Range of Meanings: A Sequential Mixed Methods Study of How English Language Learners Encounter Assessment Items on Descriptive Statistics

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Introduction

- To understand how language background affects student learning in statistics
- Understanding assessment of statistical concepts for ELL students
- English language proficiency and cultural expectations are likely to affect the validity of items assessing knowledge of statistical concepts

ELLs in Higher Education

- The population of ELLs in U.S. K-12 public schools is growing rapidly
  - 1 out of 20 in 1990
  - 1 out of 9 in 2005
  - 1 out of 4 expected by 2028
- Most ELL students speak Spanish
- 80% of ELLs in public education speak Spanish

ELLs in Mathematics and Statistics

- Most research in mathematics and ELLs
- Most research focuses on K-12 populations
- Growing body of research in statistics education
- Lesser and Winsor 2009 found
  - ELLs' movement among everyday and academic registers
  - Role of context: ELLs may find the role of context in statistics confusing

ELLs in Mathematics and Statistics

- Lesser et al. (2013) found that ELLs
  - Are more likely to experience register confusion
  - Find the context of a problem difficult to understand
  - Have difficulty understanding statistical vocabulary

Method

- Sequential exploratory mixed methods model (Johnson and Onwuegbuzie, 2004)
- Instrument: collection of items assessing conceptual knowledge of measures of center and variation from the ARTIST database
  - 6 items that reflected concepts taught in introductory statistics courses
  - Communication, Language and Statistics Survey (CLASS) found difficulty among ELLs with words like *mean*, *median,* and *mode* (Lesser et al. 2013)
  - Three items for classifying participants as ELLs or nonELLs

Research Context

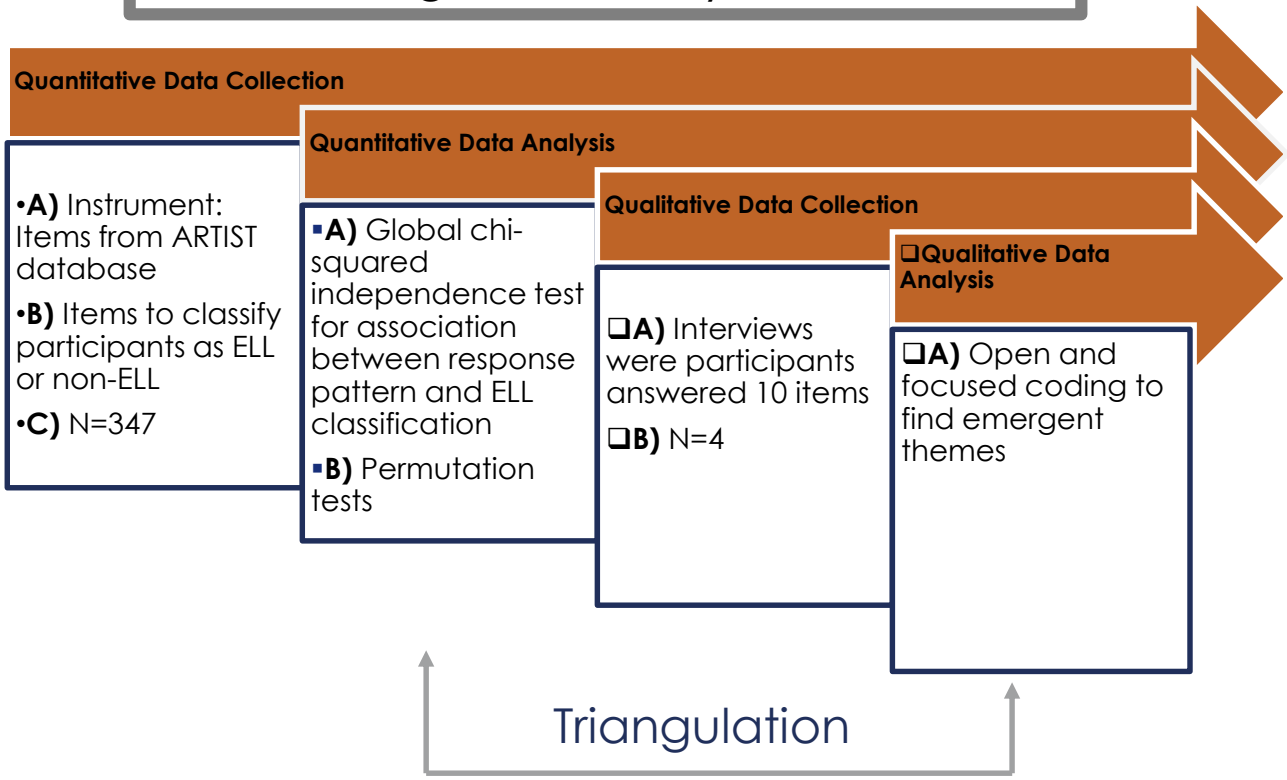
- Large urban research university or a large community college system
  - More than 80% of students were Hispanic

- Both located on the U.S.-Mexico border
- High population of Spanish-speaking ELLs

Methodology

Methodology

- Sequential exploratory mixed methods model (Johnson and Onwuegbuzie, 2004)



Background of Students Interviewed

Student	English Proficiency self-rating (out of 10)	% time speaking Spanish	First language	ELL	Course type	Instructor
1	8	80%	Spanish	yes	Practitioner	A
2	10	10%	English	no	Practitioner	B
3	10	30%	Spanish	yes	Literacy	C
4	9	30%	Spanish	no	Literacy	C

Quantitative Results

Item Type	Item		A	B	C	D
Context	6	ELL	*28*	***31***	30	11
		non-ELL	*19*	***48***	21	12
Context	*7*	ELL	29	**33**	*38*	N/A
		non-ELL	20	**35**	*45*	N/A
Context	8	ELL	11	**24**	*54*	11
		non-ELL	*7*	**36**	*51*	6
Direct	9	ELL	11	*7*	12	*70*
		non-ELL	9	4	6	*82*
Graphical	10	ELL	21	*27*	**22**	*29*
		non-ELL	18	*29*	**27**	26
Graphical	11	ELL	19	***45***	19	17
		non-ELL	18	***54***	15	13
Graphical	12	ELL	16	*34*	33	**17**
		non-ELL	10	30	*32*	**28**

Boldface numbers denotes the correct answer, italics denotes the modal answer

Quantitative Results

			Association Results		Proportion Results	
Item Type	Item	Terminology Used	P-value	P-value adjusted	P-value	P-value adjusted
Context	6*	Average, mean	0.017	0.083	0.003	0.031
Context	7	Distribution,skewed, mean, median	0.180	0.250	0.910	1.000
Context	8*	Median, distribution	0.036	0.090	0.036	0.090
Direct	9*	Range	0.015	0.083	0.015	0.077
Graphical	10	Center,spread, distribution	0.350	0.440	0.350	0.500
Graphical	11	Range	0.160	0.250	0.160	0.260
Graphical	12*	Variability	0.028	0.090	0.028	0.090
Direct	13	Range	1.000	1.000	1.000	1.000
Direct	14	Average	0.510	0.570	0.510	0.640
Direct	15	Spread	0.104	0.520	0.010	0.104

*Denotes test is statistically significant using a 10% significance level

Qualitative Results: Context-Heavy Items

Student 1
S1: Ok
R: Ok? Ok, so which one do you think is the answer? A, B, C or D?
S1: [after a pause] probably A.
R: Probably A? So, you think that is a: half the household in the time have more than 2 children? Can you tell me a little bit about why you picked that answer?
S1: because if there is more than 2 then…**I don't know that would compensate for the average and if the other half of the households have only one**… **I don't know** it makes sense to me for the average **without making any math.**

Student 2
S2: You want me to give you an answer what it means?
R: Yeah, I want you to like which one do you think is the answer for the question.
[Student takes a few more seconds to look at the paper].
S2: I would say B.
R: You would say B, so how did you come up with that answer? Or what makes you think that would be the answer for this question?
S2: **because they divided the total amount of children by 50**
R: Aha
S2: and then there are an average of 2.2 children in the town.

Qualitative Results: Direct Items

R: Ok. Could you go ahead and read question 9?
[Silence as the student reads question]
S3: [nervous smile] **I forgot about range.**
[Pause]
R: So, is there a confusion there with the word *range*?
S3: Yeah, **I forgot how to calculate range**.
R: Ok, so you don't remember the process how to calculate range of a data set?
S3: Yeah.
R: So, which one would you think is the answer? Like, how do you… Do you remember if there is any… like, the process when they give you a data set? Like, numbers?
S3: Oh my God, I am trying to remember. 'Cause, I remember, mean, median, mode… range is the one I am trying to remember but **I can't.**

Qualitative Results: Direct Items

R: Question 13.
[Student is reading the question]
S3: B?
R: So, do you see any relationship between this question and any other questions?
S3: Ah, yes, you were asking about range in [flipped the pages] number 9.
R: Number 9, ok. So, your answer will be B?
S3: Yeah.
R: So the difference between the highest and the lowest number in the data set.
S3: Yeah.
R: Ok, question 14.
[Student reading the question]
S3: B.
R: Ok, so B, average is defined as mean, so ok. What makes you think that's the answer for this question?
S3: **Just knowing the definition of mean, median and mode.**
R: So, it's a definition that you learned in class that you remembered
S3: Yeah.

Qualitative Results: Graphical Items

R: Ok. Now, the last page. Could you read question number 12?
S1: I think Standard deviation, because it's based on all the information. So, letter B.
letter B.
R: So letter B says the standard deviation; because it's based on all the information on the data set. So, why do you think this is the answer?
S1: Mmm I was going to say **because the other ones did not really make sense to**
R: Ok, so the other ones are not really familiar? They don't… ok…
S1: Aha.

Triangulation of Findings

Student # 1 | Practitioner | ELL				Student # 2 | Practitioner | Non-ELL			
Q6*	W/W	•	Deficiency in Cognitive Academic	Q6*	C	•	Academic and everyday register
Q7*	W		Language Proficiency	Q7*	C		confusion
Q8*	C	•	Statistical concept confusion	Q8*	C	•	Deficiency in Cognitive Academic
Q9#	C	•	Misconception due to context	Q9#	C		Language Proficiency
Q10&	C	•	Problem understanding context	Q10&	W		
Q11&	C			Q11&	B		
Q12&	W			Q12&	C		
Q13#	C			Q13#	C		
Q14#	C			Q14#	C		
Q15#	B			Q15#	B		
Student # 3 | Literacy | ELL				**Student # 4 | Literacy | Non-ELL**			
Q6*	W/C	•	Deficiency in Cognitive Academic	Q6*	W	•	Confusion between academic
Q7*	W		Language Proficiency	Q7*	B		and everyday registers
Q8*	B	•	Problem understanding context	Q8*	C	•	Deficiency in Cognitive Academic
Q9#	W	•	Confusion about "intact" statistical	Q9#	W		Language Proficiency
Q10&	C		phases	Q10&	C	•	Problem understanding context
Q11&	W	•	Statistical concept confusion	Q11&	C	•	Multi-modal representations
Q12&	B	•	Transfer between academic	Q12&	C	•	Misconception due to context
Q13#	C		registers	Q13#	C		
Q14#	C			Q14#	C		
Q15#	W			Q15#	B		

*=context heavy, &=graphical, and #=direct item types; W=wrong, C=correct, and B= in between; W/W=first and second attempt wrong; W/C=first attempt wrong and second attempt correct.

Discussion

- Role of context
  - Non-ELLs perform better in the context-heavy category
  - Few differences in direct items
- Difficulty with statistical vocabulary
  - Confusion with words such as average, range, and variability
- Delimitations and limitations
  - Prior schooling, cultural expectations, and socio-economic status may also influence language proficiency
  - Language proficiency test

Recommendations for Assessment of ELLs

Research Findings	Teaching Recommendations
There is evidence of ELLs confusing academic terms (such as mean and median) and everyday and academic uses of statistics terms.	Highlight vocabulary: assess participants using minute papers (Chance, 1997) describing differences between similar sounding academic words or words with both everyday and academic registers.
Role of context was more confusing to ELLs than non-ELLs.	Emphasize role of data-context when testing: regularly remind students of the data-context.
ELLs had a good working knowledge of formulas without knowing how to properly apply them.	Emphasize conceptual knowledge: Perform early low-stakes in-class assessments on the conceptual knowledge to emphasize importance.
Many participants may have been unable to identify the term interquartile range rather than IQR.	Make acronyms and their long-form explicit in assessments.
ELLs may have less familiarity with using graphics due to academic background.	Emphasize meaning and use of statistical graphics: Present these first in assessments, so it is clear that the participant is to reason using the graphics.

Conclusions

- Statistical ideas are communicated using language and conceptual knowledge depends heavily on this use of language
- If assessment items unduly favor one particular population over another, then it is not possible to make fair comparisons across populations
- Further research is needed to understand how all participants move from the everyday language to the academic language of a technical word used in statistics and how they interpret the data-context of statistical problems

Thank you! Questions?

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Based on our paper:

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