

The Impact of Setting Accommodation on Large-scale Assessment for English Language Learners with and without Learning Disabilities: Balanced vs. Unbalanced Data in Latent Class Analyses

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Abstract

This exploratory study examined the effect of setting accommodation on Grade 6 students' number sense and numeration skill in relation to whether they speak a language other than English at home, have a learning disability, and received setting accommodation for a large-scale math assessment. A set of latent class analyses was conducted to investigate students' response patterns and latent class memberships in both balanced and unbalanced data; three- and two-way ANOVA were also performed to examine the effect. The results suggest that a 4-class model with a covariate and indirect effects have better model fit to the balanced and unbalanced data. Percentage correct and missing response rate in two datasets were also compared and discussed. The results indicate that number sense and numeration skill of accommodated Grade 6 students with LD was comparable to their non-accommodated peers with LD when their response patterns were taken into account. For non-disabled groups, non-accommodated Grade 6 students outperformed their accommodated

counterparts. The language spoken at home by students was not a significant indicator of the effect. The implication for data design of latent class analysis and parametric statistics for large-scale data was also discussed in this paper.

Keywords: English language learners, Learning disabilities, Latent class analysis, Number sense and numeration skill, Setting accommodation

1. Introduction

It is well documented that in North America there is a growing population of students attending English-language schools whose first language is not English (e.g., Aud et al., 2010; OELA, 2008; Ontario Ministry of Education, 2009; Statistics Canada, 2006). Due to this large population, educators, parents and policy makers are facing special challenges for helping English language learners (ELL) -students with and without disabilities- fulfill their potential and succeed (Lovett et al., 2008). According to Zehler et al. (2003), ELL students with disabilities constituted 9% of all ELL students in kindergarten to Grade 12 in 2001-2002 in the United States. Moreover, 8.2% of all students with disabilities are ELL students. Specific learning disabilities are the most salient disability category among ELL students (5.16% of all ELL students). The challenges for ELL students with disabilities are even more profound than the challenges for other students. In particular, research has shown that ELL students with disabilities are often low achievers (e.g., Liu, Barrera, Thurlow, Guven, & Shyyan, 2005; Liu, Thurlow, Barrera, Guven, & Shyyan, 2005).

In order to measure learning outcomes of ELL students with and without disabilities, they have been included in large-scale assessments. In these assessments, some ELL students with disabilities are provided with accommodations (e.g., large print, extended time, computers), consistent with the student's Individual Education Plan (IEP) and regular classroom practices (Albus & Thurlow, 2008; EQAO, 2012). According to the interaction hypothesis, appropriate accommodations will remove unnecessary barriers and help students to demonstrate their actual skills, abilities and knowledge on the assessments (e.g., National Research Council, 2004; Sireci, Scarpati, & Li, 2005). Appropriate accommodations can help maintain the construct validity of assessments. The testing adaptations are important not only for students with disabilities, but also for ELL students who have also been diagnosed as having special needs. However, accommodations for ELL students with special needs are rarely researched in the current literature, especially for a frequently used accommodation and a fundamental numerical skill (number sense). The present study investigated this important issue in order to fill this critical gap in the current literature. In addition, this study further examined a critical measurement issue related to unbalanced sample sizes of accommodated and comparison groups. It has been reported that there has not been a large enough sample size of students with LD in accommodation-related studies (Middleton & Laitusis, 2007). The present study scrutinized the complexity of student characteristics (LD and ELL), examinees' number sense skill, and sample size of groups of interest in relation to whether or not examinees received setting accommodation for math.

1.1 Accommodations for English Language Learners

Previous studies have expressed concerns about the impact of such accommodations for ELL students in large-scale assessments; that is, some accommodations appear to be more appropriate than others for ELL students (e.g., Abedi & Gándara, 2006; Abedi, Hofstetter, & Lord, 2004; Abedi, Lord, Hofstetter, & Baker, 2000; Kopriva, Emick, Hipolito-Delgado, & Cameron, 2007) although the studies yielded inconclusive findings. In addition to accommodations, it is also important to take various student characteristics into account while

examining school achievement of ELL students with and without disabilities (e.g., Abedi et al., 2000; Abedi et al., 2004).

Many large-scale assessments provide ELL student with setting accommodation. For example, the only special provision for these students participating in Ontario's provincial assessments is setting accommodation (EQAO, 2012). However, the impact of setting accommodation is rarely examined in current literature. As such, it is important to examine the effect of this frequently used accommodation for students who speak a language other than English at home.

1.2 Setting Accommodation

Setting accommodation has been well known to be one of the most commonly used accommodations (e.g., Cawthon, 2010; Thurlow, Lazarus, Thompson, & Morse, 2005). This accommodation may accompany other accommodations that require a quiet environment (such as dictation, read aloud, tape recording of responses) or/and individual administration. Although many studies have examined the effects of multiple test accommodations including alternative setting (e.g., Bolt & Ysseldyke, 2006; Lewandowski et al., 2008; Thurlow, Elliott, & Ysseldyke, 2003), research rarely studies the separate effect of setting accommodation. To address this, the present study combined an examination of the setting accommodation for this population with latent class analysis.

1.3 Number Sense

Number sense, an ability to recognize number patterns, conduct numerical operations and calculate the relation of number to quantity, is critical for students to understand in early childhood (Gersten & Chard, 1999; Rotem & Henik, 2013). A number of studies reported indicate that young children with math disabilities are substantially weaker in many aspects of math, such as magnitude comparison, complicated counting strategies, and digit naming speed (Geary, 1990; Gersten, Jordan, & Flojo, 2005; Goldman & Pellegrino, 1987). Moreover, they are more likely to use immature and insufficient strategies such as finger counting when they attempt to solve simple arithmetic problems (e.g., Butterworth, 1999; Jordan, Hanich, & Kaplan, 2003a, 2003b; Ostad, 1999).

For ELLs, previous studies show that linguistic modified math items may affect ELLs' assessment performance (e.g., Abedi & Lord, 2001; Abedi, Lord, Hofstetter, & Baker, 2000; Alt, Arizmendi, Beal, Hurtado, 2013). More specifically, Rodriguez, Parmar, and Signer (2001) reported that a group of students from culturally and linguistically diverse backgrounds (Spanish native speakers) with LD and non-ELL students with LD only have more limited number line concepts (such as relative position of numbers and connecting number to quantity) than students without disabilities. The interactive effect of setting accommodation, LD, ELL, and this important numerical concept is still unknown, and that is why the current study focuses on these factors.

1.4 Balanced versus Unbalanced Data

Because the LD group of interest is a subgroup of the student population, it is unclear whether the statistical analyses should be conducted by using the whole population or simply the LD group. This question is further complicated by another question regarding the unbalanced

sample sizes between LD and non-disabled groups. Previous studies using latent class analysis (LCA) employed data with unbalanced sample sizes (e.g., Hickendorff, Heiser, Van Putten, & Verhelst, 2009; Lesaux & Kieffer, 2010; Penuel, Boscardin, Masyn, & Crawford, 2007). However, it is not unusual for the sample size of the studied groups to be reduced through random sampling procedures at the stage of data collection, preparation and management (e.g., Cook, Eignor, Sawaki, Steinberg, & Cline, 2010; Middleton & Laitusis, 2007). For a large-scale study by Rohde et al. (2001), 64 schools were randomly selected from 246 state schools where the analyzed sample of approximately 1,000 students was tested. The effect of unbalanced sample sizes in statistical analyses is unclear, and, therefore, the statistical models in the present study were conducted for both unbalanced and balanced data and the results were further compared for both datasets.

1.5 Research Questions

This exploratory study, as part of a larger project, is designed to investigate the impact of setting accommodation on ELL students' number sense skill by answering the following questions: (1) what are response patterns of students with different characteristics in balanced and unbalanced data? and (2) does setting accommodation significantly affect the number sense skill of students with different characteristics in balanced data compared with test results derived from unbalanced data? In particular, the effect was examined in relation to three major student characteristics: setting accommodation or standard testing, ELL or native English speakers, LD or non-disabled.

2. Method

2.1 Participants

This study used latent class analyses (LCA) to examine data from Ontario's provincial standardized testing program developed and administered by the Education Quality and Accountability Office (EQAO). The data from students who took the Junior (Grade 6) Assessment of Reading, Writing and Mathematics in 2005-2006 were analyzed ($N = 133,059$).

In preparation for data analyses, some students were excluded from the study if they: (1) took the French version, (2) were enrolled in a French Immersion program, (3) were exempted in one of more subject areas, or (4) were missing any necessary information (specifically, students who were missing information about IEP or IPRC, setting accommodation information for math, or home language information from the student questionnaire, or had no item response data), leaving a total of 131,620 students.

2.2 Unbalanced Data with Setting Accommodation

To analyze the effect of the setting accommodation alone, an unbalanced version of the dataset was created, from which students who received accommodations other than or in addition to the setting accommodation were excluded, leaving only students who received no accommodation or setting accommodation alone. This dataset was comprised of 114,034 students for math (Table 1). This dataset includes a large cohort of students who speak languages other than English ($N = 50,778$, 45%). Table 1 shows the numbers of students in this

dataset by disability status, use of the setting accommodation, and English language learning status.

Given the complexity of characteristics and the diverse backgrounds of ELLs, ELL students in this study refers to examinees who speak a language other than English at home. Because accurate ELL status information is not available from local schools and so it is not possible to determine which students receive language supports in school, language status of ELLs in this study was defined by the indicator of home language from the EQAO's student questionnaire. Many research studies have used the language variable, home language, to identify students as ELL (e.g., Abedi, Lord, & Plummer, 1997; Abedi & Lord, 2001; Chiappe & Siegel, 2006). Considering all these issues, in the present study, if students reported that they never or sometimes speak English at home (meaning that they speak another language at home instead of or in addition to English), they were classified in this study as ELL students ($N = 50,778$) (Table 1); this is a broader definition of ELL than is typically used in education. Of this study population, 1.43% of ELL students were identified as having LD. The comparison group was the students who always speak English at home ($N = 63,256$; 55%)(Table 1). Of the monolingual English-speaking students, 2.07% were identified as having LD. The percentages of students with LD in both language groups are small because students using accommodations other than or in addition to the setting accommodation were excluded from the analyses.

Students with LD in this study were the students who had been formally identified by the Identification, Placement, and Review Committee (IPRC) in Ontario (Ontario Ministry of Education, 2009); students identified with dual or multiple exceptionalities were not included in the analyses.

2.3 Balanced Data with Setting Accommodation

Because there are larger numbers of both English-speaking only and ELL students without learning disabilities than with learning disabilities, to create a balanced dataset, a number of students without disability and accommodation were randomly selected from the unbalanced dataset with only setting accommodation to avoid the possible significant impact due to having a large sample size (ELL: $n = 843$, non-ELL: $n = 1000$) (Table 1). The proportions of ELL and English-speaking only students were selected to resemble the original proportions in the population (45%, 55%, respectively).

It should be noted that the numbers of students with LD and the numbers who received the setting accommodation are the same for both balanced and unbalanced data in the present study (Table 1). However, the unbalanced dataset was much larger than the random sampling balanced dataset, and thus students with LD are 45 percent of the balanced sample, but only 1.8 percent of the unbalanced data.

Table 1. Frequencies of ELL and English-Speaking Only Students with and without LD and Setting Accommodation

<i>Unbalanced Data</i>				
Disability Status	Setting Accommodation	ELL Students	Native English Speakers	Total

LD	None	578	79.70%	1079	82.50%	1657	81.50%
	Setting Only	147	20.30%	229	17.50%	376	18.50%
	Subtotal	725	100.00%	1308	100.00%	2033	100.00%
Non-disabled	None	49706	99.30%	61661	99.50%	111367	99.40%
	Setting Only	347	0.70%	287	0.50%	634	0.60%
	Subtotal	50053	100.00%	61948	100.00%	112001	100.00%
Total		50778		63256		114034	

Balanced Data

Disability Status	Setting Accommodation	ELL Students		Native English Speakers		Total	
LD	None	578	79.70%	1079	82.50%	1657	81.50%
	Setting Only	147	20.30%	229	17.50%	376	18.50%
	Subtotal	725	100.00%	1308	100.00%	2033	100.00%
Non-disabled	None	843	70.80%	1000	77.70%	1843	74.40%
	Setting Only	347	29.20%	287	22.30%	634	25.60%
	Subtotal	1190	100.00%	1287	100.00%	2477	100.00%
Total		1915		2595		4510	

3. Data Analyses

The present study used *Mplus 5* (Muthén & Muthén, 2007) to conduct latent class analyses (McCutcheon, 1987, 2002) to determine whether examinees with different characteristics show distinct response patterns on a set of number sense and numeration items. Six math multiple-choice items of number sense and numeration were selected as outcome variables in the mixture modeling. More complex models were also estimated by allowing a covariate to have direct and indirect effects on the outcome variables. The proportion of items correct of all EQAO's 28 math binary items was calculated and included in the 2, 3, and 4 latent class models as a covariate. The latent class models with a covariate were then tested separately for direct and indirect effects to address question 1. The latent class models were built separately on unbalanced and balanced data.

To address question 2, three-way and two-way analysis of variance (ANOVA) were conducted to examine the effect of setting accommodation on students' number sense and numeration skills. These analyses were performed separately using unbalanced and balanced data.

4. Results

4.1 Question 1- Latent Class Models & Memberships

Latent class analyses were also performed using the balanced data. For these data, the 2-, 3-, and 4-class models without the covariate show a poor model fit (Appendix 1). According to the fit indices, the model fit of the 2-, 3-, and 4-class models with direct effects is considered as

good as the 4-class model with indirect effect and the covariate. However, further examination of the response patterns show that the former models rely on the accuracy of a single item to assign class membership. As a result, the subsequent analyses on balanced data were based on the 4-class model with indirect effects. This model has relatively high entropy (.797), relatively small value of -2 loglikelihood (29772.116) and relatively small Bayesian information criterion (BIC = 30024.418). Although the two compared sets of data were analyzed using the same model, there are similarities and differences regarding the results which are discussed in the following sessions.

Appendix 2 shows the parameters and fit indices for the 2-, 3-, and 4-class models with the covariate and indirect effects as well as the models without the covariate. The results showed that the three models with the covariate fit the data better than the models without the covariate. Although the 2- and 3-class models with direct effects seems to have the high entropy (.852, .839, respectively), the class assignments were exactly related to the number of items answered correctly, so that they are not an ideal model. In similar fashion, the 4-class model with a covariate and direct effects was also excluded. The 4-class model with indirect effects has a relatively high entropy (.798), a relatively small value of -2 loglikelihood (871249.658) and relatively small Bayesian information criterion (BIC = 871603.615); it also has better interpretability. Thus, this 4-class model was chosen as the best model for unbalanced data.

Appendices 3 and 4 show the numbers of the students of interest grouped in the four latent classes in the two compared datasets. Note that different numbers of students were missed in the latent class analyses in balanced ($n = 91$, 2%) and unbalanced data ($n = 134$, 0.1%). Given that the original numbers of students of interest were the same for the latent class analyses based on two datasets, the total numbers of students in latent classes has been changed.

Appendix 5 and Figure 1 show the percentage correct of each item for students in the four latent classes in both datasets. Although the percentage correct varies from item to item for students in the four latent classes in the balanced data, the item difficulty for students in different latent classes remains more consistent. Class 1 in the unbalanced data has a more distinct pattern in terms of item difficulty for a few items (Items 1 and 2). Take Item 1 as an example: the percentage correct is 100%, 50%, 48% and 58% for Classes 1 to 4, respectively. This item was much easier for students in Class 1 than those in other classes.

The distributions of class memberships are similar for students with and without disabilities using setting accommodation in both compared data sets regardless of their ELL status. They are more likely to be in classes with a lower percentage correct than their counterparts without disabilities and setting accommodation. On the other hand, ELL and native English-speaking students without disability and setting accommodation are more likely to be assigned to the classes with a higher percentage correct in both datasets. This pattern is more obvious in the unbalanced data since approximately one-third of students without disabilities and setting accommodation are in Class 1 which has the highest percentage correct (average 83.98%).

The percentage correct of students with LD is lower than their non-disabled peers for all six items in the balanced data (LD: 25% to 49%; non-LD: 35% to 61%)(Appendix 6). Students with LD also have a slightly higher missing response rate than their counterparts without disabilities (LD: 0% to 2.1%; non-LD: 0% to 1.6%). In contrast, the unbalanced data was found

to have a slightly higher missing response rate for students with and without disabilities (LD: 0% to 3.1%; non-LD: 0% to 1.9%) than those in balanced data (Appendix 7).

The percentage correct of students with different characteristics in both datasets, in general, is equivalent; however, non-disabled English-speaking only students in the balanced data have a significantly higher percentage correct (100% across all four classes) than those in the unbalanced data (average of 61.70%) of the first item. The discrepancy may result from the random sampling procedure for the balanced data.

Interestingly, native English speaking students (that is, those who speak only English at home) and use a setting accommodation are more likely to miss math items than those taking the test with standard administration (Balanced data: LD/setting 0% to 1.4% vs. LD/standard 0% to 0.9%; non-LD/setting 0% to 0.4% vs. non-LD/standard 0% to 0.1%)(Unbalanced: LD/setting 0.9% to 1.8% vs. LD/standard 0.1% to 2.3%; non-LD/setting 0.3% to 1.0% vs. non-LD/standard 0.2% to 0.7%) (Appendices 6 and 7).

Similarly, ELL students have a slightly higher missing rate if they received a setting accommodation than those tested using standard testing procedures (Balanced data: LD/setting 0% to 2.8% vs. LD/standard 0% to 1.6%; non-LD/setting 0% to 0.4% vs. non-LD/standard 0% to 0.1%)(Unbalanced: LD/setting 0% to 2.8% vs. LD/standard 0% to 1.6%; non-LD/setting 0% to 1.7% vs. non-LD/standard 0.2% to 0.8%).

In general, students with different characteristics (with/without ELL and learning disability status, setting accommodation) in the four latent classes have similar patterns in terms of percentage correct of each item with several exceptions such as Items 3, 5 and 6 in the unbalanced data and Items 1 and 2 in the balanced data (Figures 2 to 5). ELL and native English-speaking students without disabilities are the groups that have consistent response patterns in both datasets.

4.2 Question 2– Effects of Setting Accommodation on Number Sense and Numeration Skill

In order to scrutinize whether the effects of ELL and LD and setting accommodation on these six math items vary across the latent classes, two-way and three-way ANOVA, with the total number of correct answers on the six items as the dependent variable, were performed separately for the two datasets. For the balanced data, no significant three-way interaction was found for LD, setting accommodation, and latent class for ELL students ($F_{3, 1877} = 0.675, p = .567$) and native English speakers ($F_{3, 2542} = 0.610, p = .608$). However, a two-way interaction of LD and setting accommodation was found (ELL: $F_{1, 1915} = 6.756, p < .01$; English only: $F_{1, 2542} = 16.170, p < .01$). Therefore, a two-way ANOVA was conducted to further examine the interaction effects. It was found that disability status and setting accommodation have significant interaction effects for ELL students ($F_{1, 1915} = 25.418, p < .01, \eta^2 = .013$) and native English speakers ($F_{1, 2595} = 58.203, p < .01, \eta^2 = .022$). With the Bonferroni pairwise comparisons, it was found that accommodated non-disabled students have significantly poorer math performances than their peers taking the test in standard testing procedures (ELL: Standard $M = 3.54$, Setting $M = 2.40, p < .05$; English only: Standard $M = 3.38$, Setting $M = 2.06, p < .05$). No significant difference was found for students with LD using setting accommodation or standard testing procedures.

Similarly, no significant 3-way interaction was found for ELL and native English speakers in the unbalanced data (ELL: $F_{3,50721} = 5.535, p = .203$; English only: $F_{3,63179} = 0.093, p = .964$). A significant two-way interaction effect of disability status and setting accommodation was found for English-speaking only students ($F_{1,63179} = 5.696, p < .05$) and ELL students ($F_{1,50721} = 27.523, p < .01, \eta^2 = .001$) and native English speakers ($F_{1,63279} = 56.244, p < .01, \eta^2 = .001$). That these very small effect sizes were found to be statistically significant is likely due to the very large sample size. The analyses of Bonferroni pairwise comparisons revealed the same results from the balanced data for ELL and English-speaking only students: Students using the standard testing administration outperformed those students with a setting accommodation in the non-disabled groups (ELL: Standard $M = 3.54$, Setting $M = 2.41, p < .05$; English only: Standard $M = 3.32$, Setting $M = 2.06, p < .05$). No significant difference in number sense and numeration skills was found for students with LD testing with setting accommodation or standard testing procedures.

5. Discussion

The present study is meant to investigate the impact of setting accommodation on the number sense and numeration skill of students with and without LD. The results of latent class analyses and three- and two-way ANOVA were compared for both balanced and unbalanced data. The results have shown that setting accommodation did not significantly affect this particular skill of ELL and English-speaking only students with LD; however, students without disabilities receiving this accommodation perform poorly on these six math items. It is worth noticing that the interaction effects of disability and setting accommodation do not differ across the four latent classes for both ELL and native English speakers. Therefore, the impact of setting accommodation on math performance does not vary from class to class and for students with high or low math performance. The results provide some information regarding the issues of construct validity, test comparability and differential boost (Fuchs & Fuchs, 1999; National Research Council, 2004; Sireci, Scarpatti, & Li, 2005). On the one hand, the setting accommodation did not improve or decrease students' math scores on six items, and, therefore, this accommodation is less likely to bring construct relevant threats to the math assessment. Thus, students' math performance on these math items is comparable to the groups of students with LD. On the other hand, it is unknown whether there is differential boost for these students given that this accommodation did not substantially improve their math scores. Moreover, the adverse effects of setting accommodation of non-disabled students should be further investigated. The finding implies that non-disabled students' test performances may not be comparable across standard and non-standard testing conditions. However, the results should be interpreted with caution since the analyses were based on the set of six number sense and numeration items.

The aforementioned findings were applicable to both balanced and unbalanced data. The balanced data consists of comparable numbers of students of interest resulting from the random sampling procedures, whereas the unbalanced data contains all students if any necessary information (e.g., IEP/IPRC, home language, scores) was missing and if their language of instruction is English. Although no difference was found in the results of 3- and 2-way ANOVA for both compared datasets, there are similarities and differences between these two datasets

when we take the detailed information into account. Entropy, which is the index of classification uncertainty, is equivalent for the balanced and unbalanced data (.797, .798, respectively). The missing rate of classification of latent classes is slightly higher for the balanced data (2%) compared to the unbalanced data (0.1%). That is, more response patterns were identified and clustered in the unbalanced data. The classification helps achieve one of the primary goals of latent class analyses -- to understand the unobservable latent traits that contribute to the observed response patterns. The unbalanced data are more likely to be used to accurately estimate the item response probability of a set of items of a large cohort of students without disabilities. The accuracy of probability estimation may affect the way similar response patterns were clustered in a latent class as well as change the probability of examinees' class memberships.

In the present study, it was found that the balanced data contains a lower missing response rate (Appendices 6 and 7). The descriptive and parametric statistics resulting from the balanced data may be more precise and might influence the interpretation of the effects of setting accommodation for students of interest. However, the balanced data yield a higher percentage correct of the first math item than in the unbalanced data although the percentage correct of other items is equivalent in both datasets. Finally, the unbalanced design is closer to the normal data collected from the real world.

6. Conclusion

These research findings do not to conclude that balanced or unbalanced data pose problems for latent class analyses. Instead, these results of the present study suggest that researchers should consider the possible consequences (e.g., lower percentage correct or higher missing response rates) yielded from the balanced and unbalanced design for different statistical methods. For descriptive and parametric statistics of large-scale data, balanced data is recommended since it is more likely to result in a lower missing response rate. For latent class analysis, unbalanced data is preferred because it can help identify more response patterns and accurately estimate the item response probability of items.

The findings of the current study also suggest that number sense and numeration skill of accommodated Grade 6 students with LD was comparable to their non-accommodated peers with LD when their response patterns were taken into account. Moreover, for non-disabled groups, non-accommodated Grade 6 students outperformed their accommodated counterparts. The results suggest that it is critical for decision makers (e.g., teachers, test administrators) to evaluate the appropriateness of providing such accommodation to students without disabilities. Further, the reasons for using setting accommodation for students without disabilities should be justified and reported on an individual basis.

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Appendices

Appendix 1. Parameter Estimates and Fit Indices for the 2-, 3-, and 4-class Models: Balanced Data

	2-Class Model with Covariate (Direct effects)	2-Class Model with Covariate (Indirect effects)	2-Class Model without Covariate	3-Class Model with Covariate (Direct effects)	3-Class Model with Covariate (Indirect effects)	3-Class Model without Covariate	4-Class Model with Covariate (Direct effects)	4-Class Model* with Covariate (Indirect effects)	4-Class Model without Covariate
AIC	29566.924	31099.474	34298.697	29589.630	32932.580	34274.414	29428.298	29832.116	34271.424
BIC	29695.125	31189.215	34382.028	29769.223	33189.142	34402.615	29659.060	30024.418	34444.496
Entropy	0.980	0.839	0.599	0.791	0.802	0.446	0.774	0.797	0.579
-2 Loglikelihood	29526.924	31071.474	34272.698	29533.630	32852.580	34234.414	29356.298	29772.116	34217.424
# of parameters	20	14	13	28	40	20	36	30	27

* Note: 4-class model with a covariate and indirect effects is the model for LCA analyses in the present study.

Appendix 2. Parameter Estimates and Fit Indices for the 2-, 3-, and 4-class Models: Unbalanced Data

	2-Class Model with Covariate (Direct effects)	a	2-Class Model with Covariate (Indirect effects)	a	2-Class Model without Covariate	a	3-Class Model with Covariate (Direct effects)	a	3-Class Model with Covariate (Indirect effects)	a	3-Class Model without Covariate	a	4-Class Model with Covariate (Direct effects)	a	4-Class Model* with Covariate (Indirect effects)	a	4-Class Model without Covariate	a
AIC	861630.958		910666.404		1008455.485		858828.602		881946.275		1007346.986		857570.793		871309.659		1007247.696	
BIC	861826.928		910803.583		1008582.866		859102.962		882161.843		1007542.957		857923.541		871603.615		1007512.257	
Entropy	0.852		0.834		0.568		0.839		0.807		0.434		0.775		0.798		0.363	
-2 Loglikelihood	861590.958		910638.404		1008429.484		858772.602		881902.276		1007306.986		857498.794		871249.658		1007193.696	
# of parameters	20		14		13		28		22		20		36		30		27	

*Note: 4-class model with a covariate and indirect effects is the model for LCA analyses in the present study.

Appendix 3. Latent Class Assignment for Balanced Data

Disability Status	Accommodation	ELLs					Native English Speakers				
		N	1	2	3	4	N	1	2	3	4
LD	Setting Only	140	8.6%	32.9%	21.4%	37.1%	221	9.5%	35.3%	18.6%	36.7%
	None	566	14.0%	29.9%	23.0%	33.2%	1052	13.2%	33.6%	20.6%	32.6%
Non-disabled	Setting Only	340	15.0%	31.5%	21.2%	32.4%	281	7.5%	29.5%	23.5%	39.5%
	None	831	35.3%	23.3%	27.1%	14.3%	988	31.1%	23.2%	31.1%	14.7%

Appendix 4. Latent Class Assignment for Unbalanced Data

Disability Status	Accommodation	ELLs					Native English Speakers				
		N	1	2	3	4	N	1	2	3	4
LD	Setting Only	144	2.8%	33.3%	44.4%	19.4%	226	5.3%	38.9%	41.2%	14.6%
	None	573	4.0%	34.6%	38.9%	22.5%	1075	4.4%	33.4%	39.6%	22.6%
Non-disabled	Setting Only	346	7.8%	29.2%	40.5%	22.5%	287	2.8%	36.9%	45.3%	15.0%
	None	49658	17.2%	28.8%	17.1%	36.9%	61591	12.4%	32.5%	19.0%	36.1%

Appendix 5. Overall Percentage Correct of Latent Classes in Balanced and Unbalanced Data

Balanced	Class 1	Class 2	Class 3	Class 4	Overall
Item 1	71.20%	49.50%	72.80%	29.80%	54.60%
Item 2	59.40%	34.30%	24.90%	12.70%	31.60%
Item 3	96.40%	39.70%	64.90%	12.20%	50.60%
Item 4	100.00%	50.00%	66.50%	10.00%	54.10%
Item 5	89.80%	44.60%	73.20%	15.20%	53.40%
Item 6	87.10%	18.50%	38.90%	5.40%	34.40%

Unbalanced	Class 1	Class 2	Class 3	Class 4	Overall
Item 1	99.90%	49.55%	48.00%	57.50%	55.70%
Item 2	99.95%	23.60%	13.85%	36.80%	31.70%
Item 3	90.25%	60.30%	11.60%	71.55%	52.60%
Item 4	86.90%	61.20%	13.60%	82.15%	55.75%
Item 5	84.65%	54.95%	23.85%	75.50%	54.85%
Item 6	66.67%	8.33%	4.47%	46.83%	24.10%

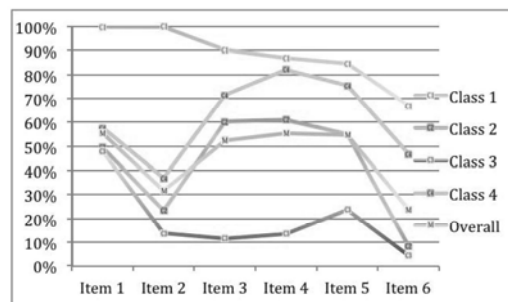
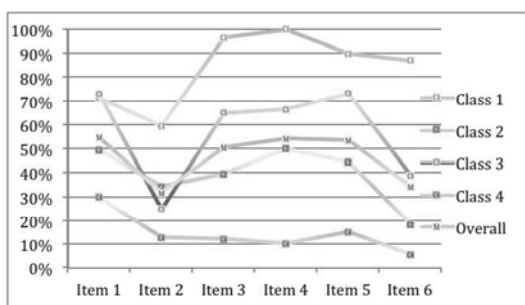


Figure 1. Overall percentage correct of latent classes on multiple-choice number sense in the balanced and unbalanced data

Appendix 6. Percentage Correct and Missing Response Rate in Balanced Data

Item	Disability	Group		ELL students (%)					Native English Speakers (%)				
				Class 1	Class 2	Class 3	Class 4	Overall	Class 1	Class 2	Class 3	Class 4	Overall
Item 1	LD	Setting	Correct	58.30	45.70	76.70	42.30	52.10	66.70	47.40	73.20	33.30	48.90
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		None	Correct	58.20	50.30	73.80	26.10	48.80	66.90	50.70	61.30	28.90	47.90
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Non-disabled	Setting	Correct	62.70	43.00	73.60	25.50	46.80	57.10	47.00	74.20	29.70	47.30
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.40
		None	Correct	76.10	52.10	81.80	26.90	65.00	100.00	100.00	100.00	100.00	100.00
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Setting	Correct	50.00	30.40	20.00	9.60	22.10	61.90	28.20	19.50	16.00	25.30
			Missing	0.00	2.20	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00
Item 2	LD	Setting	Correct	51.90	39.10	30.80	12.20	30.00	52.50	32.00	22.10	12.20	26.20
			Missing	0	0.60	0.00	0.50	0.40	0.00	0.30	0.50	0.60	0.40
		None	Correct	74.50	30.80	38.90	13.60	33.50	61.90	31.30	19.70	9.00	22.10
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Non-disabled	Setting	Correct	60.80	36.10	28.90	17.60	40.20	60.60	38.40	20.50	11.70	35.80
			Missing	0.00	0.00	0.40	0.00	0.10	0.00	0.00	0.30	0.00	0.10
		None	Correct	83.30	37.00	56.70	15.40	37.10	85.70	35.90	63.40	13.60	37.60
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.90
		Setting	Correct	100.00	43.20	61.50	11.20	44.70	96.40	35.70	63.10	9.90	41.00
			Missing	0.00	0.00	0.00	1.10	0.40	0.00	0.30	0.50	0.30	0.30
Item 3	LD	Setting	Correct	92.20	37.40	62.50	10.90	42.40	100.00	33.70	54.50	9.90	34.20
			Missing	0.00	0.00	0.00	0.90	0.30	0.00	0.00	0.00	0.00	0.00
		None	Correct	98.00	44.80	68.40	17.60	66.10	95.80	44.10	68.70	15.20	63.60
			Missing	0.00	0.50	0.00	1.70	0.40	0.00	0.00	0.00	0.00	0.00
	Non-disabled	Setting	Correct	100.00	45.70	63.30	17.30	43.60	100.00	53.80	63.40	8.60	43.40
			Missing	0.00	0.00	3.30	1.90	1.40	0.00	0.00	0.00	3.70	1.40
		None	Correct	100.00	46.70	67.70	9.00	46.50	100.00	51.00	73.30	8.70	48.30
			Missing	0.00	0.00	0.00	1.10	0.40	0.00	0.00	0.50	0.90	0.40
		Setting	Correct	100.00	46.70	58.30	10.90	45.60	100.00	47.00	69.70	9.90	41.60
			Missing	0.00	0.00	0.00	0.90	0.30	0.00	0.00	0.00	0.90	0.40
Item 4	LD	Setting	Correct	100.00	50.00	61.30	10.90	65.10	100.00	52.80	67.10	11.00	65.80
			Missing	0.00	0.50	0.00	2.50	0.50	0.00	0.00	0.00	0.70	0.10
		None	Correct	91.70	50.00	76.70	9.60	44.30	85.70	35.90	75.60	16.00	40.70
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	1.40
	Non-disabled	Setting	Correct	86.10	37.30	70.80	14.40	44.20	84.90	43.60	65.00	15.50	44.30
			Missing	0.00	0.00	0.00	0.50	0.20	0.00	0.30	0.00	0.30	0.20
		None	Correct	86.30	43.00	77.80	12.70	47.10	76.20	43.40	69.70	18.00	42.00
			Missing	0.00	0.00	0.00	0.90	0.30	0.00	1.20	0.00	0.00	0.40
		Setting	Correct	94.50	50.50	77.30	19.30	68.80	90.20	49.30	75.90	13.80	65.10
			Missing	0.00	0.50	0.40	1.70	0.50	0.00	0.00	0.00	0.00	0.00
Item 5	LD	Setting	Correct	100.00	4.30	36.70	3.80	19.30	90.50	19.20	43.90	3.70	24.90
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.90
		None	Correct	82.30	20.10	27.70	3.70	25.10	82.70	17.30	35.90	6.40	26.20
			Missing	0.00	0.00	0.00	2.10	0.70	0.00	0.00	0.50	2.30	0.90
	Non-disabled	Setting	Correct	88.20	16.80	34.70	6.40	27.90	81.00	10.80	31.80	4.50	18.50
			Missing	0.00	0.00	0.00	1.80	0.60	0.00	0.00	0.00	0.90	0.40
		None	Correct	90.10	26.30	44.40	8.40	51.10	87.00	18.80	43.60	4.10	45.50
			Missing	0.00	0.50	0.00	3.40	0.60	0.00	0.00	0.00	0.70	0.10
		Setting	Correct	100.00	4.30	36.70	3.80	19.30	90.50	19.20	43.90	3.70	24.90
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.90
Item 6	LD	Setting	Correct	82.30	20.10	27.70	3.70	25.10	82.70	17.30	35.90	6.40	26.20
			Missing	0.00	0.00	0.00	2.10	0.70	0.00	0.00	0.50	2.30	0.90
		None	Correct	88.20	16.80	34.70	6.40	27.90	81.00	10.80	31.80	4.50	18.50
			Missing	0.00	0.00	0.00	1.80	0.60	0.00	0.00	0.00	0.90	0.40
	Non-disabled	Setting	Correct	90.10	26.30	44.40	8.40	51.10	87.00	18.80	43.60	4.10	45.50
			Missing	0.00	0.50	0.00	3.40	0.60	0.00	0.00	0.00	0.70	0.10
		None	Correct	100.00	4.30	36.70	3.80	19.30	90.50	19.20	43.90	3.70	24.90
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.90
		Setting	Correct	82.30	20.10	27.70	3.70	25.10	82.70	17.30	35.90	6.40	26.20
			Missing	0.00	0.00	0.00	2.10	0.70	0.00	0.00	0.50	2.30	0.90

Appendix 7. Percentage Correct and Missing Response Rate in Unbalanced Data

Item	Disability	Group		ELL students (%)					Native English Speakers (%)				
				Class 1	Class 2	Class 3	Class 4	Overall	Class 1	Class 2	Class 3	Class 4	Overall
Item 1	LD	Setting	Correct	100.00	43.80	53.10	50.00	50.70	100.00	45.50	44.10	48.50	48.20
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.90
		None	Correct	100.00	49.00	38.60	56.60	48.70	100.00	42.10	43.40	54.70	48.00
	Missing		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.10	
	Non-disabled	Setting	Correct	100.00	42.60	40.00	44.90	46.50	100.00	44.30	43.10	58.10	47.40
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.30
		None	Correct	99.80	55.70	52.80	60.90	64.70	99.80	53.70	53.60	60.30	61.70
	Missing		0.10	0.20	0.50	0.10	0.20	0.20	0.20	0.40	0.00	0.20	
	Item 2	LD	Setting	Correct	100.00	25.00	10.90	28.60	21.50	100.00	20.50	17.20	30.30
Missing				0.00	0.00	1.60	0.00	0.70	0.00	1.10	3.20	0.00	1.80
None			Correct	100.00	27.80	15.70	47.30	30.40	100.00	24.50	13.80	36.60	26.30
		Missing	0.00	0.00	0.90	0.00	0.30	0.00	0.00	1.20	0.80	0.70	
Non-disabled		Setting	Correct	100.00	25.70	17.90	50.00	33.80	100.00	31.10	9.20	23.30	22.00
			Missing	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.30
		None	Correct	100.00	24.10	14.00	36.00	39.80	99.90	20.70	12.50	33.80	33.70
Missing			0.00	0.30	0.60	0.20	0.30	0.00	0.30	0.60	0.20	0.30	
Item 3		LD	Setting	Correct	50.00	60.40	15.60	50.00	38.20	75.00	55.70	6.50	57.60
	Missing			0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.00	1.30
	None		Correct	100.00	60.10	8.10	72.90	44.30	89.40	55.40	11.00	61.70	40.70
		Missing	0.00	0.00	1.30	0.00	0.50	0.00	0.60	0.50	0.40	0.50	
	Non-disabled	Setting	Correct	85.20	55.40	11.40	62.80	41.60	100.00	50.90	8.50	55.80	33.80
			Missing	0.00	0.00	1.40	0.00	0.60	0.00	0.90	0.80	0.00	0.70
		None	Correct	92.80	63.40	13.40	80.00	66.10	91.40	63.60	13.10	78.60	62.80
	Missing		0.00	0.20	1.10	0.10	0.30	0.00	0.20	0.90	0.10	0.30	
	Item 4	LD	Setting	Correct	100.00	54.20	18.80	75.00	43.80	83.30	61.40	11.80	69.70
Missing				0.00	0.00	4.70	0.00	2.10	0.00	0.00	3.20	0.00	1.30
None			Correct	78.30	59.60	13.00	79.80	46.80	87.20	61.80	10.80	85.60	48.10
		Missing	0.00	0.00	0.90	0.00	0.30	0.00	0.30	1.20	0.40	0.70	
Non-disabled		Setting	Correct	88.90	50.50	14.30	78.20	45.10	87.50	60.40	10.00	86.00	42.20
			Missing	0.00	0.00	2.10	0.00	0.90	0.00	0.00	0.80	0.00	0.30
		None	Correct	88.30	58.80	14.20	80.70	64.40	89.50	64.10	15.70	83.60	65.00
Missing			0.00	0.40	1.70	0.20	0.50	0.00	0.30	1.30	0.20	0.40	
Item 5		LD	Setting	Correct	100.00	54.20	21.90	67.90	43.80	100.00	38.60	25.80	66.70
	Missing			0.00	0.00	1.60	0.00	0.70	0.00	0.00	3.20	0.00	1.30
	None		Correct	78.30	49.50	20.20	69.80	43.80	76.60	48.50	22.10	71.60	44.50
		Missing	0.00	0.50	0.40	0.00	0.30	0.00	0.30	0.70	0.40	0.50	
	Non-disabled	Setting	Correct	81.50	52.50	17.90	76.90	46.20	50.00	51.90	25.40	65.10	41.80
			Missing	0.00	0.00	4.30	0.00	1.70	0.00	0.90	0.80	2.30	1.00
		None	Correct	89.10	63.10	26.60	81.70	68.20	86.70	61.30	25.10	79.70	64.20
	Missing		0.30	0.10	1.50	0.20	0.40	0.20	0.10	1.10	0.10	0.30	
	Item 6	LD	Setting	Correct	100.00	2.10	4.70	67.90	18.80	100.00	17.00	4.30	72.70
Missing				0.00	4.20	3.10	0.00	2.80	0.00	0.00	2.20	0.00	0.90
None			Correct	100.00	9.60	6.70	65.90	24.80	100.00	12.50	7.70	62.10	25.70
		Missing	0.00	1.00	3.10	0.00	1.60	0.00	2.50	3.30	0.80	2.30	
Non-disabled		Setting	Correct	100.00	14.90	7.10	56.40	27.70	100.00	9.40	6.20	62.80	18.50
			Missing	0.00	1.00	2.90	0.00	1.40	0.00	0.90	1.50	0.00	1.00
		None	Correct	100.00	14.40	7.20	77.10	51.00	100.00	12.80	6.20	75.30	44.90
Missing			0.00	0.80	2.10	0.40	0.80	0.00	0.60	1.70	0.40	0.70	

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