



Scientific Inquiry in Middle School Mathematics & Social Studies Education



Kacie Friberg
Rye Junior High School

Year 1: Summer 2016

Research

Project Title: *Designing a Model for Predicting Fatigue Cracking in Asphalt Pavement*

Affiliates: *Dr. Eshan Dave, Dr. Rasool Nemati*

Synopsis: *I used JMP Pro12 software to analyze the relationships between ten components of asphalt pavement mixtures. Statistically significant factors were identified using R^2 ($\rightarrow 1$), Chi Square (< 0.0001), p value (< 0.05), and RMSE ($\rightarrow 0$).*

Results: *I accurately predicted the entire damage characteristic curve of an asphalt pavement mixture using the generalized regression: $C = e^{as^b}$. The components that were statistically significant were % RAP, NMAS, % Air Void Content, PG temperature extremes, % Asphalt Content, and % RAS.*

Takeaways

The purpose of data is to inform.

I had been asking students in my class to look at arbitrary data to make calculations that meant nothing.

We want to prepare students for careers in an increasingly data-driven world, to become informed consumers and voters. To do so, data must have real meaning to them. An instructional change needed to be made immediately.

Classroom Impact

7th Grade: data acquisition and analysis

- Develop a research question
- Survey two school subpopulations
- Analyze the results using measures of center & variability
- Draw a conclusion that compares the two populations
- Create a poster with your conclusion and analysis

8th Grade: data acquisition and bivariate regression

- UNH lab; damage testing of asphalt & concrete pavements
- Create & Test Chocolate Asphalt Cookie (pavement design)
- Measuring thickness, time, and terminating load
- Choose two variables to analyze
- Characterize the bivariate relationship qualitatively and write a linear equation to model
- Use analysis as evidence to argue your conclusion



Year 2: Summer 2017

Research

Project Title: *Comparative Life Cycle Assessment of Traditional and Solar Water Heating in 5 U.S. Cities*

Affiliates: *Dr. Weiwei Mo, Mingcheng Ren*

Synopsis: *I used SimaPro and Excel to calculate and compare CED, GWP and Cost/Benefit of a Thermosyphon Solar Hybrid system versus a Traditional 100% Natural Gas System.*

Cities Studied	Major Factors	Avg. Household Size	Period of Frost	Transportation Distance
Boston				Market \rightarrow Consumer
Atlanta				
Chicago				
Phoenix				Transportation Distance
Los Angeles				Consumer \rightarrow Landfill
		Avg. \$/gal Water	Tax Incentives	
		Avg. Water Use (per person per day)	Direct Normal Irradiance (DNI)	

*impacts normalized to 1 gal hot water produced over expected 20 year lifetime

Results: *Only in Phoenix was the cost of the solar hybrid system lower than the traditional system. In all other cities, the costs were comparable.*

Takeaways

Personal data is memorable data.

People remember data figures that relate to them or personally impact them in some way. Further, still, people are naturally skeptical of figures presented to them. They must be convinced that the conclusions are valid and important.

Valuable data exists, waiting to be sought.

The study of history is part of the social sciences. We should be incorporating inquiry into the way students learn history. Let students seek knowledge.

Classroom Impact

7th & 8th Grade: Social Studies

Not-So-Civil Figures

- Choose & pre-search a historical figure from the time period
- Introduce that person's story through perspective taking
- Serve as the resident "expert" for that person during history

Time Traveler's Journal

- Narrate the life of an original character; their perspective & societal role through historical events & themes
- Students seek additional historical information to embellish their character's persona and experience
- Perspective-taking makes the information more personal

Acknowledgements

Thank you to the UNH Leitzel Center for these authentic inquiry experiences in engineering and to Rye Junior High School for their support of ingenuity in education.

Year 3: Summer 2018

Research

Project Title: *Recommendations & Barriers to Uniform New England Quality Assurance of Asphalt Pavement Projects* (NETC QR 15-4)

Affiliates: *Dr. Jo Sias Daniel, Dr. Eshan Dave*

Synopsis: *A uniform QA practice would simplify certification, allow shared resources, and streamline operations.*

Primary Stages of Quality Assurance

What?	Quality/Process Control	Independent Assurance	Acceptance
Who?	Contractor	3 rd Party Consultant	Agency
When?	During Construction	Periodically	End of Construction

Results: *Some Best Practices, Priority Attributes to Test, and Potential Barriers to Change were identified in existing practices. New England states and P.I.s began the conversation and identified next steps for further inquiry & discussion.*

Takeaways

Performance is personal.

There is a human element to all data. Investigators must be sensitive in their data acquisition and communication of their findings. People doing their best can take recommendations for change as criticism or censure.

Formative assessment is essential.

It is simpler to recover a fault that is caught early, rather than at the end of a task. Quality must be checked regularly.

Classroom Impact

7th Grade Math & Social-Emotional Learning

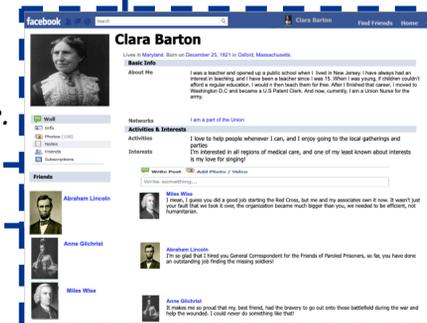
Social-Emotional Learning

- Identify a problem in your community.
- Design and conduct a survey.

- Analyze the data to form a conclusion.
- Determine elements of your analysis that can be used as evidence to support your conclusion.
- Write a letter to a local governing agency, stating the change you'd like to make and using your data analysis as evidence to argue your position.

Formative Assessment

- More intentional use of content-specific pre-assessments.
- More frequent formative assessments during instruction.
- More frequent use of standardized benchmark tests.



NSF Award # ENG-1132648
2016 & 2017

NSF Award # ENG-1711701
2018