ASSESSING DIMENSIONALITY OF THE COMMUNICATION, LANGUAGE AND STATISTICS SURVEY: A MULTI-GROUP ANALYSIS WITH INTRODUCTORY STATISTICS STUDENTS NEAR THE US-MEXICO BORDER

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Preliminary results of the theoretical and empirical characteristics of the third generation of the Communication, Language, And Statistics Survey (CLASS) are presented. Though validity is a multi-faceted concept, this manuscript focuses just on providing evidence of the dimensionality and internal consistency of the CLASS III. The information from this analysis will be used, in conjunction with more complete analysis, to demonstrate the valid use of this scale on multi-cultural student populations. This study indicates that the items asked of both ELL (English language learner) and non-ELL students have six identifiable dimensions and the ELL-only items have three. It is also concluded that revisions to the CLASS III are necessary in order to promote this survey as a research tool for statistics educators studying cross-cultural and language issues.

INTRODUCTION

Recently in the statistics education community, a sustained research focus has developed considering language-based concerns in learning introductory statistical concepts. However, few of the published research articles are concerned specifically with English Language Learners (ELLs) or non-traditional student populations. In response, this manuscript is focused on ELLs and how English language acquisition affects an introductory student's knowledge of statistical concepts. With this goal in mind, this study follows up on exploratory qualitative (Lesser & Winsor, 2009) and quantitative (Lesser, Wagler, Esquinca & Valenzuela, 2013) studies in order to explore formally the dimensionality of the third generation of the Communication, Language And Statistics Survey (CLASS III). In this paper, we use the term ELL for someone who does not speak academic English at a level commensurate with one's peers and non-ELL for someone who has the fluency of an educated native English speaker (Goldenberg, 2008). This distinction is important, as a growing proportion of tertiary students in the U.S. have or are acquiring English as a second, third, or even fourth language and this trend shows all signs of continuing in regions of the U.S. (Flores et al., 2012). Moreover, Lesser and Winsor (2009) and Lesser et al. (2013) indicate that those acquiring English experience distinctive differences when learning introductory statistical concepts and vocabulary. Principles of equity and diversity call for statistics educators to have these trends inform teaching, curriculum and research.

The current version of the CLASS (CLASS III) is intended to be utilized by researchers needing to distinguish cultural and linguistic factors that affect learning in introductory statistics. This paper seeks to demonstrate that an identified subset of CLASS III items is functional and substantively contribute to research into the role of language in statistics. The ongoing CLASS research aims to provide a scale that is: 1) useful for recognizing learning and teaching preferences among students with varying cultural and language backgrounds, 2) able to assess language-based differences students experience when learning introductory statistics, and 3) capable of identifying when and where the role of context helps or hinders students of varying cultural and language backgrounds. A particular objective is to provide empirical evidence about the dimensionality of the CLASS III. We do not intend to explore fully all components of validity (e.g., content, face, responses process, etc.), but focus solely on the evidence related to dimensionality.

METHOD

Participants

The research study sites are a doctoral research university and a community college system located in an urban region in the southwestern United States. Reflecting regional demographics, approximately three-quarters of the participants are Hispanic and roughly 10% of the Hispanic students are Mexican nationals. Most participants at either institution were either education or

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biology/pre-medicine majors. More details on student demographics are in Lesser et al. (2013). No compensation was offered for the survey, which took 20 minutes of class time. All students agreed to participate and none withdrew consent. Of the 476 students taking the survey, 200 self-identified as ELL, 243 as non-ELL, and 33 did not self-identify either way (and were dropped from the analysis). Because roughly three-quarters of the survey's 49 questions were for both ELLs and non-ELLs, a single survey could be administered discreetly to the entire sample, with a simple instruction for questions after #37 to be answered only by ELLs (six non-ELLs answered these later items anyway, and those items of their surveys were ignored since they had self-identified as non-ELL).

CLASS Subscales

A brief overview of the theory of register may be found in Lesser, Wagler, Esquinca & Valenzuela (2013), and three of those authors independently categorized each item of the CLASS III instrument as belonging to the register theory dimension of field, mode, or tenor. There was initial agreement on 92% of the items, and after discussion, those co-authors reached agreement on the four items that lacked initial consensus. The CLASS III instrument could then be described as having 4 background questions, 18 field, 9 mode, 6 tenor, and then 12 ELL-only items. Since the CLASS III items derive from an earlier version (the CLASS II), the authors preserved item order so that the last few questions of the CLASS III apply only to ELLs. Those interested in using the CLASS III instrument should contact the first author of this ICOTS paper.

Statistical Analysis

Evidence for dimensionality of the CLASS III was assessed using a combination of principal component analysis (PCA), modified parallel analysis, factor analysis (FA) and reliability analysis. The dimensionality of the CLASS III was analyzed by factor analytic models and, when subscales were identified, the reliability of these subscales was assessed by computing Cronbach's alpha. Measurement Invariance (MI) was assessed by testing the FA loadings for equality across the ELL and non-ELL populations. Analysis used the *CTT* and *psych* packages in R.

RESULTS

Dimensionality was first explored by conducting a PCA on the full set of common items to ELLs and non-ELLs. The analysis was conducted on the full populations and also separately on each cohort. The eigenvalues resulting from the covariance matrix decomposition substantially decrease after the sixth ordered value, indicating six factors may provide a reasonable fit to the data. Modified parallel analysis confirmed these results for both groups.

The FA models indicate that an orthogonal model with six factors provides a moderate level of fit. ($\chi 2$=625.8, *df*=345, p<.001, RMSEA 90% CI=(.04, .052), TLI=.853). The chi-square fit test is known to be sensitive to even small amounts of misfit and other fit statistics demonstrate an adequate fit. Inspection of covariance matrices for the ELL and non-ELL data indicated that the population covariance structures differ considerably. Hence, separate FA models were estimated. Table 1 presents the loadings for the six emergent factors of the CLASS III items. These were also identified as subscales of the field, tenor, and mode dimensions of the theory of register. The loadings for the ELL and non-ELL populations were all provided in the order ELL and non-ELL, respectively. Only items with loadings over .20 were included in the table and 10 out of the 33 items given to ELLs and non-ELLs did not load appropriately on any factor, leaving 23 items in Table 1. A paraphrase of each item is also provided with the loadings of both groups. In Table 1, the proportion of variance explained by a factor is also provided below the factor label and the uniqueness of each item and for the ELL and non-ELL populations is in parentheses next to a paraphrase of that item.

Table 1: Loadings from Factor Analysis on CLASS III Items (ELL; non-ELL)

Paraphrased Items (uniqueness)	Field			Mode		Tenor
	Everyday context (.36;.46)	Word confusion (.34;.43)	Technical words (.30;.11)	Negative wording (.51; .59)	Modes of words (.49; .41)	Professor-student dynamics
Real-life context difficulties (.73;.63)	.66;.51					
Connection to everyday (.58;.67)	.55;.41					
Include discussion of vocabulary (.77;.75)					.51;.32	
Use graphic organizers (.58;.79)					.50;.61	
Not enough wait time (.64;.68)						.61;.68
No answer due to lack of words (.58;.39)			.77;.71			
No answer due to confusion about words (.15;.45)			.76;.84			
Professor thinks I know less due to words (.44;.57)						.63;.72
Student uses pictures (.83;.66)					.34;.39	
Confusion between registers (.44;.56)	.48;.64					
Real-life connection (.33;.41)	.73;.68					
Professor uses pictures (.43;.46)					.68;.65	
Help with pronunciation (.59;.63)					.57;.65	
Confusion about “not all means are equal” (.21;.37)				.70;.91		
Confusion on “fail to reject H_0” (.40;.54)				.77;.70		
Confusion about “no playing cards are non-spades” (.48;.26)				.74;.71		
Real-world context difficult (.47;.67)	.45;.65					
Confusing similar words (.34;.45)		.69;.69				
Confusing pronunciations (.47;.39)		.66;.54				
Confusion about a specific word (.29;.22)		.98;.89				
Measures of center word confusion (.61;.64)		.34;.39				
Real-world context difficult (.42;.75)	.37;.72					
I pretend I understand (.63;.72)						.50;.59

Since the CLASS III was found to be invariant across the ELL and non-ELL populations, then it is plausible that any cross-group comparisons are valid. Other factors such as response process effects should be evaluated in future analysis. In addition to the measurement properties of the CLASS III, the reliability also needs to be assessed to ensure valid use of the CLASS items within each subscale of field, mode, and tenor. Table 2 provides the lower bounds on the scale relibility as calculated by Cronbach’s alpha. These measures of reliability are only reported for the subscales and across the two populations. Generally, the reliability estimates are reasonably commensurate across the two groups. However, some estimates are low and may call for item deletion or revision. More detailed item response modeling can provide more empirical evidence about which CLASS III items are not functional.

Table 2. Reliability analysis on CLASS III

Dimension of Register	Scale	ELL	Non-ELL
Field	Everyday Connection	.690	.688
	Word Confusion	.786	.761
	Technical Words	.569	.563
Mode	Negative Wording	.722	.796
	Modes of Words	.618	.471
Tenor	Professor/student Dynamics	.607	.609

The last ten questions of the CLASS III were taken only by those who self-identify as ELLs. These questions were assessed separately for dimensionality and reliability using FA and reliability estimators. Table 3 presents the factor loadings for this subset of items. This is a distinct set of items given only to ELLs and is not a subset of the 23 items in Table 1. The scores indicate a lack of fit for the one-factor model ($\chi2$=276.81, *df*=35, p <.001, RMSEA 90% CI=(.184, .208), TLI=.712). A three-factor model fit well and provides sound theoretical interpretation ($\chi2$=34.42, *df*=18, p =.011, RMSEA 90% CI=(.074, .109), TLI=.938). No items had loadings less than .20. We identify the three factors that emerged as: use of a Spanish-English terms handbook (*Terms Handbook*; e.g., see Lesser & Winsor, 2009, p. 25), whether the student thinks in Spanish in statistics contexts (*Think in Sp*), and whether the students can translate statistics concepts between English and Spanish (*Translate Concepts*). The Cronbach's alpha estimates were .85, .84, and .88 for the *Terms Handbook*, *Think in Spanish*, and *Translate Concepts* items, respectively.

Table 3. Factor Loadings of ELL-only questions of the CLASS III

Paraphrased Items (Uniqueness)	**Terms Handbook**	**Think In Sp**	**Translate Concepts**
I speak Spanish in class groups (.45)		.65	
I think in Spanish (in class) (.08)		.99	
Teacher saying word in Spanish helps me learn concept (.69)		.28	
I would use a Spanish-English word handbook (.51)	.50		
Most of what I know I learned in Spanish (.53)		.36	
I can translate concepts from English to Spanish (.25)			.90
I can translate concepts from Spanish to English (.19)			.87
I translate what the teacher says (.31)		.47	
List of Spanish-English statistics terms helpful (.24)	.78		
List of Spanish-English everyday terms helpful (.16)	.97		

CONCLUSION

Empirical evidence about the dimensionality and internal consistency of the CLASS III is provided here. The analysis confirms the structure of the scale aligns to some degree with the theoretical construct of register and its dimensions of field, mode, and tenor. However, this preliminary analysis demonstrates that item revision and deletion is still required. A future study will present a revised version of the CLASS III (to be called the CLASS IV) that demonstrates greater fidelity to the theoretical construct of register and takes into account use of the scale for non-Hispanic ELL populations. This research study informs a larger project with the following practical goals: 1) inform educators about how language background affects the learning of statistics, 2) produce a usable scale that helps instructors tailor instruction to student needs, and 3) identify effective teaching practices for student populations with varied language backgrounds. See Lesser and Winsor (2009) for more discussion of strategies and resources.

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