likely to have a membership that represents this population (e.g. AP listserv, Statistics Education Section of the American Statistics Association), ads placed in magazines and newsletters (e.g., AMSTAT news), and information posted on the ARTIST website. Instructors registered their students to take the ARTIST topic scales at points in their courses when students had covered the material assessed by a scale. Some instructors had their students complete the assessments in class, while others allowed students to complete the assessments out of class and at their convenience. Instructors also used the assessments for a variety of purposes: some assign a grade in the course, for review before a course exam, or to assign extra credit.

This paper presents preliminary information gathered on 909 students who took the CAOS test (97 students from three high schools and 812 students from 15 colleges or universities), and 555 students who took one or more of the ARTIST topic scales (205 students from four high schools and 350 students from 15 colleges or universities). We have learned a lot from the assessment data gathered in high school and college classrooms. In this paper we will share what we have learned about the challenge of assessing students' statistical reasoning about distribution. Items are presented that were developed to assess students' understanding of graphical displays of distributions along with student data for each item.

2.3 ANALYZING ITEMS BY TYPE OF LEARNING OUTCOME

The items related to graphical representation of distribution fall into two types of categories called statistical literacy and statistical reasoning. These terms are defined as follows:

> Statistical literacy involves understanding and using the basic language and tools of statistics: knowing what statistical terms mean, understanding the use of statistical symbols, and recognizing and being able to interpret representations of data. Assessment items are categorized as measuring statistical literacy if they assess a student's ability to:
>
> - Understand information presented in typical statistical graphs of distributions (e.g., dotplot, histogram, box plot).
> - Correctly identify and understand scales.
> - Identify some common shapes of distributions (e.g., normal, skewed, bimodal, uniform).
> - Distinguish between a bar graph or times series and a hygrogram/dot plot.
> - Understand the terms related to distribution.
>
> Statistical reasoning is the way people reason with statistical ideas and make sense of statistical information. Statistical reasoning may involve connecting one concept to another (e.g., center and spread) or may combine ideas about data and chance. Reasoning means understanding and being

able to explain statistical processes, and being able to fully interpret statistical results. We categorized them as reasoning if they asked students to:

- Identify a graph from a description of a variable.
- Match two versions (graphs) of the same data.
- Understand the impact of adding or removing value(s).
- Understand reasons for shape.

3. RESULTS

Data were gathered during the spring 2005 testing of high school and college students. All items were multiple choice format. The results are presented for each item in terms of percentages of correct and incorrect responses (see Appendix). Results are also divided into two columns: those for students enrolled in a high school Advanced Placement statistics course, and those enrolled in an introductory college-level course. Items are coded according to whether they measure statistical literacy, statistical reasoning, or a combination of both.

This section is broken into five subsections based on the type of outcome items measure (literacy, reasoning, or both) as well as the type of item task (read a graph, match a variable description to a graph, etc.). The item difficulty level is discussed for each item and plausible explanations for what may have contributed to students' difficulty with each item are presented.

3.1 LITERACY ITEMS – READING A GRAPH

Items 1 and 2 present a simple histogram and ask students to read the frequencies for one value and for the entire data set, respectively. Results show that students found these items fairly easy because they had high percents of correct responses. It appears that how to read a graph for discrete data, where each bar represents the frequency of one score or measurement, rather than an interval of values, is understood by most students. However, when asked to identify what the vertical scale was measuring (Item 3), many students indicated the score values, rather than the frequency of scores for each value. This could represent a confusion over the terms "vertical" and "horizontal", or it may indicate that some students are interpreting the histogram like a bar graph, where each bar represents an individual, and the bar height indicates the magnitude of some variable.

Many students also found it difficult to determine frequencies for specified values in a histogram when the values are grouped into intervals. An example is given in Item 4. Only about one-fourth of the students correctly identified the number of values in a specified interval.

3.2 LITERACY ITEMS – INTERPRETING A GRAPHIC DISPLAY

Item 5 and Item 6 presented students with a graph of a data set and asked them to select the most appropriate interpretation of the distribution of data. Most students were able to select a fairly complete and accurate interpretation of a graphic representation of a histogram, as illustrated by the results for Item 5. Item 6 asks students to select a statement that represents a complete description of a distribution (i.e., one that involves shape, center, and spread, in the context of the data). Almost three fourths of the students selected the correct description of item 6. While the majority answered this item correctly, a noticeable percentage chose the response that just listed the statistics without an interpretation or context.

Item 7 asks only about shape. Overall, a little less than two-thirds of the students correctly labeled the graph in Item 7 as right skewed, although high school AP students tended to do better on this item than college-level students. Many of the college-level students mixed up the direction (indicated a left skew) or saw the graph as bimodal. This difference between the high school and college-level students may be due to the longer duration of the high school course (a full academic year versus one term). Students may need to repeatedly test out their ability to recognize skew in a distribution, their understanding of the direction of a skew, and what constitutes a distinct bimodality in a distribution to develop a firm understanding of these concepts.

3.3 REASONING ITEMS – MATCHING A GRAPH TO A DESCRIPTION

Items 8, 9, and 10 asked students to match a graphs to descriptions of different variables. Item 8 required students to realize that a set of scores for an easy quiz would have a ceiling and likely be negatively skewed, which almost all students were able to do. Item 9, which asked students to reason about the distribution for a set of random digits, appeared to be more difficult. Less than half of the students correctly chose a uniform or rectangular distribution for Item 9, and more than one fourth of the students selected a graph that was more bell-shaped, indicating a possible misconception that random means normal. Item 10 was even more difficult. A majority of students incorrectly picked the graph that could represent a bar graph of daily measurements, rather than the graph that represents a more normal distribution of averages.

3.4 REASONING ITEMS – MATCHING GRAPHS OF THE SAME DATA

This type of reasoning task asked students to match one type of graphical representation for a data set with a different type of graph. Although Items 11 and 12 each show a histogram and three possible box plots of the same data, Item 12 was more difficult than Item 11. A high percentage of students correctly matched the two graphs in Item 11 by noting two features of the data that are only consistent for one of the box plots: the skewness in the histogram (that corresponds to a boxplot with a non-centered median line), and that there are no apparent outliers. In contrast, Item 12 is more difficult, with a little more than half of the students matching the correct boxplot to the histogram. Here there are two boxplots that both show an outlier (suggested by the histogram) but only one has the correct end point for the lower whisker, corresponding to the lowest data value that is not an outlier on the histogram (5 hours of sleep). The boxplot in Graph A also indicates more symmetry than is present in the distribution, which may have been another reason that students were attracted to the option.

3.5 ITEMS REQUIRING LITERACY AND REASONING

The final set of items were among the most difficult items for all students. Items 13 and 14 both present several graphic representations of a data set and ask students to select the graph that is best for characterizing the distribution of the data. Student responses to these items suggest that they tend to represent data as bar graphs, where each bar represents an individual case or value. Item 13 asked students to identify an appropriate graph to represent the shape of a distribution of quantitative data. A substantial number of students selected the bar graph (B), perhaps because it looked normal, or because it was in a form they felt comfortable with, one bar per case. Item 14 asked students to select the best graph for describing the shape, center, and spread of a quantitative data set. This was one of the most difficult item on the CAOS test, which surprised many instructors. Students tended to pick an incorrect bar graph rather than the correct histogram to represent a set of baseball statistics. They could have been guided by the normal shape (graph B was chosen by a majority of students) and/or by the cases listed by players' initials.

4. DISCUSSION

The results presented for student responses on ARTIST items suggest that students have an easy time interpreting simple histograms (where each bar represents one value) and matching different graphs of the same data when there are obvious features to guide them. When they needed to coordinate more information, the matching was more difficult. Students also were fairly good at matching graphs to descriptions of variables except when they expected each bar to represent an individual case, such as measurements collected over time.

Students revealed difficulty in many aspects of reasoning about graphical representations of distributions. In particular, they had difficulty reading the data when the bars contained intervals of values rather than single values of a variable. They probably were not sure of what the axes actually represented. And most of all, they seemed to prefer graphs where a bar represents a single value or case, rather than a frequency.

Why this preference for bar charts? We believe there are three reasons. First, students are first introduced to bar charts in elementary school, and see many bar charts in the media. It is a familiar graph that they can understand easily, which seems to override their consideration of whether a bar chart provides a correct representation for a data set, let alone appropriate to answer specific questions. Second, histograms “bury” the individual data points (see Bright and Friel, 1998). Third, it is more difficult to associate a bar with magnitude (see Konold and Higgins, 2002), as is required in a histogram, and students have difficulty reasoning about proportions (Cramer, Post, & delMas, 2002), which is required when reasoning about histograms.

Given the difficulty students seem to have interpreting and reasoning about histograms, one possible implication is to remove instruction on histograms from the course and to focus on alternative graphical representations that may be easier for students to comprehend, such as dotplots, where each value is represented by a dot. Dot plots show shape, center and spread and can be introduced as a follow up to case value bars, by dropping the end point of horizontal bars to stack up on the horizontal scale of a line plot.

These ideas were presented to two statisticians who are leaders in the Statistics Education community in the United States: Robin Lock and George Cobb. Cobb responded that students seem to find dot plots and boxplots easier to read and interpret, however he adds that if the course includes density curves (such as the normal curve) “it is essential to come to associate areas with proportions, and for that, histograms are important. Neither dotplots nor boxplots use areas to represent proportions” (personal communication, 2005).

Giving a similar argument, Lock pointed out that for large data sets, dot plots are not appropriate and histogram are much more useful. He notes that with a large data set, dotplots are actually histograms. A "true" dotplot (which is one-dimensional for continuous data) is really not very useful for seeing density function like shapes - until you start stacking. The whole idea of area as proportional to the probability of being in an interval is better motivated with histograms than dotplots. Once you start stacking the dots you either (a) only stack identical values, (b) stack values that are close to each other - in which case you are doing the binning of histograms without much control (or thought) about what you are doing, or (c) get irregular stacking when points that do not fit next to each other on the axis are raised a bit so they fit. Histograms are a much cleaner way of making the transition to density as an idealized model of the histogram (personal communication, 2005). The arguments from Cobb and Lock have convinced us to keep histograms in the curriculum. We next turn our attention to how to help students learn to read and interpret histograms better.

4.1 IMPLICATIONS FOR TEACHING

Recent work by Konold using the Tinkerplots software (Konold, 2004) suggests the value of having students create their own graphical representation, using a flexible software tool. Tinkerplots provides a “separator” tool that allows data that is easily graphed as a dotplot to be grouped into intervals. A “fuse” command is used to combine the dots in each interval into a single bar, thus constructing a histogram. We think that having students create these graphs by going through the “separate” and “fuse” steps is a good way to help students develop a better understanding of data grouped in bars of a histogram. We also like the idea of creating the dotplots from dropping endpoints of horizontal case value bars, as in the Cobb studies, to see the connection between bar graphs or case value bars and histograms.

We think that it is important to give students many opportunities to manipulate data back and forth between different graphical representations, noting what changes and what information are revealed by the manipulations. In particular, we think it will be helpful to have students go back and forth between bar graphs and histograms, noting what can and cannot be read or interpreted from these two easily confused representations. In this way they can be led to pay attention to the changing role of axes and plot elements from graph to graph (Bright and Friel, 1998).

4.2 IMPLICATIONS FOR FUTURE RESEARCH

We suggest that future studies examine ways to improve student understanding and reasoning about graphical representation of distribution, and in particular, of histograms. We recommend the implementation and evaluation of suggestions from the previous section to determine how they impact student learning and help students move away from the tendency to see all graphs with bars as bar charts. We encourage the use of items that assess not only how well students can generate graphs, but also how well they interpret and reason about graphs (see Gal, 1998). We also encourage researchers to use ARTIST items such as those presented in this paper so that results of these studies may be compared to our large set of baseline data.

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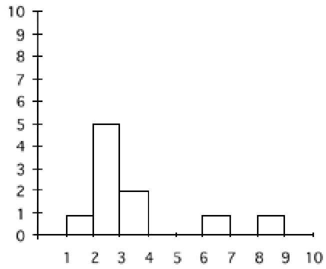
6. APPENDIX

ARTIST Scale and CAOS Test Items Measuring Distribution Literacy and Reasoning

Tabled values represent percent of students who selected a particular response.

ITEM 1

Here is a histogram for a set of test scores from a 10-item makeup quiz given to a group of students who were absent on the day the quiz was given. How many people received scores higher than 4?



Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. 1	5.1	11.9	9.4
b. 2	**90.4**	**78.8**	**83.0**
c. 3	2.5	2.9	2.8
d. 4	2.0	6.4	4.8

ITEM 2

How many people took the test and have scores represented in the graph?

Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. 5	3.0	20.9	14.4
b. 10	**93.4**	**74.5**	**81.4**
c. 20	2.0	3.5	3.0
d. 30	1.5	0.6	0.9

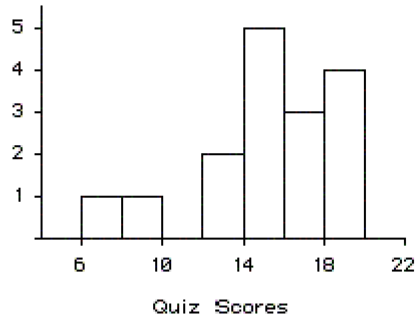
ITEM 3

What do the numbers on the vertical axis represent?

Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. Independent variable	5.1	8.4	7.2
b. Scores on the test	20.8	33.6	29.0
c. Dependent variable	15.7	8.4	11.1
d. Number of Students	**58.4**	**49.6**	**52.8**

ITEM 4

Scores for a quiz were calculated as the number of correct responses. Below is a graphical display of the quiz scores. How many of the scores are above 15? (Note: all scores are integers and bars begin at left endpoints)



Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. 6	0.5	4.1	2.8
b. 7	**32.5**	**23.8**	**26.9**
c. 12	21.3	30.4	27.1
d. 13	1.0	1.4	1.3
e. Can’t be determined	44.7	40.0	41.7

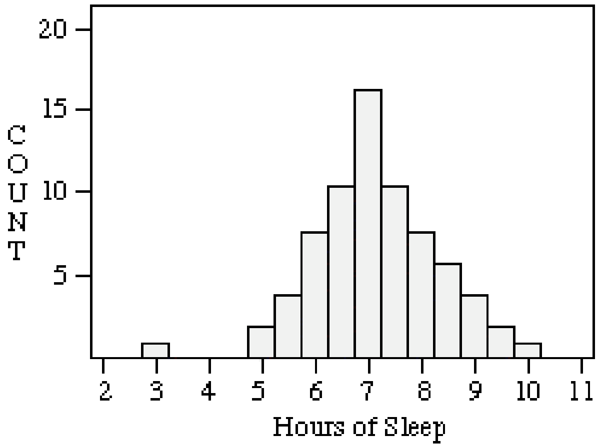
ITEM 5

One of the items on the student survey for an introductory statistics course was "Rate your aptitude to succeed in this class on a scale of 1 to 10" where 1 = Lowest Aptitude and 10 = Highest Aptitude. The instructor examined the data for men and women separately. Below is the distribution of this variable for the 30 women in the class. How should the instructor interpret the women's perceptions regarding their success in the class?

Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. A majority of women in the class do not feel that they will succeed in statistics although a few feel confident about succeeding.	**86.8**	**75.4**	**79.5**
b. The women in the class see themselves as having lower aptitude for statistics than the men in the class.	3.6	10.7	8.1
c. If you remove the three women with the highest ratings, then the result will show an approximately normal distribution.	9.6	13.9	12.4

ITEM 6

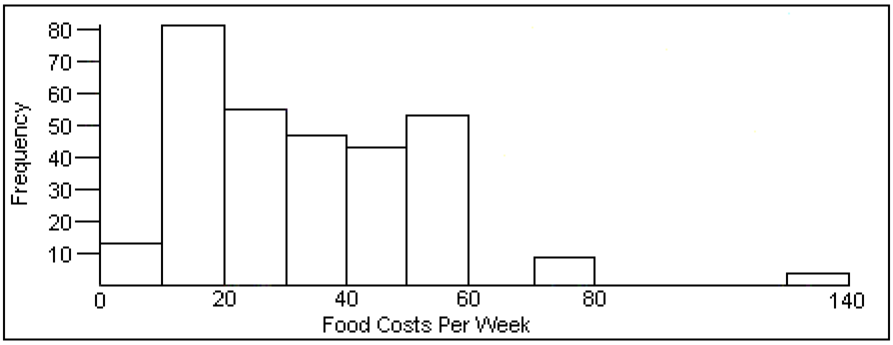
The following graph shows a distribution of hours slept last night by a group of college students. Select the statement below that gives the most complete description of the graph in a way that demonstrates an understanding of how to statistically describe and interpret the distribution of a variable.



Response		High School (N = 97)	College-Level (N = 796)	All (N = 893)
a.	The bars go from 3 to 10, increasing in height to 7, then decreasing to 10. The tallest bar is at 7. There is a gap between three and five.	5.2	4.5	4.6
b.	The distribution is normal, with a mean of about 7 and a standard deviation of about 1.	15.5	19.5	19.0
c.	Most students seem to be getting enough sleep at night, but some students slept more and some slept less. However, one student must have stayed up very late and got very few hours of sleep.	1.0	3.1	2.9
d.	**The distribution of hours of sleep is somewhat symmetric and bell-shaped, with an outlier at 3. The typical amount of sleep is about 7 hours and overall range is 7 hours.**	**78.4**	**72.9**	**73.5**

ITEM 7

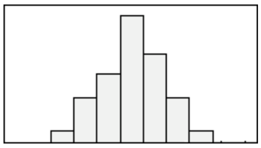
A college statistics class conducted a survey. They gathered data from a large random sample of students who estimated how much money they typically spent each week in different categories (e.g., food, entertainment, etc.). A distribution of the survey results is presented below. One student claims the distribution of food costs basically looks bell-shaped, with one outlier. How would you respond?

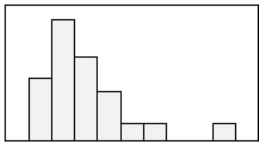


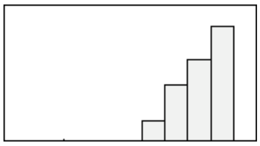
Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. Agree, it looks pretty symmetric if you ignore the outlier.	8.1	6.7	7.2
b. Agree, most distributions are bell-shaped.	0.0	6.7	4.2
c. Disagree, it looks more skewed to the left.	4.1	19.4	13.8
d. Disagree, it looks more skewed to the right.	**81.2**	**55.7**	**64.9**
e. Disagree, it looks more bimodal.	6.6	11.0	9.4

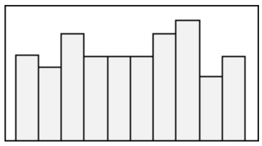
ITEMS 8, 9, AND 10

Match each description to the appropriate histogram below.

I


II


III


IV


Item 8: A set of quiz scores where the quiz was very easy.

Response	High School (N = 97)	College-Level (N = 797)	All (N = 894)
I	2.1	5.4	5.0
II	3.1	7.2	6.7
III	**86.6**	**69.4**	**71.3**
IV	8.2	18.1	17.0

Item 9: The last digits of phone numbers sampled from a phone book. Match this description to the appropriate histogram below.

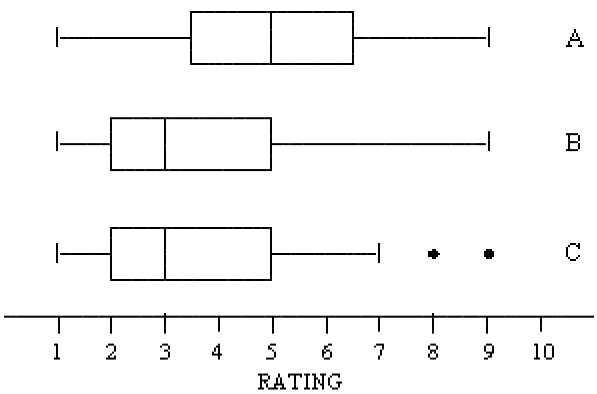
Response	High School (N = 97)	College-Level (N = 797)	All (N = 894)
I	15.5	26.2	25.1
II	20.6	21.8	21.7
III	2.1	7.2	6.6
IV	**61.9**	**44.8**	**46.6**

Item 10: A set of average weights (measured in pounds) compiled monthly over the course of two years, of one healthy adult. Match this description to the appropriate histogram below.

Response	High School (N = 97)	College-Level (N = 797)	All (N = 894)
I	**30.9**	**24.7**	**25.4**
II	5.2	8.3	7.9
III	8.2	7.3	7.4
IV	55.7	59.7	59.3

ITEM 11

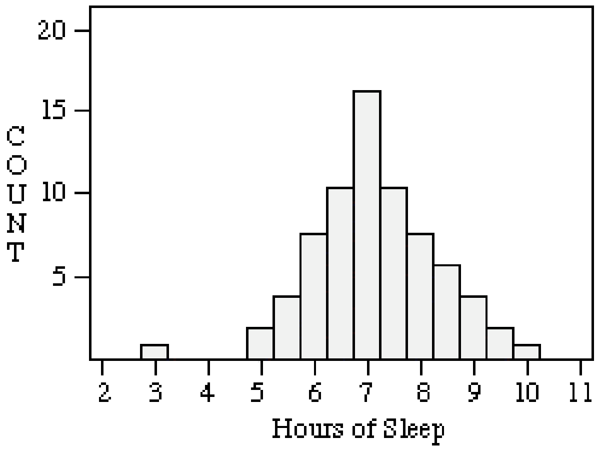
One of the items on the student survey for an introductory statistics course was "Rate your aptitude to succeed in this class on a scale of 1 to 10" where 1 = Lowest Aptitude and 10 = Highest Aptitude. The instructor examined the data for men and women separately. Below is the distribution of this variable for the 30 women in the class. Which of the following boxplots represents the same data set as the histogram shown above?

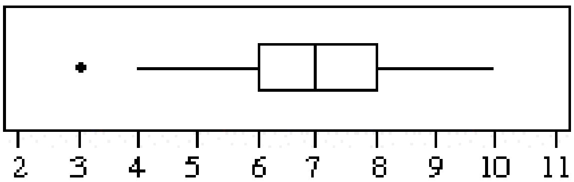
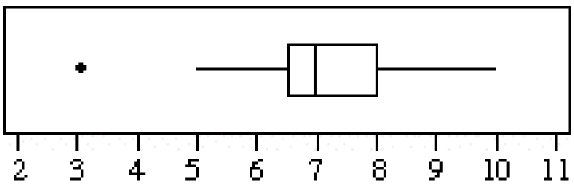
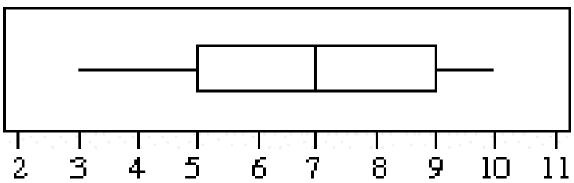


Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
A	2.5	12.8	9.0
B	**76.6**	**67.0**	**70.5**
C	20.8	18.6	19.4

ITEM 12

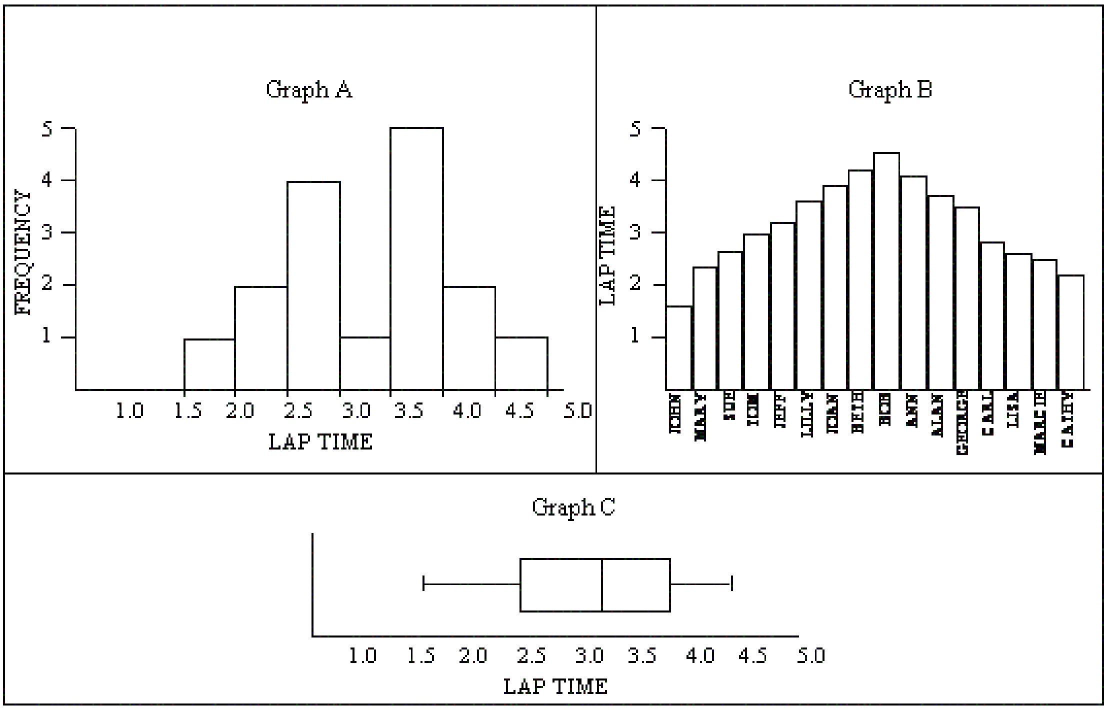
The following graph shows a distribution of hours slept last night by a group of college students. Which box plot seems to be graphing the same data as this histogram?



Response		High School (N = 97)	College-Level (N = 796)	All (N = 893))
A		22.7	30.0	29.2
B		**69.1**	**55.8**	**57.2**
C		8.2	14.2	13.5

ITEM 13

A local running club has its own track and keeps accurate records of each member's individual best lap time around the track, so members can make comparisons with their peers. Here are graphs of these data. Which of the above graphs allows you to most easily see the shape of the distribution of running times?



Response	High School (N = 197)	College-Level (N = 345)	All (N = 542)
a. Graph A	**54.3**	**35.9**	**42.6**
b. Graph B	40.6	55.9	50.4
c. Graph C	2.5	4.1	3.5
d. All of the above	2.0	2.3	2.2

ITEM 14

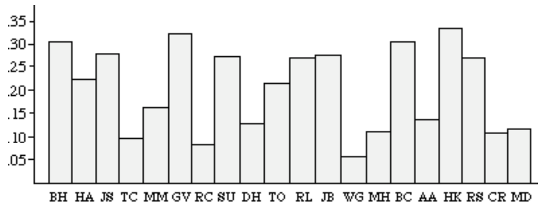
A baseball coach wanted to get an idea of how well his team did during the past baseball season. He recorded the proportion of hits obtained by each player based on their number of times at bat as shown in the table below.

Player	Proportion of hits	Player	Proportion of hits	Player	Proportion of hits
BH	0.305	SU	0.270	BC	0.301
HA	0.229	DH	0.136	AA	0.143
JS	0.281	TO	0.218	HK	0.341
TC	0.097	RL	0.267	RS	0.261
MM	0.167	JB	0.270	CR	0.115
GV	0.333	WG	0.054	MD	0.125
RC	0.085	MH	0.108		

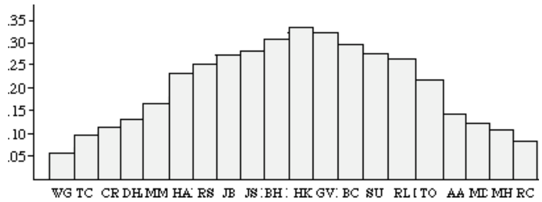
Which of the following graphs gives the best display of the distribution of proportion of hits in that it allows the coach to describe the shape, center and spread of the data?

Response	High School (N = 97)	College-Level (N = 794)	All (N = 891)
A	3.1	11.8	10.9
B.	47.4	55.9	55.0
C.	**39.2**	**20.9**	**22.9**
D.	10.3	11.3	11.2

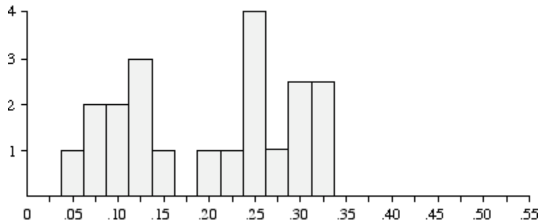
A



B.



C.



D.