Lost: Assessing Student Basic Survival Skills in the Statistical Wilderness Using Real Data

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Abstract

This presentation describes a classroom assessment activity using a 2 page "Quick Facts" summary of a U.S. government produced survey on Fishing, Hunting and Wildlife. With a combination of summary statistics, tables and graphs, this activity probes student understanding of topics which are often considered fly-over territory by many introductory statistics instructors. The results and discussion of this activity provide instructors with insight into the preparation and background knowledge of students entering introductory statistics. In addition, it becomes an excellent vehicle for demonstrating and introducing the need for statistical literacy skills using real-world data in a context that is familiar to many students and not discipline specific. Results from over 200 student groups at multiple schools will be discussed along with recommendations for instructors on improving student performance on these important yet often-ignored topics.

Key Words: statistical literacy, assessment, tables, pie charts, bar graphs

1. Background

The development of courses and teaching materials related to Statistical Literacy at Augsburg College is well documented in the literature (Schield, 2004). Based on a strong history of teaching students the principles of being a consumer of statistics, the assessment activity described in this article was created as a student activity for use in several different statistical literacy courses at Augsburg College.

1.1 Source Document

This assessment is designed around a publication created by the US Census Bureau. The *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* is a survey done every five years in conjunction with the U.S. Department of the Interior, Fish and Wildlife Service, and the U.S. Department of Commerce. The survey collects information on the number of anglers, hunters, and wildlife watchers; how often they participate; and how much they spend on their activities in the United States.

In particular, this activity focuses on reading and interpreting the two-page "Quick Facts" summary published for this survey. This document can be found online as a PDF document at http://www.census.gov/prod/2008pubs/fhw06-qkfact.pdf. As seen online, this document consists of a variety of tables, charts and graphs with a minimal

amount of text in paragraph form. In this form, the document provides an ideal source document to be used to assess student ability to read and comment on a variety of different types of statistical literacy questions. For the purposes of this paper, I will not distinguish between the terms statistical literacy, quantitative literacy and quantitative literacy although the assessment items and content discussed in this paper could be considered common to all three.

1.2 Assessment Questions

After several iterations of assessment items, the final version contains 24 questions. The questions are written to assess the quantitative / statistical literacy of students involved in the reading and interpretation of tables, charts and graphs. For a majority of the items, students responded to the given questions by either providing an answer to the given question or selecting an option to indicate that an answer is not possible given the information provided. In addition, as an element of statistical literacy, several of the assessment questions require a written statement as a portion of their answer. These were included to provide some assessment of the student's statistical literacy level in communicating in sentence format. A complete copy of the assessment form is included in the appendix of this document.

2. Methodology and Results

2.1 Methodology

The outcomes shown for this assessment of statistical literacy are the result of the administration of this activity in a number of different classes at Augsburg College and the University of St Thomas over the last 4 years. Typically the assessment was given to students early in the semester during the discussion of descriptive statistics in an introductory course. As a classroom activity, students were encouraged to complete the assessment as a team of two. From 2008 until Summer 2012, results were collected and tabulated based on a total of 215 paired student groups.

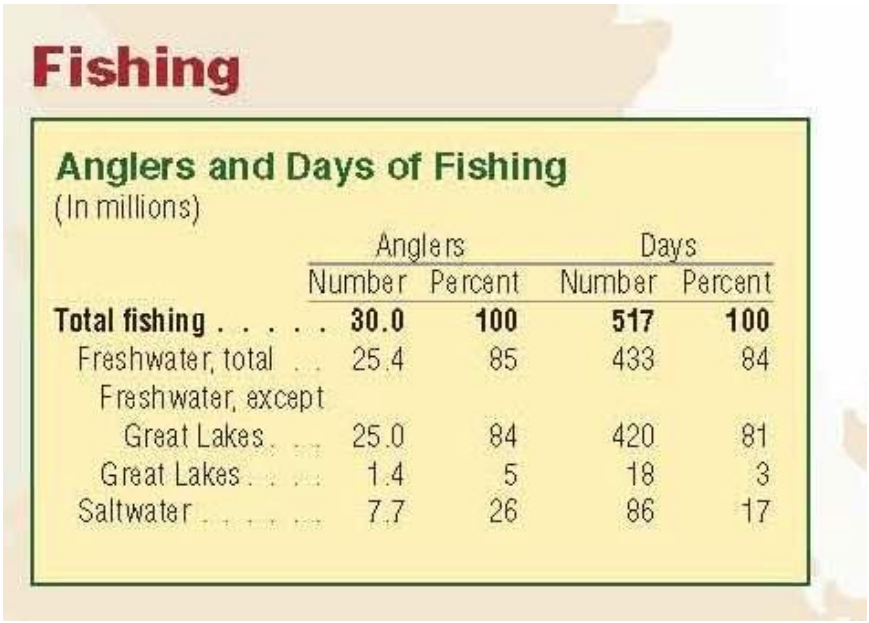
2.2 Selected Results

In this section, I will report the student assessment results for selected questions as grouped by topic. I will provide the questions along with the relevant tables, charts or graphs from the Quick Facts Survey document. Along with the results, a summary of commonly incorrect responses will be provided which may indicate student misperceptions among the various items assessed. These will provide the basis for my commentary on assessment items which may provide some insight on potential student issues / learning opportunities that can assist other instructors of Statistics and Statistical Literacy courses.

2.2.1 Reading Tables of Counts and Percents

The reading of tables is a basic skill in quantitative reasoning. In order for students to be statistically or quantitatively literate, they must be able to consume numbers in context. Tables of counts and percentages are one of the common forms of summarizing data for consumption by data consumers. In this assessment activity,

students are asked to examine several different tables in an effort to answer specific questions. In the following section, I will present the selected tables, questions and student results.



Fishing

Anglers and Days of Fishing
(In millions)

	Anglers		Days	
	Number	Percent	Number	Percent
Total fishing	**30.0**	**100**	**517**	**100**
Freshwater, total	25.4	85	433	84
Freshwater, except Great Lakes	25.0	84	420	81
Great Lakes	1.4	5	18	3
Saltwater	7.7	26	86	17

Figure 1: Table of Anglers and Days Fishing

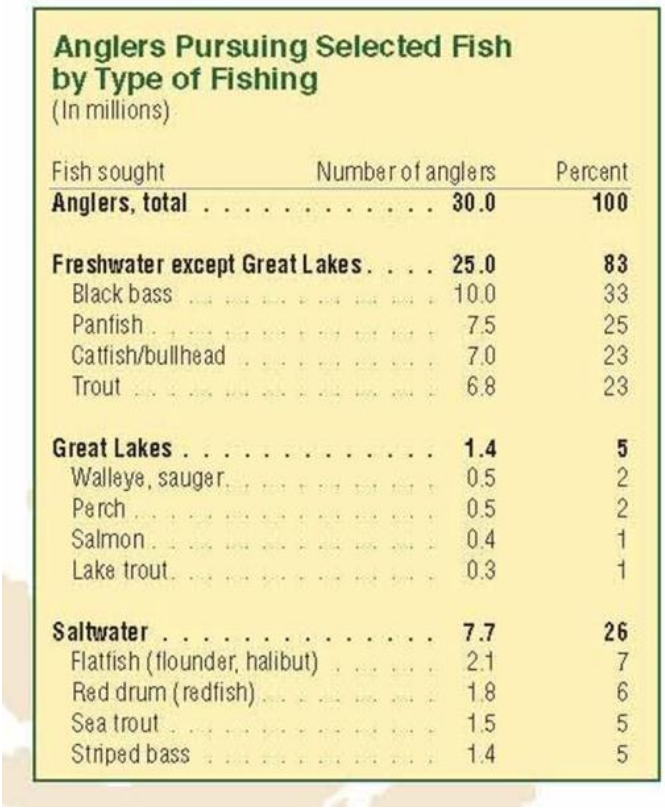
Assessment Question 3: Write out a statement comparing the number of days spent freshwater fishing versus Saltwater fishing.

In this question, student ability to read a table of counts and percents (as shown above) was tested. Besides identifying the two numbers related to the question, students were then forced to put these two numbers into sentence form. Overall, 81% of the student groups were able to identify the two correct values and then create a mathematically and grammatically correct statement. While many of the students had little trouble in identifying the two relevant values from the table, it was a more difficult challenge to incorporate them into a sentence. While college students have had many years of practice in language, grammar, punctuation, etc, very few of them have had explicit instruction in writing involving the description and comparison of numerical values.

In summarizing the types of responses student groups gave to the open-ended question, it is interesting to note that over half (53%) of the student statements involved a non-arithmetic comparison. The largest group of student responses (41%) were a statement of fact sentence along the lines of "There were 433 million fresh-water fishing days and 86 million saltwater fishing days". While this is a correct statement, it is more of an accounting and leaves the comparison to the reader. The second largest grouping of student responses (12%) was in the form of an ordinal comparison which is also non-arithmetic. In this case, responses were similar to "There were more fresh-water fishing days than saltwater fishing days". While this type of statement is correct, it is less informative and provides the reader with very little context about the numbers described.

Once beyond the non-arithmetic comparisons, relatively small numbers of students attempted to be more precise and quantitative about the comparisons being made. 10% of student groups incorrectly made the statement that "The number of freshwater fishing days are 5 times more than the number of saltwater fishing days" instead of saying "4 times more". Among other student statements, only 5 to 7% of student groups attempted to use each of the following types of comparisons: simple difference comparisons (x days more), simple ratios (x times as many), or % share (i.e. "Freshwater days were 84% of the total and Saltwater represented 17%) of the total type comparisons.

While overall results of this item were relatively high at 81% correct, it is interesting to look at the type of comparisons selected by students. In this instance, with the data provided for the activity, a majority (53%) of the students still chose to write a non-arithmetic comparison of the two values while the reminder (47%) attempted to do some sort of arithmetic comparison. It's difficult to know if this was because it was simpler and sufficient to answer the given question or whether this tendency reflects a lack of knowledge or comfort with writing arithmetic comparisons.



Anglers Pursuing Selected Fish by Type of Fishing
(In millions)

Fish sought	Number of anglers	Percent
Anglers, total	**30.0**	**100**
Freshwater except Great Lakes	**25.0**	**83**
Black bass	10.0	33
Panfish	7.5	25
Catfish/bullhead	7.0	23
Trout	6.8	23
Great Lakes	**1.4**	**5**
Walleye, sauger	0.5	2
Perch	0.5	2
Salmon	0.4	1
Lake trout	0.3	1
Saltwater	**7.7**	**26**
Flatfish (flounder, halibut)	2.1	7
Red drum (redfish)	1.8	6
Sea trout	1.5	5
Striped bass	1.4	5

Figure 2: Table of Anglers Pursuing Selected Fish by Type of Fishing

Assessment Question 7: What percentage of Great Lakes anglers fished for perch?

For this item, students read the table above and attempted to answer the given question. For this question, only 19% of the student groups correctly identified the correct answer which is 36% (0.5 million /1.4 million). Note: 40% was also counted as a correct answer if students used the percent column to complete their answer

(.02/.05 = .4). The vast majority of students (76%) misread the table and incorrectly believed the answer to be two percent. In this situation, students were seemingly unaware that the percentages provided in the table did not match the percentage requested in the problem. Only after discussion of the assessment afterwards did students begin to see that the part and whole of the percentages in the table did not match the question and that they should have calculated the percentage based using the number of Great Lakes anglers as the denominator rather than the total number of anglers.

For many students, this question was a bit eye-opening in that they realized that one could present two very similar sounding statements that are both true: 36% of all Great Lakes anglers fish for perch and 2% of all anglers fish the Great Lakes for perch. A seemingly minor switch in the order of words greatly changes the relevant percentages and meanings of the statements. As consumers of statistics, we often times remember the number or percentages but not the exact details of the wording. In most instances, far too little attention is often placed in introductory statistics classes on the importance of the words and correctly communicating numbers in context. In some cases, even those classes identified as statistical literacy often ignore or gloss over the intricacies of communicating with comparisons and other numbers while focusing more on statistical calculation competence.

2.2.2 Reading and Interpreting Pie Charts

While tables are used to summarize large and varied sets of data, pie charts are commonly used to convey specific information regarding a particular variable of interest. Pie Charts are commonly taught to students beginning in elementary school and reinforced over many educational years. Even so, not all pie charts are easy for students to read and interpret. In this section, I will present several pie charts used in this activity along with the assessment questions. Student results on these items will demonstrate that the reading and interpretation of pie charts is more than just remedial work for college students.

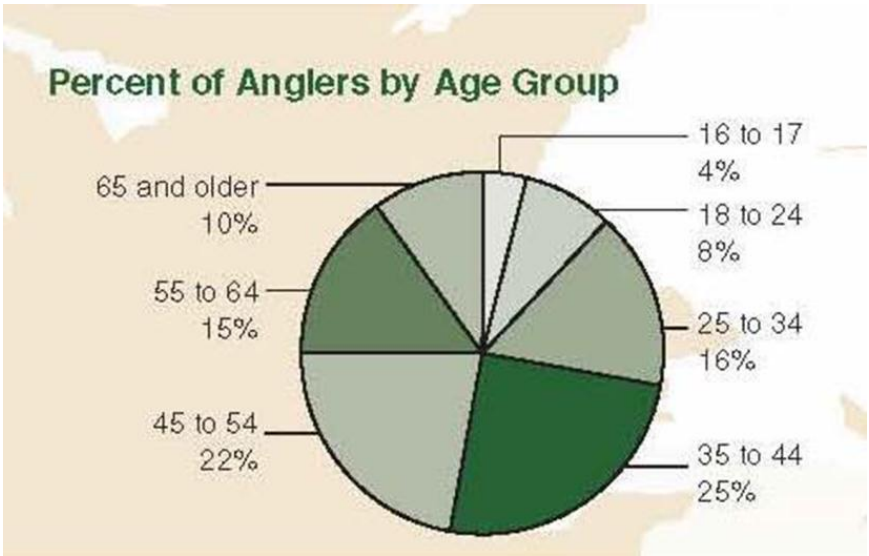


Figure 3: Pie Chart showing percent of Anglers by Age Group

Question 4: What percentage of Anglers are 55 or older?
Question 5: What percentage of Anglers are between 35 and 54 years of age?
Question 6: What percentage of 18-24 year olds are anglers?

For this set of items, students reviewed the pie chart above and attempted to answer the set of 3 given questions. As most college students have many years of experience and exposure to reading and interpreting pie charts, the first two questions were quite simplistic. Student performance demonstrated this competence by achieving 97% and 99.5% correct answers to questions #4 and #5 respectively. College students certainly have little issue reading and interpreting a pie chart when the questions match the given pie chart.

For question #6, most student groups did not recognize or realize the change in question wording made the provided pie chart irrelevant to answering the question and the correct answer should have been to circle the option "Can't tell with info given". A mere 30% of student groups got this question correct. The remainder incorrectly gave an answer of eight percent. As with the table of great lakes anglers in the previous section, the confusion of part and whole by students can lead them astray in the reading of tables and charts.

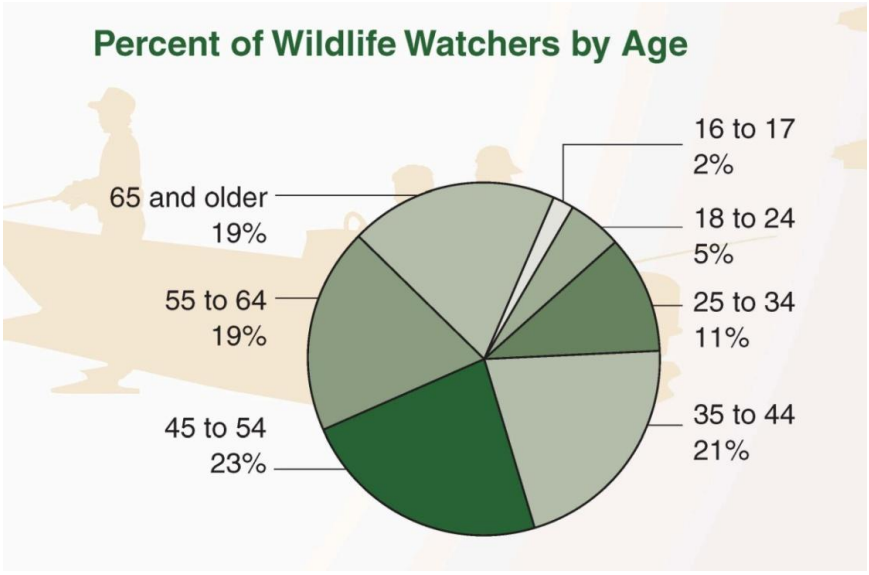


Figure 4: Pie Chart showing Percent of Wildlife Watchers by Age

Question 20: What percentage of 35 to 44 year olds are Wildlife Watchers?
Question 21: What percentage of Wildlife Watchers are between 35 and 44?

For this set of items, students reviewed another pie chart later in assessment. This time the questions focused on the pie chart shown above and the issue of part and whole was made more obvious by asking the reverse questions one after the other. During the administration of the assessment, the back to back nature of the questions certainly raised their awareness of the potential issue and raised several questions by

student groups. For the purposes of the assessment, students were not given any instruction or direction to influence their answers.

With the confusion of the inverse issue confronting them, student groups did perform better on question #20 than the previous one. 56% of the student groups correctly identified that they could not answer the question with the information given in the pie chart. This was a 26 percentage point increase from question #6 which assessed the same concept. More telling about student confusion was that it appeared that about two-thirds of those getting the correct answer on question #20 had physically changed their answer during the assessment by erasing or crossing out the incorrect answer. Presumably student groups had changed their answer after encountering the question immediately following.

Question #21 which immediately followed was a straight-forward reading of the pie chart provided and similar to those performed earlier by students in the 97-99% correct range. When confronted with the reversal of part and whole in back to back questions, some student groups chose the can't tell option even when they had the correct pie chart. Student performance on this question dropped to 87% correct. Thus, while some students (about 26%) recognized the part / whole confusion when reading the chart and the two questions and corrected their mistakes on question 21, roughly 10% were confused by the back to back questions to answer incorrectly.

2.2.3 Reading and Interpreting Bar Charts

Like pie charts, the reading and interpretation of bar charts is often thought to be a simple activity for college students. Following the results in the previous section, I will now present the student results for several assessment items involving bar charts. Student results again indicate that while some bar charts are quite simple that others involve a higher level of sophistication than traditionally considered. Based on the student performance, statistical educators might do more to include these more sophisticated items in their teaching of introductory statistics courses.

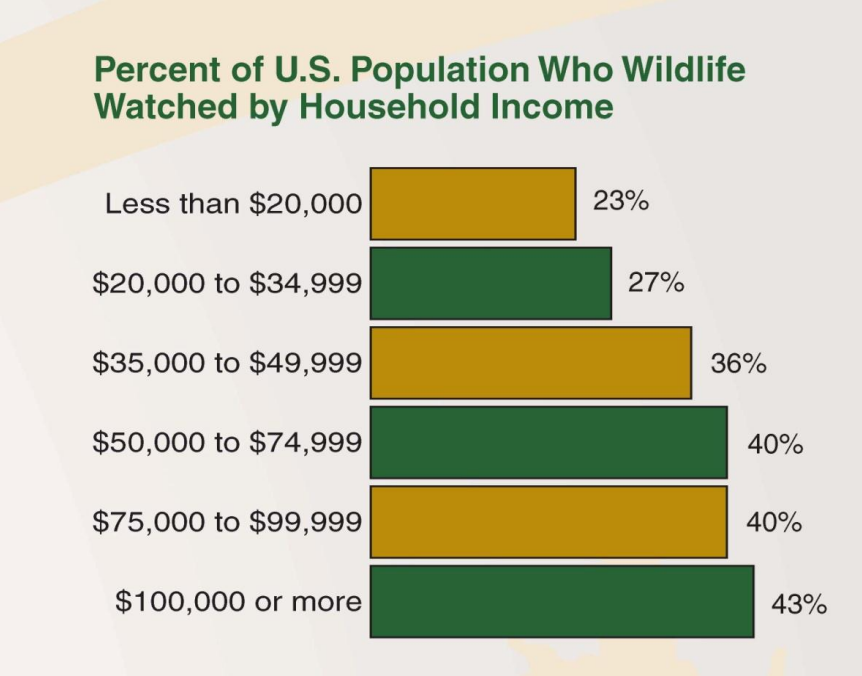


Figure 5: Bar Chart showing Percent of U.S. Population Who Wildlife Watched by HH Income

Question 22: What percentage of low income (<$20k) households are wildlife watchers?
Question 23: What percentage of those under $35k households are wildlife watchers?

The graph above showing the percent of U.S. population who are wildlife watchers by household income was the basis of two assessment questions. While most students looked at the chart as a typical bar chart, they quickly found that this chart is a bit different. For question 22 of the assessment, student groups performed quite well with 83% getting the correct answer which is simply the percentage listed next to the bar for the lowest income group.

When moving to question 23, the success rate dropped greatly to 41%. The correct answer in this particular case is "Can't tell with the information given". Out of more than two hundred responses, the best answer I got from a student group was that the correct answer was between 23% and 27%. These students recognized that the correct answer to the question was really a weighted average of the two group percentages but the chart provides no information on the number of households in each income category.

Exactly half of the student groups responded with the answer of 50% (the sum of the two bars) which is incorrect. While it is appropriate to add the percentages associated with bars in some contexts, the chart presented above contains bars which represent individual wholes. With more space, the 6 bars presented in the graph could have been shown as six separate pie charts with the slices representing the percentages of those who are and are not wildlife watchers. Instead, the creators of the graphic have consolidated the same information into 6 bars on a single chart. Based on their performance, students could use more instruction / clarification on the

interpretation of part and whole within the context of bar charts in addition to pie charts.

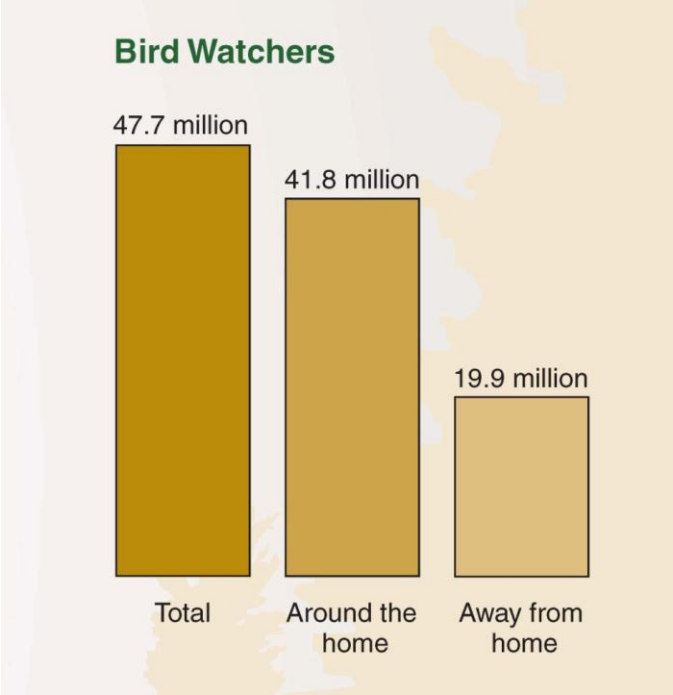


Figure 6: Column Chart showing Quantities of Bird Watchers

Question 24: How many bird watchers participate in that activity both around the home and away from home?

In the final question of the assessment students are asked to examine a bar chart of counts representing bird watchers. In response to the question of how many bird watchers participate both around the home and away, only 10% of the students groups submitted the correct answer which is 14 million (41.8 + 19.9 – 47.7). The variety of answers provided indicates a high degree of confusion by students. While a mere 10% gave the correct answer, 31% replied "Can't tell with information given", another third replied 47.7 million and 8% gave the answer of 61.1 million.

In this particular problem it is obvious that the students were unable to identify the non-mutually exclusive relationship between bird watching around the home and away from home. While not always shown as a bar chart, the identification of situations involving mutual exclusivity or not is a vital skill in learning probability in an undergraduate statistics course.

2.2.4 Other Assessment Items

While not explicitly discussed in this paper, there were several other items of assessment included in this activity. At the beginning, students are asked about the number of estimated wildlife –related recreation participants and the survey sample size in an effort to understand their knowledge regarding the difference between

population estimates and sample size. While many students do well on the question of identifying the stated estimate of wildlife participants, it is interesting that a fair number of students will state that the sample size of the survey is 87 million. In fact, one-fourth of students fail to identify that the sample size is not provided in the quick facts document.

One other item that is asked during the assessment relates to the definition of a wildlife watcher. Like any other statistic, the entire survey is based around counts and percentages of respondents based on definitions of things like wildlife related participant, angler, hunter, etc. In order to count and classify the survey subjects, a definition is required. In question 15, students are asked to identify the definition of a wildlife watcher. While this could be defined quite broadly (have you ever seen any wildlife), the survey creators had a much more narrow definition. In this case, it involved intentional participation with wildlife including feeding, photographing, observing, etc. This issue of operational definitions is an integral part of statistical literacy that currently receives very little attention in most introductory statistics courses.

3. Conclusion

3.1 Conclusion and Recommendations

While a casual reader of the items included in this assessment of student statistical literacy might be tempted to dismiss the student challenges in reading and interpreting tables and charts, the results of this assessment provide empirical evidence that the re some significant challenges that are not being addressed in current introductory statistics courses or their pre-requisites. Some tables and charts are easily mastered in the early years of education and yet there are more sophisticated issues that present themselves in real-world situations for which a large number of students are unprepared. To adequately prepare students to be educated consumers of statistics, statistical educators must find ways to incorporate the teaching and assessment of these skills in introductory statistics courses. If students do not leave Stat 101 with these essential statistical literacy survival skills, where else will they learn them?

Acknowledgements

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References

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Appendix
(Copy of Assessment Item Questions)

		2009-2012		
		Reading Survey Activity - Fishing, Hunting, and Wildlife		
Name		_____		
Column #		Question	Answer	
1	1)	In 2006, how many US Residents 16 or older participated in wildlife-related recreation activities?	_____	Can't Tell with Info Given
	2)	How many people did they interview for this survey?	_____	Can't Tell with Info Given
	3)	On the line below, write out a statement comparing the number of days spent Freshwater fishing vs. Saltwater fishing		
		_____		
2	4)	What percentage of anglers are 55 or older?	_____	Can't Tell with Info Given
	5)	What percentage of anglers are between 35 and 54 years of age?	_____	Can't Tell with Info Given
	6)	What percentage of 18 to 24 year olds are anglers?	_____	Can't Tell with Info Given
	7)	What percentage of Great Lakes anglers fished for perch?	_____	Can't Tell with Info Given
3	8)	What percentage of hunters hunt Big game?	_____	Can't Tell with Info Given
	9)	What percentage of hunting days are spent hunting Big Game?	_____	Can't Tell with Info Given
4	10)	What percentage of hunters hunt for squirrel?	_____	Can't Tell with Info Given
	11)	On the line below, write out a statement comparing the percentage of hunters less than age 35 to the percentage of hunters 55 and older		
		_____		

5	13)	What percent of those with household incomes above $100k are hunters		Can't Tell with Info Given
	14)	How many estimated wildlife watchers are there in the U.S.?		Can't Tell with Info Given
	15)	On the line below, What is the definition of a wildlife watcher? How might they have worded this as a survey question?		
	16)	What % of around the home wildlife observers were bird watchers?		Can't Tell with Info Given
	17)	What % of around the home wildlife observers watched birds or mammals?		Can't Tell with Info Given
6	18)	How much money was spent on Wild-life watching in 2006?		Can't Tell with Info Given
	19)	What was the average amount spent on trip related expenditures per trip participant?		Can't Tell with Info Given
	20)	What % of 35 to 44 year olds are wildlife watchers?		Can't Tell with Info Given
	21)	What % of wildlife watchers are between 35 and 44?		Can't Tell with Info Given
7	22)	What % of low income (< $20,000) households are wildlife watchers?		Can't Tell with Info Given
	23)	What % of those under $35k households are wildlife watchers?		Can't Tell with Info Given
	24)	How many bird watchers participate in that activity both around the home and away from home?		Can't Tell with Info Given