Abstract Title Page

Title:
Impacts of Kindergarten Classroom Organization on Mathematics Learning of English Learners.

Authors and Affiliations:

Rachel Garrett
Postdoctoral Scholar
Department of Comparative Human Development
The University of Chicago
rgarrett@uchicago.edu

Guanglei Hong, The University of Chicago
Assistant Professor
Department of Comparative Human Development
The University of Chicago
ghong@uchicago.edu

Abstract Body

Background / Context:

English learners (EL) are one of the fastest growing subgroups of students in the United States (NCES, 2009), accounting for over one-fifth of the total school age population (U.S Department of Education, 2010). At school entry, most EL children arrive with lower readiness skills; their parents tend to be poorer, less educated, and are less likely to engage with teachers and schools; and the children risk continued struggle in acquisition of academic skills (Crosnoe, 2006; Fuller et al., 2009). Most efforts to examine EL children's academic growth thus far have focused largely on acquisition of English language and literacy skills, with much less attention paid to acquisition of mathematics knowledge (Garrett, 2010). Nonetheless, when math instruction is tailored to EL students' needs, for example, when teachers target their academic language to EL students, researchers have witnessed an increase in EL participation in math classrooms (Enyedy et al., 2008; Khisty & Chval, 2002; Moschkovich, 2007a, 2007b; Wong-Fillmore, 2007). In a recent cluster-randomized experimental evaluation of a 4^{th}-5^{th} grade mathematics intervention designed to promote metacognitive mathematical behaviors (Barnett-Clarke et al., 2010), researchers found that a two year dose of the program was particularly beneficial to math skill growth among EL students. The above evidence indicates that EL students and their non-EL peers may have different needs in math learning and therefore may respond differently to instruction.

One pedagogical strategy frequently used, viewed often as useful in heterogeneous classrooms, is group work and cooperative learning (Slavin & Cooper, 1999). Group work may entail sorting students by ability or intentionally creating heterogeneous ability groups. In his comprehensive synthesis of past research, Slavin (1987) found that using targeted amounts of within class ability grouping was beneficial for mathematics learning in elementary school. Research focused on kindergarten has demonstrated that within class homogeneous ability grouping reduces externalizing behaviors in classrooms with management problems, and improves literacy learning in more manageable classrooms (Hong, Pelletier, Hong, & Corter, 2011). Robinson (2008) found that within class ability grouping was particularly beneficial to language minority Hispanic kindergartners' reading achievement, with effects persisting if the grouping continued into first grade. Both behavioral improvement and literacy growth may facilitate EL kindergartners' mathematics learning. Group work has also shown benefit for high school mathematics learning among Latino and Latina language minority students (R. Gutierrez, 2002). Yet more needs to be learned with regard to whether mixed and homogenous ability grouping influences EL students and non-EL students differently in their mathematics learning.

Purpose / Objective / Research Question / Focus of Study:

The purpose of this study is to investigate whether small group instruction in kindergarten widens or closes the achievement gap in mathematics between EL students and non-EL students. Our first objective is to examine whether the impacts of small group instruction on math learning differ between EL kindergartners and their non-EL peers. For example, if small group instruction brings more benefit to ELs than it does to non-ELs, then grouping may have the potential of helping EL students to catch up in math learning. If the opposite is true, then grouping may leave EL students further behind academically. However, even if small group instruction is beneficial to the ELs, it may not lead to a substantial reduction in achievement gap if ELs have less access to grouped instruction in comparison with their non-EL peers. Conversely, if grouping practices occur at the detriment of EL students, overuse of this practice could also exacerbate achievement disparities. Therefore, our second objective is to examine whether ELs and non-ELs have equal opportunities for small group instruction in kindergarten. If the use of grouping differs between the two groups, we ask the extent to which the amount of change in math achievement gap between ELs and non-ELs over the kindergarten year is attributable to their differential access to small group instruction. We make distinctions among within class homogeneous grouping, mixed ability grouping, and alternate use of both. Additionally, given past research evidence (Hong & Hong, 2009), we allow grouping effects to depend on math instruction time.

Setting:

This study uses data from the Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) released by the U.S. National Center for Education Statistics. The ECLS-K sample is representative of the national population of kindergarten students in the 1998-99 school year.

Population / Participants / Subjects:

The sample includes over 20,000 children attending about 1,000 public and private kindergarten programs. We use the first two waves of data collected in the fall and spring of the kindergarten year. In each wave, information was collected from children, parents, teachers and school administrators, capturing myriad factors that contribute to student development. We identify our focal group of children, English Learners, by combining information from parental report of a non-English primary home language, ECLS-K home language screen, and school record of non-English home language. A total of 3,767 EL children account for approximately 18% of the full sample.

Intervention / Program / Practice:

Teacher surveys at the end of the kindergarten year provide information on the use of mixed or homogenous ability grouping in class. Teachers were asked how often they divided children into achievement groups for math lessons and how often they used mixed ability groups in mathematics. We compare among classes using homogeneous ability groups, mixed ability groups, or both. The reference treatment condition makes no use of any grouping. Information on total instructional time in mathematics was collected in the spring of kindergarten. Teachers were asked how often children worked on mathematics, with possible responses ranging from “Never” to “Daily” and time spent ranging from “1-30 minutes a day” to “More than 90 minutes a day.” Combining these two items, we are able to capture total time spent on mathematics per week. We use a medium divide to distinguish between “high math time” and “low math time” classes.

Research Design:

We conduct secondary analysis of large-scale survey data to evaluate the time-by-grouping effects on math learning. Through propensity score based weighting adjustment for a large number of pretreatment covariates, we intend to approximate a two-way factorial design in which kindergarten classes attended by EL students or non-EL students were assigned at random to two levels of math instruction time and four types of instructional organization with regard to grouping. In our first set of analyses, we compare EL students with all non-EL students, examining whether the time-by-grouping treatments show similar effects on math learning for ELs and non-ELs. Additionally, we decompose the amount of change in the achievement gap into two parts. The first part is attributable to the difference in the distribution of time-by-grouping treatments between ELs and non-ELs. The second part is to be explained by all other differences between ELs and non-ELs including how they respond to the time-by-grouping treatments differently. In the second set of analysis, we make a comparison between EL students and non-EL students who have similar demographic background, pretreatment experience, and kindergarten readiness skills except for the difference in home language. These non-ELs will likely attend the same classes with ELs. Hence the relative effectiveness of alternative time-by-grouping treatments for the ELs and the comparable non-ELs will have direct implications for kindergarten teachers teaching linguistically diverse classes.

Data Collection and Analysis:

We make use of two measures of math achievement, child direct assessment and the Academic Rating Scale scores; the latter is based on teacher assessment of child mathematical abilities. Details on the psychometric properties of the math assessments are publicly available (Rock & Pollack, 2002; Rock & Stenner 2005; Tourangeau et al., 2009), and information on language considerations for assessing EL children, can be found in table 4. We use a maximum likelihood based procedure to generate multilevel model-based imputations of missing data (Shin & Raudenbush, 2007).

To investigate the time-by-grouping effects on math learning for ELs and non-ELs, our goal is to approximate a factorial randomized experiment within each of these two subpopulations. We use marginal mean weighting through stratification (MMWS) (Hong, 2010, 2011) to equate the observed pretreatment composition among the eight treatment groups within each subpopulation. After weighting, we analyze two ANOVA-like models, one for each subpopulation. Let $g = 1$ if a student is an English learner and 0 otherwise. For student *i* in school *j*, we analyze a two-level model for subpopulation *g* specified as follows.

$$Y_{ij}^{(g)} = \alpha^{(g)} + \boldsymbol{\beta}^{(g)}\mathbf{Z}_{ij}^{(g)} + u_{0j}^{(g)} + e_{ij}^{(g)}, \quad e_{ij}^{(g)} \sim N(0, \sigma^2), \quad u_{0j}^{(g)} \sim N(0, \tau), \text{ for } g = 0, 1.$$

Here $\mathbf{Z}$ is a vector of indicators for seven of the eight treatments; $\boldsymbol{\beta}$ is a vector of the corresponding coefficients. Under the assumption that the unobserved pretreatment covariates are independent of the potential outcomes given the observed covariates, $\boldsymbol{\beta}^{(1)}$ estimates the treatment effects on the math learning of EL students, while $\boldsymbol{\beta}^{(0)}$ estimating the treatment effects on the math learning of non-EL students. Combining the EL students and the non-EL students in one weighted sample, we test whether the time-by-grouping effects on math learning differ between the two subpopulations, that is, $\boldsymbol{\beta}^{(1)} - \boldsymbol{\beta}^{(0)} = 0$.

To examine whether the time-by-grouping instructional treatments play a role in reducing the achievement gap between EL students and non-EL students, we decompose the achievement gap as follows: $E\left[Y^{(1)} - Y^{(0)}\right] = E\left[Y_{\mathbf{Z}^{(1)}}^{(1)} - Y_{\mathbf{Z}^{(0)}}^{(1)}\right] + E\left[Y_{\mathbf{Z}^{(0)}}^{(1)} - Y_{\mathbf{Z}^{(0)}}^{(0)}\right]$. The first component is the impact of differential exposures to instructional treatments between ELs and non-ELs on the achievement gap; the second component is the remaining gap partly attributable to the differential impacts of instructional treatments on the math learning of ELs and non-ELs. Here $E\left[Y_{\mathbf{Z}^{(1)}}^{(1)}\right]$ denotes EL students' average potential math outcome if the students would receive the time-by-grouping treatments as they would be distributed among EL students under randomization; $E\left[Y_{\mathbf{Z}^{(0)}}^{(0)}\right]$ denotes non-EL students' average potential math outcome if the students would receive the time-by-grouping treatments as they would be distributed among non-EL students under randomization; $E\left[Y_{\mathbf{Z}^{(0)}}^{(1)}\right]$ denotes EL students' average potential math outcome if the students would counterfactually receive the time-by-grouping treatments as distributed among the non-EL students under randomization.

We derive the following results with regard to the three marginal mean outcomes: $E\left[Y_{\mathbf{Z}^{(1)}}^{(1)}\right] = E\left[\alpha^{(1)} + \boldsymbol{\beta}^{(1)}\mathbf{Z}_{ij}^{(1)}\right]$; $E\left[Y_{\mathbf{Z}^{(0)}}^{(0)}\right] = E\left[\alpha^{(0)} + \boldsymbol{\beta}^{(0)}\mathbf{Z}_{ij}^{(0)}\right]$; $E\left[Y_{\mathbf{Z}^{(0)}}^{(1)}\right] = E\left[\alpha^{(1)} + \boldsymbol{\beta}^{(1)}\mathbf{Z}_{ij}^{(0)}\right]$. Hence we have that $E\left[Y_{\mathbf{Z}^{(1)}}^{(1)} - Y_{\mathbf{Z}^{(0)}}^{(1)}\right] = \boldsymbol{\beta}^{(1)}E\left[\mathbf{Z}_{ij}^{(1)} - \mathbf{Z}_{ij}^{(0)}\right]$ and $E\left[Y_{\mathbf{Z}^{(0)}}^{(1)} - Y_{\mathbf{Z}^{(0)}}^{(0)}\right] = \left(\alpha^{(1)} - \alpha^{(0)}\right) + \left(\boldsymbol{\beta}^{(1)} - \boldsymbol{\beta}^{(0)}\right)E\left[\mathbf{Z}_{ij}^{(0)}\right]$. We use the delta method to compute the approximate standard errors.

Findings / Results:

Basic descriptive information by EL status, presented in table 1, indicates that EL students are disadvantaged in numerous background characteristics relative to their non-EL peers, including health, household SES, and literacy resources at home. The math achievement gap in the direct assessment scores is approximately 4 points at the start of kindergarten, and 4.5 by the end of kindergarten. Comparatively, EL students also received lower teacher ratings on math skills in comparison with non-EL students at the start and end of kindergarten.

Table 2 shows student access to different types of grouping practices. As many as 48% of the EL-students were in classes using both homogeneous grouping and mixed ability grouping, 36% of them attended classes with mixed ability grouping only. Only 6% ELL students were in classes with homogeneous grouping only, and 10% in classes with no grouping. In comparison with EL students, non-EL students were slightly less likely to attend classes using both homogeneous and mixed ability grouping (44%), or using homogeneous grouping only (3%). Yet non-EL students were more likely to attend classes with mixed ability grouping only (39%) or using no grouping (14%).

Our preliminary results with regard to the associations between grouped instruction and student math assessment scores can be found in Table 3. Among both EL and non-EL students, those with higher average baseline scores were more likely to attend classes making no use of grouping. EL students showed lower growth than non-EL students in direct assessment except when they attended classes using homogenous grouping only. EL students and non-EL students showed the largest difference in growth rate in classes using mixed ability grouping only.

Conclusions:

Evidence has pointed to the importance of early math skills for later school success in reading, math, and science (Claessens et al., 2009; Claessens & Engel, 2011; Duncan et al., 2007) and the high labor market rewards on analytic and technical skills (Grogger & Eide, 1995), even post adjustment for selection based on ability and preferences (Arcidiacono, 2004). The importance of math in long-term outcomes, the size of the EL population in the nation, and the lack of knowledge how to best instruct EL students despite the indications for their specific needs all compel improved study of EL mathematics instruction. Our work addresses a void in the current knowledge base about how the use of grouping during math instruction may impact the achievement gap between EL and non-EL students. To the extent that both groups of students respond similarly to the choices in groupings, teachers can use these findings to help guide instructional choices in kindergarten mathematics instruction. However, a categorically differential response between ELs and non-ELs would indicate that teachers must optimize instructional organization given classroom composition; in diverse classrooms teachers may need to use other alternative strategies to differentiate instruction and maximize the math learning for all students.

Appendices

Appendix A. References

Arcidiacono, P. (2004). Ability sorting and the returns to college major. *Journal of Econometrics*, 121, 343-375.

Barnett-Clarke, C., Heller, J., Hanson, T. & Darling, K. (2010). The impact of *Math Pathways & Pittfalls* on Students' Mathematics Achievement and Mathematical Language Development: A study conducted in schools with high concentrations of Latino/a students and English Learners. Retrieved September, 2011 from http://www.wested.org/mpp2/docs/mpp-ies-report.pdf

Claessens, A. & Dawsett, C. (2009). The inter-relations between achievement and classroom inattention and disruptive behavior from kindergarten to fifth grade: evidence for causal direction. Mimeo, University of Chicago.

Claessens, A., Duncan, G., & Engel, M. (2009). Kindergarten Skills and fifth-grade achievement: Evidence from the ECLS-K. *Economics of Education Review*, *28*, 415-427.

Crosnoe, R. (2006). Health and the Education of Children from Racial/Ethnic Minority and Immigrant Families. Journal of Health and Social Behavior, 47 (1), 77-93.

Duncan, G., Dowsett, C., Claessens, A., Magnuson, K., Huston, A., Klebanov, P., Pagani, L., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K, & Japel, C. (2007). School Readiness and Later Achievement. *Developmental Psychology*, 43 (6), 1428– 1446.

Enyedy, N., Rubel, L., Castelln, V., Mukhopadhyay, S., Esmonde, I., & Secada, W. (2008). Revoicing in a multilingual classroom. *Mathematical Thinking and Learning, 10*(2), 134-162.

Fuller, B., Bridges, M., Bein, E., Jang, H., Jung, S., Rabe-Hesketh, S., Halfon, N. & Kuo, A. (2009). The health and cognitive growth of latino toddlers: At risk or immigrant paradox? *Maternal and Child Health Journal*, 13 (6), 755-768.

Garrett, R. (2010). Multilingualism, Mathematics Achievement, and Instructional Language Policy. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses. (Accession Order No. 3419635).

Grogger, J. & Eide, E. (1995). Changes in college skills and the rise in the college wage premium. *Journal of Human Resources*, 30, 280–310.

Gutiérrez, R. (2002). Beyond essentialism: The complexity of language in teaching mathematics to Latina/o students. *American Educational Research Journal*, *39*(4), 1047-1088.

Hong, G., & Hong, Y. (2009). Reading instruction time and homogeneous grouping in kindergarten: An application of marginal mean weighting through stratification. *Educational Evaluation and Policy Analysis*, *31*(1), 54-81.

Hong, G. (2010b). Marginal mean weighting through stratification: Adjustment for selection bias in multilevel data. *Journal of Educational and Behavioral Statistics*, *35*(5), 499-531.

Hong, G. (2011). Marginal mean weighting through stratification: A generalized method for evaluating multi-valued and multiple treatments with non-experimental data. *Psychological Methods*. Advanced online publication. Doi:10.1037/a0024918.

Hong, G., Pelletier, J., Hong, Y., & Corter, C. (Revised and resubmitted). Does literacy instruction affect kindergartners' externalizing problem behaviors as well as their literacy learning? Taking class manageability into account. *Child Development*.

Khisty, L., & Chval, K. (2002). Pedagogic discourse and equity in mathematics: When teachers' talk matters. *Mathematics Education Research Journal*, 14(3), 154-168.

Moschkovich, J. (2007a). Bilingual mathematics learners: How views of language, bilingual learners, and mathematical communication impact instruction. In N. S. Nasir & P. Cobb (Eds.), *Improving access to mathematics: Diversity and equity in the classroom* (pp. 89-104). New York, NY: Teachers College Press.

Moschkovich, J. (2007b). Examining mathematical discourse practices. *For the Learning of Mathematics, 27*(1), 24-30.

National Center for Education Statistics. The Condition of Education, Language Minority School-Age Children Indicator, retrieved November, 2009 from http://nces.ed.gov/programs/coe/2009/pdf/8_2009.pdf.

Robinson, J. (2008). Evidence of a differential effect of ability grouping on the reading achievement growth of language-minority Hispanics. *Educational Evaluation and Policy Analysis*, 30 (2), 141-180.

Rock, D., & Pollack, J. (2002). *Early Childhood Longitudinal Study-Kindergarten Class of 1998-99 (ECLS-K), Psychometric Report for Kindergarten Through First Grade* (NCES Working Paper No. 2002-05). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Rock, D. & Stenner, J. (2005). Assessment Issues in the Testing of Children at School Entry. *The Future of Children*, 15(1), 15-34.

Shin, Y., & Raudenbush, S. W. (2007). Just-identified versus over identified two-level hierarchical linear models with missing data. *Biometrics*, 63(4), 1262-1268.

Slavin, R. (1987). Ability grouping and student achievement in elementary schools: A best-evidence synthesis. *Review of Educational Research*, 57 (3), 293-336.

Slavin, R., & Cooper, R. (1999). Improving intergroup relations: Lessons learned from cooperative learning programs. *Journal of Social Issues, 55*(4), 647-663.

Tourangeau, K., Nord, C., Lê, T., Sorongon, A. G., Najarian, M., & Hausken, E. G. (2009). Early childhood longitudinal study, kindergarten class of 1998-99 (ECLS-K) combined user's manual for the ECLS-K Eighth-Grade and K-8 full sample data files and electronic codebook. Washington DC: U.S Department of Education.

U.S. Department of Education, National Center for Education Statistics. (2010). *The Condition of Education 2010* (NCES 2010-028), Indicator 5. Retrieved June 2010, from http://nces.ed.gov/programs/coe/2010/section1/indicator05.asp

Appendix B. Tables and Figures

Table 1. Child math scores, ability grouping use and background characteristics

	EL			Non-EL		
	N=2,791			N=15,246		
	Mean	SD	N	Mean	SD	N
Fall of K math						
Direct assessment	15.7	6.5	2807	19.7	7.2	14769
Teacher rating	2.2	0.8	2437	2.6	0.8	11153
Spring of K math						
Direct assessment	23.4	8.4	3003	27.9	8.7	14791
Teacher rating	3.2	0.9	2974	3.6	0.8	14109
Child characteristics						
Asian	13%		3200	1%		14794
Hispanic	73%		3200	9%		14794
Black	2%		3200	19%		14794
White	9%		3200	66%		14794
Other Race	3%		3200	5%		14794
Female	49%		3218	48%		14819
Age	5.6	0.4	3198	5.7	0.4	14785
First-time in K	95%		2706	95%		14143
Birth weight (oz)	116.4	21.2	2574	117.9	21.6	13857
In good health	71%		2702	85%		14133
Mother/HH characteristics						
Teen mother	33%		2640	29%		13888
HS dropout	40%		2955	11%		14256
HS graduate	27%		2955	32%		14256
Some college	20%		2955	34%		14256
College or more	13%		2955	23%		14256
SES	-0.4	0.8	2989	0.0	0.8	14493
Poor	39%		2989	18%		14493
# of child books	29.8	35.8	2677	79.5	59.4	14023

Note: All statistics are weighted by the ECLS-K provided child-level Kindergarten year longitudinal weight BYCW0.

Table 2. Access to ability grouping practices by EL status

	EL		Non-EL	
	Mean	N	Mean	N
No grouping used	10%	238	14%	1947
Homogenous grouping only	6%	153	3%	463
Mixed grouping only	36%	895	39%	5450
Both groupings used	48%	1173	44%	6175

Note: All statistics are weighted by the ECLS-K provided child-level Kindergarten year longitudinal weight BYCW0.

Table 3. Child math scores by EL status and ability grouping practices

		EL students			Non-EL students	
		Mean	SD	N	Mean	SD	N
No grouping							
Direct Assessment							
	Fall	17.6	7.7	253	20.3	7.4	2032
	Spring	25.2	9.6	272	28.3	8.8	2033
	Growth	7.6			8.0		
Teacher rating							
	Fall	2.2	0.8	193	2.6	0.8	1349
	Spring	3.2	0.9	293	3.5	0.9	1942
Homogenous grouping only							
Direct Assessment							
	Fall	15.3	6.4	156	18.6	6.9	443
	Spring	23.2	8.7	168	25.9	8.3	444
	Growth	7.9			7.3		
Teacher rating							
	Fall	2.1	0.7	128	2.4	0.7	342
	Spring	3.1	0.9	175	3.3	0.8	425
Mixed grouping only							
Direct Assessment							
	Fall	16.1	6.5	905	20.0	7.2	5418
	Spring	23.6	8.4	971	28.3	8.6	5422
	Growth	7.4			8.2		
Teacher rating							
	Fall	2.4	0.8	794	2.7	0.8	4189
	Spring	3.3	0.9	1019	3.6	0.8	5361
Both groupings used							
Direct Assessment							
	Fall	15.6	6.2	1261	19.6	7.2	6108
	Spring	23.4	8.1	1342	27.8	8.8	6119
	Growth	7.9			8.2		
Teacher rating							
	Fall	2.2	0.7	1123	2.6	0.8	4684
	Spring	3.2	0.8	1411	3.5	0.9	6016

Note: All statistics are weighted by the ECLS-K provided child-level Kindergarten year longitudinal weight BYCW0.

Table 4. Language considerations for EL students

	Direct Child Assessments	Teacher Assessments
Language Used	English or Spanish	English
Excluded portion of the sample	Children not proficient in either English or Spanish, less than half of the EL children from non-Spanish backgrounds are baseline	None, all children were eligible for teacher assessment.
Extra considerations	Assessors were trained to handle potential content assessment problems due to language difficulties.	Teachers were prompted to consider the child's skills, abilities and behavior in their native language as appropriate to help remediate langue confounding.