Original Research

The Effects of Growth Mindset and Resilience on Immigrant Students' PISA Science Achievement: The Mediating Role of Attitudes Toward School

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Abstract

In recent years, self-theories such as growth mindset and resilience have gained interest as they have a sizable influence on achievement and school-related motivation. The aim of this study is to investigate the relationship between immigrant students' growth mindset, resilience, and science achievement in PISA 2018 by considering the mediating effect of attitudes toward school. Using secondary data for Australia, the UK, and the USA obtained from PISA 2018, we conducted a series of Structural Equation Modeling analyses to unravel the relationship between self-theories and science achievement. The growth mindset had the strongest effect on science achievement for both immigrants and non-immigrants in all three countries; resilience was positively related to science achievement for immigrants in the US, and attitudes toward school were positively related to science achievement for immigrants in Australia. The mediating role of attitudes toward school between growth mindset, resilience and science achievement could not have been confirmed. We speculate that self-theories might be affecting immigrant groups differently in different countries. Implications regarding these findings are discussed.

Plain Language Summary

Immigrant Students' Growth Mindset and Resilience

In recent years, there has been a lot of interest in self-theories, such as growth mindset and resilience. These theories have a big impact on achievement and school-related motivation. This study looked at the relationship between immigrant students' growth mindset, resilience, and science achievement in PISA 2018. The researchers also looked at whether attitudes toward school mediated this relationship. The researchers used secondary data from PISA 2018 for Australia, the UK, and the USA. They used structural equation modeling to analyze the relationship between self-theories and science achievement. The results showed that growth mindset had the strongest effect on science achievement for both immigrants and non-immigrants in all three countries. Resilience was positively related to science achievement for immigrants in the US, and attitudes toward school were positively related to science achievement for immigrants in Australia. The researchers could not confirm that attitudes toward school mediated the relationship between growth mindset, resilience, and science achievement. They speculate that self-theories might affect immigrant groups differently in different countries.

Introduction

Migration takes place to search for a better future to avoid conflict, economic and political instability, famine, and natural disasters (Masten et al., 2019; McAuliffe & Khadria, 2019). Migration usually originates from low- to middle-income countries in the Global South and

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Data Availability Statement included at the end of the article

flows toward more affluent Western countries (OECD, 2020a). According to the latest data from the International Organization for Migration (2020), between 12% and 30% of the total population of Europe, North America, and Australia are international immigrants. This study focuses on these immigrants and their science achievement in the OECD's Programme for International Student Assessment (PISA) in three Anglophone countries: The United Kingdom, the United States and Australia, that is, the top-three countries that attract immigrants according to OECD (2020a). Although these countries are located on three separate continents, they all have a high influx of immigrants.

Previous reports and studies have found the impact of self-theories of students (Gouëdard, 2021; OECD, 2021), motivational and metacognitive variables (Kaya et al., 2022) and their attitudes toward science (Lau & Ho, 2022) on their science and reading achievement in PISA; however, not many studied have compared the varying impact and interplay between the self-theories of immigrant students and their non-immigrant peers on science achievement. Self-theories include psychological variables such as motivation, self-efficacy, goal orientation, growth mindset and resilience (Dweck, 1999). Among these, growth mindset and resilience have attracted the attention of researchers in recent years. These two constructs are closely related to school achievement as well as school-related motivation (Blackwell et al., 2007; Martin & Marsh, 2009; Meltzer et al., 2004; Zeng et al., 2016). By employing a Structural Equation Modeling (SEM), this study examines the effects of growth mindset and resilience on the science achievement of immigrant students in three Anglophone countries in PISA 2018 by taking into consideration the mediating effect of attitudes toward school.

Immigration in Australia, the United Kingdom and the United States

Immigration is a global phenomenon that includes many challenges and controversies worldwide, with its positive and negative impact on society (Branza, 2017). This impact of immigration can be based on the countries' demographic, economic and cultural situation as well as the immigrants' demographics, such as their educational background, age and gender (Butkus et al., 2018). Hochschild and Cropper (2010) group immigration into two (a) labor and (b) selective immigration. (a) Labor immigrants are those intended to benefit from the opportunities provided by the host country through generic worker admissions and (b) selective immigrants are those who carry the skills required by the host country. An OECD report states that immigrant students tend to outperform their non-immigrant peers in countries with

highly selective immigration policies in international exams such as PISA (Schleicher, 2015). Among our focus countries, Australia and the United Kingdom gave the most incentives in the early 2000s to appeal to skilled immigrants. However, the United States, which has the highest number of immigrants, was hesitant to attract them (Lowell, 2005). Permanent immigrant inflows and the ratio of the foreign-born population in Australia, the United Kingdom and the United States are provided in Table 1 according to the data obtained from OECD (2019a).

In Australia, 28% of school-age children are immigrants (Washbrook et al., 2012). A recent longitudinal study showed that immigrant children with non-English-speaking parents outperform children of both English-speaking immigrant parents and native-born Australians (Islam et al., 2022). According to the 2018 census, 7% of primary school and 10% of secondary school pupils in England were born outside the UK. The Department for Education's attainment data shows that these pupils have slightly lower attainment levels than their UK-born counterparts at age 7, but this difference disappears by age 16 (Briggs, 2019). In the United States, 23% of school-age children are immigrants (Caramota et al., 2023). While disparities exist between immigrants and non-immigrants in early childhood and elementary school, by secondary school age, immigrant pupils outperform their non-immigrant counterparts (Crosnoe & Turley, 2011). Overall, immigrant children in these three countries have similar, if not higher, levels of educational attainment compared to their non-immigrant peers.

Immigrants' Achievement in International Assessments

The relationship between immigration status and achievement is a rather complex one, yielding mixed results (Areepattamannil & Kaur, 2013) and the performance of immigrant students varies substantially across countries (Schleicher, 2015), which makes it a topic of interest, especially in international exams. Compared to their non-immigrant peers, immigrant students usually study with a cohort of low-income and minority students in more crowded classes (Schleicher, 2015). Also, among

Table 1. Permanent Immigration Inflow and Ratio of Foreign-born Population in Target Countries.

Country	Permanent immigration inflow	Ratio of Foreign-born population (%)
Australia	223,474 (2016)	29.6 (2018)
United Kingdom	350,085 (2016)	13.8 (2018)
United States	1,183,505 (2016)	13.6 (2018)

immigrant students, achievement can be mediated by some factors such as home language and socioeconomic status (Areepattamannil & Kaur, 2013). According to PISA 2015 results, overall immigrant ratios in schools did not impact the achievement levels of students when the analysis was controlled for SES (OECD, 2016). With TIMSS mathematics data, Arikan et al. (2020) found no sizable differences between the achievement levels of immigrants and non-immigrants when background variables were controlled for in some European countries.

Similarly, when controlled for SES, in PISA 2003 (Schnepf, 2007) and PISA 2012 (OECD, 2013), the achievement gap between immigrant and non-immigrant students was insignificant. Some studies reported mixed results. For example, in their analysis of TIMSS, PIRLS and PISA data sets, Alieva et al. (2018) did not report significant achievement gaps between immigrant and non-immigrant students' mathematics and reading achievement in traditional immigration countries (Australia, Canada, and New Zealand) whereas, in European countries, non-immigrants scored significantly higher than their immigrant peers. In another study with international assessment data for OECD countries, Andon et al. (2014) found significant differences favoring non-immigrants in reading, mathematics and science, with the largest effect size being in science. Another strand of studies reported results in favor of immigrant students compared with their non-immigrant peers in terms of achievement (Crosnoe & Turley, 2011; Duong et al., 2016; Palacios et al., 2008). These mixed results call for further research on this topic.

Growth Mindset

Dweck (1999) proposed that learners have adaptive and maladaptive cognitive-motivational inclinations toward learning. These inclinations are called self-theories, and they influence achievement as well as well-being. One of the important aspects of these self-theories is how people view intelligence. Dweck (1999, 2006) and Dweck and Yeager (2019) introduced the concept of *mindsets* as a powerful psychological construct that is commonly used in educational psychology research (Noels et al., 2019). Accordingly, people have two common presumptions about their intelligence: some people believe that intelligence is fixed. There is not much one can do to change it (fixed mindset), while others think that intellectual capabilities can progress through hard work and practice (growth mindset) (Dweck, 1999). In other words, a growth mindset refers to "our core belief that our talents can be developed through practice" (Tao et al., 2022).

One of the strengths of the mindset lies in its critical role in impacting achievement (Yeager et al., 2019). The mindset theory posits that a fixed mindset would negatively affect academic achievement, whereas a growth mindset affects achievement positively (Cury et al., 2006; Kaya et al., 2023; Yuksel et al., 2021). The mindset-achievement relationship can be either direct (e.g., Bostwick et al., 2017; Zhao & Wang, 2014) or via some other personal features such as self-regulation strategies, goal orientations, and effort (e.g., Blackwell et al., 2007; Müllensiefen et al., 2015). However, some studies reported no sizable influence of mindsets on achievement (e.g., Li & Bates, 2019). Two meta-analyses on mindsets revealed weak relationships between mindsets and achievement (Costa & Faria, 2018; Sisk et al., 2018).

Another strength of the mindset is its relationship with some key personality variables. In general, holding a growth mindset increases an individual's resilience, perseverance and attitudes toward learning (Duckworth, 2016; Dweck, 1999). Students with a growth mindset are more likely to perceive academic challenges as opportunities to improve their ability and learning skills, and therefore, they exhibit higher levels of resilience (Blackwell et al., 2007; Yeager & Dweck, 2012). With a large sample of primary and middle school students, Zeng et al. (2016) found significant positive effects of a growth mindset on resilience and school engagement. Students with fixed mindsets perceive mistakes and failures as indications of their inherent inability. Instead of putting in effort to tasks they find challenging and learning from their mistakes, they tend to avoid those tasks altogether. This avoidance hinders their resilience and negatively influences their future success and career prospects (Dweck, 2007).

Research indicates that growth mindsets have a more pronounced impact on the motivation and competence of students from disadvantaged backgrounds (Burnette et al., 2013; Paunesku et al., 2015). Growth mindsets play a crucial role in developing resilience, especially among disadvantaged students who frequently face academic setbacks (Paunesku et al., 2015). Immigrant students who experience language challenges in social and academic contexts are more likely to be disadvantaged learners (Lou & Noels, 2019). However, growth mindset studies with immigrant students have been very limited. Among the few studies, Corradi et al. (2019) investigated the role of migrant background, among other contextual variables, in the relationship between growth mindset and academic achievement among Belgian university students. Students with migrant backgrounds had a significantly higher growth mindset, but this did not compensate for the negative effects of minority status on academic outcomes. Contrary to the literature, a growth mindset was negatively associated with academic outcomes but positively associated with educational motivations. These contradicting findings warrant further exploration of growth mindset for immigrant students as well as non-immigrants.

In 2018, PISA measured the students' growth mindset for the first time with a single-item scale. A recent PISA

report revealed that students who were inclined to a growth mindset scored 27 points higher in science than those who opted for a fixed mindset (Gouëdard, 2021). In some countries like Australia and the United States, the difference between growth mindset and fixed mindset-oriented students reached 50 points after controlling for individual and school-level socioeconomic status. Recent research demonstrated that domain-specific beliefs can better predict academic performance compared to general beliefs (Lottero-Perdue & Lachapelle, 2020). However, we could only use the general mindset in this study because we benefited from secondary data available in PISA 2018. In PISA 2018, overall, no clear pattern was detected between students with or without an immigrant background regarding growth mindset (OECD, 2021). However, in Philippine PISA data, Bernardo (2021) found that SES moderated the relationship between growth mindset and achievement in science and mathematics. Therefore, studying some specific countries can give us a better picture of explaining the impact of self-theories on achievement. This study aims to do that by examining this relationship in three Anglophone countries. We hypothesize that a growth mindset in the PISA 2018 science assessment is positively and directly associated with resilience and attitudes toward school.

Resilience

Masten et al. (1990) defined resilience as "the process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances" (p. 426) or the capability to achieve positive outcomes despite the presence of adversity (Masten and Coatsworth, 1998). Resilience is also operationalized as "the ability of individuals (on their own and collectively) to navigate to the culturally relevant resources they need to do well when confronting adversity" (Ungar, 2015, p. 40). Individuals who succeed despite adverse circumstances are identified as resilient, and these people develop certain strengths to protect them under adverse conditions, and they thrive (Zolkoski & Bullock, 2012).

Increasing resilience is especially beneficial for adolescents (Edwards et al., 2016) since they can be vulnerable under stress (Romeo & McEwen, 2006). Resilience is positively related to academic achievement (Allan et al., 2014; Hernández et al., 2019; Johnson et al., 2015). Resilience may also indirectly affect achievement mediated by other psychological constructs such as strategy use (de la Fuente et al., 2017; Johnson et al., 2015) and effort (Meltzer et al., 2004). Resilience also positively influences adolescents' psychological well-being and school engagement (Zeng et al., 2016). Resilient students who thrive despite adverse circumstances tend to have some common strengths, such

as working hard and having high intrinsic motivation to succeed (Martin & Marsh, 2009).

With the increasing numbers of immigrants around the globe, the adaptation and resilience of immigrant populations gained the interest of researchers. Owens and Lynch (2012) examined the resilience of 1,865 first-, second-, and third-generation immigrants in 28 American universities. They found that the first-generation immigrants were the most resilient among all three, and their grades increased despite negative circumstances. They speculate that the strong self-determination and perception of opportunities in mainstream society lead first-generation immigrants to work hard, which eventually pays off.

Resilience is deemed crucial for school-aged immigrant students in overcoming challenges, maintaining their mental and physical health, and successfully finishing their education (Cinkara, 2017; Earnest et al., 2015; Polat & Kröner, 2023). In a recent scoping review, Polat and Kröner (2023) found that family and school support, as well as individual factors such as self-efficacy, self-regulation and desire to learn, are important factors in developing resilience.

Studies investigating the resilience of immigrant students used two definitions of the resilience concept. The first one is academic resilience, which is defined as high levels of academic achievement despite disadvantaged socioeconomic backgrounds (Agasisti et al., 2018). The second one is social/psychological resilience, which means bouncing back and adapting in the context of adversity (Motti-Stefanidi, 2019). The current study focuses on the latter. The Programme for International Student Assessment (PISA) used self-efficacy as a measure of students' resilience beliefs in the 2018 assessment (Nelis et al., 2021); positive values on this index indicating higher resilience beliefs than the Organization for Economic Cooperation and Development (OECD) average (OECD, 2019a, 2019b). Self-efficacy is considered a key intrapersonal characteristic of resilience (Fergus & Zimmerman, 2005; Hays-Grudo & Morris, 2020; Henry et al., 2015).

The use of large-scale assessment data to investigate achievement levels of disadvantaged students in terms of resilience has gained interest in recent years (Agasisti et al., 2018; Erberer et al., 2015; Sandoval-Hernández & Białowolski, 2016). However, immigrants' resilience has not been addressed by these studies. The current study aims to contribute to the literature by examining this issue using PISA 2018 data. We hypothesize that resilience affects PISA science achievement directly and indirectly through attitudes toward school.

Attitudes Toward School

Previous research showed that attitudes toward school strongly predict academic achievement (Borger, 2021;

Burgess & Heller-Sahlgren, 2018; Cain & Hattie, 2020; Miyamoto et al., 2020). As Miyamoto et al. (2020) summarize, students with positive academic attitudes put more time and effort into performing a task, which, in general, contributes to their performance. The relationship between attitudes toward school and achievement is rather complex for immigrant students. High levels of attitudes may not always contribute to their achievement (OECD, 2006). Immigrant students' perceptions of school depend mostly on students' social environment and culturally driven actions within those environments (Kaufman, 2004). Suarez-Orozco and Suarez-Orozco (2001) speculate that when immigrant children live in poor, urban neighborhoods where they experience economic obstacles, their optimism and attitudes toward school might be negatively affected.

On the other hand, Zhou and Bankston (1998) claim that even though immigrants live in poverty when social bonds and networks are strong in their community, they tend to show more effort and become successful. Common academic goals set by their school, family and society, added to cultural values they bring from their country of origin, can be a driving force to academic achievement. Similarly, Burgess and Heller-Sahlgren (2018) reported that immigrant students have significantly more positive attitudes toward education than their non-immigrant peers. These positive attitudes might be inherited from their parents, who tend to have more qualities such as aspiration and risk-taking.

Immigrant students' achievement in large-scale assessments has been investigated before; however, how attitudes toward school influence their achievement compared to their non-immigrant peers has rarely been addressed. In a recent study, Borger (2021) investigated the PISA 2018 achievement of immigrant children of highly skilled parents in Australia and Canada. He found that there was a positive effect of attitudes toward the school on achievement for immigrant students and that there was not a significant difference between immigrants and non-immigrants in terms of attitudes. The current study aims to explore this issue further. Moreover, Islam et al. (2022) recommend the investigation of unobservable psychological factors in the achievement of immigrant students as they continue to perform better than their non-immigrant peers even after parental characteristics are controlled for.

Hypotheses and Proposed Model

Figure 1 illustrates our hypothesized model of interconnectedness among growth mindset, resilience, attitudes toward school and science achievement. We expanded Zeng et al.'s (2016) model of growth mindset, resilience and school engagement relationship. Since immigrant
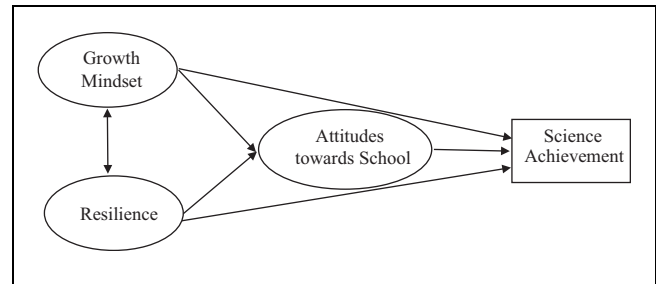
Figure 1. The proposed model.

students' reading and mathematics achievements have been examined by numerous studies before, we focused on science achievement. We employed separate path analyses in three countries to test our model. Fit indices are used to determine whether the relationships in the proposed model are acceptable. We hypothesized to find direct effects of growth mindset, resilience, and attitudes toward the school on science achievement. Indirect effects of a growth mindset and resilience through attitudes toward school are also expected. The differences between non-immigrant and immigrant student groups in the three countries are examined.

Methods

Data

This study conducted a secondary data analysis using the PISA 2018 data set. The PISA 2018 collected data from approximately 600,000 15-year-old students across 79 countries and economies about their literacy in mathematics, science and reading domains. In addition to students' cognitive domains, PISA collects a broad spectrum of background characteristics information concerning students, parents, teachers, and schools to explain the circumstances and better understand how these contextual characteristics impact students' academic performance levels.

The sampling method in PISA involves selecting a representative sample of schools and students. Participating schools are chosen based on stratified random sampling, and students within chosen schools are randomly sampled. This ensures that the collected data is representative and allows for meaningful comparisons at both the national and international levels.

The present study conducted analyses with three English-speaking education systems in PISA 2018: Australia, the United Kingdom and the United States. The survey was administered in English in these countries. Table 2 shows the surveyed sample of immigrant and non-immigrant students in the analyzed data (OECD, 2019b).

Table 2. Distribution of Non-Immigrant and Immigrant Samples in Target Countries.

Country	Australia	United Kingdom	United States
Non-immigrants	9,245	11,249	3,696
Immigrant	3,329	1,730	990

Dependent Variable

The dependent variable of the study is students' Science Literacy Score (SCIE), which was considered for this study as *science achievement*. PISA uses item response theory (IRT) to acquire the science achievement scores based on individual student answers. Large-scale assessments do not use students' raw scores but plausible scores. Since students take only a portion of the test due to time constraints, plausible values provide a more reliable measurement of achievement by reducing the measurement error. Furthermore, they allow a fair comparison of different groups or countries. PISA provides 10 plausible values for science achievement. The plausible values utilized in the analysis are not arbitrary random values but rather samples drawn from the posterior distribution of the student's scores. These values are derived through a statistical modeling process incorporating the uncertainty and variability inherent in measuring student abilities. Drawing from the posterior distribution, the plausible values provide multiple estimations of the student's true score, encompassing a range of plausible values that effectively capture the inherent uncertainty in the measurement process (OECD, 2020b). The scores are transformed to align with approximately normal distributions, where the average scores for OECD countries tend to be around 500 points, and the standard deviations are approximately 100 points. Notably, the score distributions can vary across countries due to differences in their educational systems. Moreover, it is commonly observed that about two-thirds of students in OECD countries achieve scores ranging from 400 to 600 points, providing a general indication of the performance distribution (OECD, 2020b).

Independent Variables

Growth Mindset. In PISA 2018, growth mindset was assessed by asking students *How much do you agree with the following statement?: "Your intelligence is something about you that you cannot change very much."* The response option was a four-point Likert scale from 1 = Strongly Disagree to 4 = Strongly Agree). The original scale responses were reverse-coded to make the interpretation of this scale consistent, which means a higher score indicates a higher growth mindset. The mean of the

reverse response score was 2.86 ($SD = 0.87$) in Australia, 2.87 ($SD = 0.88$) in the United Kingdom, and 2.88 ($SD = 0.95$) in the United States. This variable's score was used as a continuous variable to investigate its association with science achievement in our proposed model. It is important to acknowledge that single-item constructs are not optimal since they do not produce internal consistency estimates. However, in the literature, previous studies have made use of the same single-item using a four-point Likert scale and treated these scores as a continuous variable (see Bernardo, Cai, & King, 2021; Bernardo, 2021; Hwang et al., 2019; Nix et al., 2015).

Resilience. The resilience scale (RESILIENCE) was constructed with five items, asking the students, How much do you agree with the following statements?: "I usually manage one way or another"; "*I feel proud that I have accomplished things*"; "*I feel that I can handle many things at a time*"; "*My belief in myself gets me through hard times*"; "*When I'm in a difficult situation, I can usually find my way out of it*". The OECD's technical report showed that the internal consistency of this scale is 0.781 for Australia, 0.766 for the United Kingdom, 0.781 for the United States (OECD, 2020b). The factor loadings for this scale changed between 0.591 and 0.702 with data from all three countries.

Attitudes Toward School. The attitudes toward school scale (ATTLNACT) was constructed with three items asking the students, *Thinking about your school: to what extent do you agree with the following statements?: "Trying hard at school will help me get a good job"; "Trying hard at school will help me get into a good <college>"; "Trying hard at school is important."* According to the OECD's technical report, this scale mean indicates how the student values schooling. The OECD's technical report indicated that the internal consistency of this scale is 0.905 for Australia, 0.889 for the United Kingdom, 0.899 for the United States (OECD, 2020b). The factor loadings of this scale changed between 0.853 and 0.877 with data from all three countries.

Covariates

In this study, we added two control variables at the student level: sex as a dummy variable (females coded as 1, males coded as 0) and students' socioeconomic status (SES). In PISA 2018, students' SES was an index of economic, social, and cultural status (ESCS). This index was a composite score of highest parental occupation (HISEI), parental education (PAREDINT), and home possessions (HOMEPOS), such as books in the home (OECD, 2019a). Table 3 shows descriptive statistics for

Table 3. Descriptive Statistics for Independent Variables.

Independent variables	Immigrant			Non-immigrant		
	Min	Max	Mean (*sd*)	Min	Max	Mean (*sd*)
Growth mindset	1	4	2.93 (0.90)	1	4	2.86 (0.88)
Resilience	−3.17	2.37	0.06 (0.98)	−3.17	2.37	−0.06 (0.96)
Att. toward school	−2.54	1.08	0.20 (1.01)	−2.54	1.08	0.18 (0.99)
SES	−5.10	3.48	0.15 (1.02)	−4.46	3.89	0.28 (0.88)

Note. All variables are based on the student questionnaire.

independent variables for total immigrants and non-immigrants in three Anglophone countries.

Analytical Strategy

In this study, to address our research hypotheses, we implemented a secondary PISA 2018 data analysis of the representative samples from Australia, the United Kingdom and the United States. The analyses were conducted using the Mplus 8.2 software package (Muthén & Muthén, 2017). Our purpose is to examine the direct effects of students' growth mindset (*ST184Q01HA*), students' resilience (RESILIENCE) and students' attitudes toward school (ATTLNACT) on science achievement (SCIE), as well as the indirect effects of students' growth mindset and resilience on science achievement for both immigrant and non-immigrant student groups within each country mentioned above. Structural Equation Modeling (SEM) enables researchers to examine the structural relationships among observed and latent variables through confirmatory factor analysis, linear regression and path analysis (Byrne, 2016), was used in the study in R lavaan (R Core Team, 2019; Rosseel, 2012). We used the MLR-Estimator since it allows robust statistics in the existence of non-normal or incomplete data (Lei & Shiverdecker, 2020).

Our model consists of a measurement model representing each latent construct used in this study and an SEM representing the relationships between each latent variable (Bollen, 1989). In order to evaluate the model fit consistency, we utilized the cut-off values suggested by Hu and Bentler (1999), Hair et al. (2014), and Kline (2016) as $CFI > 0.90$, $TLI > 0.90$, $RMSEA < 0.10$, and $SRMR < 0.10$.

Given that we would like to carry out our analyses at the student level, we used student weight and student-level replicate weights as well as the 10 plausible values provided for science achievement in the corresponding dataset (Rutkowski et al., 2010). Individual estimates for each plausible value are computed and aggregated using Rubin's method to produce final estimates (Rubin, 2004). We did not use multilevel structural equation modeling because all of our interest variables were derived from student-level data. We used the design-based method to fit our SEM to the PISA dataset's weights and replicate weights (Stapleton et al., 2016). We used the *lavaan.survey* package (Oberski, 2014) to account for PISA's complex sampling design in our SEM. This package allows us to use the final student weight and its 80 replicates in the PISA dataset in the SEM. In the end, we aggregated the final parameter estimates and calculated the final standard error based on the combined average sampling and imputation variance of the estimates (Rubin, 2004).

The variation in the sample sizes of the six different subgroups can be considered as a limitation for the current study (e.g., $n = 990$ immigrants in the USA and $n = 11,249$ non-immigrants in the UK) (see Table 2). Both very small and very large sample sizes may influence the statistical inference; therefore, caution must be taken. A smaller sample size may have less power to detect significant relationships in the population, which leads to type II error. On the other hand, larger samples may cause the detection of a false significance, which leads to a type I error (Raudenbush & Bryk, 2002).

Results

Descriptive Statistics

Descriptive statistics of independent variables for immigrants and non-immigrants are reported for the entire sample in Table 3.

Results of SEM

The results of the direct and indirect effects of the SEM for Australia for non-immigrant and immigrant students are provided in Table 4. A growth mindset is positively related to science achievement for both non-immigrant (β = .206, $p < .001$) and immigrant students (β = .249, $p < .001$). Resilience is positively related to science achievement for non-immigrants (β = .036, $p < .05$); however, it is not significantly related to science achievement for immigrants. The attitudes toward school are

Table 4. SEM Results for Australia.

Direct effects	Immigrant	Non-immigrant
GM $\rightarrow$ Science	0.249*** (2.296)[a]	0.206*** (1.258)
R $\rightarrow$ Science	−0.026 (2.195)	0.036* (1.439)
AS $\rightarrow$ Science	0.074** (2.215)	0.054*** (1.151)
GM $\rightarrow$ AS	0.095*** (0.026)	0.089*** (0.017)
R $\rightarrow$ AS	0.108*** (0.029)	0.159*** (0.017)
Sex $\rightarrow$ Science	−0.054* (5.016)	−0.033** (2.351)
SES $\rightarrow$ Science	0.253*** (2.520)	0.278*** (1.420)
GM $\leftrightarrow$ R	0.140*** (0.030)	0.148*** (0.013)
Indirect effects		
GM $\rightarrow$ AS $\rightarrow$ Science	0.007** (0.303)	0.005*** (0.161)
R $\rightarrow$ AS $\rightarrow$ Science	0.008** (0.296)	0.009*** (0.177)
Model fit indices	CFI = 0.933, TLI = 0.911, RMSEA = 0.069, SRMR = 0.051	CFI = 0.923, TLI = 0.898, RMSEA = 0.075, SRMR = 0.059

Note. Standard errors are in parentheses. GM = growth mindset; R = resilience; AS = attitudes toward school.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

positively related to science achievement for both non-immigrants (β = .054, $p < .001$) and immigrants (β = .074, $p < .01$). Growth mindset (β = .089, $p < .001$) and resilience (β = .159, $p < .001$) are positively related to attitudes toward school for non-immigrant students as well as for immigrants (β = .095, $p < .001$ and β = .108, $p < .001$, respectively).

One of our research objectives is to examine how attitudes toward school might mediate the effects of growth mindset and resilience on student science achievement. For non-immigrant students, growth mindset (β = .005, $p < .001$) and resilience (β = .009, $p < .001$) have positive and significant indirect effects on student science achievement through attitudes. Similarly, for immigrants, the indirect effects of growth mindset (β = .007, $p < .01$) and resilience (β = .008, $p < .01$) on science achievement are significant.

The results of the direct and indirect effects of the SEM for the United Kingdom are provided in Table 5. A growth mindset is positively related to science achievement for non-immigrants (β = .148, $p < .001$) and also for immigrant students (β = .133, $p < .001$). On the other hand, resilience is not significantly related to science achievement neither for non-immigrants nor for immigrants. The attitudes toward school are positively related to science achievement for non-immigrants (β = .038, $p < .01$); however, it is not significantly related to science achievement for immigrants. Growth mindset (β = .114, $p < .001$) and resilience (β = .143, $p < .001$) are positively related to attitudes for non-immigrants as well as for immigrants (β = .094, $p < .01$ and β = .154, $p < .01$ respectively).

In terms of the indirect effects, growth mindset (β = .004, $p < .05$) and resilience (β = .006, $p < .05$) have positive and significant indirect effects on student

science achievement through attitudes toward school for non-immigrants. However, for immigrants, the effects are not significant for growth mindset or resilience.

The results of the direct and indirect effects of the SEM for the United States are provided in Table 6. A growth mindset is positively related to science achievement for both non-immigrants (β = .238, $p < .001$) and immigrants (β = .180, $p < .001$). Resilience is not significantly related to science achievement for non-immigrants, but for immigrants, this effect is significant (β = .096, $p < .05$). The attitudes toward school are not significantly related to science achievement for non-immigrants or immigrants. Growth mindset (β = .076, $p < .001$) and resilience (β = .114, $p < .001$) are positively related to attitudes for non-immigrants. For immigrants, only resilience is positively related to attitudes (β = .143, $p < .01$). Growth mindset and resilience did not show any significant indirect effects on student science achievement through attitudes toward school for non-immigrant students. Similarly, the indirect effects of growth mindset and resilience were not significant for immigrants.

Discussion and Recommendations

The purpose of this study was to examine the impact of the direct effects of students' growth mindset, resilience and attitudes toward school and the indirect effects of growth mindset and resilience on science achievement for immigrant and non-immigrant student groups in three anglophone countries. SEM analyses were conducted with PISA 2018 science data from Australia, the United Kingdom, and the United States. Students' sex and SES were used as covariates.

Table 5. SEM Results for the United Kingdom.

Direct effects	Immigrant	Non-immigrant
GM → Science	0.133*** (3.379)[a]	0.148*** (1.419)
R → Science	−0.064 (3.757)	0.010 (1.679)
AS → Science	0.033 (3.848)	0.038** (1.330)
GM → AS	0.094** (0.039)	0.114*** (0.021)
R → AS	0.154** (0.051)	0.143*** (0.023)
Sex → Science	−0.003 (6.686)	−0.035 (3.623)
SES → Science	0.292*** (3.170)	0.308*** (1.972)
GM ↔ R	0.203*** (0.040)	0.171*** (0.017)
Indirect effects		
GM → AS → Science	0.003 (0.418)	0.004* (0.195)
R → AS → Science	0.005 (0.640)	0.006* (0.225)
Model fit indices	CFI = 0.948, TLI = 0.930, RMSEA = 0.061, SRMR = 0.046	CFI = 0.914, TLI = 0.885, RMSEA = 0.075, SRMR = 0.059

Note. Standard errors are in parentheses. GM = growth mindset; R = resilience; AS = attitudes toward school.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6. SEM Results for the United States.

Direct effects	Immigrant	Non-immigrant
GM → Science	0.180*** (3.300)[a]	0.238*** (1.604)
R → Science	0.096* (3.582)	−0.003 (1.943)
AS → Science	0.039 (3.624)	−0.001 (1.592)
GM → AS	0.035 (0.056)	0.076*** (0.019)
R → AS	0.143** (0.050)	0.114*** (0.029)
Sex → Science	−0.030 (5.343)	−0.033 (3.169)
SES → Science	0.347*** (3.459)	0.324*** (2.029)
GM ↔ R	0.088 (0.043)	0.070** (0.022)
Indirect effects		
GM → AS → Science	0.001 (0.230)	0 (0.130)
R → AS → Science	0.006 (0.522)	0 (0.184)
Model fit indices	CFI = 0.922, TLI = 0.896, RMSEA = 0.073, SRMR = 0.050	CFI = 0.942, TLI = 0.923, RMSEA = 0.065, SRMR = 0.047

Note. Standard errors are in parentheses. GM = growth mindset; R = resilience; AS = attitudes toward school.
*$p < .05$. **$p < .01$. ***$p < .001$.

The common finding in all three countries was that a growth mindset was positively related to science achievement for both non-immigrant and immigrant students, and it had the strongest effect only after SES. The results regarding the effects of resilience and attitudes toward the school on science achievement were somewhat mixed. Resilience was positively related to science achievement for non-immigrants in Australia and immigrants in the US. The attitudes toward school were positively related to science achievement for both non-immigrants and immigrants in Australia and only for non-immigrants in the UK.

The positive effect of a growth mindset on achievement confirms the findings of previous research that used the PISA dataset (see Bernardo, 2021; Bernardo, Cai, & King, 2021; Gouëdard, 2021). This finding shows

that, regardless of immigration status, holding a growth mindset significantly contributes to students' scientific literacy measured by PISA. A growth mindset also positively influences attitudes toward school, influencing science achievement. This finding supports the OECD report on growth mindset (OECD, 2021). Gouëdard (2021) reported that a growth mindset in PISA is associated with a larger score gain for immigrants when compared to non-immigrants. We did not confirm this finding for three anglophone countries. However, we can claim that the growth mindset influences immigrant students' science achievement at least as much as non-immigrant students' science achievement. Similar to previous research (see Blackwell et al., 2007; Jones et al., 2012; Tempelaar et al., 2015), the positive effect of a growth mindset on attitudes toward school was found in

this study. In other words, students who endorsed a growth mindset showed more positive attitudes toward school regardless of their immigrant status, except for the UK. These students also reported higher levels of resilience, which were associated with higher science achievement to some degree. The validation of indirect effects of attitudes through growth mindset and resilience did not yield significant results. Hence, it is advised for future research to consider and investigate alternative models.

The most important implication of this study is to help students develop a growth mindset, regardless of their immigration status. The most practical way is to help them understand the elasticity of the brain and the malleability of intelligence (Dweck, 2014). This can be possible through interventions, and previous research demonstrated positive results (i.e., DeBacker et al., 2018; Paunesku et al., 2015; Rattan et al., 2015). Growth mindset interventions can convey that students' intelligence is not fixed, and intelligence can develop when students work hard and practice. The brain makes new connections when working on challenging tasks. Many scientists we know are not "born geniuses" but rather "hard workers." Researchers claim that interventions can be low-cost without extensive involvement of researchers or the training of teachers. They can even be online through reading materials and writing assignments about the brain's ability to grow through practice and study (Paunesku et al., 2015; Yeager et al., 2019). These interventions are especially important for students at critical developmental turning points, such as adolescence, to make sense of the challenges (Yeager et al., 2019). However, Brez et al. (2020) warn against one-time interventions and suggest that continued interventions that combine a growth mindset with other psychological elements can be more effective in increasing achievement. Regarding immigrant students' science achievement, resilience was a predictor in the US, and attitudes toward school was a predictor in Australia; therefore, intervention studies might consider including these psychological elements alongside mindset in these countries.

Another implication could be supporting teachers to learn more about growth mindset and training them on how their instructional practices can promote growth mindset (Park et al., 2016). Teachers have great potential to influence the mindsets of their students through their behavior and instruction (Rattan et al., 2012). A recent study showed that some teachers associate a fixed mindset with the immigration status or SES of students (Patrick & Joshi, 2019). Immigrant students can be negatively influenced if they implicate this view in their instructional practices. Teachers rather should be aware of the effect of a growth mindset on immigrant students, and they should try to promote it for all students.

This study tested a model regarding self-theories and achievement for immigrant students who were not highlighted in this line of research before. However, some limitations need precaution. One of the limitations of this study was that OECD's specifications of self-theories were used, which were related to general mindset and resilience. Claiming that mindsets about specific domains exist independently, recent studies used domain-specific mindsets to explain the differences in student achievement (Hwang et al., 2019; Lou & Noels, 2019). It is argued that such domain-specific beliefs can be better predictors of academic performance than general beliefs (Bandura, 2006). These arguments can be tested by conducting similar studies using subject-specific self-theories, such as self-theories related to science learning. Another limitation, which was already mentioned in the methodology, was that a one-item measure was used in this study. Even though the item related to mindset is very similar to those items in Dweck's (2007) original mindset scale, a one-item measure of mindset was previously used by other researchers (see Bernardo, Cai, & King, 2021; Bernardo, 2021; Hwang et al., 2019; Nix et al., 2015), a three-item model (as in the original scale) could have better psychometric properties.

In terms of attitudes toward school, the current study found differential results. The attitudes toward school seem to be effective in achievement for immigrants in Australia. This finding is consistent with those of Borger's (2021) study. Islam et al. (2022) indicate that Australia's immigrants are mainly of Chinese, Indian, and Vietnamese origin who tend to have strong beliefs in the value of education. This may manifest itself as more positive attitudes toward school and, thus, greater achievement. As for immigrants in the UK and the USA, attitudes toward school did not play a significant role in PISA achievement. This finding contradicts Burgess and Heller-Sahlgren's (2018) study in which they used PISA 2015 data for England. As Miyamoto et al. (2020) put it, there is variation across immigrant groups in terms of educational attitudes and motivation. This might be the case for immigrants in the UK and the USA. As challenging as it might be due to sample sizes, further studies are recommended to investigate immigrants' motivation and achievement by taking their country of origin or motives for immigration into consideration.

Conclusion

The findings of this study suggest that no matter the immigration status, a growth mindset profoundly influences students' science achievement. This finding is especially noteworthy for scientific literacy and STEM education. Bostwick et al. (2019) highlight that sustaining a growth mindset throughout schooling may help

students engage and commit to STEM fields. Research suggests that when students do not have a growth mindset, they do not put much effort into learning when faced with difficulties, which often brings failure (Yeager & Dweck, 2012). Rather than working hard on the subjects they struggle with, they prefer to avoid the subject altogether and possibly change their career path (Dweck, 2007). As an important implication, growth mindset interventions, which can be carried out via simple reading materials and writing assignments, can be used to boost the success of the students in science and scientific literacy.

Data Availability Statement included at the end of the article

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