Using Innovative Technology and Interactive Songs to Engage Students in Standards-based Introductory Statistics Learning Objectives: Discussing Lessons Learned from NSF-funded Project SMILES



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joint work with Dennis Pearl (Pennsylvania State University), John Weber (Perimeter College at Georgia State University), and Dominic Dousa & Steve Haddad (UTEP)

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http://www.math.utep.edu/Faculty/lesser/Fun.html

(or you can Google my "Mathemusician" page)

supported in part by NSF grant Project



Student-Made Interactive Learning with Educational Songs (for introductory statistics) PSU (1544426); UTEP (1544237); GPC (1544243)

smiles@causeweb.org



the math of UTEP's Bhutanese architecture was in Sept. 2008 Mathematics Teacher!

Who are you?

 Educator at ES? MS? HS? College? Supervisor? Other?

 Which best describes your song usage? already use a lot already use a little none, but am open to it none, and I want to be convinced quickly, 2 slides we <u>won't</u> discuss (but feel free to photograph)

....so we keep focus on (interactive statistics) SONGS

MATH	MUSIC
Ordinal numbers	naming intervals (e.g., fifths)
Geometric shapes	instrument shapes (e.g., triangle)
Geometric transformations	melodic transformations
Least common multiple	rhythm patterns; harmony (from pitches w/ low LCM)
Fractions	time signature; interval is a ratio of frequencies
Arithmetic sequence	overtones (f, 2f, 3f, 4f,)
Geometric sequence	chromatic scale (in equal temperament)
Graph (pitch over time)	musical notes on a staff
Sine function	graph of (pure tone) sound wave
Permutations, Probability	"change ringing" of bells; Mozart's "Musical dice game" (1793)
Statistics	DATA \rightarrow SOUND: sonification SOUND \rightarrow DATA: traits of hit songs
Group theory, modular arithmetic	analyze the set of pitches in a scale
Fourier series, partial differential equations	musical sound, acoustics

stats in lyrics of "regular songs"...

(from Lesser 2000, 2001, 2014)

- "100% <u>chance</u> of rain" Gary Morris
- "reduce me to the <u>mean</u>" Richard Shindell
- "random sample, hold the one you need" Rush
- "at the edges of the bell-shaped curve" David Wilcox
- OR concept without terminology:
- regression to the mean
- in Christine Lavin's "Attractive Stupid People"

know others? email me!

for more math & music (resources, lyrics, MP3s, etc.), than there's time to share today, just *Google* me!

Google	Larry Lesser		
Ŭ			
Search	About 8,820,000 results (0.24 seconds)		
Veb	Larry Lesser - Mathematical Sciences		
mages	www.math.utep.edu/Faculty/lesser/ QUICK BIO: Statistics/math educator Larry Lesser has taught university math,		
Maps	statistics and math education courses in Colorado, Georgia, and Texas and since Math Ed - Statistics - Equity - Study Tips		
/ideos			
Vews	Mathemusician.html - University of Texas at El Paso www.math.utep.edu/Faculty/lesser/Mathemusician.html		
Shopping	ABOUT THE MATHEMUSICIAN: To support his mission in increasing awareness and motivation in mathematics, Professor Lesser has tapped and merges two		

OUTLINE

Not all students love statistics, but all love music! This NSF-funded multi-institution webbased intervention has students supply concepts and contexts that get incorporated (in a loose "Mad Libs style") and highlighted in a finished song (of high artistic quality) for them! We'll tour the 26-song standards-based collection (spanning an intro statistics course) and discuss results of recent informal pilot studies and randomized experiments to assess student engagement and learning gains. BYOD!

- Background
- Inspirations & Guiding Criteria
- Songs from the Collection
- Lessons Learned
- Tips for Use
- Q&A

How to find STATISTICS songs

without a big search of YouTube or individual people's pages, etc.?

www.math.utep.edu/Faculty/lesser/Mathemusician.html

Resources & Bibliography	SONGS!	Cool Math & Music Quotes
More on Lesser	Presentations & Press	Contact Info



The MatheMySician

"Find, find the value of pi -- starts 3 point 1 4 1 5 9. A good ol' fraction you may hope to define, but the decimal never dies" -- from Larry Lesser's award-winning "<u>American Pi</u>"



ABOUT THE *MATHEMUSICIAN*: To support his mission to motivate learning mathematics/statistics, Professor Lesser integrates two great loves – math and music! An awardwinning songwriter in general songwriting contests, Lesser has also won awards for educational songs and song videos in recent national contests (ASA, National Museum of Mathematics, <u>CAUSE</u>, <u>QL-SIGMAA</u>) and a <u>video of songs was shown at Bridges 2014</u>. His songs have yielded statistically significant learning gains in an <u>NSF-funded randomized experiment</u>, helped

causeweb.org

- site launched in 2005 (part of NSF's National Science Digital Library)
- Its curated, searchable 748-item fun collection includes 167 songs (almost all with soundfiles), 10 modalities, bibliography, & lesson guidance

CAU	web	Fun	Collection	۱

In this section wide fun items related to statistics, including cartoons, a gallery of statistical art, jokes, games, magic, poems, word puzzles, quotes, songs, short stories, and videos. Click he an introduction to the literature and some usage guidance on teaching statistics using fun items. Consider participating in the A-µ-Sing contest to contribute to this collection to the statistic and contest rules for more information.

CONFERENCES ~

Search for...

CONTESTS ~

PROF DEV 🗸

RESEARCH

CAUSEweb

Displaying 1 - 10 of 724

Keyword(s)	Туре	Торіс	ltems per page	
	Song 🔻	- Any - •	10	APPLY
	- Any - Cartoon			
	Gallery	(This is How) Stats are	Like Diamonds	
	Game Joke Magic	Lyrics © 2016 Lawren v sing to the tune of the Beatles' "Lu	ce M. Lesser cy in the Sky with Diamonds"	
	Poem Puzzle Quote	Picture statistics in the With context all missing or	e newspaper half summarized;	
	Song	Somebody chose just who v	vould be surveyed	
	Story	And the order the it	ems arise.	
	Video	are each chosen and given a settin	g, polished and cut for a view:	
	1	ook for the angle that reaches you	r eves when they're done	

HOME

fun fact: 21% of CAUSEweb songs are from a Texas HS teacher!

Aledo High School > Teachers > Mary Mclellan > Welcome



Phone: 817-441-8711

Email: mmclellan@aledoisd.org

Degrees and Certifications:

Degrees: Bachelor of Science in Mathematics

Mrs. Mary McLellan

My name is **Mary McLellan** and I teach AP Statistics. I absolutely love teaching AP Statistics because I feel as though it is extremely applicable to almost every aspect of life and certainly almost every career choice. I am passionate about teaching my students the fundamental concepts and the language of the world of Statistics.

I am a graduate of Texas Christian University with a Bachelor of Science in Mathematics as well as a Bachelor of Music in Piano Pedagogy. While I do not currently have a career that actively utilizes my music degree. I enjoy incorporating a musical component into my classes. I have fun creating songs to help my students remember and understand much of the vocabulary and concepts of statistics.

Subjects Taught: AP Statistics, grades 10-12

Math Bridge, grades 10-12

song helps recall

(which can free up resources for higher order thinking):

- "The Alphabet Song" to learn ABCs
- Ray Charles' "Fifty Nifty United States" to learn 50 U.S. states (in alphabetical order!)
- about 60 Schoolhouse Rock (on ABC) songs spanned Multiplication (by 2,...,12), Grammar (e.g., "Conjunction Junction"), America, Science, Money, Earth
- Quadratic formula has been sung as:

Pop Goes the Weasel, Frère Jacques, Battle Hymn of the Republic, Amazing Grace, Macarena, Jingle Bells, Over the Rainbow, Gilligan's Island, etc.

but song can also go beyond recall (Lesser, 2014)

- introduce concepts/terms
- reinforce thinking process
- connect to history/real-world
- humanize

Motivations

- Motivating learning,
- Math/stat anxiety reduction,
- Memory aid,
- Multidisciplinary connections,
- Multiple intelligences,
- Making community,
- Mashing stereotypes (content, class, teacher),
- Modelling stretching, etc.

who heard Chris Emdin at 2018 NCTM?

Opening Keynote



When Content Meets Context: Towards a Revolution in STEM Education

Christopher Emdin, Columbia University, New York

Wednesday, April 25 | 5:30-7:00 p.m.

In this address, Professor Emdin explores the historical and contemporary landscape of urban education and provides a new lens for viewing how and why teachers must focus on deep excavations of culture in order to gain new approaches to improving STEM pedagogy. In particular, he merges cutting edge research with real life examples to provide ways that educators may reimagine their roles in STEM teaching and learning and meet the needs of their most marginalized students.

Hesitations	Solutions
Can't quickly find good examples	CAUSEweb.org, singaboutscience.org, etc.
No skills/talent	Press "PLAY"; tap student talent
Uses too much time	Streamline length. Use as students enter or papers handed back or have students access online outside class.
Clash with students' cultures	Know your audience (week 1 survey, etc.)
Need to be seen as serious by students	Make connections to content (or assessment); make a mini-lesson plan
Need to be seen as serious by colleagues/supervisor; Unaware of evidence of helping learning	See studies and statements supporting engaging/active learning
Copyright permission	Apply "fair use test" as with other materials

OUTLINE

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- Inspirations & Guiding Criteria
- Songs from the Collection
- Lessons Learned
- Tips for Use
- Q&A

our NSF-funded Project UPLIFT study (July 2016 JSE)

JOURNAL OF STATISTICS EDUCATION 2016, VOL. 24, NO. 2, 54–62 http://dx.doi.org/10.1080/10691898.2016.1190190



OPEN ACCESS

Assessing Fun Items' Effectiveness in Increasing Learning of College Introductory Statistics Students: Results of a Randomized Experiment

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ABSTRACT

There has been a recent emergence of scholarship on the use of fun in the college statistics classroom, with at least 20 modalities identified. While there have been randomized experiments that suggest that fun can enhance student achievement or attitudes in statistics, these studies have generally been limited to one particular fun modality or have not been limited to the discipline of statistics. To address the efficacy of fun items in teaching statistics, a student-randomized experiment was designed to assess how specific items of fun may cause changes in statistical anxiety and learning statistics content. This experiment was conducted at two institutions of higher education with different and diverse student populations. Findings include a significant increase in correct responses to questions among students who were assigned online content with a song insert compared with those assigned content alone.

KEY WORDS

CAUSEweb fun collection; Humor; Song; Statistics education research

diverse settings/populations for a statistical literacy course

	Two-Year College	University (medium-size)
Region of U.S.	Southeast	Southwest
Student population	mostly Black	mostly Hispanic
Sample size (n)	53	194
Main audience	General education	Pre-service teachers
Text	Sullivan (2014) Fundamentals of Statistics: Informed Decisions Using Data	Utts (2005) Seeing Through Statistics
LMS (Learning Management System)	Desire2Learn	Blackboard

student-randomized experiment

 All students told their exams would have (12-14) embedded (MC) items related to online (LMS) content readings.

 Half the students randomized to always have "fun inserts" (song, cartoon, etc.) in those readings

mini-reading with insert

G,

🖄 My Home > Introduction t...

📽 | 🖄 | 🦘

It's a Sign: A Connection between Correlation and Slope

The correlation coefficient *r* tells us something about the strength and linear relationship of a scatterplot of data. By strength, we mean how tightly the points cluster around the regression line (i.e., the line of best fit). All else being equal, a correlation value of *r* = 0.7 (or *r* = -0.7) generally indicates a stronger linear relationship than a value such as *r* = 0.3 (or *r* = -0.3).

The direction of the relationship has to do with the sign of r. If r > 0, we have positive correlation, which means higher values of Y are associated with higher values of x, and lower values of Y are associated with lower values of X. In other words, X and Y go up and down together. Such a scatterplot would be described best with a line of fit that has a positive slope, and indeed this is always the case: positive correlation happens when the regression line slope is positive. Likewise, r < 0 means negative correlation, with X and Y moving in opposite directions from each other, thus suggesting a line of fit with a negative slope. Finally, a scatterplot with no real linear trend at all (i.e., r = 0) would have a line of fit that is horizontal, which means slope of 0. Whether positive, negative, or zero, the sign of the correlation r is the same as the sign of the slope of the line.

Here are lyrics to a song (sung to the tune of the familiar folk tune "Twinkle, Twinkle Little Star" that helped you learn the alphabet) to help you rehearse and permanently acquire this fact in your mind:

Correlation Song (lyric © 2013 Lawrence M. Lesser)

Are points near a line, or far? What's the correlation, r? If the fit supports a line, Its slope and r would share the sign. Twinkle, twinkle, you're a star: Knowing stats will take you far!

Click on this MP3 file (https://www.causeweb.org/resources/fun/mp3/CorrelationSong.mp3) so you can hear this 20-second jingle. Now play it one more time (and sing along!).

% Correct without and with Song Inserts

Торіс	Without song <i>n</i> = 88	With Song <i>n</i> = 80	Difference
Margin of error: down with n down by √n	57.3% 9.1%	61.3% 10.0%	4.0% 0.9%
Standard score	62.5%	75.0%	12.5%
Correlation & slope	60.2%	73.8%	13.6%
Equiprobability bias	40.9%	50.0%	9.1%
Multiplicity	36.1%	37.0%	0.9% (medium university)
<i>p</i> -value	44.4%	50.0%	5.6% (2-yr. college)
OVERALL	42.3%	50.0%	7.7%

2-tailed *p*-value ≈ 0.04

we wondered.....

why did songs make significant difference but not cartoons?

and if it's because songs are more interactive, how could songs get still *more* interactive?

Note: **Active learning** is a principle for good practice in undergraduate education (Chickering & Gamson, 1987); active learning in STEM is supported by meta-analysis of 225 studies (Freeman et al., 2014)

Inspiration from songs of HS teacher Dane Camp:

students complete rhymes in real time!

Example using "Correlation Song", the experiment's top-performing song

(using the tune that helped us all learn the alphabet)

Are points near a line, or far? What's the correlation, ____? If the fit supports a line, Its slope and *r* would share the ____. Twinkle, twinkle, you're a star: Knowing stats will take you ____!

Lyric © 2013 Lawrence M. Lesser

Tune: "Twinkle, Twinkle Little Star"

LIMITATIONS of "complete the rhyme" approach

- Need simple rhyme scheme.
- Only one word can be the correct answer, which limits what can be assessed.
- May be too easy to fully engage students.
- May need a live whole-class setting for best results.

continuum of interactiveness of song (see my 2017 VOICES talk:

https://www.causeweb.org/voices/2017/panel/1-3)

For example: having a student...

provide inputs > just hearing a completed song

An exclamation

An exclamation

An adverb (hint: most end in 'ly')

- An exclamation
- An adverb (hint: most end in 'ly')
- A verb ending in 'ing' (i.e., a gerund)

- An exclamation
- An adverb (hint: most end in 'ly')
- A verb ending in 'ing' (i.e., a gerund) A plural noun

now let's read the "result":

"____!" she said _____. This [exclamation] [adverb]

 talk is like
 !"

 [verb ending in 'ing']
 [plural noun]

a Mad Libs approach...

has been adapted for educational use, including in teaching statistics (e.g., Trumpower, 2010)

A researcher uses a 2 <u>height (short, tall)</u> \times 2 <u>relationship status</u> (<u>unmarried, married</u>) between-subjects, factorial design to study the effects on <u>maximum bench press ability</u> (as measured on a 10-point scale, with 10 indicating the greatest and 1 indicating the least <u>maximum bench press ability</u>). After collecting data, the researcher calculates the mean <u>maximum bench press ability</u> of participants in each condition of the study, as summarized in





by Roger Price & Leonard Stern

other inspirations:

- script song by Sheri Robb in Jan. 1996 Music Therapy Perspectives inspired my icebreaker song in May 2000 Mathematics Teacher
- "Choose your own adventure" books (or Roy Zimmerman's song video: "What would you rather get for Christmas?")
- automated "customized songwriting" websites



https://www.causeweb.org/smiles/ (NSF EAGER DUE 1544426, 1544237, 1544243)

STUDENT-MADE INTERACTIVE LEARNING WITH EDUCATIONAL SONGS

YTLE?

Project SMILES Pls:



DENNIS PEARL PROFESSOR OF STATISTICS PENN STATE UNIVERSITY



LARRY LESSER PROFESSOR OF MATHEMATICS EDUCATION THE UNIVERSITY OF TEXAS AT EL PASO





JOHN WEBER PROFESSOR OF MATHEMATICS PERIMETER COLLEGE AT GSU







2015 - present NSF EAGER grant (DUE 1544426, 1544237, 1544243)

Project SMILES:

Student-Made Interactive Learning with Educational Songs for introductory statistics

Wrote (and assessing) two dozen *interactive* songs of high artistic and pedagogical quality to maximize learning and engagement; collection was released May 2018 at: https://www.causeweb.org/smiles/

see our 2017 VOICES & 2018 STEM for ALL Showcase videoposters
a great vehicle for the grant: statistics, "often required, rarely desired"

 Statistics is offered in several departments and taken by students in many disciplines, and is also offered in HS

 Statistics anxiety occurs across disciplines (e.g., in the humanities, social sciences, and in classes for pre-service elementary school teachers), and anxiety-reduction is one potential benefit of the use of fun items

here's a CAUSEweb song after being "SMILE-ified"....

What P-Value Means



 Note that the word NULL is revealed in question #2 only after you've correctly provided NULL as the answer to question #1. Green color also has checkmark in case someone is red-green colorblind.

What P-Value Means

data

hypotheses

- Calculating the p-value assumes the null
 hypothesis is true.
- The p-value is a probability associated with the variation of the Select if the null hypothesis is true.
- Please answer question 2 to reveal this question.

What P-Value Means

- Calculating the p-value assumes the null
 hypothesis is true.
- The p-value is a probability associated with the variation of the data if the null hypothesis is true.



key input words are highlighted in the playback display:

What P-Value Means

It is key to know

What p-value means --

It's the chance

(with the <u>null</u>)

you obtain

data that's

At least that extreme!

It is key to know



but we found most CAUSEweb songs can't be retrofitted, due to:

- parodying a song that is unduly profane, sacred, or obscure or is copyrighted, and thus limiting usage
- not focused deeply on a single statistics learning objective, such as including statistical terms without conceptual grounding
- too lengthy
- content too advanced for intro course
- having, in constrained rhyming positions, important wording unlikely to be supplied in response to open-ended prompts
- uses elaborated examples, so student inputs would be entire sentences
- limited only to lower-order thinking or recall
- interesting artistically or for community-building among insiders, but not useful for a novice learner

Inputs must...

avoid end-rhyme spots

(though lyrics usually DO put key words there)

Correlation Illustration Song

How do <u>shoe length</u> values go When <u>height</u> is high or when it's low? Like horses on a merry-go-round Where they're both up or they're both down, This provides an illustration of a positive correlation!

How do <u>used car prices</u> go When <u>mileage</u> is high or low? Like horses on a merry-go-round Where one is up when the other's down, This provides an illustration of a negative correlation!

[CHORUS:] 🖃

Whoa-oh-oh, Central Limit Theorem

For populations with finite variance and mean.

If you know-oh-oh the samples are **independent**

And distributed identically: that's a stat person's dream.

The further that the population is from normal,

The larger that your sample size must be.

If you're sampling Chicago household incomes,

Sample lots of them to use the CLT!

[REPEAT CHORUS:] 🕀

Inputs...

must avoid end-rhyme spots

(though lyrics usually DO put key words there)

Correlation Illustration Song

How do <u>shoe length</u> values go When <u>height</u> is high or when it's low? Like horses on a merry-go-round Where they're both up or they're both down, This provides an illustration of a positive correlation! How do <u>used car prices</u> go When <u>mileage</u> is high or low? Like horses on a merry-go-round Where one is up when the other's down, This provides an illustration of a negative correlation!

 must be scaffolded for part of speech, and robust for number of syllables, etc.

process



finding the SMILES Dream Team:

who has backgrounds in statistics <u>AND</u> songwriting??



external collaborative of music and STEM professionals...

Amy Adler, Greg Crowther, Monty Harper, Tom Toce



external collaborative of music and STEM professionals...

- **Amy Adler** (Austin, TX) songwriter, cantorial soloist, music teacher, CPA, Certified Fraud Examiner
- **Greg Crowther** (Seattle, WA) college biology lecturer, researches in science ed (STEM songs) and science, curates singaboutscience.org database of 7000+ songs
- Monty Harper (Stillwater, OK) award-winning full-time performer/writer of educational science songs; MS in math
- Tom Toce (NYC) theater/cabaret songwriter with album cuts and ASCAP awards; senior actuarial adviser at Ernst & Young; Fellow of Casualty Actuarial Society

...and internal (UTEP) collaborators

- Larry Lesser stat ed researcher; award-winning songwriter; published 85+ math/stat lyrics and several papers on using music in statistics/math courses
- Dominic Dousa music theory and composition faculty; (piano) accompanist and chamber musician; MS in statistics; college teaching experience in statistics





Songs need to align with

- Literature
- GAISE: Guidelines for Assessment and Instruction in Statistics Education
- GOALS: Goals and Outcomes Associated with Learning Statistics instrument

SMILES song criteria

- Short
- Built for inputs
- Connect to real-world data if possible
- Lyrics: help learning of intro statistics learning objective (aligned with GOALS, GAISE, etc.)
- Music: original or public domain
- Genre: lyrics prominent and easy to hear
- Maximize intelligibility of the synthetic voice singing student inputs

for intelligibility of the synthetic voice singing student inputs:

- DURATION: to allow for the longest available response, we lengthened rhythm of some words where recorded sounds would be inserted and quickened the rhythm of words surrounding the insertion point.
- **PITCH**: we tried to avoid skips or even having more than one note in the insertion point to help the process of programming the pitch of the inserted material

Steve Haddad coordinates talented music majors in UTEP's Commercial Recording studio, then Bob Carey integrates it into the website with the Festival Speech Synthesis System/FestVox







Diversity factors/feedback

- Good to vary singer gender, genre, etc.
- Song affected by specific diversities of instructor and campus population; e.g., don't parody a hymn, "Yellow Rose of Texas", etc.
- Readings have gender diversity and avoid stereotypes (my April 2014 *MT* op-ed)
- Ethical/respectful fun builds community!
- Red/green colorblindness addressed

Equity: ELL support

- Lyrics have direct, conversational sentence structure (not lots of clauses and inverted order) and less jargon than textbook prose
- Students can pause, rewind, and replay songs (which are slower than speech)
- Scaffolding for those new to English or US: Hypothesis on Trial
 - At the beginning of the courtroom criminal trial in the United States, the defendant is presumed to be innocent
 of the crime.
 - If we think of the null hypothesis as the person (defendant) on trial, then "failing to reject the null hypothesis" would be analogous to a decision to Select
 the defendant on trial. Hint

To **convict** means to decide that there **is** a sufficient level of evidence that **s convict** used of a crime is guilty. To **acquit** means to decide that there **is NOT** a sufficient level or evidence that someone accused of a crime is guilty.

acquit

Equity: ELL support

- More informal language is used
- Some songs unpack notation:

Estimation Notation: It's Greek (and Roman) to Me

Greek letters refer to the population.

<u>Mu (μ)</u> stands for mean, sigma's (σ) standard deviation,

Greek letters refer to the population.

<u>Beta (β)</u> is the slope, <u>rho (ρ)</u> is the correlation.

Description of **<u>part</u>**, not <u>whole</u>

that's what sample statistics are:

standard deviation's <u>s</u>, the mean is <u>x-bar (\bar{x}) </u>,

the slope is <u>b</u>, the correlation's <u>r</u>,

Y Hat Dance

Sung to the tune of "Mexican Hat Dance"

For (X, Y) data pairs, we call the Y's

The values **observed**. Now, let's fit a line!

For each X, the value of Y where on the line you would hit

Is known as a **fitted** value -- the value we say we predict.

And those **<u>fitted</u>** Y's always wear a hat: ^

A caret or circumflex are other names for that.

Subtracting the Y hat from Y is vertical error defined;

The **<u>sum of the squares</u>** of all these we want to minimize.

inspiration: ELL "sentence frame" tool

such as in Lesser & Winsor (2009, p. 6):

"The p-value obtained was_____, which is [less / greater] than our preset significance level of _____, and therefore we [reject / fail to reject] the null hypothesis that _____."

A Fitting Conclusion

0.007 is the *p* that we get.

That's **smaller** than the alpha we set.

So when it comes to the null we reviewed,

Reject the null we conclude!

FYI: for more on my work on ELLs in statistics....

math.utep.edu/Faculty/lesser/ELL.html

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- Lessons Learned
- Tips for Use
- Q&A

The SMILES songs

- 26 songs (includes 4 SMILE-ified songs)
- Median length = 1.5 min. (3rd Q = 2 min.)
- I coordinated outside songwriters to ensure their work was grounded in learning objectives and spanned intro topics

song topics

- Levels of measurement
- Mean vs. median
- Convenience vs. random sampling
- Correlation vs. causation
- Patterns of correlation
- Correlation and slope
- Statistic vs. parameter
- Descriptive vs. inferential
- Estimator bias
- Margin of error in poll
- Probability rules
- Effects on width of CI
- Framework of testing H_o

- *p*-values
- Reporting test conclusion
- Concepts of X² test
- Effect of *n* on significance
- Concepts of regression model
- Observed/fitted/residuals
- Standard error (sqrt law)
- Concepts of ANOVA test
- Bayesian reasoning (most tests for rare traits yield false positives)
- Central Limit Theorem
- Simpson's Paradox
- Ethics in statistics

Pre-song prompts

- About 5 per song
- More than a quarter contain hints
- 43% involve free response with synthetic voice on playback, the rest are forcedchoice answers highlighted on playback but sung with human voice
- 96% require statistical knowledge

Prompts vary in....

format

- Drop down from menu
- Drag-and-drop matching
- Fill-in (numerical)
- Fill-in (words)

Some not revealed before previous questions done, if that would "give away" an answer.

purpose

- Solicit context, example, or variable
- Apply procedure
- Make conceptual connection
- Connections across
 questions
- Playfulness

Some questions have > 1 reasonable answer

Throw That Out?

1. A possible **bad** reason for excluding a point from a data set is just to:



prompts for "Super Bowl Poll"

Super Bowl Poll

- 1. Pick your favorite NFL team; if you don't have a favorite, just pick a team you think might be good: (Select -).
- 2. The margin of error for a **sample proportion** for a survey of 1000 people would be



- If 17% is the sample percentage, then the margin of error you entered in the above item gives an interval estimate as low as % and as high as %.
- 4. If you multiplied the sample size by a factor of nine, that would select the margin of error by a factor of .

Continue Θ

decrease

Super Boll Poll

Will the **<u>Texans</u>** win next season's Super Bowl?

We asked about 1,000 fans in a scientific poll.

The margin of error was <u>3</u>%

That's roughly the reciprocal of the square root of *n*.

17% answered 'YES' in the poll,

But what could it be for the population as a whole?

At the 95% level of confidence

The interval goes from <u>14</u> to <u>20</u> %.

If we multiply the sample size by a factor of 9,

The new margin of error that we could find

Would be a *third* as large as what we had before.

Thanks to the formula, you know the score.

Go Texans !

The margin of error was 3 %

STUDIO VERSION



open-ended prompts solicit context

Regression Rumba

- Insert the name of a visual graph you could view to decide if there is a linear relationship between the heights and weights of students in your class. (Hint)
- For a relationship that interests you, insert the name of a quantitative variable (Y) that might play the role of a response (i.e., dependent) variable. Please do not use height or weight.
- For a relationship that interests you, insert the name of the quantitative variable (X) that might play the role of an explanatory (i.e., independent) variable. Please do not use height or weight.

SONG UNDER CONSTRUCTION

Correlation Illustration Song

 Think of two specific real-world variables that are quantitative (i.e., a variable whose values are numerical, not something like "eye color") and that should have a (strong or moderately strong) positive correlation.

Give the name of one of the variables:

Correlation Does Not Imply Causation

For questions 1 – 3, consider this sentence: "She likes to _____ in order to get _____."

1. For the first blank, please give a one-syllable **action verb** that is an activity someone does. **Hint**

Simpson's Paradox

Please fill in the blanks below with words that are as short as possible. Refer to these examples

if you need help. Show examples: Example 1

- Example 2 Example 3
- Give the name of a group that people could leave or join, comprised of two mutually exclusive types of people or individuals. Hint
- Give a general label for any individual in your group (plural noun). (Hint)
- Give a label (plural noun) for one type of individual in your group, ideally a type likely to score the higher average measure of your variable. Hint
- Give a label (plural noun) for a second type of individual in your group, ideally a type likely to score the lower average measure of your variable. Hint

Checks on open-ended inputs

- Auto-corrects close spellings & grammar
- Allows British spelling
- Screens for profanity
- Checks if too many syllables
- Check for values out of range (e.g., r > 1) or inconsistent with other answer (sign of r & b)
- Accepts synonyms (scatterplot, scattergram, XY plot; normal, Gaussian, bell-shaped; bigger, larger, greater)



Some reasons for hints:

- not getting an answer could leave a student unduly "stuck" from continuing,
- a definition or symbol is used that a student might not know,
- academic wording of a question might not be clear to all,
- a word might be unfamiliar to someone new to the English language and/or American society,
- we want to teach the student something along the way by giving them a way to deduce the answer rather than repeatedly guess, or
- seeing example or visual may help understand a definition



The union of events A or B is often described using the words "A or B" (A \cup B). This





If we think of the null hypothesis as the person (defendant) on trial, then "failing to reject the null hypothesis" would be analogous to a decision to Select v the defendant on trial. Hint

To **convict** means to decide that there **is** a sufficient level of evidence that someone accused of a crime is guilty. To **acquit** means to decide that there **is NOT** a sufficient level of evidence that someone accused of a crime is guilty.

OUTLINE

- Background
- Inspirations & Guiding Criteria
- Songs from the Collection
- Lessons Learned
- Tips for Use
- Q&A
Informed by feedback from...

- students in spring/summer 2017 classes
- fall 2017 & spring 2018 randomized trials
- conference talks/posters (2016 present)
- USCOTS 2017 workshop (faculty from 3 continents) and eCOTS 2018 workshop
- Advisory Board communications
- External Evaluator recommendations

spring/summer 2017 pilot [at research univ. (dark bars) and 2-year college]: students agreed songs were engaging, relevant, userfriendly, & anxiety-reducing, but split on "high quality"









The songs used in the activities we did to class were high quality.



and we're analyzing results of these student-randomized trials

	Fall 2017	Spring 2018
2-year college (mostly Black)	4 instructors, 12 sections	6 instructors, 15 sections
Research university		1 section (115 students)
Control Group	readings only	readings only
Treatment Group 1	SMILES platform, but not readings	SMILES platform, but not readings
Treatment Group 2		readings and (noninteractive) studio versions of songs

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collection launched May 2018!

https://www.causeweb.org/smiles/



Excerpt from song library page

(assessments visible to teachers upon request)

15. Hypothesis on Trial – 1:38

Identify counterparts in the courtroom analogy for hypothesis test (innocence ≈ null; acquit ≈ fail to reject; etc.). Identify errors of Type I and II in context.

🚓 Build a Song 📔 🎍 Studio Demo 📔 🗉 View Reading 📔 🖄 Assessment

16. Inferential and Descriptive Statistics - 1:27

Contrast inferential and descriptive statistics with respect to their different goals and typical tools/outputs.

🕀 Build a Song 🕼 Studio Demo 🗐 🗐 View Reading 🕼 Assessment

17. It Might Not Be That Bad - 3:03

Applying Bayes rule or examining marginal and conditional proportions in a table to see how, for rare conditions, most positive test results may be false positives.

🕀 Build a Song 🖉 Studio Demo 🗐 View Reading 🕑 Assessment

18. Levels of Measurement – 2:01

Give 4 levels of measurement (nominal, ordinal, interval, ratio scales) in appropriate hierarchical order and identify examples of each level in a real-world context.

🕀 Build a Song 🛛 🎍 Studio Demo 🗍 🗐 View Reading 🗍 🔁 Assessment

Tips for Using SMILES

- Choose songs whose learning objectives align with your curriculum/notation
- Use to introduce or review a topic
- Use to break up or vary a lecture
- Try whole-room teacher-led mode (drop-down prompts can be clicker questions, fill-in items be class discussion items) or have students with earbuds in lab mode
- Formative assessment (website lets teachers access a MC item)
- Let students write their own (see my 2018 eCOTS poster)



was May 21-25, 2018

Google eCOTS 2018

and view archived keynotes, breakout sessions, virtual posters, birds-of-a-feather gatherings, and workshops such as our

2-hour workshop

on using the SMILES collection!

https://www.causeweb.org/cause/ecots/ecots18/workshops/2

these ideas apply across STEM!

have STEM colleagues browse archived 2017 VOICES meeting & save the date for Sept. 26, 2018! (proposals still being accepted) email leadvoices@causeweb.org to join VOICES e-list

(STEM-focused, almost free, pedagogy/research/practitioner angles) <u>causeweb.org/voices/</u>



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Let's play & explore: https://www.causeweb.org/smiles

suggested trio to start with....

- Central Limit Theorem
- Super Bowl Poll
- Correlation Does Not Imply Causation

thanks for attending

Using Innovative Technology and Interactive Songs to Engage Students in Standards-based Introductory Statistics Learning Objectives: Discussing Lessons Learned from NSF-funded Project SMILES

WE WELCOME YOUR QUESTIONS & FEEDBACK





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Benefits of student-created songs

(Crowther et al., 2017)

compact phrasing required by a lyric (vs. prose) forces the writer to more deeply engage with the concepts to get to the essence, and this process can not only consolidate existing knowledge but also generate new insights

Guidance for student-created songs

- See my May 2018 eCOTS videoposter for rubric, assignment sheet, resources/tips https://www.causeweb.org/cause/ecots/ecots18/posters/4-04
- Due 2 weeks before end of term so it could synthesize or review material from any part(s) of the course
- Don't require performance/display
- Allow teamwork
- Make it extra-credit
- Limit length to 3 minutes

Example of prosody: "Chi-squared Dance"

- the title is playfully invoked by the entire piece having "square dance" music
- the phrase "a large gap occurred"
 [between observed & expected values]
 is set to a large melodic leap
- the phrase "long right tail" [of the chi-squared distribution] is set to a long descending phrase