

▼ Teaching Statistical Thinking

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Why?

- Many times over, we have seen surveys of employers who indicate “critical thinking” is one of the top skills needed by their employees
- I believe statistical thinking is critical thinking about statistics
- Many students, even those who have had courses with critical thinking, do not know they have that skill because it was not made explicit
- We want students to leave our courses saying, “Here is a skill I have. I can look at statistics and graphs and think more deeply about them.”
- We need to be explicit with students when engaging them with critical/statistical thinking ... we need to tell them this is what they are doing

GAISE (2016)



Teach statistical thinking



Focus on conceptual understanding



Integrate real data with a context and a purpose



Foster active learning



Use technology to explore concepts and analyze data



Use assessments to improve and evaluate student learning

GAISE (2016)

The authors indicate that “the desired result of all introductory statistics courses is to produce statistically educated students, which means that students should develop the ability to think statistically” (p. 8)





IMPACT (2018)

IMPACT describes engagement through the development of student-centered learning environments that promote discourse, critical thinking, and students' self-monitoring of their learning.

“when students have the ability to apply [statistics] to real-world problems they have moved beyond observing and executing a series of isolated skills to the realm of critical thinking” (p. 24)



IMPACT (2018)

“A learning environment that promotes and cultivates critical thinking integrates learning activities and instructional strategies that reflect knowledge of students’ skills, interests, cultural backgrounds, language proficiency, and individual needs.” (p. 24)

Definitions of Statistical Thinking

“We propose that it is essential to work on the development of skills that will allow students to think critically about statistical issues and recognize the need for data, the importance of data production, the omnipresence of variability, and the quantification and explanation of variability. In other words, statistical thinking – the type of thinking that statisticians use when approaching or solving statistical problems – should be taught and emphasized in introductory courses” (GAISE, 2016).

“Statistical thinking is a different way of thinking that is part detective, skeptical, and involves alternate takes on a problem” (Frank Harrell, 15 Sept 2020)

Definitions of Statistical Thinking

Chance (2002) indicated that “it seems that a definition of ‘statistical thinking’ includes ‘what a statistician does.’ These processes clearly involve, but move beyond, summarizing data, solving a particular problem, reasoning through a procedure, and explaining the conclusion. Perhaps what is unique to statistical thinking, beyond reasoning and literacy, is the **ability to see the process as a whole** (with iteration), **including ‘why,’** to understand the relationship and meaning of **variation** in this process, to have the ability to explore data in ways beyond what has been prescribed in texts, and to **generate new questions** beyond those asked by the principal investigator.” (p. 4)

Definitions of Statistical Thinking

Pfannkuch & Wild (2004) describe a variety of concepts related to statistical thinking, emphasizing that “the ability to question claims in the media and to critically evaluate such reports requires high-level thinking skills (Watson, 1997). When students are confronted with having to form a judgment on a report, they have to weigh up what they are willing to believe, what else should be done, or what should be presented to them to convince them further ... [this] requires students to have ... a critical disposition” (p. 35).

Definitions of Critical Thinking

“A well-cultivated critical thinker:

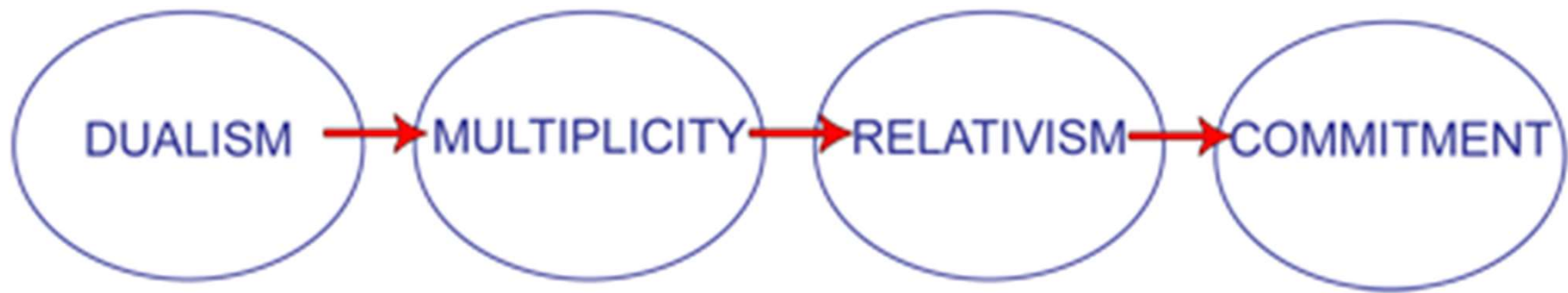
- Raises vital questions and problems, formulating them clearly and precisely
- Gathers and assesses relevant information, using abstract ideas to interpret it effectively
- Comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards
- Thinks open-mindedly within alternative systems of thought, recognizing and assessing, as needs be, their assumptions, implications, and practical consequences
- Communicates effectively with others in figuring out solutions to complex problems”

Source: <http://www.criticalthinking.org/pages/our-conception-of-critical-thinking/411>

Definitions of Critical Thinking

“Critical thinking is the intellectually disciplined process of actively and skillfully **conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication**, as a **guide to belief and action**. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness” (Michael Scriven & Richard Paul, presented at the 8th Annual International Conference on Critical Thinking and Education Reform, Summer 1987)

PERRY'S SCHEME



One Critical Thinking Scheme: Perry (1970)

William Perry created a scheme for the cognitive development of college students that is often referenced with respect to critical thinking.

Source: <https://ii.library.jhu.edu/2013/12/13/perrys-scheme-understanding-the-intellectual-development-of-college-age-students/>

Applying Perry's Scheme to Statistical Thinking

Dualism: "knowledge is received, not learned ... there is a correct answer"
Example: This histogram tells us the true state of affairs.

Multiplicity: "there may be more than one solution to a problem, or there may be no solution; students recognize that their opinions matter" Example: This histogram is one representation of many. I think it is questionable because ...

Relativism: "knowledge is seen as contextual; students evaluate viewpoints based on source and evidence" Example: Where did this data come from?

Commitment within Relativism: "integration of knowledge from other sources with personal experience and reflection" Example: Here is what I think of this histogram based on what I know about it and my own experience.

Source: <https://ii.library.jhu.edu/2013/12/13/perrys-scheme-understanding-the-intellectual-development-of-college-age-students/>

Statistical Thinking Dispositions (Wild & Pfannkuch, 1999)

Skepticism

Imagination

Curiosity and
Awareness

Openness

Propensity to
Seek Deeper
Meaning

Being Logical

Engagement

Perseverance

Critical Thinking Dispositions (Measured by CCTDI)

Truth Seeking

Open-
mindedness

Analyticity
(awareness of
consequences)

Systematicity

Confidence in
Reasoning

Inquisitiveness

Maturity of
Judgment

<https://www.insightassessment.com/article/california-critical-thinking-disposition-inventory-cctdi-2#>



Poll Time

Which of the following concept categories would be your **first choice** for working with statistical thinking?

- a) Graphing
- b) Descriptive Statistics
- c) Probability
- d) Correlation/Regression
- e) Other

Histogram Unit



Time initially spent on process for creating a histogram (students need to know how they are created in order to know how to evaluate them)



Time spent understanding characteristics of a histogram:

Outliers
Shape
Center
Spread/Variability

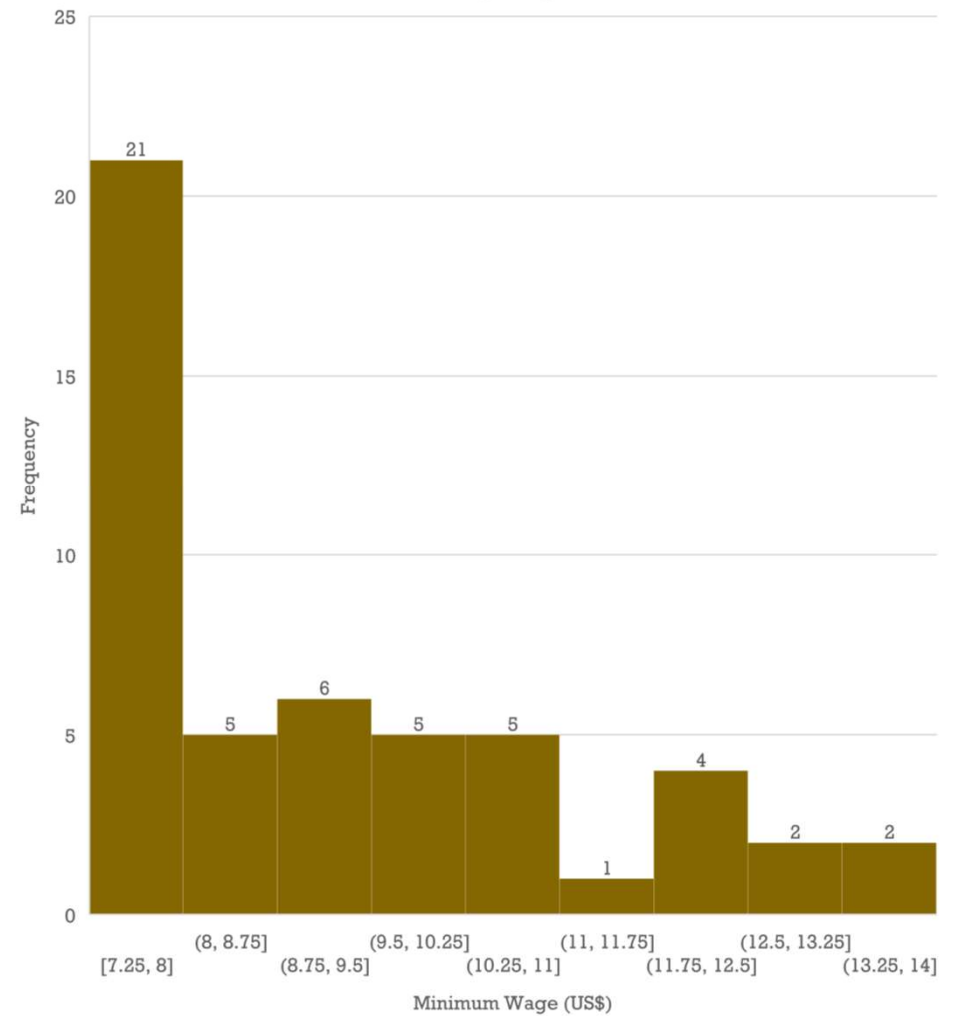


Finish with time spent discussing what the histogram means

Histogram Unit

18

2020 Minimum Wage by State, n = 51



Histogram Unit

- First is a discussion of how the histogram was created – present students with the raw data and talk about classes, class width, and frequencies
- Next is a discussion of the characteristics of the histogram:
 - No outliers present
 - Shape = skewed to the right
 - Center = \$8.00 - \$8.75
 - Spread = \$7.25 up to \$14.00

Histogram Unit

Now, what does it all mean?

- What does “skewed to the right” tell us about minimum wage?
- Is the first bar on the left surprising if you know the federal minimum wage is \$7.25?
- What questions does this histogram bring up for you?
- How was this data created? Is it trustworthy information?
- What would you say to a friend who wonders what minimum wage looks like in the U.S.?
- What else do you want to know about minimum wage?
- How would you go about learning more?

Modeling Statistical Thinking

- Each example we use in class or videos is a chance for instructors to say, “Here is what and how I think about this.”
- This is key early in the process, when students have no experience thinking critically about statistics. They are looking for “right answers” not multiple answers.
- Engage in class discussion about the possibilities and questions raised.
- Eventually move to a point where students can say, “Here is what I think about this. And here is why.”

Assessing Statistical Thinking

- Three Tiers (Watson, 1997):
 - 1 = Basic understanding of terminology: students creating and analyzing their own data sets
 - 2 = Embedding language and concepts in wider context: read and interpret written reports
 - 3 = Questioning of claims: confidence to challenge what they read in the media
- Possible to create any type of assessment item (objective or open-ended) that assesses statistical thinking, but to really “get to know their thought process,” more open-ended items prevail.
- *EXAMPLE: For Question 11.14 you generated a graph of data based on obesity data gathered by the CDC (Centers for Disease Control and Prevention). Beyond shape, center, and spread, what does this graph tell you about obesity in the United States in 2009? How would you describe the 2009 obesity situation to a friend? What more would you like to know? How will you go about learning that?*

Assessing Statistical Thinking: Contemporary Issues Journal

- K. Patricia Cross Academy = variety of assessment options for a variety of outcomes including “Online Adaptations” (kpcrossacademy.org)
- This assessment has students selecting any topic important to them
- Seek and discuss a statistic or graph related to that topic
- Build a portfolio of such statistics and graphs throughout semester
- Reflect on what they learned

Assessing Statistical Thinking: Contemporary Issues Journal

Questions I Ask:

- Summarize the information. What did you find, what is it about, how was it created, who created it, what does it say?
- List below two questions you have about this information.
- Reflect on how specific course content (e.g., a specific concept, chapter, or example) you have covered so far relates to what you found.
- Reflect on how this information relates to your personal or professional (current or future) life.

Wrap Up

- I feel it is a commonly accepted fact that critical/statistical thinking is an important skill for students to develop
- We must be intentional about this – we must state clearly and often “you are now thinking critically and statistically”
- The culture of critical/statistical thinking needs to be built starting Day 1
- Model it, ask for it, comment on it, and assess it

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Q & A