

## TEACHING STATISTICS FOR CRITICAL THINKING

Hanan Innabi

UAEU

United Arab Emirates

*The implicit power of Statistics is that it is a tool of thinking, in particular critical thinking. The paper will clarify how can we teach statistics in order to help students to use the statistical concepts in their cognitive activities according to standards and elements of critical thinking. Some practical, interesting and different examples from secondary school statistics will be given.*

### CRITICAL THINKING AND STANDARDS

Etymologically, the word “critical” derives from Greek language roots: "kriticos," which means “discerning judgment,” and "kriterion," which mean “standards.” Based on that, we adopt the following definition of critical thinking: *Critical thinking is a discerning judgment based on standards.* To put this definition in a practical way we can say that to be critical thinker one should be able to judge what she or he thinks or feels in a discerning way. Now to judge whether we are judging in a discerning way there are some standards, which can be depended on. These standards are:

*Clarity:* The issue or the statement should be clear in order to enable us to think properly about it. If the statement is not clear we cannot tell anything about it because we do not yet know what it is saying. The critical thinker should be aware of the clarity of the issue. If the issue is not clear some questions should be asked such as: Could you clarify more? Could you elaborate further on that point? Could you say it in another way? Could you give me an illustration? Could you give me an example? For example, the instruction: “Write an article about Jordan” is not clear. This instruction can be clearer if we say: “In two pages write an article about the economic situation in Jordan.”

*Accuracy:* Accuracy means to what extent this statement is valid or true or believable. The critical thinker is usually asked questions regarding accuracy such as: Is that really true? How could we check that? How could we find out if that is true? To what extent is this valid?

*Precision:* The critical thinker asks questions about the precision of the issue, such as: Could you give me more details? Could you be more specific or precise? For example, the statement “Shereen is older than Anwar” is clear and accurate, but not precise, as we do not know how much older she is, one day or ten years!

*Relevance:* In some conversation or writing or thinking some irrelevant points appear which may negatively affect reasoning. The critical thinker has to be aware whether the point is relevant to the question at issue. The following questions can reflect this standard: Is this related to the main issue? How is that connected to the question? How does that bear on the issue? Where are we from the main point?

*Depth:* This standard means that we have to go deeper beneath the surface and deal with the complexities in the issue. Asking for explanations and asking the *WHY* questions can reflect this standard. Why are you saying that? How does your answer address the complexities in the question? Is that dealing with the most significant factors?

*Breadth:* Breadth is expanding our view to see the other related points and issues. For example, when a math educator says that he is supporting the idea of using calculators by elementary students, this person has to recognize the insights of the people who do not support this idea.

*Logic:* In order to be critical, “thinking” should be “logical.” Logical thinking means that “when we think, we bring a variety of thoughts together into some order and the combination of thoughts are mutually supporting and make sense in combination.” (Paul, 1994)

### ASSUMPTIONS

1. Critical thinking is a basic value in our lives, which can empower our students and us in living and learning. Accordingly, it is a goal for most educational systems in the world.

2. One can be trained to use and apply these intellectual standards, which are supposed to become infused in the thinking and form part of the inner voice, which then leads to better reasoning.
3. Teachers can help students to practice these standards in a direct or indirect way. The direct way means that teachers explain these standards and explain their role in improving thinking skills in the subject matters as well as in life. After the students understand what each standard means, the teacher can apply them on the discipline content whenever it is convenient. The indirect way depends on teaching these standards through the content without spelling out that these are standards for critical thinking.

#### IMPLEMENTATION IN SECONDARY STATISTICS

The literature in critical thinking reflects big variations in its definitions of critical thinking and variations in how people look into critical thinking. In spite of that, most of these different views agree that “statistics” or “statistical thinking” or “statistical ability” is part of the critical thinking skills or abilities (see for example Ennis 1985). This may lead us to say that as statistics is one of the important parts of critical thinking, it maybe worthwhile to teach them both and together! As we have already explained, we are adopting the universal intellectual standards to teach a profile of critical thinking. We suggest the direct strategy where teacher explains these standards and applies them using statistical content. Following are some example to clarify what we mean by teaching secondary statistics using these standards.

#### EXAMPLES

*Clarity:* In a particular survey about people’s habits in the city of Amman, one question was “Do you eat outside?” Fatema, who in all her life had eaten very few times outside her house, answered “Yes,” whereas her brother, who was like her in that regard, answered the question as “No” because he understood the question in another way. Can we draw a valid conclusion from the results of the data collected regarding this question? Why? What do you think about the clarity of this question?

*Accuracy:* A local newspaper reported that in Jordan, boys are doing better in math than girls. We can teach students to ask about the precision of what they hear and read by asking questions like: Can we believe this story? Where did the data come from? Who did this study? How were the data collected? What was the population and what was the sample? How was the ability of “doing math” measured?

*Precision:* Examples could be taken from situations when we try to describe data while not giving enough statistical indicators about this data, for example, when we give the mean of the yearly individual income in the United Arab Emirates (UAE) to describe every individual’s income in the UAE. In such situations teachers can talk about precision using the ideas of skewness and maybe the median.

*Relevance:* Teaching sampling and determining the population gives us good opportunities to focus on this standard. In the following three questions the teacher can, in addition to discussing the right answers, discuss also the irrelevancy of the wrong answers.

\*A person claimed that Jordan television programs teach students violence. A researcher wanted to test the validity of this claim. What population do you advise the researcher to take to test the validity of his claim?

- a- All children’s programs broadcast by Jordan television.
- b- All programs of Jordan television.
- c- All children in Jordan.
- d- All children who watch all Jordan television programs.

\*In a supermarket there is a special brand of canned food. A health inspector from the ministry of health randomly picked five cans from this brand and examined their quality. Why do you think the inspector took this sample and examined it?

- a- To know the number of unhealthful cans in this sample.
- b- To determine the percentage of unhealthful cans from this brand in the supermarket.
- c- To know the content of these cans.

d- To determine the percentage of unhealthful cans from this brand in all the supermarkets in the area.

\*A factory in Jordan has been producing a kind of electronic lamps since 1995. An engineer wanted to test the length of life of this product. What population do you advise this engineer to take?

a- All lamps produced by the factory since 1995.

b- All families in Jordan who have been using these lamps since 1995.

c- All lamps in stock at the factory.

d- All families in Jordan who had used or not used these lamps.

*Depth:* When we tell our students to know some statistical facts and principles without explaining why we are not teaching for critical thinking and we are not teaching for the “depth” standard. We often make statements such as that adding a constant to all observed values in a sample changes the measures of center by the constant but does not change measures of spread or the general shape of the distribution. Many years ago I remember that my secondary math teacher told us to “remember that a correlation does not mean causation,” but she did not explain why and I continued for several years after that knowing this fact but do not understand it. If we want to teach for critical thinking we have to help students to understand what we are teaching them.

*Breadth:* One clarification example can be of relating the “sampling” concepts such as “representatives” and “bias” with the “breadth” standard. If one wants to know how the university students feel when they come to the campus cafeteria and find it crowded with students, a sample might be drawn from the students who were sitting in the cafeteria in one of those crowded hours. The sample here does not take into account those students who came to the cafeteria and left because it was so crowded. Taking into account all the related opinions and not avoiding some people for some reasons reflects the breadth standard and also the idea of a representative sample.

It is worthwhile to mention here that most of the points or ideas which can be used in teaching these standards are very flexible, meaning that there are possibilities in changing the way we are looking at this point or idea and accordingly changing the standard to fit. Here is an example from the subject of “standardized scores”:

Mageda got a score of 80 in math and 60 in geography.

- Can she conclude from these data that she is better in math than in geography? (logic)
- Even with this information Mageda may be better in geography or maybe there is no difference between the two subjects. Can you explain why? (Depth)
- In order to be able to compare between the two scores we need to know first the number of the questions in each exam. What do you think about the questions’ number? Is it relevant? (Relevance)
- What more information we need in order to make the comparison between the two scores? (Precision)
- Mageda is doing better in math than in geography. Is this true? (Accuracy)
- How can we know about which subjects she is doing better in, art subjects or science? (Breadth)
- What can you say about the above information? (Clarity)

#### A NOTE

This paper is assuming that teaching statistics for critical thinking as was explained above can improve teaching statistics. There are some research works that examine this assumption. In particular my ongoing research is trying to get some evidence of what is called teaching statistics for critical thinking regarding:

- Teachers’ and students’ attitudes toward teaching and learning statistics.
- Improvement in students’ critical thinking ability (in general and specifically in statistics).
- Achievement in statistics content.

#### REFERENCES

- Ennis, R. (1985). A logical basis for measuring critical thinking. *Educational Leadership*, 43 (2).
- Paul, R. (1994). What are intellectual standards? *Educational vision: The magazine for critical thinking*.