



# Society-level social axiom moderates the association between growth mindset and achievement across cultures

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**Background.** Meta-analytic studies show that the benefits of the growth mindset on academic achievement are heterogeneous. Past studies have explored how individual characteristics and proximal environmental factors could explain these variations, but the role of the broader sociocultural environment has seldom been explored.

**Aims.** We investigated society-level social axioms to explain variations in growth mindset effects on achievement across cultures. We hypothesized that three society-level social axioms (social complexity, fate control, and reward for application) imply social norms that would either support or obstruct the growth mindset effect.

**Sample and methods.** We conducted multilevel SEM with random slopes using data from 273,074 students nested within 39 countries/territories.

**Results.** We found *weaker* growth mindset effects in societies with *stronger* social complexity beliefs; societies believing that there are multiple solutions to problems have social norms that obstruct the growth mindset effects on achievement. No moderating effects were found with other social axioms.

**Conclusion.** Relevant cultural-level normative beliefs should be considered to better assess the relevance of the growth mindset construct.

The implicit theory that intelligence can be changed with effort, referred to as the incremental theory or the growth mindset (Dweck, 2007), continues to attract adherents even as meta-analysis of relevant research suggests that its relationship with achievement is small and heterogeneous (Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). As the theoretical and empirical foundations of growth mindset theory continue to be debated, researchers have focused on the socio-demographic, psychological, and proximal environmental factors that moderate the growth mindset effect on achievement. However, the role of the broader socio-cultural environment in moderating the growth mindset effect has not been well-explored. A meta-analytic investigation (Costa & Faria, 2018) indicated that culture might be an important moderator of the growth mindset effect, but the study did not identify the specific cultural factors that might explain the disparities in the growth mindset effect. In this study, we explore a specific cultural

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moderator, society-level social axioms, by analysing secondary data on growth mindset, social axioms, and achievement from 39 countries/territories.

### **Growth mindset and social moderators**

The growth mindset construct emerged from research on people's implicit theories about whether important human qualities (e.g., intelligence) are changeable or fixed (Dweck, Chiu, & Hong, 1995). Two implicit theories were defined: entity theory (or fixed mindset) assumes that intelligence is unchanging even with effort, and incremental theory assumes that intelligence can be increased with effort and persistence. Implicit theories research suggested that students who had a growth mindset attained higher academic achievement (Blackwell, Trzesniewski, & Dweck, 2007; Romero, Master, Paunesku, Dweck, & Gross, 2014) as the mindset has a network of allied motivations, attributions, emotions, and behaviours that sustain students through the learning process. However, recent meta-analyses and reviews (Burgoyne, Hambrick, & Macnamara, 2020; Sisk et al., 2018) concluded that there was a high degree of heterogeneity in the effects of growth mindset on academic achievement, and also weak overall growth mindset effects. While there are studies that show positive associations between holding a growth mindset and students' achievement (Blackwell et al., 2007; Cury, Elliot, Da Fonseca, & Moller, 2006), there are other studies that find no positive association (Furnham, Chamorro-Premuzic, & McDougall, 2003; Kornilova, Kornilov, & Chumakova, 2009; Rheinschmidt & Mendoza-Denton, 2014). There are even a few studies that found a *negative* relationship between growth mindset and students' achievement in school (Corradi, Nicolai, & Levrau, 2019; Flanigan, Peteranetz, Shell, & Soh, 2015).

In this regard, the first aim of the study is to test the basic assumption that holding a growth mindset is positively associated with students' achievement. However, given the heterogeneity in growth mindset effects, researchers have shifted their enquiries into understanding under which conditions the growth mindset affects achievement. Meta-analytic investigations have found some demographic, psychological, and proximal environmental factors that could moderate the growth mindset effect. For example, the growth mindset intervention effects on student learning were moderated by SES (stronger effects on lower SES students; Sisk et al., 2018), school's level of achievement (stronger in low-achieving schools; Yeager et al., 2019), and whether the students' peers were also supportive of the growth mindset assumptions (Yeager et al., 2019). Less attention has been paid to the role of the broader socio-cultural environment. To our knowledge, only Costa and Faria (2018) examined culture as a potential moderator. However, their study did not identify the specific cultural factors that could account for these cross-cultural differences.

A tentative explanation for cultural differences in the growth mindset effect could relate to whether the societal norms and values related to achievement in schools provides a supportive context for the growth mindset and its allied motivations, emotions, and behaviours. This is consistent with previous research showing that growth mindset interventions have stronger benefits for students whose peers also hold beliefs consistent with the mindset (Sheffler & Cheung, 2020; Yeager et al., 2019). The implication is that social norms are needed to sustain the psychological processes associated with the growth mindset, and such norms may be more prevalent in some cultures compared to others. We propose that cultural differences in the strength of the growth mindset effect would be related to cultural-level factors that either support or obstruct the growth mindset and allied psychological processes.

### **Social axioms: Cultural moderators of growth mindset**

In this study, we propose that social axioms could moderate the growth mindset effect at the cultural level. Social axioms are generalized beliefs about the social world (Leung et al., 2002); they are distinct from values and personalities (Bond, Leung, Au, Tong, & Chemonges-Nielson, 2004; Chen, Fok, Bond, & Matsumoto, 2006) and are known to predict important psychological processes and outcomes. Five social axioms have been defined: (1) social cynicism represents a negative view of human nature and an expectation that negative outcomes are likely from other people, (2) social complexity refers to beliefs that behaviours and outcomes may vary across different situations and that there are usually multiple solutions to problems, (3) reward for application represents the belief that positive outcomes come from one's effort, (4) religiosity pertains to beliefs in the existence of supernatural beings and in positive outcomes associated with religious practices, and (5) fate control refers to the belief in the role of fatalistic forces in determining outcomes, but that people may take action to alter these outcomes.

Leung and Bond (2004) characterize the five social axioms as evolved responses to basic human requirements of survival and adaptation to the physical and social world, which they classify into three: detection of deception in the social domain, problem-solving domain, and searching for meaning domain. First, social cynicism is proposed to be an adaptive response to a social world fraught with deception and where gullibility makes one vulnerable to deceit, exploitation, oppression, and other threats to well-being. Thus, beliefs about whether the social world is full of treachery or is relatively benign shapes how an individual will cope with the social world. Three social axioms are proposed to be related to problem-solving in the social world. Leung and Bond (2004) identify three fundamental problem-solving issues, each of which is associated with the functionality of one social axioms. The first issue is whether problems are solvable or not. The degree to which one believes that problems are intractable and fated on the one hand or controllable on the other influences how decides to cope with the problem. Belief in fate control makes individuals attend to signals that foretell about the fates, avoid whatever negative signs there are, and enhance luck that could alter fated events. The second fundamental issue is whether one's personal efforts in problem-solving are likely to result in some resolution. The belief may derive from a sort of cost-benefit analysis of whether one's effort will be rewarded with the desired problem outcomes. Thus, belief in reward for application expresses a positive assessment of the controllability of outcomes based on one's work and persistence. The final issue relates to assessing whether solutions to problems can be dealt with a one-size-fits-all strategy or with a more contingent approach that requires taking into account personal and situational variations. The latter assessment reflects a belief in social complexity, which is likely to entail a pluralistic view of pathways to a problem goal and more flexible thinking regarding the problem solution. Finally, Leung and Bond (2004) propose that human beings have basic need to seek meaning that historically has been addressed by religious practices. They further note that religious practices and institutions also help provide social stability and psychological security that strengthen this sense of meaning, and endorsement of such ideas are expressed in the fifth social axiom of religiosity.

We propose that the three problem-solving related social axioms – fate control, reward for application, and social complexity – as most relevant to the growth mindset effect. Of the three, reward for application is likely to support the growth mindset effect. The belief that good outcomes result from one's own effort and perseverance aligns with the belief that one's intelligence can be improved with effort and persistence. Previous studies showed that reward for application was positively associated with achievement values

(Leung et al., 2007), intrinsic attitudes towards striving (Zhou, Leung, & Bond, 2009), and trying harder after failure (Singelis, Hubbard, Her, & An, 2003). Among students, reward for application was associated with higher academic aspirations (Leung, Chen, & Lam, 2010), perceived academic control, and behavioural intentions to study (David, 2012; Liem, Hidayat, & Soemarno, 2009).

In contrast, social complexity and fate control are not likely to align with the growth mindset as the knowledge and instrumentality functions of these beliefs seem to controvert the assumptions of the growth mindset. Consider social complexity, the belief that problems have multiple solutions might suggest that desired educational outcomes could be attained through a variety of approaches – not just one's effort and that the best approach might vary for each person. Previous studies have shown that social complexity is associated with active problem-solving in a manner that involves compromise (Bond et al., 2004), creativity (Leung et al., 2012), and flexible thinking (Nalipay, Bernardo, & Mordeno, 2016). Although these correlates of social complexity could help in students' efforts towards changing their intelligence, we believe that these correlates would focus a students' attention on a wider range of options beyond personal effort to attain educational outcomes. Moreover, a student who believes in social complexity might not even view success in school as the most important pathway to attain their goals in life as they are more likely to entertain multiple paths to perceived success.

Fate control should also undercut the growth mindset assumptions that underscore the role of fatalistic forces in determining outcomes. While fate control also involves the belief that one could take actions to alter fatalistic outcomes, at the core, the focus on unknown forces does not align with a growth mindset. In previous studies, fate control had no relationship with positive attitudes towards academic striving (Liem et al., 2009; Zhou et al., 2009), but was positively associated with avoiding thinking of difficulties (Bond et al., 2004). At the society-level, fate control was negatively associated with a positive work ethic (Leung & Bond, 2004).

It is at the society-level that we hypothesize social axioms would moderate the growth mindset effect. Consistent with findings that students benefit more from having a growth mindset when their peers hold growth mindset consistent beliefs (Sheffler & Cheung, 2020; Yeager et al., 2019), we hypothesize that society-level social axiom could provide social norms that may or may not support an individual students' growth mindset. In societies that are high in reward for application, students are likely to hear and see messages regarding how hard work and effort will pay off, and people in their family and in their school are also likely to refer to exemplars of how persons who have succeeded due to industriousness and persistence. Such normative beliefs are likely to support individual students who believe in the growth mindset and their strivings to improve themselves. On the other hand, in societies that are high in social complexity, students are likely to frequently encounter expressions of the need to be flexible as there are many different ways of achieving goals in society, and they are also likely to see how different people succeed in life by going through different paths. While students in societies that are high in fate control are likely to grow up with ideas of how unseen forces determine future outcomes and also observe practices that try to avoid being in the path of negative forces. Students in societies where fate control and social complexity are social norms are likely to find social support for varied forms of goal-directed approaches different from the application of effort to improve oneself; students who hold the growth mindset in such societies are not likely to get support for this belief.

### **The current study**

Research on the growth mindset effect has recently given attention to recognizing and understanding the conditions where the growth mindset effect on achievement is observed. Aligned with the focus, we investigate society-level social axioms as moderators of the growth mindset effect across cultures. We assume that society-level social axioms indicate normative beliefs that may or may not support the growth mindset assumptions as discussed in the preceding section, and thus moderate the expected benefits on achievement. But before exploring these moderators, we also test whether there will be a positive relationship between the students' growth mindset and their achievement in three subject areas—reading, mathematics, and science. We study these propositions using secondary data on students' growth mindset and achievement and on society-level social axioms from 39 countries/territories. We posit several hypotheses, and the first is based on the results of various meta-analytic studies (Costa & Faria, 2018; Sisk et al., 2018) suggesting small but positive relationships between holding a growth mindset and school achievement:

*H1.* Growth mindset is positively associated with achievement in reading, mathematics, and science.

Our other hypotheses refer to the moderating role of country-level social axioms on this positive relationship in H1:

*H2.* The growth mindset effect varies across countries/territories; the variation of growth mindset effects on achievement across countries/territories is associated with society-level social axiom;

H2.1: Reward for application is associated with stronger growth mindset effects;

H2.2: Social complexity is associated with weaker growth mindset effects; and

H2.3: Fate control is associated with weaker growth mindset effects.

In testing these hypotheses, we control for student sex and socioeconomic status (SES) at the individual level, given the sex-related and SES-related gaps in learning achievement tracked by PISA (OECD, 2019) and other researchers (e.g., Autor, Figlio, Karbownik, Roth, & Wasserman, 2019; Brenøe & Lundberg, 2018; Howard et al., 2011; Parker, Marsh, Jerrim, Guo, & Dicke, 2018). Although PISA 2018 results suggest a narrowing of gender gaps in learning achievement in reading, mathematics, and science, there are still statistically significant and consistent differences. The differences are generally small in mathematics and sciences, with boys typically scoring higher than girls; the gap is reversed in reading, girls score higher than boys with a larger margin (Stoet & Geary, 2013). The learning gaps associated with students' SES are more notable, and the gaps associated with differences in students' SES do not seem to be affected by the country/territory's level of spending on education (OECD, 2019).

## **Method**

### **Data**

We used OECD PISA 2018 data, specifically the student questionnaire data (<https://www.oecd.org/pisa/data/2018database/>), but only data from 39 countries/territories where there were available country/territory-level social axioms data. We analysed data from 273,074 students (51% girls, mean age = 15.79,  $SD = 0.29$ ).

## Measures

### Growth mindset

In PISA 2018, growth mindset was measured using a four-point item (1 = *Strongly Disagree*, 4 = *Strongly Agree*) asking students to endorse their agreement on the statement ‘Your intelligence is something about you that you can’t change very much’. This item was adopted from the Implicit Theories of Intelligence Scale (Dweck et al., 1995) that included three items congruent with the entity theory or fixed mindset and that used a six-point response option. The item reflected a fixed mindset because in their original theory (Dweck & Leggett, 1988) proposed that items congruent with the incremental theory or growth mindset were more desirable and could lead a drift in responses towards the growth mindset. Consistent with the interpretation of the scores in the original scale, the response was reversed so that a higher score indicated a growth mindset. The mean of the reversed response was 2.63 ( $SD = 0.91$ ). Although the PISA 2008 report (OECD, 2019) classified students as either holding a growth mindset or not, we treated this score as a continuous variable to examine its relationship with achievement for purposes of testing our hypotheses.

We note that although single-item measures are not ideal as they do not yield internal consistency estimates, past studies have used similar single-item measures using the same four-point response option and have also treated the scores as a continuous variable (Hwang, Reyes, & Eccles, 2019; Ingels et al., 2007; Nix, Perez-Felkner, & Thomas, 2015; Perez-Felkner, McDonald, Schneider, & Grogan, 2012).

### Social axioms

Social axiom scores at the country/territory level were obtained from published sources (mainly from Leung & Bond, 2004, additionally from Bernardo & Nalipay, 2016; Bou Malham & Saucier, 2014). The mean values across countries/territories for the five social axioms are as follows: Social Cynicism ( $M = 2.97$ ,  $SD = 0.24$ ), Reward for Application ( $M = 3.71$ ,  $SD = 0.25$ ), Fate Control ( $M = 2.68$ ,  $SD = 0.25$ ), Social Complexity ( $M = 3.99$ ,  $SD = 0.21$ ) and Religiosity ( $M = 3.14$ ,  $SD = 0.38$ ). These values were imported into the PISA 2018 data.

### Achievement

The measure of achievement used refer to the proficiency scores in the three cognitive domains in PISA 2018: reading, mathematics, and science. PISA 2018 does not provide actual student achievement scores; instead, it provides 10 plausible values for each domain, with each plausible value representing a random value drawn from the posterior distribution of a student’s scores. PISA plausible values are considered to enhance accuracy by using item response theory to control for measurement error and using regression modelling to control for errors due to contextual factors (OECD, 2020). To obtain unbiased estimates, the same model had to be run ten times with each of the plausible values and compute for the unbiased estimates based on these sets of estimates. However, the results generated from the different plausible values are nearly identical such that we only report the first plausible value for the sake of simplicity and as set by prior precedent (Spiezia, 2010). The means of the plausible values were 474.47 ( $SD = 109.60$ ) for reading, 479.26 ( $SD = 106.52$ ) for mathematics, and 480.63 ( $SD = 103.92$ ) for science.

### *Covariates*

At the student level, we included two covariates: sex (girls coded as 1, boys as 2), and students' socioeconomic status. PISA 2018 represented students' SES using an index of economic, social, and cultural status (ESCS), which captured information regarding students' family background such as parents' education and occupation, home possessions indicating family wealth, and cultural resources like books, connection to the internet, and so forth (OECD, 2019). The mean of ESCS for our data was  $-0.32$  ( $SD = 1.14$ ).

### **Data analysis**

For the current study, PISA 2018 data with missing values on growth mindset, achievement in any of the three areas, or either covariate were dropped from the analysis. To explore the moderation of social axioms on the variation of the growth mindset effect on achievement, we conducted multilevel modelling with random slopes (MLM-RS) (Muthén, 1994). This technique has two essential assumptions: the effect of the predictor (here, growth mindset) on the dependent variable (here, achievement) vary across clusters (here, countries/territories) and the variation depends on cluster level variables (here, the five social axioms) (Heck & Thomas, 2015).

MLM-RS shares some similarities and differences with the more commonly used hierarchical linear model (HLM), also called random coefficient modelling or mixed effects modelling. However, MLM-RS has been shown in recent psychometric studies to perform better than HLM techniques as the former is more sensitive to contextual effects and is better able to account for sampling error (see Preacher, Zhang, & Zyphur, 2011 for a detailed discussion of the benefits of MLM-RS as compared to HLM).

When conducting MLM-RS, we followed the procedures of Preacher, Zhang, and Zyphur (2016): (1) assessing the appropriateness of using multilevel modelling by examining intra-class correlations (ICC) of outcome variables between clusters (Bartikowski, 1981); (2) testing the significance of the slope factors representing the random effect of mindset on achievement across countries/territories; and (3) testing the predictive effect of social axioms on the slope factors at the cluster level. The ICCs of the achievement variables were .15, .20, and .17 for reading, mathematics, and science, respectively, all larger than zero and indicating the need for conducting multilevel modelling (Heck & Thomas, 2015). The equation expressing the final model is available in the Appendix S1.

MLM-RS was computed on *Mplus* 8.2 (Muthén & Muthén, 1998-2018) with the estimator of Maximum Likelihood Robust. Multiple criteria were consulted when evaluating the quality of the baseline multilevel model (without random slopes). Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) values not larger than .05 and Comparative Fit Index (CFI) and Tucker-Lewis index (TLI) values not smaller than .95 together indicate a good fit (Mueller & Hancock, 2010). The meaningfulness of adding a random slope term was determined by the significance of the variance of the random slope (Aguinis, Gottfredson, & Culpepper, 2013). The social axioms dimension is determined to shape the strength of the association between growth mindset and achievement if the covariance between the value of the social axiom dimension and growth mindset is statistically significant.

For MLM-RS with each achievement score, we tested three models recommended by Muthén (1994): Model 1 was a regular two-level path analysis without the random slope and only included fixed effects. Model 2 freed the parameter between growth mindset and

achievement thereby adding a random slope at the country/territory level. Model 3 was the full model with social axioms predicting the slope factor at the country/territory level. Essentially, Model 3 is a cross-level interaction wherein a higher-level factor, in this case society-level social axioms, was posited to modify the relationship between lower level factors (i.e., growth mindset and achievement). The use of random slopes is crucial and it is suggested that this component always be included in multilevel models that involve cross-level interactions as failure to do so will result in anti-conservative statistical inference (Hesig & Schaeffer, 2019). Monte Carlo simulation studies have demonstrated that multilevel models that neglect the random slope component increase the likelihood of Type 1 errors, and reviews of past studies have found that many purported cross-level interactions are reduced to non-significance when a random slope component is added (Aguinis et al., 2013; Hesig & Schaeffer, 2019). Such findings underscore the value of using a random slope component to understand how higher-level factors modify relationships between lower level factors.

## Results

### *Preliminary analysis*

Before the main analysis, we conducted some preliminary analysis and the results are summarized in Table S1 and S2. Ecological correlations indicated that a growth mindset was positively associated with achievement scores ( $r$ s from .20 to .23). SES was positively associated with all achievement scores, and that sex was negatively associated with reading and science in favour of girls and positively associated with mathematics in favour of boys (see Table S1 for details).

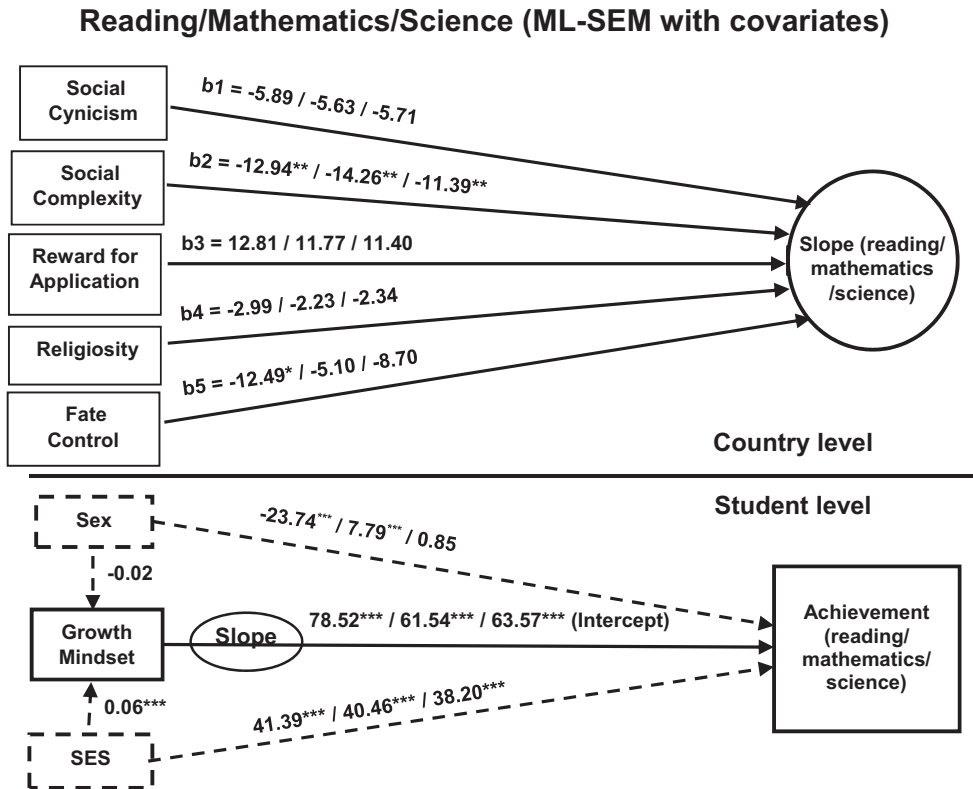
Our preliminary analysis also looked into the correlation between growth mindset and achievement for each of the 39 countries/territories and across the 39 countries/territories (see Tables S2 and S3). Growth mindset was generally positively associated with achievement in all areas. But the correlations in some countries were very small and near zero (e.g., Czech Republic, Germany, and Turkey), and negative in two regions within China (Hong Kong and Beijing-Shanghai-Jiangsu-Zhejiang). These preliminary analyses suggested that the mindset effect on achievement was random across countries.

### *Results of MLM-RS*

We first tested a baseline path model with fixed effects (Model 1) by regressing the achievement scores simultaneously on growth mindset. Both achievement scores and growth mindset were also regressed on SES and sex. The model fit perfectly:  $\chi^2 = .000$ ,  $df = 0$ , TLI = 1.00, CFI = 1.00, RMSE = .00, and SRMR = .00. Growth mindset positively predicted achievement in reading ( $\beta = 0.15$ , 95% CI [0.14, 0.15],  $p < .001$ ), mathematics ( $\beta = 0.11$ , 95%CI [0.11, 0.11],  $p < .001$ ), and science ( $\beta = 0.13$ , 95% CI [0.13, 0.14],  $p < .001$ ).

Next, we freed the slope factor (the parameter representing the effect of growth mindset on achievement) and tested the significance of the slope at the country level (Model 2). Results of Model 2 indicated the slope factor was significant for reading ( $\sigma^2 = 34.557$ ,  $p < .001$ ), mathematics ( $\sigma^2 = 13.616$ ,  $p < .001$ ), and science ( $\sigma^2 = 20.846$ ,  $p < .001$ ). Such information suggests the variation of mindset effect on achievement across cultures was significant and necessitates the inclusion of slope factors.





**Figure 1.** Multilevel-level structural equation modeling with random slopes (estimate unstandardized). Notes:  $**p < .01$ ;  $***p < .001$ ,  $*p = .063$ ; Intercept = recalibrated starting value of mindset effect on achievement.

The full MLM-RS model added social axioms to predict the slope factors at the country/territory level (Model 3). The diagram of the full MLM-RS is shown in Figure 1 and detailed results are shown in Table 1. The effect of social axioms on the association between growth mindset and achievement is represented by the estimates of the paths from social axioms to the slope factors. Among the five social axioms, only Social Complexity significantly negatively predicted the slope factor across all three areas. Social Complexity weakened the association between growth mindset and achievement in reading, mathematics, and science. This meant that in cultures which endorse Social Complexity more, the association between growth mindset and achievement was weaker.

There was also a trend suggesting that fate control also negatively predicted the slope factor for reading but did not reach significance, although the 95% CI range did not include 0 (Table 1). There was also no relationship between fate control and the slope factor for mathematics and science. There was no evidence supporting the hypothesized moderating effect of reward for application on the growth mindset effect.

### **Covariate effects**

At the student level, SES predicted achievement in all three domains:  $b = 41.39$ , 95% CI [36.61, 46.18],  $p < .001$  for reading,  $b = 40.46$ , 95% CI [35.79, 45.13],  $p < .001$  for mathematics, and  $b = 38.20$ , 95% CI [34.05, 42.34],  $p < .001$  for science. Boys had lower

**Table 1.** Parameter estimates of the multilevel SEM with random slopes (with 95% CI)

Level 1 estimates				
	Reading	Mathematics	Science	Growth mindset
SES	41.39 [36.61, 46.18]***	40.46 [35.79, 45.13]***	38.20 [34.05, 42.34]***	0.06 [0.05, 0.08]***
Sex	-23.74 [-26.47, -21.00]***	7.79*** [4.43, 11.14]	0.85 [-2.25, 3.95]	-0.02 [-0.04, 0.00]
Intercepts	523.34 [512.22, 534.46]***	480.78 [467.15, 494.41]***	491.76 [479.95, 503.57]***	0.05 [0.01, 0.09]*
Residual Variances	9,290.51 [8,443.18, 10,137.84]***	8,952.55 [7,821.31, 10,083.79]***	8,606.46 [7,488.73, 9724.21]***	0.79 [0.76, 0.82]***
Level 2 estimates				
	Reading slope	Mathematics slope	Science slope	
Intercept	78.52 [28.23, 128.67]***	61.54 [12.55, 110.34]***	63.57 [12.79, 114.16]***	
Social cynicism	-5.89 [-16.93, 5.22]	-5.63 [-15.95, 4.77]	-5.71 [-15.92, 4.59]	
Social complexity	-12.94 [-22.20, -3.64]**	-14.26 [-23.35, -5.10]**	-11.39 [-20.76, -1.97]**	
Reward of application	12.81 [-3.28, 28.81]	11.77 [-3.08, 26.49]	11.40 [-3.73, 26.39]	
Religiosity	-2.99 [-13.23, 7.26]	-2.23 [-11.43, 6.99]	-2.34 [-11.63, 6.97]	
Fate control	-12.49 [-25.61, 0.66] <sup>†</sup>	-5.10 [-16.83, 6.67]	-8.70 [-21.14, 3.80]	
Residual variances	49.77 [19.18, 80.42]***	39.61 [17.32, 61.89]***	43.67 [17.45, 69.90]***	

Note. Values in brackets are 95% confidence intervals.

\* $p < .05$ , \*\* $p < .01$ , and \*\*\* $p < .001$ , <sup>†</sup> $p = .063$ , slope = random effect of mindset on achievement.

reading scores ( $b = -23.74$ , 95% CI [-26.47, -21.00],  $p < .001$ ) and higher mathematics scores ( $b = 7.79$ , 95% CI [4.43, 11.14],  $p < .001$ ). There was no difference between sexes in science ( $b = 0.85$ , 95% CI [-2.25, 3.95],  $p = .591$ ). SES significantly but minimally predicted mindset in a positive way:  $b = 0.06$ , 95% CI [0.05, 0.08],  $p < .001$ . Girls appeared to be more likely to hold a growth mindset, but the difference was not significant:  $b = -0.02$ , 95%CI [-0.04, 0.00],  $p = .109$ .

### Robustness check

To check the robustness of the results, we tested the same MLM-RS without the covariates. Results were nearly identical, except that the estimates for the growth mindset effect at the individual level and of the social axioms on the slope factors became higher (see Figure S1).

### Discussion

A previous meta-analysis (Costa & Faria, 2018) suggested cultural variations in the growth mindset effect on achievement; in this study, we identified a specific cultural factor that

could predict the variations. We hypothesized that society-level social axioms provide the societal context which may either support or obstruct the network of motivations and behaviours associated with the growth mindset beliefs. Our hypotheses were partly supported, and we discuss these below, but first we need to note that the measure used to measure the growth mindset in the PISA 2018 and in this investigation is not the typical measure used in most growth mindset research. Typically, the growth mindset is assessed using a version of the Implicit Theories of Intelligence Scale which had either three items (Dweck et al., 1995), six or eight items (Dweck, 1999). The three items in the original scale all stated a fixed mindset (or entity theory of intelligence), and the later version included addition items that stated a growth mindset (or incremental theory). In all these versions, respondents were asked to indicate their agreement in a six-point scale. The scale used in PISA 2018 and in this study was a one item from the original scale that was congruent with the fixed mindset and the students had to respond using a four-point scale. In other domains of study, single-item measures have been shown that they perform well compared to their longer multi-item counterparts (Leung & Xu, 2013; Sloan, Aaronson, Cappelleri, Fairclough, & Varricchio, 2002), but there has been no research done to compare the performance of the single-item growth mindset measure compared to the more typically used multi-item scales. However, we note that a similar single-item with four-point response has been used in other published studies (Hwang et al., 2019; Ingels et al., 2007; Nix et al., 2015; Perez-Felkner et al., 2012). Other published studies have also used the single-item four-point measure of growth mindset in PISA 2018 to investigate different hypotheses (Bernardo, 2020; Govorova, Benítez, & Muñiz, 2020). The use of the one item that is congruent with the fixed mindset is consistent with Dweck and Leggett's (1988) original theoretical argument that items stating a growth mindset or incremental theory of intelligence are more desirable, and thus, are likely to lead respondents to drift towards growth mindset responses. Thus, the practice of using the reversed score of the fixed mindset measure to indicate the growth mindset is most consistent with the original versions of the growth mindset measures (Dweck et al., 1995; Dweck & Leggett, 1988). But readers should keep in mind this atypical measure of growth mindset used in the current study, as we consider the implications of our findings below.

First, we found evidence that the growth mindset is positively associated with achievement in reading, mathematics, and science (Model 1). The preliminary analysis (Table S2) showed that growth mindset was positively associated with achievement in most countries/territories, but there was significant heterogeneity in this effect across countries/territories which could be surmised from the statistically significant variance of the slope factors (Model 2). The association between growth mindset and achievement varied across cultures.

We hypothesized that society-level values for three social axioms (Leung & Bond, 2004) would moderate the growth mindset effects across countries/territories, but our results verified the hypothesis for only one social axiom.<sup>1</sup> We found evidence for the weakening of the growth mindset effect in cultures with higher Social Complexity beliefs: the higher the societal Social Complexity score, the smaller the growth mindset effect on achievement in all learning domains. There seemed to be a trend showing a similar moderating effect of society-level fate control in the area of reading, but none of the moderating effects of society-level Fate Control and reward for application on the growth mindset effect on learning were statistically significant.

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<sup>1</sup> The large sample size at the within level ( $N = 273,074$ ) made the low power analysis less of a concern.

Our hypotheses took cues from previous findings (Scheffler & Cheung, 2020; Yeager et al., 2019) that the benefits of their growth mindset intervention were stronger in those schools where the students' peers also hold growth mindset consistent beliefs. At the society-level, we proposed that social axioms would work similarly, by providing the social belief norms that could support the motivational and behavioural processes related to the growth mindset. But our results provided evidence mainly for how social belief norms might be obstructing the growth mindset processes instead, and thus weakening its positive relationship with students' achievement. This obstructing social effect was observed with Social Complexity. This social axiom refers to the belief that problems have multiple solutions (Leung et al., 2002) and has been associated with active problem-solving that involves compromise (Bond et al., 2004) and flexible thinking (Nalipay et al., 2016).

In social contexts where people tend to believe in Social Complexity, students are likely to be encouraged and supported to consider a range of pathways to succeed in school and in life. The students are also likely to have a range of models of people in their society who succeed using different paths, some of which may not involve the use of intelligence or the effortful improvement of once intelligence; and these students are also likely to get support for flexible and multiple strategies to succeed. Perhaps more importantly, it is unlikely that people in the students' social environment will support the idea that achieving in school will be primarily associated with efforts related to improving one's intelligence. Instead, people might encourage a variety of flexible problem-solving approaches to attaining one's educational goals as has been suggested in previous research (Bond et al., 2004; Nalipay et al., 2016). For that matter, in societies where Social Complexity belief is high, there might also not be as much emphasis on achievement in school as the pathway to future success; instead, students are likely to see academic success as just one of the various pathways to creating a good future for themselves. There are some findings that seem to support this notion; individual level Social Complexity beliefs were found to be negatively associated with subjective norms about studying and indirectly to intentions to study (Liem et al., 2009). Therefore, while there are students who hold a growth mindset in such societies, they are not likely to get support for this belief in their social environment, which may limit the growth mindset effect in these social contexts (Yeager et al., 2019).

As regards the other social axioms, although there were trends, the hypotheses about Fate Control and Reward for Application were not supported by the data. We hypothesized that a society where most people hold Fate Control beliefs may not be supportive of motivations and behavioural intentions related to improving intelligence by effort that would lead to higher educational achievement. But the data did not support the hypothesis, and this might be because belief in Fate Control may be more relevant in domains where fate is thought to play a salient role. Zhou et al. (2009) propose that academic achievement is usually not a domain that is associated with fate, at least not in most cultures. Domain misalignment of the social axiom might also explain why the reward for application hypothesis was not verified. The core beliefs of the social axiom converge with the growth mindset's emphasis on effort, but in a previous study, Leung and colleagues (Leung et al., 2007) suggested that Reward for Application is a social axiom that developed as a response to impoverished economic environments, and as such, the belief of Reward for Application is likely to be associated with *physical* efforts and application, the outcomes of which are more easily and immediately seen. Building on this point, Zhou et al. (2009) suggest that Reward for Application as a social axiom does not typically refer to beliefs about improving long-term efficacy and efficiency, which are

relevant for growing one's intelligence and success in the academic domain. We cannot ascertain whether the Reward for Application scores for the various countries/territories are associated only with physical effort and application, and not with more cognitive forms of striving, but this is one possible explanation for the lack of support for this hypothesis.

The foregoing discussions point to some limitations in our enquiry. The social axioms, although conceptualized as being general beliefs that do not refer to particular problem domains, might be associated with specific forms of problems and approaches in particular societies. Thus, it is possible that how a particular social axiom relates to the growth mindset varies somewhat across cultures if a social axiom has different sets of cognate ideas across societies, and will be good to enquire into how such cognate ideas that may or may not relate to the academic domain may be related to the variations in how social axioms related to academic achievement across different societies. Thus, although our results show variations in at least one social axiom across societies moderates the academic benefits of holding a growth mindset, studies that enquire into specific cognates of social axioms in the academic domain in specific cultures might provide more nuance and insight into the role of social axioms in these specific contexts. This points to a related limitation regarding the scope of the enquiry; the current study did not enquire into and measure the possible psychological mechanisms through which the social axioms moderate the benefits of growth mindset on achievement in a specific culture.

But we should underscore that our attempt to identify social axioms as a cultural factor that could explain variations in the growth mindset effect on achievement deepens theorizing about the sociocultural dimensions of growth mindset in significant ways. It goes beyond initial attempts to understand these cultural variations by comparing countries across continents. Costa and Faria's (Costa & Faria, 2018) meta-analysis was the first thoughtful and systematic attempt to understand possible cultural variations, and their findings established a cultural basis for the variations. Our study identified the specific cultural factor, that is, Social Complexity beliefs, that could account for variations in the growth mindset effect. In their instrumentality function, the three problem-related social axioms that are widely held in a cultural or social group, provide social belief norms within which the growth mindset and its network of allied motivations and behaviours may be supported. Our results provide evidence for how societal differences in one social axiom – Social Complexity – might be creating a social context wherein the assumptions of growth mindset may not thrive.

It is theoretically interesting that the most consistent evidence indicates that the growth mindset effect on achievement tends to be weaker in societies that tend to hold the belief that problems may have multiple solutions and that people's behaviours may vary across social context. In such contexts, one can view effort and persistence towards improving intelligence as only one of many possible strategies for succeeding in school, and a student might be receiving many different social messages about how to succeed in school and beyond. For example, schools in such societies might not be solely focusing on demonstration of cognitive or intellectual abilities as the main measure of success in school. The schools might also encourage developing leadership, socioemotional skills, service orientation in the community, artistic and athletic abilities, among others. Success in such school environments does not depend primarily on improving one's intelligence. This might extend to notions of success in larger society, which society might provide and encourage more pathways for children and adolescents to define their pathways to succeed and meet their future aspirations. Intelligence and

improving one's intelligence through effort indicate just one pathway, and societies high in Social Complexity may support a range of pathways that have very little to do with using intelligence such as cultivating other personal qualities and non-cognitive strengths, social connections, among others. In such societies, holding a growth mindset may not be as critical in a student's academic success, and for that matter success outside the school system.

Unfortunately, our results do not point to a social context wherein specific social beliefs are likely to strengthen the benefits of the growth mindset. But the analytic approach we take, which broadly draws from the linkage approach in cross-cultural psychology (Matsumoto & Yoo, 2006) and is cognizant of the different layers of sociocultural contexts in which students function (Bernardo & Liem, 2013), could be applied to explore other possible culture-/society-level factors that could be moderating the growth mindset effect. Moreover, our theoretical approach is consistent with the emerging understanding that the students' context plays an important role in whether growth mindset and related interventions are positively associated with student achievement. Thus, similar to how the school's level of achievement and the social beliefs of the students' peers may support the growth mindset effect in schools (Yeager et al., 2019), we believe that sociocultural norms also provide social supports for the growth mindset effect.

Presumably, the broad sociocultural norms like society-level social axioms are more distal predictors of variations in the growth mindset effect compared to the social norms within the students' learning environment which are likely to be stronger, more proximal predictors of the growth mindset effect. And the norms in these different social levels might not always be aligned. For example, one school might strongly cultivate a set of values that are not shared by people in their community or country, while another school might operate in ways that reflect the beliefs and values of their larger community. Similarly, teachers' growth mindset beliefs, may also either aligned or not with their larger community. Studies on teachers' growth mindset beliefs suggest that they are influenced by some assumptions in the broader culture (Cutler, Mallaburn, Putwain, & Daly, 2019; Rissanen, Kuusisto, Hanhimäki, & Tirri, 2018), and because of these cultural specificities, teachers who hold the growth mindset but come from different cultures might still have very different approaches to their pedagogy (Zhang, Kuusisto, & Tirri, 2020). We speculate that the growth mindset effect on students' achievement would also be influenced by how beliefs, values, and other sociocultural factors are consistent across students' social environments and among the key social actors in these environments. We also surmise that the impact of the layers of sociocultural factors will be more complex for students who are immigrants in the culture or country of their school. The PISA 2018 data indicates that 13% of the students in the total sample had an immigrant background and this proportion varied across countries/territories, but these students may also be influenced by social norms from their heritage culture. As such, further studies are needed to have a more nuanced understanding of whether or not the growth mindset will be a meaningful, useful, and constructive concept in different types of students' achievement in diverse sociocultural contexts.

In conclusion, cultural-level factors should be more extensively considered in discussions on the relevance of the growth mindset construct. Implicit theories like the growth mindset do not occur in a sociocultural vacuum; whether or not such theories will have meaning and consequence on students' achievement will need to be assessed within the belief systems that function in the students' environment.

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## Conflicts of interest

All authors declare no conflict of interest.

## Author contributions

Allan B. I. Bernardo (Conceptualization; Investigation; Project administration; Supervision; Writing – original draft; Writing – review & editing) Yuyang Cai (Conceptualization; Formal analysis; Methodology; Writing – original draft) Ronnel B. King (Conceptualization; Methodology; Writing – original draft; Writing – review & editing).

## Data Availability Statement

The data that support the findings of this study are openly available in OECD PISA 2018 dataset at: <https://www.oecd.org/pisa/data/2018database/>

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### **Supporting Information**

The following supporting information may be found in the online edition of the article:

**Figure S1.** Multilevel-level structural equation modeling with random slopes (unstandardized estimates).

**Table S1.** Correlations among key variables and covariates.

**Table S2.** Descriptive statistics of key variables and correlations between growth mindset and achievement for different countries/territories.

**Table S3.** Correlations between country/territory level social axioms and country/territory growth mindset-achievement correlations.

**Appendix S1.** The equation representing the MLM-RS model.