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Classroom compositional effects on low-ability students' achievement in China

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Abstract

Peer effects are at the center of educational policy debates regarding school choice, ability grouping, and instructional design. Though emerging empirical evidence suggests that positive peer effects exist, less is known about how it affects students with varying cognitive abilities. Using a nationally representative sample from China, we generated a student-level measure of classroom composition of peers based on cognitive ability to understand the benefits or pitfalls of placing low-ability students with heterogeneous or homogeneous classmates. We conducted this analysis separately for grades seven and nine students after controlling for student background, family characteristics, and school endogeneity. We reaffirmed the overall positive—but small—peer effects on the performance rankings. Low-ability children scored much lower than their counterparts when they studied in cognitively diverse classrooms. However, this effect negates the overall positive impact of studying with high-ability peers and the pattern is consistent across rural and urban schools.

KEYWORDS

China, classroom composition, low-ability student, peer effect

1 | INTRODUCTION

Peer influence is central to educational, social, and behavioral research. Diverse traditions have covered this topic, ranging from psychology (e.g., Chen et al., 2003, 2008), sociology (e.g., Lauen & Gaddis, 2013), economics (e.g., McEwan, 2003; Xu et al., 2022), and demography (e.g., Wodtke & Parbst, 2017). A peer is typically defined as

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"another student with whom the individual student comes in contact in school-related activities" (Harris, 2010, p. 1167). Researchers have thus conceived peer effect as a student's performance or behavior as influenced by their interactions with peers. Based on this concept, researchers have tried to identify: (1) whether peers influence student learning; (2) through what mechanism does this effect work?

This paper focuses on the first question, whether peers influence student learning, in the context of Chinese schools. The topic is relevant to the study of the Chinese educational setting, where various types of student groupings are widely practiced in schools. The idea of learning from high-ability peers is deeply rooted in cultural ethos throughout Chinese history. One of the most influential intellectual figures, Mencius (372–289 BC), was believed to have moved with his mother three times until she found an ideal learning environment for her son that included positive influences from neighbors to better his education (Fan, 2011). The emphasis from parents on choosing the right learning environment for their children has a modern iteration. Today's Chinese parents are equally, if not more, concerned with their children's academic outcomes. Parents actively seek opportunities for their children to be placed in "good" schools or classrooms, and many are willing to pay hefty fees to make that happen (Kipnis, 2011).

In modern Chinese schools, students typically stay with the same group of students throughout their formative years. Therefore, such an arrangement reinforces the influence that classmates have on each other (Carmen & Zhang, 2012). It is not surprising that a growing body of research examines the impact of studying with high-ability peers on the achievement level of low-ability peers (Carmen & Zhang, 2012; Chen et al., 2003, 2008; Chou et al., 2015; Ding & Lehrer, 2007; Hu, 2015). While most studies focus on quantifying the overall effect of peer groups on student achievement, few have addressed whether ability grouping benefits students with different levels of ability. This is an important issue when considering low-ability and disadvantaged children, as the benefit of peer influences is not well understood. The scope of literature on these questions is limited. Apart from Hu (2015), Huang and Zhu, (2020), and Xu et al. (2022), most studies of peer effects in China currently use regional samples.

This study uses a national sample of grades seven and nine heterogeneous students who studied in middle school during the 2013–2014 school years. Instead of relying on classroom-level identification of peer effects, we generated a unique student-level measure of peer group ability mixing based on their cognitive ability. This approach was influenced by cognitive theorists and relative deprivation theorists. With this measure, we account for the overall cognitive environment of the classroom and students' individual positions in the classroom. Benefiting from a rich set of student survey information, we can control for student background variables. We are interested in understanding whether low cognitive ability students benefit from studying with homogeneous or heterogeneous peers. In the next section, we review related literature, followed by a description of our method and data. We then present our analytical results and discuss the implications of our findings for educational practice and policy.

2 | LITERATURE REVIEW

2.1 | Conceptualizing peer effects

Within educational literature, researchers traditionally consider peer effect as an emergent property of the classroom or school organization. Stemming from the input–output paradigm popularized by James Coleman in the 1960s, researchers view school-level variables and classroom variables as having a distinctive influence on students (Reynolds et al., 2000). Following this line of reasoning, typical measures regarding peer effects study a proportion of students with certain characteristics in the classroom or school, including immigrant students (Scharenberg, 2016), students from impoverished families (Lauen & Gaddis, 2013), racial or ethnic mixes (Benner & Crosnoe, 2011), and the proportion of students who repeated grades (Huang & Zhu, 2020).

Although the emergentist tradition still attracts sizable followers, there is no inherent reason for us to conceive of peer influences at the emergent level. In a comprehensive review conducted by Harris (2010), he examined the empirical strategy of 11 theoretical approaches, including epidemic, cognitive, various institutional theories, disruption, relative deprivation, oppositional culture, signaling, focus-boutique, home influence, and tracking. At least two of these theories—the cognitive theory and relative deprivation theory—can be operationalized at the individual level.

For cognitive theorists, the idea that one's growth is affected when one enters an unfamiliar situation is nothing new. This work dated back as early as Piaget (1985) and Vygotsky (1978) who proposed that cognitive development is realized under such a scenario. A good educational environment to create such scenarios hence must break the students away from "automatic process and facilitate active thinking" (Gurin et al., 2002, p. 337). Diversity works because it brings discontinuity and discrepancy to the individual learner. When transitioning into a new learning environment with diverse peers, the environment will force the learner to develop new ideas and ways to process information. According to this perspective, studying with diverse peers is beneficial either via the learner's internal recognition of such discrepancy or during the external social interaction with surrounding peers (Ruble et al., 1994). This perspective is also known as social comparison theory (Dijkstra et al., 2008). It has garnered quite a number of empirical evidence (e.g., Gest et al., 2005, Lapan & Boseovski, 2017).

The overall gains for students studying within a diverse peer group are not always positive. In particular, studying with high-ability peers could have negative consequences for low-ability peers. The notion of *relative deprivation*, where an individual's well-being could be affected by their relative standing within a peer group, is well-known among sociologists (Jencks & Mayer, 1990). This theory also has several variants. In public health, the relative deprivation hypothesis suggests that lower-status individuals may be worse off living in communities with a high-status population than in communities with similar status groups (Robert, 1999). Intermingling between high and low statuses can create something called structural relative deprivation. This phenomenon occurs when one competes with neighbors from higher-status backgrounds for scarce resources. Relative deprivation also exerts a psychosocial effect when people compare themselves to those around them with higher status. Similarly, a study by Pickett and Wilkinson (2007) researched the relationship between income inequality and child well-being in developed countries. They found that relative poverty level is as significant as absolute inequality in income when correlating rates of teenage births, juvenile homicides, and infant mortality. Pickett and Wilkinson (2007) hypothesized that this could be because of the inequality caused by relative differences in the material resources to which children have access or the increased self-awareness caused by the differentiation in wider society, which enables invidious social comparisons by individuals.

Regarding educational settings, Jencks and Mayer (1990) argued that less-able children might stop making an effort when surrounded by more able peers. Therefore, the relative position a child occupies in the peer groups would determine their achievement. John Ogbu's version attributes relative deprivation to a cultural mechanism (Ogbu, 2004), where low-status students withdraw from interacting with the dominant group and form their own social clique.

Despite an increase in research using relative measures of peer composition to investigate heterogeneous peer effects, there is no consensus on the direction of such effects within educational research. For instance, Kang (2007) found that low-performing students were better off when mixed with high-performing children in the case of the South Korean education system. Kaufman and Rosenbaum (1992) found African American students who move to predominantly white neighborhoods are more likely to stay in high school, enroll in college-track courses, and attend 4-year colleges as compared to their peers who remained in predominantly black neighborhoods. They argue that because these students had access to better school resources and role models, which they previously did not have, they could engage academically at a higher level.

These two traditions have not generated meaningful dialogues. Both theories can conceptualize peer influence as an individually experienced mechanism even though students from each study were placed in similar learning environments, characterized by a mix between low- and high-ability peers. The contrasting relationship between these theories has inspired educational research to operationalize them using a student-level distance dissimilar measure (Chudgar et al., 2013). As the discussion below shows, this novel approach brings additional methodological benefits to allow researchers to control for unobserved school-level factors.

2.2 | School peer influence in China

While the study of peer influence is not new among social scientists, the debate within the Chinese discourse is somewhat different. To the public, that debate is typically categorized under "ability grouping," one of the most common practices of peer grouping in Chinese schools.

Teaching mixed ability students has generated long and lasting concerns in the People's Republic. After its establishment in 1949, during an era of rapid massification, educators in China soon discovered that their traditional belief in intellectual elitism was challenged by the Soviet egalitarianism they were told to emulate. Suzanne Pepper noted in her historical study that Chinese educators openly debated whether it was educationally desirable to hold all students to the same performance standard or if they should focus on only a few elite students while demanding less from the rest (Pepper, 1996). At the time, Chinese educators questioned whether individual students learned at varying paces and whether students should be taught according to their ability level. The issue did not concern merely sporadic cases, but it appeared throughout the country among elementary and secondary educators. Giving the same instruction to every student meant that "better students were unable to do their best" and "underachievers became dependent on the former [high-achievers]" (Pepper, 1996, p. 234). The debate concerning ability grouping was never settled, and the decision regarding how to group students has been left to individual schools. In the following years of the 20th century, whether teachers should teach in heterogeneous classrooms and how to best address children from different backgrounds has become a recurrent theme in the Chinese education narrative.

In schools today, ability grouping is often based on test scores. Carman and Zhang (2012) reported that it is common for schools to administer diagnostic tests to all students after admission and to assign students to classrooms based on their scores. Another common practice is to identify the best students based on their admission test scores and to concentrate the high-performing students in a single classroom, a "key-point class" (*zhongdian ban*), then divide the rest of the students evenly into several classes, termed a "regular class" (*putong ban*). Based on the groupings, different teachers and curriculums would be applied to each type of class. The idea of ability groupings has both educational considerations and pragmatic concerns. Such practices have allowed for unequal grounds regarding teacher assignments. For example, ability groupings have allowed schools to rationalize placing specific teachers in certain classrooms (Wang, D., 2013), which in turn justified differential treatment to students.

The practice of ability grouping also resembles the Chinese approach of focusing on the education of talented children. Such practices have been in place for many years but have drawn increased criticism. Parents blame schools for causing low self-esteem in their children, who did not do well on the diagnostic tests, thus excluding them from the "advanced class." There are also concerns about nepotism and favoritism when class allocation procedures are not transparent. The practice became so problematic in the 1990s that, in recent years, the Chinese central educational authority called ability grouping at the secondary level to a halt (Tan, 2013). However, despite the official stance, schools, educators, and parents still use some version of the grouping and tracking policy in practice. This indicates that although formal grouping/tracking might be currently limited, informal practices are still prevalent (Carman & Zhang, 2012). Such an arrangement creates a hierarchy inside classrooms, and low-ability students are at risk of feeling disheartened or even stigmatized as they acknowledge the gap between them and advanced students. Though plausible, it was only until very recently that researchers started examining whether low-ability students actually suffer from being in heterogeneous learning environments. Using the same data set as this paper, Huang and Zhu (2020) and Xu et al. (2022) adopted an emergentist approach, showing that students who attended classrooms with more grade repeaters will be negatively affected academically. In particular, Huang and Zhu (2020) found that peer effects due to studying with grade repeaters exert the greatest influence on low-achieving students but not on high-achieving students.

2.3 | Methodological challenges

Though studied extensively as early as school effectiveness research which dated back three decades (Reynolds et al., 2000), peer effect research is often clouded by methodological issues. The central challenge is to identify peer influence properly, separating it from other influences and related mechanisms. This is due to the fact that peer interactions could be "contextual," that is, changes in learning behavior due to exogenous shocks, or it could be "endogenous," that is, changes due to the student being part of the peer group (Gaviria & Raphael, 2001). A third problem may rise because peer influence is a product of parental choices of schools and neighborhood and schooling processes (Hanushek et al., 2003; Lauen & Gaddis, 2013). Empirical strategies designed to avoid these problems vary. While experimental data is ideal from a causal inference point of view, the type of orthogonal design suggested by Angrist (2014, p. 106) is arguably unrealistic in K-12 school settings because of administrative hurdles and possible pushbacks from parents. Therefore, large-scale evaluations of peer influence using the experimental approach are rare.

Currently, most empirical studies deploy strategies to adopt cross-cohort variations in student characteristics or prior performance to address the abovementioned problems (Xu et al., 2020). A common strategy regarding observational setting is the fixed effects (FEs) model, which accounts for time (cohort) and school-invariant factors. The FEs approach then uses the cohort or school as a proxy for peer interactions. Using this strategy, Zimmer and Toma (2000) found significant positive effects of classroom peer quality in five industrialized countries. McEwan (2003) reported similar results using data from Chile. McEwan (2003) found that the mother's education of peers is important in the Chile case, while Zimmer and Toma (2000) found that a peer's father's education is more important.

Another common approach is using the instrumental variable (IV) method to control for confounding variables. IV studies typically implement the average peer performance with average peer characteristics. This approach works in settings where the IV is randomly assigned to peer groups and simultaneously meets two conditions. A good instrument should be *irrelevant* to explaining individual performance, except via average peer performance. It should also be *relevant* to explaining the endogenous outcomes averaged across peer groups (von Hinke et al., 2019, p. 2). Using this approach, Ammermueller and Pischke (2009) estimated the effects on fourth-grade peers regarding reading test scores in six European counties with PIRLS (Progress in International Reading Literacy Study) data. They found significant peer influences regarding reading test scores across the different student grouping. Kang applied IV to the South Korean data from TIMSS95 (Trends in International Mathematics and Science Study-1995) and found that peer quality had a positive effect on student math levels (Kang, 2007). He also found that weak students are more likely to interact with weak students, while strong students are more likely to interact with their strong peers. This partly explains why peer effects impact students differently (Zimmer & Toma, 2000). Meanwhile, Hanushek et al. (2003) reported few distributional effects caused by peers in their study of Texas students.

In more recent studies, researchers examined the variation in student ability using proxy variables as another type of identification strategy. Both Huang and Zhu (2020) and Xu et al. (2020) used the percentage of students who have repeated grades in previous years as an indication of peer quality. Yet, since grade repetition is a locally defined status, it is not clear whether repeaters reflect the learning environment per se or a stigmatized label.

The literature on peer effect is vast and diverse. Distinctive theories permit the conceptualization of peers at the individual level. This study was developed based on two key considerations regarding peer effect. First, peer grouping and tracking in Chinese school settings are typically implemented by students' ability level, not race or ethnicity. Therefore, using these variables, as many previous studies have, might be inappropriate for research on peer effects in Chinese schools. Instead, we use a more global trait of peer identification by assessing cognitive ability. Second, according to the relative deprivation theory, it is plausible that the distribution of peer effects is not homogenous among all the students. Past studies have suggested that low-ability students might not benefit when mixed with high-ability students. To address the limitations in previous studies, we utilize the following: (1) a nationally representative sample of middle school students; (2) cognitive ability instead of socio-economic status or school tests result as peer identification; and (3) indirect school influence with FE. We focused our analysis on three subjects: Chinese language, English, and mathematics. However, we used percentile ranking within each school rather than basing our parameters on the absolute performance level. This study's primary research question is: how does the performance of low-ability students vary when they are with dissimilar versus similar peers?

3 | METHODOLOGY

3.1 | Data collection

This study collected data from the China Education Panel Survey (CEPS). CEPS is a large-scale survey comprising a nationally representative sample of seventh- and ninth-grade students at the lower secondary level. We used the baseline data collected in the 2013–2014 academic year. CEPS uses stratified, multistage sampling with a probability proportional to size (PPS) design. In the first stage, schools were randomly selected in mainland China. Within each school, intact classrooms from the two grade levels were selected, and all the students studying in the classroom were included as the baseline sample. Approximately 20,000 students in 438 classrooms of 112 schools were included in the baseline.[1] To address the potential problem of reflection and nonrandom allocation, we adopted the method utilized by Xu et al. (2020) and Huang and Zhu (2020); we only analyzed those who were randomly assigned to classrooms upon entry into each junior high school. The final analytical sample yielded 12,359 students in 362 classrooms from 93 schools.

3.2 | Variables

Our study used three dependent variables: Chinese language, English, and mathematics standardized test scores. Test scores were reported by each school based on the most recent midterm exam. Since the testing and grading would differ by school and grade, we converted the scores into percentiles. Within each school, students' percentile rankings on the three subjects were computed independently. This procedure is commonly used in educational settings when unequated test instruments are used (Hanushek & Woessmann, 2010; Krueger, 1999). Two separate analyses were conducted for the seventh- and ninth-grade samples. In addition to the subject-related testing, each student also took a standardized 15-min cognitive test. Another feature of CEPS is that because of the rigorous data reporting procedure, there is very little missing data on dependent variables; less than 3% of each test score had missing data. There were no missing values for the cognitive scores.

Two key independent variables were created following a similar procedure used by Chudgar et al. (2013) and Nie et al. (2015). First, a dummy variable was created indicating whether a student was of low cognitive ability (LCOG, "low-ability" henceforth). At each grade level, the variable takes "1" if the student was in the bottom quartile

[1]We did not use the follow-up wave of CEPS (2014–2015) for methodological reasons. The follow-up waves only track the seventh-grade sample from the baseline. There is also unexplained attrition in the sample (about 8% of students who were in the previous sample had not been accounted for). Most of all, classroom composition changed with old students leaving and new students coming in). We were concerned that the changes in classroom composition were nonrandom.

of the national cognition distribution and "0" if the student was not in the bottom quartile of the national cognition distribution. Second, we generated a student-level distance dissimilarity measure to indicate how far, in absolute terms, students deviated from the average cognitive ability of all other students in their classroom. We did so by calculating the average classroom ability level and excluding the particular student's level to determine the comparison. Then, we subtracted the student's own cognitive score from the classroom average. While converting the findings to absolute terms as we focus on the magnitude of cognitive diversity, we added a dummy variable that indicates the direction of distance—1 being positive, 0 otherwise. In a numerical sense, we defined a homogeneous environment experienced by the student as when they are closer to the classroom average cognitive ability of their peers.[2]

This approach has an added methodological benefit since it enables researchers to use school FEs to control for any unobserved and indirect school-level factors, such as implicit ability grouping practice. The school-fixed approach is critical because reporting various forms of grouping can be a sensitive issue; it also reflects what is happening in the Chinese classroom today. Formal grouping and tracking have been replaced by more subtle and informal mixing strategies.

For regression models, we included information on the following from CEPS data: proportion of repeaters, student's gender, living status (urban, rural, rural left behind, or migrant children), attachment to school, hours spent doing homework, whether they have experienced depression recently, ethnicity, whether they attended kindergarten, retention status, number of siblings at home, boards at school or not, whether they had low birth weight (from parental survey), parent's highest level of education, occupation status, and income level (low, medium, or high). A description of the variables is presented in Table 1.

3.3 | Statistical models

For this study, we are interested in the direct effects of peer composition (Chudgar et al., 2013; Harris, 2010). We used ordinary least square models (OLS) with school FEs and robust standard errors at the school level to estimate the relationship between classroom composition and student academic performance.[3] We repeated the same specification for seventh and ninth grade separately regarding each of the three subjects. Our models consider sampling weights to produce robust standard errors (Wooldridge, 2010). The purpose of using a school FE model is to account for the influence of school-related factors that may not be directly observable. The school FE approach considers: (1) the hierarchical data structure created by student nesting inside schools; (2) the nonrandom distribution of students across schools that might lead to the variation in student performance, and thus compare students within each school rather than across schools. We primarily focused on coefficients associated with LCOG and distance:

$$y_{ij} = \alpha_0 + \lambda \times \text{student} + \zeta \times LCOG + \gamma \times \text{distance}\ \ \alpha_i\ \ e_{ij}, \quad (1)$$

$$y_{ij} = \alpha_0 + \lambda \times \text{student} + \zeta \times LCOG + \gamma \times \text{distance} + \beta \times LCOG \times \text{distance} + \alpha_i + e_{ij}. \quad (2)$$

[2]In Chudgar et al. (2013), the distance is defined only in absolute terms (p. 303). At the request of one reviewer, this paper isolates the directional effect using a second variable. In addition to the approach reported here, we have compared several alternatives: (1) using one distance variable by keeping its sign; (2) rescaling the distance variable at the classroom level (with classroom min and max values; (3) rescale the distance variable at school level (with school min and max values). The latter three alternatives produce very similar results. The distance variable is still significant, and its effect has the same sign as the current approach. But the magnitude of the effects is significantly reduced. The table is available upon request.

[3]As a robustness check, we replicated our analysis by adding FEs at the classroom level and by using the random effect model. The results are consistent with what we reported here. Please refer to Tables A1 and A2. We also use an alternative measure for the dependent variable. We used the cognitive ability measured in wave 1 as an independent variable and the mid-term exam outcomes in wave 2 as a dependent variable. The results were consistent with those obtained from the first wave. For simplicity reasons, they are not shown here, and the full tables are available upon request.

TABLE 1 Variable description

Variables	Grade 7 Mean	Grade 7 Std.	Grade 9 Mean	Grade 9 Std.
LCOG	0.18	0.38	0.17	0.38
Abs distance	0.58	0.45	0.57	0.43
Sign distance	0.51	0.50	0.51	0.50
Proportion of repeaters in class	0.15	0.18	0.15	0.16
Male	0.51	0.50	0.50	0.50
School attachment	0.07	0.52	0.00	0.51
Hours spent on homework daily	2.12	2.24	2.65	2.38
Depression index	−0.08	0.79	0.08	0.81
Attended kindergarten (1 = yes)	0.82	0.39	0.79	0.41
Retention at lower grade (1 = yes)	0.15	0.35	0.15	0.36
Ethnic minority (1 = yes)	0.09	0.28	0.10	0.29
Number of siblings	0.72	0.82	0.73	0.83
Board at school (1 = yes)	0.27	0.45	0.31	0.46
Low birth weight (1 = yes)	0.16	0.36	0.16	0.36
Migrant status	Count		Count	
Urban	3131		2750	
Migrant	827		553	
Left-behind	793		780	
Regular rural	1655		1870	
Parental highest education level				
No education	15		13	
Primary school	471		581	
Middle school	2643		2561	
Vocational middle school	392		278	
Vocational high school	137		136	
High school	1349		1185	
2-year college	466		419	
4-year college	781		645	
MA or above	152		135	
Family income category				
Low	1224		1109	
Medium	4765		4461	
High	417		383	

TABLE 1 (Continued)

Variables	Grade 7		Grade 9	
	Mean	Std.	Mean	Std.
Parental occupational status				
Cadre or top management	479		466	
Mid- and upper-mid management	688		513	
Professionals	557		410	
Technical and associate professionals	1103		955	
Production worker	690		582	
Service workers and shop and sales workers	591		449	
Getihu (independent business owner)	897		1067	
Peasants	1085		1263	
Unemployed	109		113	
NA	207		135	
Total	6406		5953	

Abbreviation: LCOG, low cognitive ability.

The y_{ij} stands for the standardized test score for the *j*th student *j* in the *i*th school; α_0 is the overall intercept; the vector λ represents a collection of coefficients for the student and classroom level covariates; α_i is the school-specific FE; e_{ij} is the student-level error term that follows a normal distribution. In the FEs specification, ζ is the estimated performance differential of a low-cognitive student compared with other students within the same school. γ is the estimated difference in performance associated with the distance to which each student is similar or different from their peers. Given our research interest that low-ability students might exhibit different relationships compared to other students, we include an interaction term in Equation 2.

Regarding the interactions between variables, we paid special attention to the coefficient in β. It estimates the unique association between the distance from classmates with the status of being a low-ability student. The coefficient associated with interaction β combines the two variables and could be interpreted as an additional effect of distance experienced by low-ability students. If β is statistically different from zero, it suggests that peer effect does not affect all students equally. A negative number would suggest low-ability students suffer from being placed in a diverse classroom, while a positive number would suggest extra benefits from being placed in a diverse classroom. Numerically, the combined distance effect for low-ability students (LCOG = 1) is, therefore:

$$\zeta + (\gamma + \beta) \times \text{distance}, \tag{3}$$

And for nonlow-ability students, the distance effect will be:

$$\gamma \times \text{distance}. \tag{4}$$

4 | RESULTS

The results of OLS models with school FEs are presented in Tables 2 and 3. For the results based on the models in Equation 1 (Table 2), the model without the interaction effect, both seventh- and ninth-grade students showed similar relationships regarding the low cognitive group and distance in Chinese, mathematics, and English test scores. Overall, low-cognitive ability students (i.e., LCOG students) had significantly lower test scores in all three

TABLE 2 OLS estimates of relationship between three subjects, cognitive ability, and distance using school fixed effects

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
LCOG (1 = yes)	−2.42***	(0.62)	−4.31***	(0.72)	−2.74***	(0.65)	−3.97***	(0.71)	−5.59***	(0.63)	−4.42***	(0.57)
Abs distance	0.23	(0.32)	1.95***	(0.47)	0.63	(0.46)	0.74+	(0.43)	1.42**	(0.52)	1.16*	(0.48)
Sign distance	3.77***	(0.38)	4.82***	(0.43)	3.65***	(0.42)	2.52***	(0.49)	3.44***	(0.52)	2.37***	(0.52)
Proportion of repeaters	−7.87**	(6.42)	−14.92*	(7.06)	−21.95***	(5.27)	2.71	(10.53)	1.16	(11.84)	2.21	(13.13)
Migrant status (urban as reference)												
Migrant	1.01	(0.71)	0.72	(0.73)	0.69	(0.75)	1.62**	(0.61)	2.03**	(0.62)	0.95	(0.61)
Left-behind	0.12	(0.47)	0.64	(0.53)	−0.01	(0.49)	1.21*	(0.49)	0.90	(0.64)	0.40	(0.46)
Regular rural	−0.24	(0.38)	0.56	(0.54)	0.06	(0.39)	0.06	(0.49)	0.49	(0.50)	0.18	(0.53)
Male	−5.33***	(0.36)	−1.02**	(0.30)	−5.05***	(0.32)	−5.66***	(0.37)	−0.45	(0.47)	−5.56***	(0.33)
School attachment	3.47***	(0.34)	3.46***	(0.35)	3.83***	((0.34)	3.45***	(0.35)	3.35***	(0.33)	3.06***	(0.37)
Hours spent on homework daily	0.11+	(0.06)	0.13**	(0.04)	0.06	(0.05)	0.15*	(0.07)	0.09	(0.07)	0.11	(0.08)
Depression index	−0.17	(0.20)	−0.44*	(0.20)	−0.30	(0.20)	0.45*	(0.22)	0.14	(0.23)	0.44+	(0.23)
Attended kindergarten (1 = yes)	1.03*	(0.41)	0.75+	(0.44)	0.31	(0.40)	−0.26	(0.34)	−0.13	(0.45)	−0.21	(0.44)
Retention in G1–G6	−1.20*	(0.46)	−1.35***	(0.39)	−1.75***	(0.44)	−0.02	(0.46)	−0.49	(0.46)	−1.09*	(0.54)
Ethnic minority	0.86	(0.58)	0.87	(0.56)	1.02	(0.81)	−0.32	(0.68)	−0.60	(0.98)	0.48	(0.61)
Number of siblings	−0.50*	(0.22)	−0.62*	(0.28)	−0.60*	(0.24)	−0.08	(0.23)	−0.33	(0.23)	−0.28	(0.18)
Board at school (1 = yes)	1.15*	(0.50)	0.72	(0.66)	0.94	(0.60)	0.07	(0.53)	1.24+	(0.71)	0.29	(0.69)
Low birth weight (1 = yes)	0.06	(0.45)	−0.32	(0.40)	−0.08	(0.42)	0.20	(0.41)	−0.09	(0.35)	−0.43	(0.35)
Parental education (no education as reference)												
Primary school	3.91+	(2.29)	2.25	(2.35)	3.19*	(1.52)	0.90	(3.75)	1.21	(2.67)	−1.41	(3.10)
Middle school	5.59*	(2.31)	3.10	(2.12)	4.50**	(1.55)	1.47	(3.78)	1.92	(2.68)	−0.65	(3.27)
Vocational middle school	7.07**	(2.48)	5.03*	(2.41)	5.62**	(1.73)	1.95	(3.73)	2.85	(2.70)	−1.18	(3.41)
Vocational high school	5.80*	(2.34)	3.88	(2.34)	4.38*	(1.71)	3.77	(3.85)	2.89	(3.24)	1.46	(3.60)

TABLE 2 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
High school	6.09*	(2.44)	3.86+	(2.15)	5.65***	(1.58)	3.02	(3.77)	4.11	(2.73)	1.21	(3.29)
2-year college	8.26***	(2.39)	5.05*	(2.33)	6.88***	(1.61)	4.40	(3.80)	6.16*	(2.53)	2.69	(3.24)
4-year college	7.80**	(2.41)	5.37*	(2.26)	7.15***	(1.66)	4.51	(3.78)	6.37*	(2.68)	2.81	(3.11)
MA or above	6.62*	(2.59)	3.62	(2.58)	6.42**	(2.00)	4.60	(4.01)	7.98**	(2.94)	2.84	(3.57)
Family income category (low as reference)												
Medium	−0.60*	(0.26)	0.13	(0.34)	−0.03	(0.30)	−0.11	(0.42)	0.12	(0.39)	0.11	(0.42)
High	−1.38*	(0.59)	−0.69*	(0.79)	−1.27*	(0.63)	−0.67	(0.64)	−0.64	(0.65)	−0.23	(0.71)
Parental occupational status (others as reference)												
Unemployed	0.37	(0.65)	−0.05	(0.78)	−0.06	(0.57)	−0.35	(1.00)	0.03	(0.94)	−0.12	(0.86)
Peasants	0.49	(0.73)	−0.23	(0.67)	0.44	(0.70)	1.94**	(0.73)	0.94	(0.68)	1.32+	(0.73)
Getihu (independent business owner)	0.27	(0.76)	−0.50	(0.73)	0.17	(0.64)	−0.08	(0.76)	0.78	(0.70)	−0.45	(0.72)
Service workers and shop and sales workers	0.41	(0.87)	−0.51	(0.76)	−1.05	(0.79)	0.36	(0.84)	1.22	(0.91)	0.45	(0.88)
Production worker	−0.19	(0.73)	−1.30+	(0.74)	−1.16	(0.83)	−1.11	(0.86)	−0.60	(0.90)	−1.61+	(0.82)
Technical and associate professionals	1.25*	(0.62)	−0.52	(0.71)	0.60	(0.61)	0.21	(0.74)	0.76	(0.81)	−0.13	(0.72)
Professionals	0.76	(0.76)	0.22	(0.84)	0.47	(0.71)	−0.53	(0.84)	0.47	(0.91)	−0.23	(0.85)
Mid- and upper-mid management	1.65	(1.05)	−0.85	(1.18)	0.29	(1.00)	−1.92	(1.46)	−0.60	(1.09)	0.48	(1.22)
Cadre or top management	0.36	(1.28)	−0.89	(1.14)	0.73	(0.97)	−2.75+	(1.62)	−0.03	(1.53)	−1.81	(1.31)
Constant	68.52***	(2.70)	67.48***	(2.88)	70.87***	(1.97)	69.83***	(4.81)	65.26***	(3.68)	72.06***	(4.25)
Observations	6285		6289		6284		5822		5813		5823	

Note: Standard errors in parenthese. LCOG = 1 if the student belongs to bottom quartile of the national cognitive distribution. Distance measures the absolute distance a student deviates from the average cognitive ability of all other students in his/her classroom.

Abbreviation: LCOG, low cognitive ability; OLS, least square model.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

+$p < 0.10$.

subjects, ranging from 2.42 to 5.59 percentiles lower than nonlow-ability students (i.e., non-LCOG students). The distance variable was positively correlated to all three performance rankings, showing that students with larger distance values tended to have better test scores, especially for mathematics. This result suggests that the students in the ability mixing classrooms might modestly increase their academic achievements.[4]

To understand whether the relationships between distance and student test scores would differ by students' own cognitive ability levels, we included the interaction term of distance and low cognitive group variables in Equation 2. Based on Table 3, the interaction terms are significant in all the models. These findings suggest that for students who were not in low cognitive ability groups, their academic achievements could benefit from increased cognitive diversity (distance) in the classroom. However, increased cognitive diversity in the classroom might cause learning disadvantages for students with low cognitive ability. We graphed the patterns of effects associated with the interaction terms in Figure 1 to illustrate these findings. We also describe the distance experienced by different groups of students in Table 4.

For seventh graders, when LCOG students were placed in classrooms with those of the same cognitive level, their expected performance was 68.73 percentile in Chinese, 65.51 in math, and 70.04 in English. Their non-LCOG peers performed slightly better in math and English. The average performance ranking is 67.54 and 70.92, respectively. However, their performance levels dropped when LCOG students were put in a cognitively diverse classroom (experienced distance at 90th percentile among all seventh-grade students). The expected performance in the three subjects was now 66.44, 65.21, and 68.85. Their non-LCOG peers actually performed much better, with percentiles ranking at 69.72, 70.28, and 72.20. Thus, the performance gap between LCOG and non-LCOG students grew from the −0.14, 2.03, and 0.88–3.28, 5.07, and 3.35 percentiles.

For ninth graders, the performance gap change was even more pronounced, with an expected performance gap of 1.04, 0.46, and 0.04 for Chinese, math, and English in a cognitively homogenous classroom between non-LCOG and LCOG students. When moved into a cognitively diverse classroom, the expected performance gap increased to 5.17, 7.69, and 6.22 percentiles.

In line with previous studies (e.g., Huang & Zhu, 2020; Xu et al., 2020), we found that the proportion of repeaters in the classroom is negatively correlated to three performance rankings, but only for the seventh grade, ranging from 14.92% to 21.95%; while the positive sign of distance measure is coupled with a positive effect on all three performance rankings across grades. By looking at the results of the student level covariates, male students in grade seven had significantly lower Chinese ($b = -5.35$, $p < 0.001$), mathematics ($b = -1.03$, $p < 0.001$) and English ($b = -5.06$, $p < 0.001$) performance ranking than female students. For grade nine males, Chinese and English test scores were also lower than female students ($b = -5.66$, $p < 0.001$ and $b = -5.56$, $p < 0.001$, respectively). School attachment was positively correlated to all three test scores for seventh- and ninth-grade students with a $p < 0.001$. The estimated coefficients of school attachment in Chinese, mathematics, and English were 3.42, 3.42, and 3.89 for grade seven students and 3.39, 3.25, and 2.97 for grade nine students, respectively. Other than these covariates, the relationship we found in our regression models did not have any consistent interpretation regarding student performance. Students whose parents have attended some degree of tertiary education had a slight advantage in Chinese and English in grade seven and mathematics in grade nine.

5 | DISCUSSION

The current study confirms the literature that peer compositional effects do matter for student learning. We studied a specific form of learning environment composition: classroom cognitive ability makeup. We did so by relating to individual students' "dissimilar" experiences after accounting for the overall ability level in each classroom. The compositional effects vary significantly for students of different cognitive abilities. Students in the top 75% of cognitive distribution benefit from heterogeneous learning environments (i.e., more dissimilar

[4]Usual disclaimer for an observational data set applies to our data. The CEPS data did not provide any direct measures of perceived peer distance or other measures to build a causal pathway to explain how students' performance change. Our estimates are associational.

TABLE 3 OLS estimates of relationship between percentile ranking of three subjects, cognitive ability, distance, and interaction using school fixed effects

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
LCOG (1 = yes)	0.14	(1.12)	−2.03*	(0.94)	−0.88	(1.08)	−1.04	(1.15)	−0.46	(1.23)	−00.04	(1.15)
Abs distance	1.13**	(0.39)	2.74***	(0.55)	1.28**	(0.49)	1.53***	(0.41)	2.81***	(0.51)	2.38***	(0.48)
LCOG × Abs distance	−3.42**	(1.13)	−3.04**	(0.97)	−2.47*	(1.02)	−4.13***	(1.12)	−7.23***	(1.21)	−6.18***	(1.25)
Sign distance	3.54***	(0.38)	4.61***	(0.45)	3.48***	(0.41)	2.35***	(0.49)	3.14***	(0.54)	2.10***	(0.54)
Proportion of repeaters	−18.38**	(6.40)	−15.38*	(7.10)	−22.31***	(5.21)	2.76	(11.36)	1.23	(13.41)	2.30	(14.47)
Migrant status (urban as reference)												
Migrant	0.98	(0.70)	0.69	(0.74)	0.66	(0.74)	1.59*	(0.63)	1.99**	(0.65)	0.91	(0.61)
Left-behind	0.09	(0.46)	0.61	(0.53)	−0.03	(0.48)	1.21*	(0.49)	0.91	(0.64)	0.41	(0.47)
Regular rural	−0.25	(0.38)	0.54	(0.54)	0.05	(0.39)	0.08	(0.50)	0.51	(0.48)	0.20	(0.54)
Male	−5.35***	(0.36)	−1.03***	(0.30)	−5.06***	(0.32)	−5.66***	(0.36)	−0.46	(0.48)	−5.56***	(0.33)
School Attachment	3.42***	(0.34)	3.42***	(0.35)	3.79***	(0.33)	3.39***	(0.35)	3.25***	(0.33)	2.97***	(0.37)
Hours spent on homework daily	0.11+	(0.06)	0.13**	(0.04)	0.05	(0.05)	0.15*	(0.07)	0.10	(0.07)	0.12	(0.08)
Depression index	−0.17	(0.20)	−00.44*	(0.20)	−0.30	(0.20)	0.46*	(0.22)	0.14	(0.23)	0.44+	(0.22)
Attended kindergarten (1 = yes)	0.99*	(0.41)	0.70	(0.45)	0.28	(0.40)	−00.26	(0.34)	−0.14	(0.45)	−0.23	(0.44)
Retention in G1–G6	−1.16*	(0.46)	−1.31***	(0.38)	−1.72***	(0.43)	0.00	(0.46)	−0.46	(0.45)	−1.06+	(0.54)
Ethnic minority	0.78	(0.58)	0.80	(0.56)	0.97	(0.81)	−0.44	(0.69)	−0.82	(0.99)	0.29	(0.64)
Number of siblings	−0.52*	(0.21)	−0.63*	(0.27)	−0.61*	(0.23)	−0.07	(0.24)	−0.33	(0.22)	−0.27	(0.18)
Board at school (1 = yes)	1.11*	(0.50)	0.68	(0.68)	0.91	(0.61)	0.02	(0.54)	1.16	(0.72)	0.22	(0.71)
Low birth weight (1 = yes)	0.05	(0.44)	−0.33	(0.40)	−0.09	(0.42)	0.21	(0.42)	−00.08	(0.36)	−0.42	(0.36)

(Continues)

TABLE 3 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
Parental education (no education as reference)												
Primary school	3.76^{+}	(2.23)	2.12	(2.37)	3.08^{+}	(1.59)	0.49	(3.87)	0.50	(2.91)	−2.02	(3.51)
Middle school	5.46*	(2.25)	2.98	(2.12)	4.40**	(1.61)	0.97	(3.90)	1.06	(2.95)	−1.39	(3.68)
Vocational middle school	6.90**	(2.40)	4.88*	(2.39)	5.49**	(1.77)	1.42	(3.85)	1.93	(2.96)	−1.97	(3.80)
Vocational high school	5.58*	(2.26)	3.69	(2.35)	4.22*	(1.77)	3.24	(3.99)	1.97	(3.45)	0.67	(4.00)
High school	5.96*	(2.37)	3.74^{+}	(2.15)	5.55***	(1.63)	2.51	(3.89)	3.22	(2.96)	0.45	(3.67)
2-year college	8.05***	(2.32)	4.87*	(2.34)	6.74***	(1.67)	3.77	(3.91)	5.07^{+}	(2.75)	1.76	(3.63)
4-year college	7.58**	(2.33)	5.17*	(2.25)	6.99***	(1.72)	3.87	(3.89)	5.25^{+}	(2.94)	1.85	(3.50)
MA or above	6.43*	(2.53)	3.46	(2.59)	6.28**	(2.06)	3.97	(4.10)	6.88*	(3.19)	1.90	(3.96)
Family income category (low as reference)												
Medium	−0.61*	(0.25)	0.12	(0.34)	−0.04	(0.31)	−0.08	(0.43)	0.18	(0.40)	0.16	(0.42)
High	−1.42*	(0.59)	−01.72*	(0.80)	−1.30*	(0.63)	−0.65	(0.65)	−0.61	(0.67)	−0.20	(0.73)
Parental occupational status (others as reference)												
Unemployed	0.41	(0.64)	−1.02	(0.78)	−00.03	(0.57)	−00.35	(0.99)	0.03	(0.92)	−0.12	(0.85)
Peasants	0.47	(0.71)	−0.25	(0.66)	0.42	(0.69)	1.94**	(0.74)	0.95	(0.68)	1.34^{+}	(0.74)
Getihu (independent business owner)	0.21	(0.74)	−0.56	(0.72)	0.13	(0.64)	−0.02	(0.77)	0.88	(0.70)	−0.36	(0.72)
Service workers and shop and sales workers	0.37	(0.84)	−0.55	(0.75)	−1.08	(0.79)	0.35	(0.85)	1.21	(0.92)	0.45	(0.89)
Production worker	−0.19	(0.70)	−1.29^{+}	(0.74)	−1.17	(0.83)	−1.17	(0.85)	−0.70	(0.90)	−1.71*	(0.81)
Technical and associate professionals	1.17^{+}	(0.61)	−0.58	(0.70)	0.54	(0.61)	0.21	(0.75)	0.75	(0.81)	−0.13	(0.72)
Professionals	0.72	(0.73)	0.18	(0.81)	0.43	(0.69)	−0.51	(0.83)	0.52	(0.90)	−0.18	(0.83)

TABLE 3 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
Mid- and upper-mid management	1.47	(1.05)	−1.01	(1.20)	0.16	(1.00)	−.89	(1.44)	−0.55	(1.08)	0.52	(1.16)
Cadre or top management	0.31	(1.27)	−0.93	(1.13)	0.70	(0.97)	−2.78^{+}	(1.62)	−0.09	(1.51)	−1.85	(1.33)
Constant	68.59***	(2.62)	67.54***	(2.90)	70.92***	(2.02)	69.96***	(4.95)	65.48***	(4.06)	72.24***	(4.74)
Observations	6285		6289		6284		5822		5813		5823	

Note: Standard errors in parentheses. LCOG = 1 if the student belongs to bottom quartile of the national cognitive distribution. Distance measures the absolute distance a student deviates from the average cognitive ability of all other students in his/her classroom.

Abbreviations: LCOG, low cognitive ability; OLS, least square model.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

$^{+}p < 0.10$.

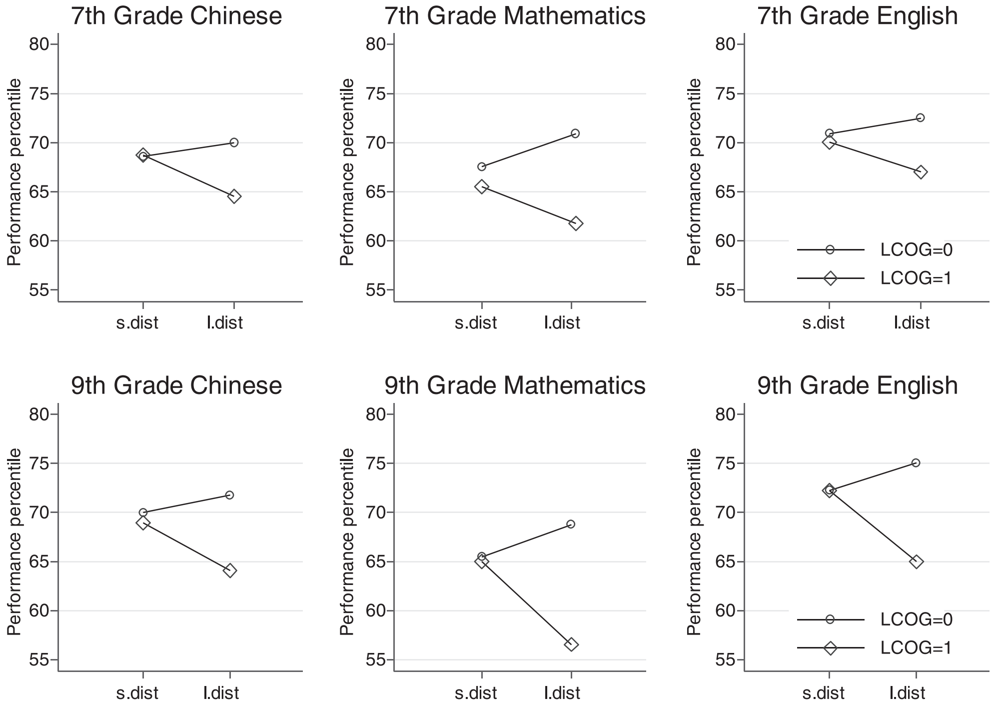

FIGURE 1 Interaction between cognitive ability and experienced cognitive distance in performance ranking. LCOG = 1 if the student belongs to the bottom quartile of the national cognitive distribution. Small distance (s. dist) characterizes an average student (cognitive distance is 0, which means the student's own cognitive level is equal to the classroom average minus the student him/herself). Large distance (l. dist) characterizes a student whose distance to the classroom average is at the 90th percentile among all the students in that grade. All estimates account for repeaters in the classrooms. LCOG, low cognitive ability.

TABLE 4 Distance experienced by students

		Cognitive distance experienced				
Grade	**LCOG students**	**Mean**	**SD**	**Min**	**Max**	***N***
7th	No	0.51	0.40	0	2.50	5283
	Yes	0.90	0.50	0	2.57	1123
9th	No	0.52	0.41	0	2.79	4924
	Yes	0.82	0.44	0	2.33	1029

Abbreviation: LCOG, low cognitive ability.

cognitively from their peers). In contrast, students with a low-cognitive ability (those who belong to the bottom 25% of the distribution) are negatively impacted by cognitive diversity. The findings demonstrate that cognitive diversity in the learning environment has differential effects. We confirmed the cognitive theory that students who study with diverse peers have positive effects in Chinese schools. However, for the cognitively weak students, that positive effect was soon overshadowed by the negative influence, as the relative deprivation theory proposed. They suffered in performance ranking, while their able peers benefited from the same environment.

This research sheds light on the scholarly debate regarding learning environment design. Although most purposeful classroom assignment practices are based on prior test scores, by not specifically using cognitive assessment, we can easily expect a version of such placement with a specific focus on cognitive ability. It seems that student ability tracking proponents could find evidence from our results. Proponents of ability tracking maintain that it is an organizational practice to "increase the effectiveness and efficiency of instruction" (Hallinan, 2011, p. 349). Lower ability diversity is believed to help enhance the teachers' pedagogical efficiency, as they can employ curricula and techniques better tailored to the specific ability groups.

We caution the reader that counter argument is still plausible, though the current data does not permit us to test this issue. It is equally possible that grouping and tracking can discriminate against students from lower social classes and racial and ethnic minorities, which can lead to a widening of inequality (Hanushek & Woesmann, 2006; Oakes, 2011). Once assigned to the lower track, students often receive a watered-down curriculum, less qualified teachers, and poor learning materials (Chiu & Walker, 2007). Even with equal educational resources, students in lower tracks are deprived of the opportunity to learn from their high-achieving peers and thus enjoy fewer intellectual resources offered by those peers.

Our central message delivers a nuanced picture regarding the context of the Chinese educational system. Our findings do not necessarily falsify the arguments from the heterogeneous-grouping supporters but indeed remind us that the impact of cognitive diversity in the learning environment cannot be assumed or taken for granted. The peer effects may be subject to the influence of a lot more nuanced conditions than diversity alone. The cognitively weak students may require specific guidance or attention. Furthermore, weaker students may have even lower efficacy in a high diversity environment when competing with peers whose ability and achievements are much higher. These alternative interpretations expose the limitations of the homogenous-grouping arguments. The grouping process may not improve learning for all students unless it is supported by specific school cultures and practices that genuinely embrace diversity and equality. We also point out that national or even local context matters for educational practices. Larger class sizes may affect how students perceive their peers (average class size is 47 for grade seven and 42 for grade nine in CEPS, considerably larger than in many countries).

Due to the cross-sectional nature of CEPS baseline data, we caution readers that the findings demonstrated in this paper are associational rather than causal. We verified the robustness of our findings using alternative identification strategies suggested by Huang and Zhu (2020) and Xu et al. (2020). Though our findings are supported, we concur that there is a long way to go in establishing causality between grouping and achievement, which requires longitudinal information on students' learning status and environment across longer a temporal duration. Our data set and analytical approach also confined us to studying the classroom experience only. We did not explore other aspects of schooling. We leave these issues for future inquiries.[5]

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DATA AVAILABILITY STATEMENT

This paper analyzed a publically available data set collected by Renmin University of China. The data set can be accessed here for replication purpose: http://www.cnsda.org/index.php?r=projects/view&id=61662993

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/jcop.22939

[5]Another important nonanalytical issue is data quality. As a reviewer of this paper correctly pointed out, CEPS, like many large-scale surveys, did not disclose enough information regarding the testing instruments. In particular, the psychometric quality of the cognitive and school-based tests was not available to us. We followed the convention by taking the face value of the data (e.g., Huang & Zhu, 2020; Xu et al., 2020), but this is an area worth further scrutiny.

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APPENDIX

Tables A1 and A2

TABLE A1 OLS estimates of relationship between percentile ranking of three subjects, cognitive ability, distance, and interaction using classroom fixed effects

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
LCOG (1 = yes)	0.84	(0.93)	−1.65*	(0.83)	−0.11	(0.98)	1.35	(1.15)	2.58**	(0.84)	3.27***	(0.98)
Abs distance	1.16**	(0.38)	2.76***	(0.50)	1.26**	(0.44)	1.38**	(0.44)	2.83***	(0.50)	2.22***	(0.46)
LCOG × Abs distance	−3.90***	(0.98)	−3.42***	(0.96)	−3.01**	(0.97)	−5.86***	(1.21)	−9.55***	(0.95)	−8.68***	(1.05)
Sign distance	3.64***	(0.33)	4.56***	(0.38)	3.47***	(0.37)	2.79***	(0.45)	3.68***	(0.49)	2.67***	(0.48)
Migrant status (urban as reference)												
Migrant	1.10+	(0.64)	0.68	(0.68)	0.50	(0.64)	1.55*	(0.60)	2.12***	(0.61)	1.09	(0.68)
Left-behind	0.32	(0.47)	0.88+	(0.49)	0.13	(0.52)	1.48**	(0.53)	1.23+	(0.62)	0.75	(0.52)
Regular rural	−0.17	(0.35)	0.58	(0.47)	0.03	(0.39)	0.08	(0.49)	0.69	(0.53)	0.40	(0.54)
Male	−5.40***	(0.33)	−1.02**	(0.36)	−5.03***	(0.32)	−5.58***	(0.37)	−0.28	(0.39)	−5.37***	(0.34)
School attachment	3.50***	(0.35)	3.36***	(0.38)	3.76***	(0.33)	3.20***	(0.36)	2.98***	(0.36)	2.67***	(0.36)
Hours spent on homework daily	0.12+	(0.06)	0.12*	(0.05)	0.03	(0.05)	0.14*	(0.06)	0.08	(0.07)	0.08	(0.07)
Depression index	−0.24	(0.21)	−0.51*	(0.21)	−0.35+	(0.20)	0.41+	(0.22)	0.11	(0.22)	0.35	(0.22)
Attended kindergarten (1 = yes)	0.95**	(0.36)	0.51	(0.38)	0.11	(0.38)	−0.05	(0.42)	0.07	(0.42)	0.08	(0.35)
Retention in G1–G6	−1.32***	(0.39)	−1.43***	(0.42)	−1.88***	(0.42)	−0.21	(0.45)	−0.64	(0.47)	−1.22**	(0.45)
Ethnic minority	0.99	(0.70)	0.44	(0.58)	0.93	(0.76)	−0.29	(0.67)	−0.54	(0.99)	0.35	(0.63)
Number of siblings	−0.47*	(0.21)	−0.53*	(0.24)	−0.59**	(0.22)	−0.03	(0.23)	−0.28	(0.24)	−0.18	(0.18)
Board at school (1 = yes)	0.93+	(0.50)	0.53	(0.56)	0.90	(0.57)	0.04	(0.48)	1.22*	(0.61)	0.22	(0.60)
Low birth weight (1 = yes)	0.02	(0.45)	−0.13	(0.41)	0.05	(0.41)	0.29	(0.43)	0.17	(0.45)	−0.22	(0.35)

TABLE A1 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
Parental education (no education as reference)												
Primary school	2.99	(2.39)	2.05	(2.25)	3.58*	(1.71)	1.06	(3.89)	0.81	(3.67)	−1.61	(3.67)
Middle school	4.51+	(2.32)	2.95	(2.16)	4.76**	(1.70)	1.41	(3.93)	1.17	(3.69)	−1.14	(3.76)
Vocational middle school	5.69*	(2.39)	4.54*	(2.26)	5.60**	(1.80)	1.73	(3.87)	1.95	(3.73)	−2.03	(3.84)
Vocational high school	4.81*	(2.37)	3.60	(2.35)	4.55*	(1.84)	3.40	(4.02)	1.57	(3.99)	0.49	(4.16)
High school	5.01*	(2.39)	3.64	(2.14)	5.76**	(1.74)	2.76	(3.91)	3.16	(3.69)	0.48	(3.72)
2-year college	6.82**	(2.37)	4.66*	(2.21)	6.81***	(1.84)	3.73	(3.84)	4.62	(3.52)	1.64	(3.71)
4-year college	6.41**	(2.36)	5.15*	(2.17)	7.25***	(1.82)	3.83	(3.93)	4.89	(3.67)	1.65	(3.72)
MA or above	5.48*	(2.53)	3.61	(2.61)	6.68**	(2.07)	3.98	(4.06)	6.44+	(3.70)	1.69	(3.85)
Family income category (low as reference)												
Medium	−0.58+	(0.32)	0.08	(0.38)	−0.08	(0.30)	−0.23	(0.49)	0.05	(0.49)	0.06	(0.45)
High	−1.51*	(0.70)	−2.09**	(0.79)	−1.68*	(0.65)	−0.56	(0.75)	−0.54	(0.70)	−0.06	(0.78)
Parental occupational status (others as reference)												
Unemployed	0.29	(0.65)	−1.15	(0.84)	0.02	(0.56)	−0.28	(0.88)	0.09	(0.77)	−0.00	(0.73)
Peasants	0.34	(0.65)	−0.24	(0.69)	0.50	(0.65)	2.06**	(0.69)	1.05	(0.64)	1.35+	(0.72)
Getihu (independent business owner)	−0.02	(0.69)	−0.50	(0.71)	0.15	(0.59)	0.05	(0.72)	0.96	(0.70)	−0.38	(0.73)
Service workers and shop and sales workers	0.26	(0.79)	−0.76	(0.79)	−1.14+	(0.66)	0.33	(0.70)	1.23	(0.81)	0.58	(0.82)
Production worker	−0.57	(0.73)	−1.24+	(0.74)	−1.17	(0.72)	−0.95	(0.75)	−0.39	(0.80)	−1.52+	(0.78)
Technical and associate professionals	0.80	(0.70)	−0.62	(0.74)	0.43	(0.61)	0.44	(0.69)	1.08	(0.67)	0.09	(0.70)
Professionals	0.45	(0.76)	0.31	(0.79)	0.59	(0.59)	−0.32	(0.68)	0.84	(0.74)	0.10	(0.72)
Mid- and upper-mid management	0.81	(1.00)	−0.45	(1.21)	0.20	(1.14)	−1.84	(1.34)	−0.13	(0.93)	0.81	(1.13)

(Continues)

TABLE A1 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
Cadre or top management	0.25	(1.19)	−1.07	(1.07)	0.66	(0.95)	−2.65+	(1.43)	0.15	(1.34)	−1.77	(1.21)
Constant	65.83***	(2.40)	64.55***	(2.24)	66.12***	(1.78)	69.47***	(4.17)	64.54***	(3.85)	71.42***	(3.79)
Observations	6285		6289		6284		5822		5813		5823	

Note: Standard errors in parentheses. LCOG = 1 if the student belongs to bottom quartile of the national cognitive distribution. Distance measures the absolute distance a student deviates from the average cognitive ability of all other students in his/her classroom.

Abbreviation: LCOG, low cognitive ability; OLS, least square model.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

+$p < 0.10$.

TABLE A2 Estimates of relationship between percentile ranking of three subjects, cognitive ability, distance, and interaction using classroom random effects

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
LCOG (1 = yes)	0.84	(0.91)	−1.64*	(0.82)	−0.10	(0.96)	1.35	(1.13)	2.58**	(0.82)	3.28***	(0.96)
Abs distance	1.16**	(0.37)	2.77***	(0.49)	1.26**	(0.43)	1.38**	(0.43)	2.83***	(0.49)	2.22***	(0.45)
LCOG × Abs distance	−3.89***	(0.96)	−3.42***	(0.94)	−3.02**	(0.95)	−5.86***	(1.18)	−9.55***	(0.93)	−8.68***	(1.03)
Sign distance	3.65***	(0.33)	4.56***	(0.37)	3.47***	(0.37)	2.79***	(0.44)	3.68***	(0.48)	2.67***	(0.47)
Migrant status (urban as reference)												
Migrant	1.10+	(0.63)	0.68	(0.66)	0.50	(0.63)	1.55**	(0.58)	2.12***	(0.60)	1.10+	(0.66)
Left-behind	0.32	(0.46)	0.88+	(0.48)	0.13	(0.51)	1.48**	(0.51)	1.23*	(0.61)	0.75	(0.51)
Regular rural	−0.17	(0.34)	0.59	(0.46)	0.03	(0.39)	0.08	(0.48)	0.69	(0.52)	0.40	(0.52)
Male	−5.40***	(0.32)	−1.02**	(0.35)	−5.03***	(0.31)	−5.58***	(0.37)	−0.28	(0.38)	−5.37***	(0.34)
School attachment	3.50***	(0.34)	3.37***	(0.37)	3.76***	(0.32)	3.20***	(0.35)	2.98***	(0.35)	2.67***	(0.35)
Hours spent on homework daily	0.12*	(0.06)	0.12**	(0.05)	0.03	(0.05)	0.14*	(0.06)	0.08	(0.07)	0.08	(0.07)
Depression index	−0.24	(0.20)	−0.51*	(0.21)	−0.35+	(0.19)	0.41+	(0.22)	0.11	(0.21)	0.35	(0.22)
Attended kindergarten (1 = yes)	0.95**	(0.35)	0.51	(0.37)	0.11	(0.37)	−0.05	(0.41)	0.07	(0.41)	0.07	(0.34)
Retention in G1–G6	−1.32***	(0.39)	−1.43***	(0.41)	−1.88***	(0.41)	−0.21	(0.44)	−0.64	(0.46)	−1.22**	(0.44)
Ethnic minority	0.99	(0.68)	0.44	(0.57)	0.93	(0.75)	−0.29	(0.65)	−0.55	(0.97)	0.35	(0.61)
Number of siblings	−0.47*	(0.21)	−0.53*	(0.24)	−0.59**	(0.22)	−0.03	(0.22)	−0.29	(0.23)	−0.18	(0.18)
Board at school (1 = yes)	0.93+	(0.49)	0.53	(0.55)	0.90	(0.56)	0.04	(0.47)	1.22*	(0.60)	0.22	(0.58)
Low birth weight (1 = yes)	0.02	(0.44)	−0.13	(0.40)	0.05	(0.40)	0.29	(0.42)	0.17	(0.44)	−0.22	(0.35)
Parental education (no education as reference)												
Primary school	2.94	(2.34)	2.11	(2.20)	3.49*	(1.68)	1.02	(3.81)	0.74	(3.59)	−1.68	(3.59)
Middle school	4.46*	(2.27)	3.01	(2.12)	4.66**	(1.67)	1.37	(3.84)	1.10	(3.61)	−1.21	(3.68)

(Continues)

TABLE A2 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
Vocational middle school	5.64*	(2.34)	4.60*	(2.21)	5.50**	(1.77)	1.69	(3.78)	1.87	(3.65)	−2.1	(3.76)
Vocational high school	4.76*	(2.32)	3.65	(2.31)	4.46*	(1.81)	3.36	(3.93)	1.50	(3.91)	0.42	(4.07)
High school	4.96*	(2.34)	3.70^{+}	(2.10)	5.67***	(1.71)	2.72	(3.82)	3.09	(3.61)	0.41	(3.64)
2-year college	6.77**	(2.33)	4.73*	(2.17)	6.72***	(1.81)	3.69	(3.76)	4.55	(3.45)	1.57	(3.64)
4-year college	6.37**	(2.31)	5.22*	(2.12)	7.15***	(1.80)	3.79	(3.84)	4.81	(3.60)	1.58	(3.65)
MA or above	5.42*	(2.48)	3.67	(2.55)	6.60**	(2.03)	3.94	(3.98)	6.36^{+}	(3.62)	1.62	(3.77)
Family income category (low as reference)												
Medium	−0.58^{+}	(0.31)	0.08	(0.37)	−0.08	(0.29)	−0.23	(0.48)	0.04	(0.48)	0.06	(0.45)
High	−1.50*	(0.68)	−2.10**	(0.77)	−1.68**	(0.64)	−0.56	(0.74)	−0.55	(0.69)	−0.07	(0.76)
Parental occupational status (others as reference)												
Unemployed	0.30	(0.64)	−1.13	(0.82)	0.02	(0.55)	−0.28	(0.86)	0.07	(0.75)	−0.01	(0.71)
Peasants	0.35	(0.64)	−0.22	(0.67)	0.5	(0.64)	2.07**	(0.68)	1.05^{+}	(0.63)	1.35^{+}	(0.70)
Getihu (independent business owner)	−0.01	(0.67)	−0.48	(0.70)	0.15	(0.58)	0.05	(0.70)	0.94	(0.68)	−0.39	(0.72)
Service workers and shop and sales workers	0.27	(0.77)	−0.74	(0.78)	−1.14^{+}	(0.65)	0.33	(0.69)	1.22	(0.80)	0.57	(0.80)
Production worker	−0.56	(0.72)	−1.22^{+}	(0.73)	−1.18^{+}	(0.71)	−0.95	(0.73)	−0.41	(0.79)	−1.53*	(0.77)
Technical and associate professionals	0.81	(0.69)	−0.6	(0.73)	0.43	(0.60)	0.44	(0.67)	1.06	(0.66)	0.08	(0.69)
Professionals	0.45	(0.75)	0.33	(0.78)	0.59	(0.58)	−0.31	(0.67)	0.82	(0.72)	0.09	(0.70)
Mid- and upper-mid management	0.82	(0.98)	−0.42	(1.19)	0.21	(1.12)	−1.84	(1.31)	−0.15	(0.91)	0.80	(1.11)
Cadre or top management	0.25	(1.17)	−1.04	(1.05)	0.66	(0.93)	−2.65^{+}	(1.40)	0.14	(1.32)	−1.78	(1.18)
Constant	64.71***	(2.35)	62.99***	(2.19)	67.11***	(1.76)	67.82***	(4.06)	66.59***	(3.79)	71.95***	(3.71)
σ_u^2	4.10***	(0.33)	3.68***	(0.32)	4.64***	(0.41)	5.10***	(0.56)	5.15***	(0.45)	4.82***	(0.49)

TABLE A2 (Continued)

	Grade 7						Grade 9					
	Chinese		Math		English		Chinese		Math		English	
σ_e^2	60.21***	(2.08)	67.50***	(2.04)	62.87***	(2.03)	67.92***	(2.24)	70.62***	(2.20)	70.59***	(2.15)
Observations	6285		6289		6284		5822		5813		5823	

Note: Standard errors in parentheses. LCOG = 1 if the student belongs to bottom quartile of the national cognitive distribution. Distance measures the absolute distance a student deviates from the average cognitive ability of all other students in his/her classroom.

**p* < 0.05; ***p* < 0.01; ****p* < 0.001.

+*p* < 0.10.