



Stunted upward mobility in a learning environment reduces the academic benefits of growth mindsets

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Does stunted upward mobility in an educational system impede beneficial psychological processes of learning? We predicted that growth mindsets of intelligence, a well-established psychological stimulant to learning, would be less potent in low-mobility, as compared to high-mobility, learning environments. An analysis of a large cross-national dataset and a longitudinal experiment accumulated converging evidence for this hypothesis. Study 1 examined data from 15-y-old students across 30 countries ($n = 235,141$ persons). Replicating past findings, growth mindsets positively predicted students' math, science, and reading literacy. More importantly, the country-level indicator of educational mobility (i.e., the percentage of children from low-education households to graduate from tertiary education) moderated the effect of growth mindsets. Depending on the subject, the gain in predicted academic performance from a one-unit increase in growth mindsets was reduced by 42 to 45% from a high-mobility to a low-mobility country. Results were robust with or without important covariates. Study 2 experimentally manipulated people's perception of mobility in a carefully constructed learning environment. The moderating role of educational mobility was replicated and extended to learning behavior, which subsequently predicted performance. Evidence further suggests that in high-mobility environments, both advantaged and disadvantaged learners benefited from growth mindsets, albeit likely through diverging mechanisms; when the effect of growth mindsets was attenuated in low-mobility environments, the potential for the disadvantaged to overcome the performance gap was also limited. Implications for galvanizing the upward mobility of the disadvantaged, evaluating the effectiveness of mindset interventions, and conceptualizing social mobility from a psychological perspective are discussed.

social mobility | educational mobility | academic achievement | mindset | psychology of learning

There is a long-standing concern that the American education system fails to promote the upward mobility of children from low-income and less educated households (1–3). College admission is a case in point. Children in higher, as opposed to lower, social classes are grossly overrepresented in universities (4–6), with the greatest imbalance found in the most prestigious institutions. A recent analysis suggests that children from the wealthiest 1% of households are 77 times more likely to attend an Ivy-Plus college than those whose parents are in the bottom income quintile (7). Given the strong relationship between education and social status and income in adult life, much research has scrutinized the profound implications of a low-mobility educational system for social justice and stability (1, 3, 8).

What if a low-mobility education system also incurs psychological costs to individual learners? The education system serves the society by building human capital and selecting talents (9), but it also serves individuals by providing opportunities for learning and personal development (10). If an environment with stunted upward mobility also interferes with individuals' potential for learning and growth, then there is double the reason (and urgency) to address this condition.

The learner's psychology is examined here. As individuals actively decode information that is pervasive in the learning environment

and derive meaning relevant to their behavior (11, 12), their learning could be influenced by the system-level mobility of the disadvantaged. Specifically, we predict that learners in a low-mobility environment are less likely than those in a high-mobility environment to employ certain adaptive mindsets to guide their learning and academic achievement.

Growth Mindsets Stimulate Learning

A substantial body of research has shown that the belief that one's abilities and talents can be developed (growth mindsets), as opposed to fixed, stimulates long-term learning. More than just simple beliefs, growth mindsets are at the center of a meaning system that provides an interpretative framework about active learning behavior; it prioritizes the development of abilities, ascribes positive beliefs about effort, and embraces setbacks as information about the learning process rather than signals of inaptness (13, 14). In terms of behavioral outcomes, growth mindsets motivate persistence in the face of obstacles and challenge-seeking behaviors and exert a positive influence on academic achievement across both secondary and tertiary education (15). Intervention-based studies affirm the utility of inculcating a growth mindset (16–19). Most notably, in a study with a large, nationally representative sample ($n = 12,486$), two 25-min online sessions of growth mindset training at the beginning of the ninth grade improved American students' end-of-the-year performance (19), outperforming many more resource-demanding educational interventions (20).

Significance

Recent debates about the failure of the education system in uplifting the disadvantaged have focused on the implications for social justice and stability. Learners' psychology is understudied. How may a low-mobility learning environment, which signals a reduced potential for disadvantaged learners to achieve success, impact individuals' recruitment of adaptive psychological processes? In both naturally existing and experimentally constructed contexts, we observe that low-mobility environments, as compared to high-mobility ones, are associated with reduced potency of the otherwise highly beneficial growth mindsets—the beliefs that one's abilities and talents can be developed. Our study shows that stunted upward mobility in a learning environment incurs costs to individuals' active learning and development.

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Growth mindsets, however, are more adaptive for learning under some than other circumstances. Recent meta-analyses find substantial heterogeneity in the effects of trait mindsets as well as mindset interventions on academic achievement, suggesting the presence of boundary conditions (21). The large-scale intervention study mentioned above, in particular, reveals the moderating role of a contextual factor: the mindset intervention was more effective when the peer norms in schools supported challenge-seeking behavior than when they did not. Indeed, there is a recent call to identify the contexts, or “a fertile soil,” that would sustain the perspective of growth mindsets, or “the seed” (22).

Educational Mobility Moderates the Effect of Growth Mindsets

Our psychological approach necessitates a distinction between the mobility construct within and beyond the learning environment. For clarity, we define educational mobility as the potential, at the system level, for disadvantaged learners to achieve academic success despite salient obstacles. Disadvantaged learners, as compared to advantaged ones, are at a greater risk of poor performance due to external or internal obstacles such as family background (e.g., a low-educated family provides poor parental support in learning) or past experiences (e.g., nonnative speakers in a language class). In a low-mobility environment, these obstacles have an outsized influence on disadvantaged learners and constrain them to low levels of achievement. In a high-mobility environment, on the other hand, disadvantaged learners readily overcome the obstacles and elevate beyond the low levels of achievement. Admittedly, because low levels of income and social status are key obstacles that put certain students at a disadvantage (4, 6), educational mobility and other conceptions of social mobility, especially those from the sociological tradition, are intimately related (23). Given the importance of contexts in the study of psychological processes (24), however, it is the former that should directly impact learners’ psychology.

Educational mobility can convey information about the psychological affordances of a learning environment. Affordances of a physical object signal fitting actions one can adopt to interact with it (e.g., the rungs of a ladder afford climbing [25]). Psychological affordances of a social environment, on the other hand, signal mindsets, beliefs, and reactions that are applicable (22). An environment that “affords” the use of growth mindsets would thus be one that invites learners to recognize the utility of growth mindsets and apply them to guide behavior. Since people are generally attuned to cues that reflect the psychological affordances of a learning environment (12, 26, 27), they should also derive informational value from educational mobility.

We submit that learners are more likely to apply growth mindsets to increase active learning behavior when they perceive the environment to be high, as opposed to low, on mobility. High-mobility environments inform individuals that active learning behaviors such as putting in extra effort and seeking challenges are instrumental to learning and success. As disadvantaged learners are observed to overcome obstacles and attain respectable outcomes, active learning behaviors are perceived as salient contributors to academic success. Because growth mindsets and the associated meaning system provide a rich interpretative framework for active learning (13, 28), the perception of a high-mobility environment invites individuals to recruit growth mindsets in determining how much to engage in active learning themselves (29). Conversely, because disadvantaged learners are stuck with poor performance in low-mobility environments, the obstacles that put them at risk would be viewed as the primary determinants of academic success; the role of active learning is obscured. In such an environment, growth mindsets are less applicable and less used.

Accordingly, a high-mobility, but not low-mobility, environment affords the use of growth mindsets. That is, learners with growth mindsets would be likely to use them, and hence to benefit from

them, in environments they perceive to have high educational mobility. In environments they perceive to have low educational mobility, learners’ growth mindsets would have attenuated effects on learning and achievement. This is our main hypothesis.

Overview of Present Research

As an initial test of our prediction, we examined two instances of educational mobility that would implicate the proposed psychological mechanism: a country-level index of upward mobility in the education system and an experimentally manipulated perception of mobility in a carefully constructed learning environment.

Study 1 analyzed a subset of the Program for International Student Assessment 2018 (PISA 2018). PISA 2018 measured academic performance in mathematical, scientific, and reading (MSR) literacy and, for the first time, the growth mindsets of 15-y-old students from 79 countries around the world. For 30 of these countries, the Organization for Economic Co-operation and Development (OECD) reported an objective measure of educational mobility (i.e., the percentage of children from low-education households to graduate from tertiary education) (30). Since it is well established that children from low-education households, as compared to those from high-education households, are at a disadvantage to perform well in school (31, 32), this index reflects the upward mobility of disadvantaged learners to achieve academic success. Among these 30 countries, the country-level variable of educational mobility was predicted to moderate the relationship between growth mindsets and academic performance at the student level.

This dataset permitted a rigorous testing of our hypothesis. All the target countries are modern democracies with nationalized, compulsory primary and secondary education systems. This minimized the risk that the effect of educational mobility is due to major cross-county differences in political and educational structures. Next, it included a gamut of factors, supplemented from additional sources (e.g., the World Economic Forum and World Bank), where necessary, that allowed us to test whether our hypothesis was robust over 1) theoretically known correlates of growth mindsets, 2) school- and country-level educational resources, and 3) other measures of social mobility (e.g., income inequality) at the country level.

Study 2 examined the viability of the proposed psychological mechanism with a longitudinal experiment. Student participants underwent a 2- to 3-wk selection program, in which a purported aspect of intelligence was evaluated. The program had four sessions: an initial assessment, two optional practice sessions, and a final assessment.

The first session incorporated two manipulations. First, students were allocated to either an upper or a lower track following the initial assessment. Contrary to their belief that the allocation was based on their performance, it was based on random assignment and constituted the initial advantage manipulation. Perceived mobility was manipulated with bogus statistics about the likelihood that the initial disadvantage—the salient obstacle here—could be overcome. In the high-mobility environment, the upper track afforded three times the likelihood to ostensibly qualify for attractive rewards than the lower track. In the low-mobility environment, the odds stood at 33 times.

Our primary objective was to test whether stronger growth mindsets would positively predict learning (i.e., practice engagement) in the high- but not low-mobility environment. The downstream consequences of learning behavior on the final performance were also examined.

This paradigm complemented Study 1 in important ways. First, only learners’ perception of mobility was manipulated, with other key aspects of the learning environment kept constant; both the high- and low-mobility environments offered the same learning opportunities and did not differ in either the structure or the culture of learning. Since we surmise that the informational value of educational mobility can impact learners’ use of mindsets, this

design permitted a strong test of our proposed psychological mechanism. Second, the initial (dis)advantage was established meritocratically from participants' perspective. As it was not arbitrarily determined or based on any of participants' social identities (e.g., gender or race), the confounding effects of feelings of unfairness (33) or preexisting social stigma (34) were minimized. Third, Study 1 assumed but did not test that growth mindsets affected learning behavior; this was addressed in Study 2.

Finally, while the different ways to operationalize educational mobility in the two studies allowed us to provide converging evidence for the main hypothesis, questions remained as to whether they could implicate the instrumentality of active learning in the same manner as we had theorized. We reported two pilot studies to affirm that learners did perceive and understand these implications of mobility.

Datasets and syntax for our main analyses can be found at <https://doi.org/10.17605/OSF.IO/ZYV89>.

Results

Study 1: Cross-National Data. Multilevel mixed-effects models were conducted on the MSR scores, with students nested in schools nested within countries. Intraclass correlations revealed that differences between schools and differences between countries accounted for 25.6 to 29.5% and 6.4 to 7.7% of the variance in MSR scores, respectively. Hence, there was sufficient dependence in the data to warrant the use of multilevel models.

Analytical approach. Following PISA guidelines, sampling weights were applied to our analyses to account for 1) any unequal probabilities when selecting schools and students to participate and 2) any overrepresentation of certain school or student characteristics due to nonresponse during sample selection (35). This ensured that results obtained with this sample were representative of the population, which was key to our test of cross-country differences. Additional details about data handling, such as estimating the probability distributions for MSR scores and the centering methods for predictors, are reported in *SI Appendix, section 1D*.

Consistent with past recommendations, we compared results between models with and without covariates to guard against false-positive findings (36). As our predicted patterns remained unchanged (Table 1), we focus our reporting on covariate-inclusive models to demonstrate the unique effects of growth mindsets and educational mobility.

Covariates. Theoretical correlates of the key predictors and canonical predictors of student performance were identified. At the student level, we factored in two well-established correlates of growth mindsets: self-report ratings of grit (e.g., "Once I start a task, I persist until it is finished") and self-efficacy (e.g., "My belief in myself gets me through hard times"). With them as covariates, the unique predictability of mindsets could be better isolated. Age, gender, and socioeconomic status (SES) were also controlled for. At the school level, we included variables that represented each school's quality of teaching and instruction: learning-hindering behaviors, student to teacher ratio, proportion of fully certified teachers, and shortage of staff and educational resources.

At the country level, we controlled for variables that had strong theoretical overlaps with educational mobility. The first was each country's Gini coefficient—an index of economic inequality that has been shown to correlate negatively with mobility indices (37). The second was a global index of social mobility (SMI) from the World Economic Forum, which incorporates an extensive line of social indicators ranging from the availability and access to high-quality health care, education, and technology to work opportunities, fair wages, and social protections (23). However, as the SMI did not include any direct measure of educational mobility, it would act as the ideal adversary in our analyses by encompassing all other mobility-relevant aspects. We also controlled for educational expenditure, which measures each country's per capita

investment into secondary education, and the gross domestic product per capita. Together, a total of 13 covariates were included. More details about the covariates are provided in *SI Appendix, section 1C*.

The covariates explained 9.4 to 11.3% of the variance in MSR scores. Specific effects were largely consistent with past findings. Grit, self-efficacy, and SES positively predicted performance. Males obtained better performances in math and science and a worse performance in reading. At the school level, a shortage on educational and staff resources and a school's inability to maintain a conducive and disciplined environment negatively predicted performance. On the other hand, a higher proportion of fully certified teachers and, surprisingly, a greater student to teacher ratio were positively associated with performance. At the country level, only SMI emerged as a significant predictor for science performance, with countries higher on SMI exhibiting better performance.

Main test. Over and above this extensive range of highly potent covariates, growth mindsets, educational mobility, and their interaction explained an additional 3.2 to 5.0% of the variance in MSR scores. To start with, true to past findings, student-level growth mindsets had positive main effects on MSR performance ($b = 8.73$, $SE = 0.98$, and $\beta = 0.08$ for math; $b = 11.22$, $SE = 1.14$, $\beta = 0.10$ for science; and $b = 12.41$, $SE = 1.25$, and $\beta = 0.11$ for reading; all P s < 0.001; Table 1, Model B).

More importantly, these effects were qualified by the predicted interactions between student-level mindsets and country-level educational mobility ($b = 0.23$, $SE = 0.09$, $\beta = 0.02$, and $P = 0.01$ for math; $b = 0.31$, $SE = 0.11$, $\beta = 0.03$, and $P = 0.005$ for science; and $b = 0.31$, $SE = 0.11$, $\beta = 0.03$, and $P = 0.006$ for reading; Table 1, Model B), with educational mobility accounting for 19.8 to 21.9% of the variance in the mindset coefficients across countries. The nature of the interaction was such that lower educational mobility was associated with weaker effects of growth mindsets on performance (Fig. 1). Growth mindsets predicted performance stronger among high-mobility countries (+1 SD above mean; $b = 11.18$, $SE = 1.50$, and $\beta = 0.10$ for math; $b = 14.56$, $SE = 1.92$, and $\beta = 0.13$ for science; $b = 15.78$, $SE = 2.02$, and $\beta = 0.14$ for reading; all P s < 0.001) than among low-mobility countries (−1 SD below mean; $b = 6.27$, $SE = 1.22$, and $\beta = 0.06$ for math; $b = 7.89$, $SE = 1.34$, and $\beta = 0.07$ for science; and $b = 9.04$, $SE = 1.44$, and $\beta = 0.08$ for reading; all P s < 0.001). Thus, depending on the subject, the gain in predicted performance from a 1-unit increase in growth mindsets was reduced by 42 to 45% from a high-mobility to a low-mobility country.

Further tests of robustness. There is a distinct possibility that the moderating power of educational mobility is derived from its relationship with Gini or SMI. To test this, we expanded our model with Gini and SMI, respectively, as an additional moderator alongside educational mobility in separate analyses. The mindsets × educational mobility interaction remained virtually unchanged in the new models. Furthermore, neither Gini nor SMI emerged as a significant moderator on any subject (Table 1, Models C and D; full model estimates are shown in *SI Appendix, Tables S4 and S5*).

Supplemental analyses. Based on the well-established link between SES and academic performance (5, 38), which we also replicated here (Table 1), we considered students from high- and low-SES backgrounds as advantaged and disadvantaged learners, respectively. Supplemental analyses showed that 1) the benefits of growth mindsets were evident for both advantaged and disadvantaged students, especially in high-mobility countries, and 2) reduced educational mobility is associated with reduced benefits for both groups of learners (Fig. 2). A descriptive analysis also found that the reduced effectiveness of growth mindsets was associated with a reduced potential for mindsets to narrow the SES gap in performance (39). The detailed results are presented in *SI Appendix, section 1D*.

Table 1. Results from linear mixed-effects regression models: Cross-level interactions (student-level growth mindset × educational mobility)

Variable	Math			Science			Reading		
	<i>b</i>	SE <i>b</i>	β	<i>b</i>	SE <i>b</i>	β	<i>b</i>	SE <i>b</i>	β
Model A, without covariates									
Student-level variables									
GM L1	10.21***	1.03	0.09	12.57***	1.18	0.12	14.13***	1.30	0.12
School-level variables									
GM L2	65.90***	7.37	0.20	71.48***	6.95	0.21	84.59***	6.51	0.25
Country-level variables									
GM L3	-24.35	27.49	-0.05	-5.66	24.90	-0.01	9.96	24.19	0.02
Educational mobility	0.83	0.46	0.10	0.90	0.46	0.10	0.96*	0.45	0.10
Cross-level interaction									
GM L1 × educational mobility	0.32***	0.10	0.03	0.40***	0.12	0.04	0.39***	0.12	0.04
Intercept	495.94	4.47		495.85	3.97		494.65	3.69	
Model B, with covariates									
Student-level variables									
GM L1	8.73***	0.98	0.08	11.22***	1.14	0.10	12.41***	1.25	0.11
Grit	5.48***	0.68	0.06	5.98***	0.79	0.06	7.66***	0.96	0.08
Self-efficacy	2.50***	0.70	0.03	1.49*	0.74	0.02	1.00	0.80	0.01
Age	11.98***	1.74	0.04	11.00***	1.27	0.03	10.35***	1.31	0.03
Male	12.29***	1.07	0.07	5.65***	1.24	0.03	-20.96***	1.54	-0.11
Socioeconomic status	19.04***	1.66	0.20	18.25***	1.50	0.19	17.35***	1.64	0.16
School-level variables									
GM L2	52.15***	6.90	0.16	56.59***	6.60	0.17	68.16***	6.67	0.20
Student-teacher ratio	0.78***	0.23	0.05	0.73***	0.23	0.04	0.88**	0.29	0.05
Shortage of school resources	-3.37***	0.72	-0.03	-2.96***	0.82	-0.03	-3.53***	1.10	-0.03
Proportion of teachers qualified	5.90*	2.48	0.02	6.56**	2.47	0.02	7.90**	2.58	0.02
Learning-hindering behaviors	-10.08***	1.00	-0.10	-9.60***	1.10	-0.09	-10.43***	1.21	-0.09
Country-level variables									
GM L3	-28.99	36.22	-0.06	-13.05	29.09	-0.02	6.17	33.94	0.01
Educational mobility	0.40	0.30	0.05	0.32	0.26	0.04	0.38	0.23	0.04
SMI	2.08	1.32	0.17	2.63*	1.07	0.21	1.28	1.17	0.10
Gini index	0.17	1.80	0.01	1.42	1.16	0.08	0.63	1.15	0.03
GDP per capita	-0.03	0.32	-0.01	-0.13	0.28	-0.03	0.24	0.30	0.05
Educational expenditure	0.95	1.40	0.03	0.57	1.13	0.02	0.95	1.16	0.03
Cross-level interaction									
GM L1 × educational mobility	0.23*	0.09	0.02	0.31**	0.11	0.03	0.31**	0.11	0.03
Intercept	497.98	3.55		499.31	3.09		498.26	3.03	
Model C, SMI added as moderator									
Cross-level interactions									
GM L1 × SMI	0.08	0.12	0.01	0.15	0.12	0.01	0.11	0.14	0.01
GM L1 × educational mobility	0.22*	0.09	0.02	0.29**	0.11	0.03	0.29**	0.11	0.03
Model D, Gini added as moderator									
Cross-level interactions									
GM L1 × Gini index	0.14	0.20	0.01	0.15	0.20	0.01	0.21	0.22	0.01
GM L1 × educational mobility	0.22*	0.10	0.02	0.30*	0.12	0.03	0.29*	0.12	0.03

Values are unstandardized (*b*) and standardized coefficients with SEs. GM, growth mindset; L1, 2, and 3 differentiates student, school, and country level of measurement. GDP, gross domestic product. * $P < 0.05$, ** $P < 0.01$, and *** $P < 0.001$.

Study 2: Experiment. Study 2 aimed to 1) provide causal evidence of the moderating role of perceived educational mobility and 2) extend the effect of mobility × mindsets interaction to actual learning behavior (engagement in practice), which was predicted to have downstream consequences on performance. Finding support for our hypothesis in a highly controlled setting would testify to the viability of our proposed psychological mechanism. **Analytical approach.** When testing for moderation effects, we treated the experimental conditions as one factor with four levels: high mobility lower track, high mobility upper track, low mobility lower track, and low mobility upper track. Three orthogonal

contrasts were created to represent our theoretical interests while protecting against inflated type 1 error. The first contrast (0.5, 0.5, -0.5, and -0.5) compared the high-mobility conditions with the low-mobility conditions, constituting our primary confirmatory test. The second contrast (1, -1, 0, and 0) compared the lower track with the upper track in the high-mobility environment, exploring whether high mobility benefited the advantaged and disadvantaged learners differentially. The third contrast (0, 0, 1, and -1) explored any difference between the advantaged and disadvantaged students in the low-mobility environment.

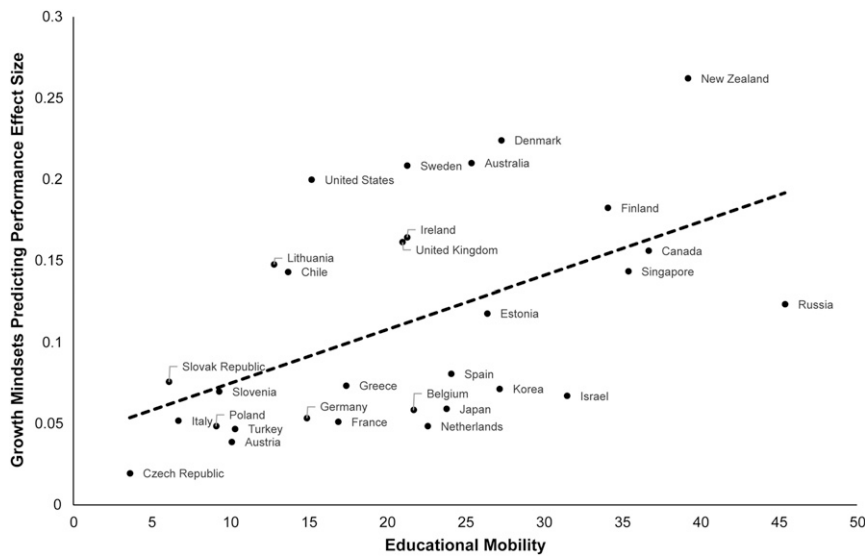


Fig. 1. Linear trend line between educational mobility and the effect of growth mindsets (in standardized betas) on academic performance across 30 countries (Study 1). Effect sizes shown have been composited across math, science, and reading performance. Individual data points represent each country's mindsets to performance effect size, while the dashed line shows the overall linear trend. The higher a country's educational mobility is, the stronger the relationship between growth mindsets and performance.

To demonstrate the unique effect of mindsets, grit and self-esteem were entered as covariates in all analyses. The results remained unchanged when covariates were removed (*SI Appendix, section 2B* for correlations among variables).

Learning behavior. Total practice time and the number of practice trials attempted ($r = 0.91$) were standardized and averaged to create the index of practice engagement.

Growth mindsets positively predicted practice engagement only in the high-mobility lower-track condition ($b = 0.36$, 95% CI = 0.22 to 0.50, SE = 0.07, $\beta = 0.31$, $t[733] = 4.96$, and $P < 0.0001$). A one-unit increase in growth mindsets corresponded to 135 s more in practice time (mean = 458 s) or 13.9 more trials attempted (mean = 53.3). Growth mindsets had no effect on practice engagement in any other conditions ($t_s < 1$) (Fig. 3).

The effects in the high-mobility lower-track condition thus underlay the significant mindsets \times condition (first contrast) interaction ($b = 0.27$, 95% CI = 0.11 to 0.43, SE = 0.08, $\beta = 0.23$, $t[733] = 3.27$, and $P = 0.0011$) and the significant mindsets \times condition (second contrast) interaction ($b = 0.15$, 95% CI = 0.05 to 0.26, SE = 0.05, $\beta = 0.13$, $t[733] = 2.81$, $P = 0.0052$).

In sum, growth mindsets positively predicted learning behavior in the high- but not low-mobility environment; this effect was primarily driven by the disadvantaged learners (*SI Appendix, Tables S10 and S11* show the full results).

Downward consequence of practice engagement. A moderated mediation model (Fig. 4) was conducted. The target mediation pathway (mindsets \rightarrow practice engagement \rightarrow completion time) was significant only in the high-mobility lower-track condition

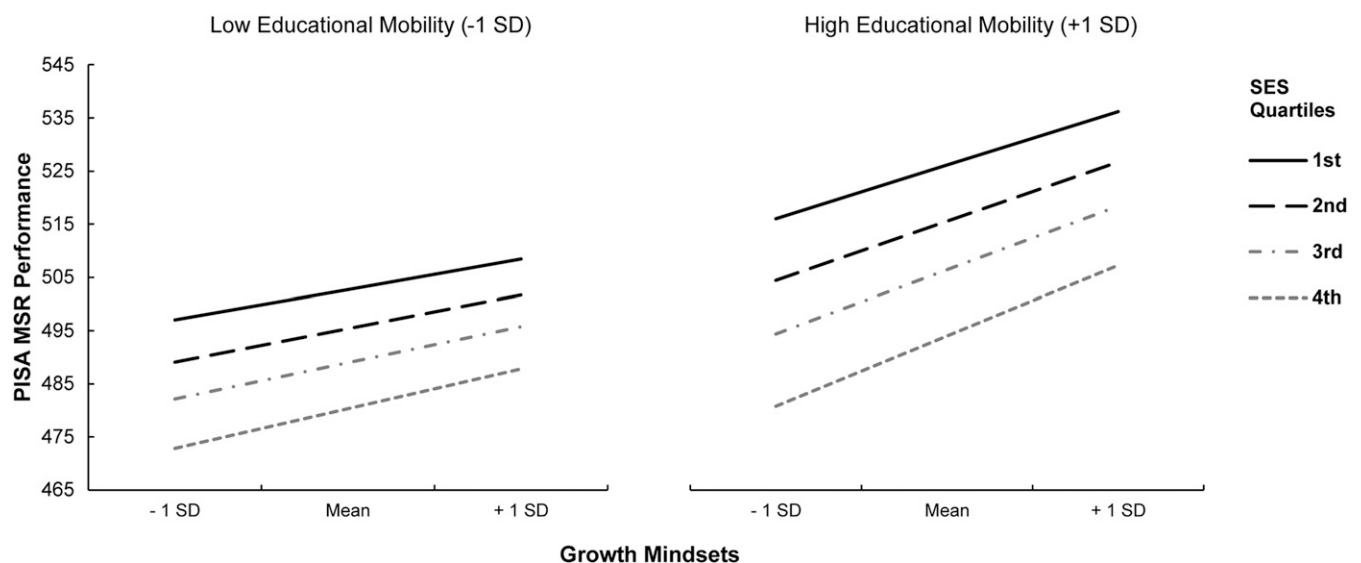


Fig. 2. Graphical pattern depicting the relationship between growth mindsets, educational mobility, and SES (as quartiles) in predicting PISA performance across math, science, and reading literacy scores (Study 1). The left and right panels, respectively, correspond to low mobility and high mobility. Black lines represent the top half of the SES spectrum, while gray lines represent the lower half. *SI Appendix, Fig. S1* shows the same graph with SES in deciles.

($b = -15.05$, 95% CI = -22.09 to -8.59 , $\beta = -0.08$, and bootstrap SE = 3.42).

Indeed, the indices of moderated mediation for condition (first contrast) ($b = -11.37$, 95% CI = -18.54 to -4.37 , $\beta = -0.06$, and bootstrap SE = 3.64) and for condition (second contrast) ($b = -6.38$, 95% CI = -11.04 to -2.00 , $\beta = -0.03$, and bootstrap SE = 2.33) were both significant (SI Appendix, Table S12 shows full results). That is, growth mindsets improved performance via practice only in the high- but not low-mobility environment; the effect was primarily driven by the disadvantaged learners.

Supplemental analysis. We did not make strong predictions about the total effect of mindsets on the final performance. The evaluative setting of the final performance, which was necessary for the paradigm, might have introduced too much noise (e.g., from performance anxiety) to the data for the brief practice sessions to overcome.

Nonetheless, supplemental analyses revealed unpredicted insights. In the high-mobility environment, the overall positive link between mindsets and performance (shorter time) was nonsignificant in the lower-track condition ($t < 1$) but significant in the upper-track condition ($b = -28.58$, 95% CI = -47.18 to -9.98 , $\beta = -0.16$, SE = 9.47, $t[732] = -3.02$, and $P = 0.0026$).

In the low-mobility environment, there was no effect of growth mindsets (both t s < 1). Instead, the initial advantage manipulation predominantly predicted performance. Participants in the lower track performed worse (longer completion time) than those in the upper track ($b = 18.28$, 95% CI = 4.62 to 31.94, $\beta = 0.12$, SE = 6.96, $t[732] = -2.63$, and $P = 0.0088$) (see SI Appendix, Tables S13 and S14 for full results).

Two conclusions can be drawn. In the high-mobility environment, our findings corroborated Study 1 that both disadvantaged and advantaged learners could benefit from growth mindsets, albeit through different mechanisms. While the disadvantaged learners benefited in terms of increased learning behavior, the advantaged learners seemed to have directly benefited in terms of performance. In the low-mobility environment, in which growth mindsets had no effect, the initial inequality, created by random assignment, perpetuated till the end of the study.

Discussion

Recent debates about the failure of the education system in upholding social mobility have focused on the implications for social justice and stability. One understudied perspective is that of the learners. Given the critical role of growth mindsets in learning, we ask how stunted upward mobility in a learning environment could interfere with individuals' use of these adaptive mindsets to guide their learning and achievement.

Analyses of a large cross-national dataset and a longitudinal experiment accumulated converging evidence that growth mindsets become less potent in a low-mobility as opposed to a high-mobility environment. At the country level, while growth mindsets positively predicted secondary school students' academic performance, the effects were less pronounced in countries with low than those with high educational mobility. The fact that this moderating effect held true when educational resources, at both the school and the country levels, wealth of the country, and other social mobility indices were controlled for aligned with our conceptualization that educational mobility can directly impact learners' psychology.

Indeed, manipulating learners' perception of educational mobility alone replicated the moderating pattern in carefully constructed learning environments. In a high-mobility environment, growth mindsets positively predicted initially disadvantaged students' learning, which subsequently predicted their performance; mindsets also positively predicted initially advantaged students' final performance. Growth mindsets, however, had no effect in a low-mobility environment.

Both studies further suggested that, when the effect of growth mindsets was attenuated in a low-mobility environment, the potential for the disadvantaged to overcome the performance gap was also limited. Finally, growth mindsets boasted unique predictability over individuals' hard work, passion, and confidence in the self, testifying to the precision of our predictions.

Our findings press for the urgency to galvanize the upward mobility in the education system (7, 8). The mobility in American education, particularly with respect to college admission, has not been improving and is showing signs of regression (4–7). While measures to arrest the downward spiral are important for social justice and stability (2, 3), we suggest another benefit. A high-mobility education system is superior to a low-mobility one in allowing learners to benefit from growth mindsets; learners with strong growth mindsets showed the best achievement and learning outcomes in both our studies. In other words, leaving the education system in the current level of diminished mobility not only jeopardizes the chances for the less privileged to achieve economic success but also hinders their potential for personal development.

The present investigation also has important implications for educational interventions. First, a high-mobility environment may be more conducive for growth mindset interventions. If so, the currently observed effect sizes of mindset interventions in the United States may not reflect the full potential of such endeavors. After all, the United States is ranked 20th in educational mobility among the 30 democracies studied here. Admittedly, the observed effect of mindsets in the United States is higher than predicted in

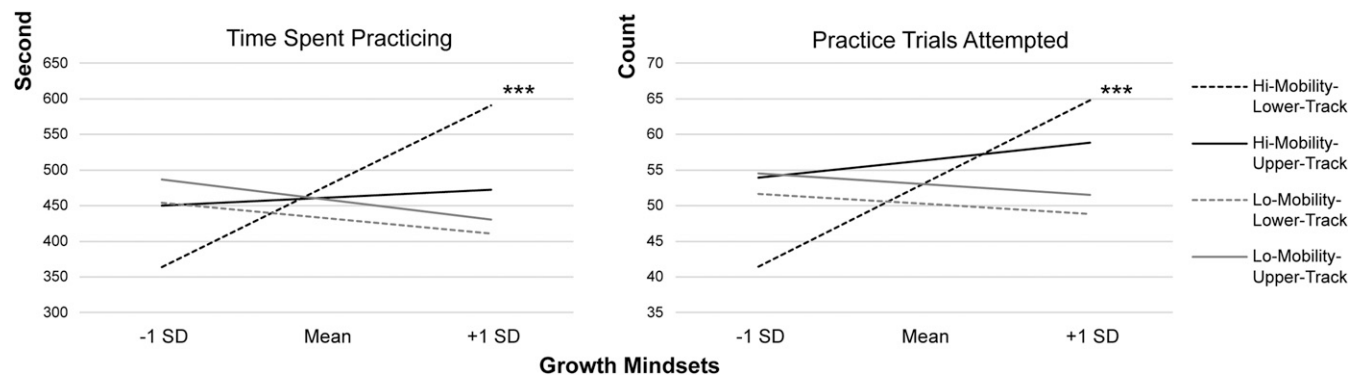


Fig. 3. Practice with growth mindsets by experimental conditions (Study 2). The left panel shows the total time spent on practice, and the right panel shows the total number of practice trials attempted. Black lines represent high-mobility environments, and gray lines represent low-mobility environments. Dashed lines represent lower-track conditions, and solid lines represent upper-track conditions. The main analysis was conducted on the computed average of the standardized values of total time and trials attempted. Analyses on the two separate indices yielded the same pattern of results. *** $P < 0.001$.

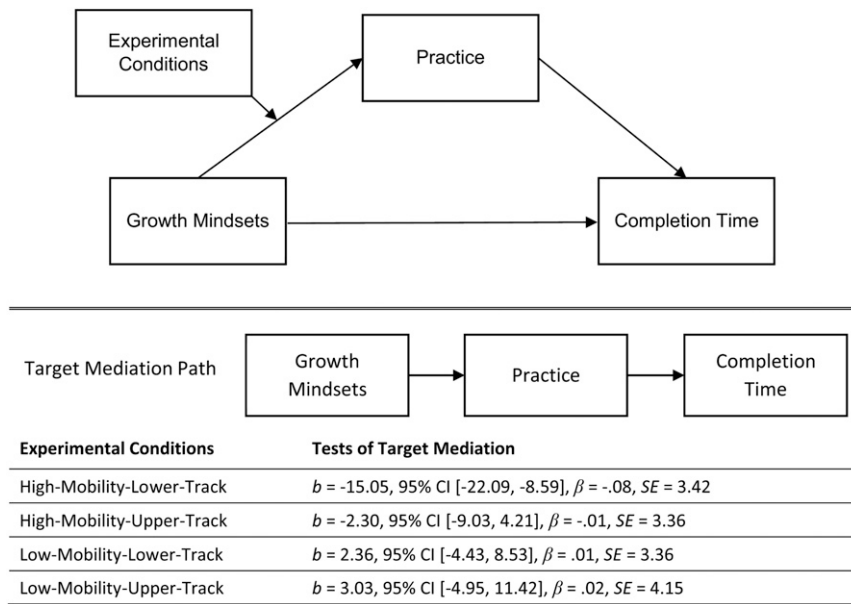


Fig. 4. The moderated mediation analysis (Study 2). (Top) The moderated mediation model. (Bottom) The target mediation path tested in each of the experimental conditions. Performance was measured by completion time, with shorter time representing better performance. Significant pathways are represented with CIs that exclude 0.

our analysis, suggesting that additional factors in the United States, such as a distinctively high belief in meritocracy (40), might have contributed to this pleasant surprise. Nonetheless, our prediction model implies that even larger intervention effects could be observed when the educational mobility in the United States is improved.

In fact, a virtuous cycle involving mobility, mindset intervention, and achievement in education can be conceived. To begin with, a high-mobility environment enhances the potency of mindset interventions. As mindset interventions have been shown to benefit the disadvantaged students more, an immediate outcome would be a narrowing of racial and socioeconomic achievement gaps (17, 41). In other words, mindset interventions actually increase the mobility in the education system, which would amplify the potency of future interventions. This dynamic cycle 1) anticipates the long-term effectiveness of mindset interventions and, more importantly, 2) may also apply to interventions that are aimed at enriching the learning environment (42) or removing biases in standardized tests (43) for the disadvantaged. Increasing upward mobility in the education system may, thus, pay dividends in accelerating virtuous cycles involving educational interventions.

Finally, our work underscores the utility of a psychological approach in examining social mobility—a key health indicator of modern democracies. According to our results, not all conceptions of mobility are interchangeable and have similar psychological effects. Although educational mobility is an important component of a broader conception of social mobility, we find that learners respond mostly to the former rather than the latter (e.g., Gini index and SMI). This demarcation between the learning and societal contexts is not surprising considering adults’ effort to shield secondary school students from worldly concerns. To these young learners, disadvantaged individuals’ academic achievement (i.e., getting a college degree) is psychologically more relevant; their eventual economic and career success is less so. The situation may change, however, once students enter tertiary education. In college, class differences directly impact the culture of learning (44); here, educational mobility and social mobility may begin to overlap and influence students in a similar fashion. Conceptualizing social mobility in a way that is context specific and psychologically meaningful to the target population can, thus, enhance

the precision of our predictions and the effectiveness of our interventions to support the disadvantaged in the society.

Limitations and Future Directions. The present work resonates with the recent call to identify conducive contexts for growth mindsets (22). While past work examines contextual factors that directly support active learning behavior (e.g., student norms [19]), we identify a system-level factor of the learning environment, suggesting another avenue for future investigations. Our investigation is, however, largely limited to Western, educated, industrialized, rich, and democratic populations (45), with a few exceptions from non-Western democracies (e.g., Japan, Korea, and Singapore). On the one hand, this may prove useful for our initial demonstration of the phenomenon, for it lowered the risk that the effect of educational mobility was due to major cross-county differences in political and educational structures. On the other hand, future work on countries with fewer educational resources would greatly enrich our understanding of the synergy between educational mobility and adaptive mindsets.

Next, while we both measured and manipulated educational mobility, we only measured growth mindsets in our studies. This leaves open the question of whether educational mobility had primarily moderated the effect of a third variable, with which growth mindsets were correlated. Even though we controlled for the effects of highly relevant factors (grit, self-efficacy, and self-esteem), which has somewhat mitigated this concern, future experiments that manipulate both mindsets and educational mobility are needed to affirm that the causal effect of mindsets is moderated by educational mobility.

Intriguing differences were observed between advantaged and disadvantaged learners in our experiment. In the high-mobility environment, the disadvantaged, and not advantaged, learners benefited from growth mindsets in terms of learning behavior, which subsequently impacted performance. The advantaged learners, however, somehow directly benefited from growth mindsets in their final performance. While we offer no immediate explanations, this result aligns with recent findings that a growth mindset intervention impacted high- and low-achieving students in different ways (19). Together, they might partially contribute to our cross-national finding that both advantaged and disadvantaged students’

achievement benefit from growth mindsets. Studying the divergent effects of mindsets thus represents a key direction for future research.

In our framework, educational mobility is conceptualized as a psychological affordance for growth mindsets, but can it directly affect learners' endorsement of mindset beliefs? Since low educational mobility reflects the reality that disadvantaged learners are "shackled" to poor performance by relevant obstacles, it is plausible that it would discredit and discourage peoples endorsement of the core beliefs of growth mindsets—one's abilities and talents can be developed. We found no evidence for this proposition. Supplemental analysis on Study 1 found no reliable evidence that educational mobility predicted growth mindsets. Similarly, a pilot study found no evidence that the manipulations in Study 2 affected growth mindsets (detailed results reported in *SI Appendix, section 4*). Nonetheless, the absence of evidence is not evidence of absence, and future work is encouraged to explore if educational mobility serves as an antecedent to growth mindsets, especially in the long run.

Finally, it is essential to recognize that not all indicators of educational inequality may moderate the use of growth mindsets. Scholars have invoked a wide range of constructs and operationalizations to capture mobility and inequality in the education system. From the sociological perspective, our investigation corresponded to a case of intergenerational mobility (Study 1; ref. 30) and a case of intragenerational mobility (Study 2; ref. 46), respectively. By showing that the two operationalizations had similar effects, our results implicate the broad relevance of the present conceptualization. Closer scrutiny, however, suggests that it is premature to assume that our predictions would generalize to all other relevant constructs. For example, the educational mobility manipulation in Study 2 is akin to an instance of tracking: a practice that groups students in different courses of study. While past research highlights how tracking exacerbates inequality (47), our results suggest that not all structures of tracking signal low educational mobility; when low-achievement students still had respectable chances to succeed, the tracking system signaled high mobility and encouraged the use of adaptive mindsets. This echoes recent emphasis on the heterogeneity in conceptualizing tracking, which actually found positive outcomes of certain forms of tracking (48). Not all constructs related to learners' mobility are thus created equal. We believe that only operationalizations that directly reflect disadvantaged learners' upward mobility and, more proximally, make salient the role of active learning in academic achievement can encourage learners to apply the adaptive growth mindsets. Therefore, considering psychological processes present new opportunities to understand students' inequality and mobility in the educational system.

Materials and Methods

Study 1.

Participants. This study uses data from PISA 2018, a triennial assessment conducted by OECD (49), which evaluates the MSR literacy of 15-y-old students globally (*SI Appendix, section 1A* for more details). Surveys were administered to each student and each school. Growth mindsets and educational mobility are available in data from 30 countries ($n = 235,141$), which form the basis for our tests without covariates. Tests with covariates excluded four countries due to missing data on student- or school-level covariates ($n = 160,257$). The pattern of results was nearly identical whether 26 or 30 countries were included in the model without covariates (*SI Appendix, section 1D*). Across all tests on reading performance, the data for Spain were not available.

Key measures. Each student responded to a single item, "Your intelligence is something about you that you can't change very much," adapted from Dweck's original scale (50). This item was scored in our analyses such that higher scores meant greater endorsement of growth mindsets. The educational mobility index was obtained from OECD's "Equity in Education" report (30). It measures the proportion of individuals from low-education households who eventually went on to complete tertiary education. Low-education households were defined as having parents who did not complete

upper secondary education. A more detailed breakdown of the population and list of measures can be found in *SI Appendix, sections 1B and 1C*.

Study 2.

Participants and design. Participants were 744 students (mean age = 21.3 y, 68.8% females) from a large university in Singapore, which is a country included in PISA 2018. The sample size exceeded the minimum target determined by a conservative power analysis (*SI Appendix, section 2A*). The National University of Singapore Institutional Review Board approved all procedures (nus-derc-2019-711), and participants granted informed consent at the beginning of the first laboratory session.

The perceived mobility manipulation (high versus low) was fully crossed with the initial advantage manipulation (upper track versus lower track). Participants were randomly assigned to one of the four conditions.

Procedure and materials. The procedure had four sessions, with the first and fourth sessions conducted in the laboratory and the second and third sessions conducted online. Research assistants, who were unaware of the experimental hypotheses or the conditions participants were in, coordinated with each participant and ensured a 3- to 5-d interval between consecutive sessions. Hence, each participant completed the procedure in 2 to 3 wk.

At the beginning of the first session, participants completed trait measures of growth mindsets (50), the two components of grit, perseverance of effort and consistency of interests (51), self-esteem (52), and demographics (see *SI Appendix, section 2B* for details).

Cover story. From participants' perspectives, they enrolled in a pilot program evaluating their "change perceptiveness," a purported newly identified aspect of intelligence that predicts various positive life outcomes. Those who excelled at the end of the program would qualify for well-paid follow-up experiments and attractive internships.

They would complete an initial assessment in the first session. Based on their performance, participants were told they would be allocated to one of two tracks: Track A or Track B, thereby referred to as the upper track and the lower track, respectively. In reality, they were given false performance feedback and allocated to the two tracks by random assignment.

This preliminary banding supposedly informed them of their likelihood to qualify in the fourth session during the final assessment. Participants in the high-mobility condition were informed that, based on past data, the upper and the lower track had around 90% and 30% chance to qualify, respectively. In the low-mobility condition, the corresponding chances were 99% and 3%, respectively (*SI Appendix, section 2C*).

Tests of change perceptiveness. We adopted a change blindness paradigm as the instrument to ostensibly assess "change perceptiveness" (53). In each trial, two near-identical images of a scene alternated quickly on the computer screen (240 ms) separated by a blank interval (80 ms), with one image containing an object that was missing in the other. Participants were given up to 60 s to spot and click on the object as quickly as possible.

The initial assessment (first session) and the final assessment (fourth session) contained 40 trials each. The two practice sessions (second and third) contained a maximum of 50 trials each. No two trials were identical. Images were taken from an established change blindness database (*SI Appendix, section 2C*).

For the two assessments, the total amount of time spent to complete all trials was computed, with the response times of incorrect trials replaced with the maximum response time of 60 s. Hence, shorter total times corresponded to better performance.

For the two practice sessions, participants received online links at their time of convenience and were free to practice as much or as little as they desired; they could skip any trial before the 60-s time limit was up, even if they could not identify the difference, and they could end the entire practice at any time. Hence, a greater total time spent and a larger number of trials attempted represented greater engagement in learning.

A total of 630 participants completed all four sessions (15.3% cumulative dropout), with no evidence of different dropout rates across the conditions. In our setting, however, not participating partly indicated disengagement from the learning environment and should not be excluded as missing responses. Consistent with the intent-to-treat principle, we replaced missing practices with zero seconds and zero trials attempted and missing final assessments with participants' completion time in the initial assessment plus a penalty (+1 SE) to represent disengaged performance. Analyses on participants with completed responses yielded the same results (*SI Appendix, section 2D*).

Pilot Studies. In two separate pilots, participants rated that active learning was more instrumental to improving their academic outcomes in high-mobility than low-mobility environments, as operationalized in Study 1 ($t[118] = 7.32$,

$P < 0.001$, $d = 1.34$) and as operationalized in Study 2 ($t[123] = 2.11$, $P = 0.036$, $d = 0.38$) (see *SI Appendix, sections 3A and 3B* for detailed methods and results). Hence, the different operationalizations of educational mobility in the two studies affected learners' perception in the same way as we had theorized.

Data Availability. Study 1 includes the comma-separated values (CSV) participant data files as well as the Mplus syntax and output files of our analyses. Study 2 includes the CSV/Statistical Package for the Social Sciences (SPSS) participant data file as well as the SPSS syntax and output files of our analyses.

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