METALS
Masters of Educational Technology & Applied Learning Science

Developing Critical Thinking through 6th Grade Statistics

Zach Mineroff — 12/12/2017
Educational Goals, Instruction, and Assessment

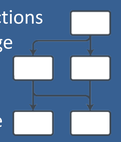
BIG IDEAS

Big Ideas are essential concepts from EGIA synthesized into an organized set. Each is supported by readings and experiences from the course. I use them here to justify decisions in my instructional unit.

1. Constructing Models of Reality

1.1. Make connections to prior knowledge

1.2. Provide structure to organize knowledge



1.3. Engage, but avoid cognitive overload

2. Communal Motivation

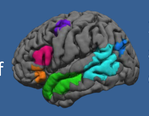
2.1. Reframe negative beliefs

2.2. Consider contextual norms when instructing and assessing

2.3. Create a culture where it's safe to fail

3. Deep and Sustainable Learning

3.1. Encourage grappling with ideas instead of memorization

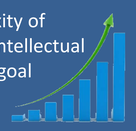


3.2. Use formative assessments that deepen understanding

3.3. Promote transfer by solidifying underlying structure of concepts

4. Authentic Assessments

4.1. Scale complexity of assessment with intellectual depth of learning goal



4.2. Keep assessments practical in context of learning environment

4.3. Meet standards of assessment triangle

5. Experiments Where Everybody Wins

5.1. Vary a targeted aspect of instruction, but keep in mind alternative explanations

5.2. Use experimental methods that are both rigorous and ethical

For detailed descriptions and sources, see my portfolio at https://zachmineroff.com/

OVERVIEW

Domain

6th grade statistics as guided by section 6.SP of the Common Core standards

Importance

Forms basis for critical thinking
- Sensible political discussions
- Apply knowledge to other courses
- Critical of scientific claims in media

Main learning challenges
- Making and justifying choices
- Appreciating value of stats
- Self-efficacy & growth mindset

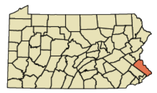
> *"why does it matter which way you represent the data?"*
>
> *"oh my GOD idk how 2 do this"*
>
> — Khan Acad. Students

Addressing the challenges

Combine power of
- eLearning → instant feedback, personalized practice
- Projects → application of material, target dispositions

A — LEARNERS IN CONTEXT

Community
- 6th graders in a public school
- Doylestown (relatively affluent east coast suburb)



Timing
- Later in school year to ensure enough prior knowledge
- 10 1-hour lessons during math portion of day (2 weeks total)

Prior knowledge
- Facts: simple units of measurement, order of operations
- Skills: basic algebra, organizing tables, recognize patterns
- Dispositions: varying levels of math anxiety

Learner profile
- Out of middle childhood and into young teens
- Developmental level = double-edged sword
  - → Growing ability to think more critically and abstractly
  - → Physical & social changes act as distractions to learning

B — GOAL SPECIFICATION

		Cognitive	Metacognitive
Primary	Concepts	Recognize a statistical question Recognize (dis)advantages of visual methods used to summarize statistical data	Self-awareness of deep understanding of main concepts
	Skills	Form a statistical question Make and justify choices about the method of summarizing a dataset (numerical & visual)	Self-monitoring of willingness to plan solution before starting calculations
	Dispositions	Self-efficacy Willingness to experiment Value different visualizations & measures	Reflect on own beliefs about what it takes to learn statistics/math Adjust approach to statistical problems based on values
Secondary	Concepts	Understand useful info to extract from a dataset Recognize numerical ways of finding center/spread Recognize visual methods of displaying data	Shift learning focus based on difficulty mapping terms to definitions
	Skills	Describe the context surrounding a dataset Calculate measures of center/spread Construct relevant plots to display data	Monitor and evaluate process and change course if necessary
	Disp.		Monitor own anxiety and frustration

C — ASSESSMENT DESIGN

Semester-long project targets primary goals[4.1]
- Students formulate stat. questions they want to answer[2.2] and collect real data to draw a conclusion
- Segmented milestones allow students to continuously apply new information[1.1] and enable multiple chances for feedback[2.3]
- Students make choices about which methods best support their argument and reflect on their learning through guided questions[3.1]
- Instructors use rubrics to ensure learners are reaching goals and offer more instruction as necessary[4.3]

eLearning modules target secondary goals[4.1]
- Students complete formative assessments that provide instant feedback based on performance[3.2]
- Data logs allow platform to tailor scaffolding for individual students on the fly[1.2]
- Summative post-quizzes highlight muddy points[4.3]
- Preview quizzes get students thinking about next topic

Example assessment: Part of project milestone

Cognition
- Aligned with goal: Justify choice of measure of center

Observation
- Prompt: Which numerical measure of center best indicates the typical value of your dataset?

Interpretation
- Evaluate soundness of argument and give feedback

D — INSTRUCTIONAL DESIGN

Statistical questions → Datasets in context → Dot plots → Histo-grams → Mean → Median & mode → MAD → IQR & box plots → Choosing methods

Before class
- Instructor infers what students struggled with on HW
- Instructor assesses progress on project using rubric

In class (1 hour)
- Review previous topics; adjusted based on assessments
- Application of previous lessons to statistics project[3.1]
- Lecture on new topic; incl. self-efficacy norms[2.1]
- eLearning formative assessments on new topic

Homework (~15 minutes)[1.3]
- Go over formative assessments
- Summative assessments for today, plus previous days[1.1]
- Quick intro to next topic with a pre-quiz[1.2]
- Work on project if necessary

Example instruction: Part of choosing methods
- *Aligned with goal*: Justify choice of measure of center
- *Pre-quiz*: Give example plot and ask students why median is better than mode as an indicator of typical value
- *Lecture*: Make use of contrasting cases with graphs
- *Application to project*: Students receive a peer's dataset and offer advice about which measure of center is best
- *Homework*: Make argument about own dataset

E — EVALUATION RESEARCH

Implementation: Fidelity check of teacher
- 2 courses run at the same time (different instructors)
- Test inter-rater reliability of rubric by having each instructor assess student projects from other class

Implementation: Fidelity check of students
- Track student interactions with eLearning platform
- From click logs, can determine time spent on problems, likelihood of gaming the system, etc.

Efficacy

Research Question
- Do motivational prompts in eLearning modules lead to higher measures of self-efficacy on the project?

Experimental design
- Experimental Group: Sees motivational prompts[5.1]
- Control Group: Sees progress update page[5.1]

Method
- Split-class design; stratified random assignment to groups[5.2]

Data collection and scoring
- Students write self reflections for project milestones
- Instructor uses rubric to rate self-efficacy
- Improvement = score on final milestone - score on first

Hypothesis
- Students in experimental group will have higher improvements in self-efficacy measures

Assessment of design quality
- Inter-rater reliability: multiple instructors independently determine self-efficacy score for each student[5.1]