

*Association of Engagement, Drive and Self-beliefs to Academic Resilience:
An Analysis of Data from PISA 2012*

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Abstract

This article explored the association of three broad themes – students’ school engagement, drive and motivation, and self-beliefs, dispositions and participation in mathematics activities - to academic resilience. The analysis was based on the mathematics performance of students in the Programme for International Student Assessment (PISA) 2012. Academically resilient students (RES) were disadvantaged in terms of their economic, social and cultural status but have transcended their circumstances to perform above expectations. On the other hand, disadvantaged low achievers (DLA) were disadvantaged students who have performed below expectations. The differences between RES and DLA students in the indicators under each theme were first examined individually. A logistic regression model was next used to explore which of the indicators, when analysed simultaneously, were associated with higher likelihood of academic resilience. A cross-country comparison using multidimensional scaling analysis was made of the similarities and differences in the indicators which were associated with academic resilience. Results showed that students’ self-efficacy has the strongest association to academic resilience. Students’ self-concept and intrinsic motivation were also positively associated with resilience but the associations were weaker. The limitations and implications of the findings were discussed.

Keywords: academic resilience, engagement, drive, self-beliefs

Note: The views expressed in this article are the authors’ and do not necessarily reflect those of the Ministry of Education, Singapore.

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Introduction

This article explored the association of three broad themes – students’ school engagement, drive and motivation, and their self-beliefs, dispositions and participation in mathematics activities - to academic resilience. The analysis was based on students’ mathematics performance in the Programme for International Student Assessment (PISA) 2012.

In the context of PISA, academically resilient students (RES) were defined as belonging to the bottom quartile of economic, social and cultural status (ESCS) in their countries but scored within the top quartile when ranked by the difference between actual and expected performance based on the regression of all students’ mathematics scores on ESCS. On the other hand, disadvantaged low achievers (DLA) were those who belonged to the bottom quartile of ESCS but scored within the bottom quartile when ranked by the difference between actual and expected performance.

This article first examined the differences between RES and DLA students in each of the indicators under the broad themes. A logistic regression model was next used to explore which of the indicators, when analysed simultaneously, were associated with higher likelihood of academic resilience. A cross-country comparison was made of the similarities and differences in the indicators associated with academic resilience using multidimensional scaling (MDS) analysis. Implications for educational practice and research were discussed.

Factors Associated with Academic Resilience

Data from PISA 2006 (Science) showed that, for the theme of approaches to learning motivation to learn science, engagement in science activities outside the school, confidence in science abilities, and perspectives towards science-related careers - students’ confidence in their academic abilities exhibited one of the strongest associations to resilience, in particular, self-efficacy (strongest association) and self-concept. Motivation, and in particular internal rather than instrumental motivation was also associated with resilience but the association was weaker (OECD, 2011). PISA 2009 (Reading) did not have these measures of confidence (OECD, 2010). Instead, a cross-country analysis of PISA 2009 showed that among the approaches to learning – memorisation strategies, elaboration strategies, control strategies, metacognition (understanding and remembering) and metacognition (summarising) - the awareness of both metacognition strategies were among the strongest associations of resilience (Chua, 2013).

Data from PISA 2006 also showed that, for the theme of engagement in science courses – the number of science courses students took, and the amount of time they spent learning science at school - the associations were strong between attending a compulsory general science course (second strongest association) and more learning time at school in science with the likelihood of being resilient (OECD, 2011). In the cross-country analysis of PISA 2009, results showed that for the theme of engagement in reading activities, students’ enjoyment of reading and diversity of online reading activities were among those indicators exhibiting stronger associations to resilience but not the time spent reading for enjoyment (Chua, 2013). Perhaps it’s the quality of the activity rather than the amount of time spent that mattered more.

Research Questions

The research questions addressed in this study were: (i) What were the differences in the indicators of engagement, drive and self-beliefs between RES and DLA students? (ii) Which particular indicators were associated with higher likelihood of academic resilience? and (iii) What were the similarities and differences of resilient students across countries?

Methodology

Participants

Data used in the study came from the PISA 2012 database. About 510,000 students completed the assessment in 2012, representing about 28 million 15-year-olds in the schools of the 65 participating countries and economies. The ESCS index, used in this study, captured aspects of a student's family and home background by combining information on parents' education and occupations, and home possessions. The focus of the study was however on the 43,000 disadvantaged students from the top performing countries in terms of their percentages of resilient students. The countries selected for analysis include countries from the regions of Asia (9 countries/economies), Europe (11) and North America (1) (OECD 2013a).

Procedure

From the regression of PISA plausible mathematics scores against ESCS (including its squared term), residual scores for each student were obtained. These residuals which measure the differences between actual and expected performance were used to identify two groups of students: (i) Resilient (RES) students - students who were in the bottom quartile of ESCS but were among the top quartile of mathematics residual scores; and (ii) Disadvantaged low achievers (DLA) - students who were in the bottom quartile of ESCS and also among the bottom quartile of mathematics residual scores.

Student weights were normalised such that the sum of weights for each country was the same for all the countries. In the normalisation, the sum of weights across the countries was made equal to the number of students in the dataset while maintaining the same proportion of weights as in the original student weights within each country. Variance estimations were done using the balanced repeated replication (BRR) method. Only one plausible value was used in this study as this does not really make a substantial difference when large samples are involved (OECD, 2009).

The PISA indices which represent the indicators of students' engagement, drive and self-beliefs were compared to provide insights into the profiles of the two groups of students. Tests performed on the mean value of the indicators for each group indicate if there were any statistical differences between them. To better understand the associations of these indicators to academic resilience, they were then considered together in a logistic regression with the logarithm of the odds of being academically resilient as the response variable. To study the similarities and differences in the profiles of resilient students across the countries, a multidimensional scaling (MDS) analysis was performed on those indicators associated with academic resilience.

Measures

The indicators used in the analysis could be categorised as: (i) control variables e.g. ESCS and gender; (ii) school engagement e.g. truancy (which reports on the number of times students had skipped classes or days of school in the two weeks before the PISA test) and sense of belonging (students' feelings of social connectedness, happiness and satisfaction at school); (iii) drive and motivation e.g. self-responsibility for failing in mathematics (which students with high value in this index tend to attribute failure to themselves and not to other factors) and intrinsic motivation (whether students enjoy mathematics and work hard because they enjoy the subject); and (iv) self-beliefs, dispositions and participation in mathematics activities e.g. mathematics self-efficacy (the extent to which students believe in their own ability to handle mathematical tasks effectively and overcome difficulties) and mathematics self-concept (students' beliefs in their own mathematics abilities) (OECD, 2013b). The list of indicators is shown in Table 1.

Missing Data

ESCS is a critical indicator in this study as it was used to identify the resilient students. As such, students with missing ESCS values were excluded from the analysis. For all other indicators, multiple imputations were done to account for the variability introduced by the process of selecting a value for the missing data point (Rubin, 1987). The imputations were necessary as otherwise the sample size would be severely reduced when it comes to the logistic regression model.

All analyses were performed in SAS which includes PROC SURVEYMEANS, PROC SURVEYREG, PROC SURVEYLOGISTIC, PROC MI, PROC MIANALYZE and PROC MDS. Multiple imputation and analysis of imputed data were done in three steps: Step 1 - multiple imputation of missing data using PROC MI (five sets of imputed data were produced); Step 2 – the imputed data sets were then analysed using the appropriate SAS procedures e.g. PROC SURVEYREG; and Step 3 – the analysis of the estimates and standard errors from Step 2 were done using PROC MIANALYZE (Berglund, 2009).

Results

What were the differences in the indicators of engagement, drive and self-beliefs between RES and DLA students?

On average, there were statistical differences ($p < 0.05$) between resilient students (RES) and disadvantaged low achievers (DLA) in all the indicators of interest except one (sense of belonging to school). For students' engagement, RES students scored higher in their attitude towards school (both in terms of what they have learned, labelled as "learning outcomes" and what they think about their school, labelled as "learning activities") but were late for school, skipped school and skipped classes less often. For students' drive and motivation, RES students scored higher in perseverance, openness to problem solving, both intrinsic and instrumental motivation and control in success for mathematics but scored lower in their perceived self-responsibility for failing in mathematics. For self-beliefs, RES students scored higher

in self-efficacy, self-concept, mathematics intentions and mathematics behaviour but were lower in mathematics anxiety and subjective norms.

While the results were within expectations, RES students reported that they encountered more negative social norms towards mathematics (mean score = -0.214) compared to DLA students (mean score = -0.111). They nevertheless have transcended these negative norms to perform above expectations.

Table 1 presents the detailed descriptive statistics of RES and DLA students in the indicators of interest.

Table 1: Descriptive Statistics for Resilient Students (RES) and Disadvantaged Low Achievers (DLA)

Indicator	RES		DLA		Difference Tests	
	Mean	SE	Mean	SE	t Value	Pr > t
Reading score	565.51	0.72	331.55	1.00	183.75	<.0001
Control variables						
Economic, social and cultural status (ESCS)	-1.465	0.011	-1.242	0.017	-10.77	<.0001
ESCS squared	2.726	0.044	1.930	0.055	10.95	<.0001
Gender (Female=1; male=0)	0.481	0.006	0.499	0.014	-1.21	0.2307
Immigration background (Yes=1; No=0)	0.186	0.006	0.242	0.014	-3.55	0.0004
Home language (is test lang=1; otherwise=0)	0.154	0.005	0.235	0.014	-5.28	<.0001
Grade (compared to modal grade)	-0.181	0.008	-0.690	0.027	18.19	<.0001
Engagement with and in school						
Truancy - Late for school	1.293	0.006	1.738	0.024	-18.09	<.0001
Truancy - Skip whole school day	1.110	0.004	1.382	0.016	-16.65	<.0001
Truancy - Skip classes within school day	1.130	0.005	1.374	0.018	-13.01	<.0001
Sense of Belonging to School	-0.180	0.012	-0.212	0.028	0.95	0.3459
Attitude towards School: Learning Outcomes	-0.066	0.012	-0.230	0.029	4.98	<.0001
Attitude towards School: Learning Activities	-0.220	0.015	-0.343	0.034	3.22	0.0022
Drive and motivation						
Perseverance	0.052	0.011	-0.324	0.028	11.75	<.0001
Openness for Problem Solving	-0.225	0.011	-0.535	0.028	10.35	<.0001
Self-responsibility for Failing in Math	-0.184	0.013	0.166	0.039	-8.79	<.0001
Control of Success in Mathematics	-0.032	0.014	-0.358	0.038	7.49	<.0001
Intrinsic Motivation for Mathematics	0.178	0.014	-0.267	0.028	14.07	<.0001
Instrumental Motivation for Mathematics	-0.045	0.012	-0.378	0.027	11.38	<.0001
Mathematics self-beliefs						
Mathematics Self-Efficacy	0.082	0.011	-0.743	0.041	19.92	<.0001
Mathematics Self-Concept	0.053	0.011	-0.511	0.026	20.00	<.0001
Mathematics Anxiety	-0.053	0.012	0.405	0.021	-17.00	<.0001
Mathematics Intentions	0.067	0.013	-0.275	0.025	11.81	<.0001
Subjective Norms in Mathematics	-0.214	0.012	-0.111	0.038	-2.58	0.0115
Mathematics Behaviour	0.069	0.016	-0.158	0.032	6.90	<.0001

Which particular indicators were associated with higher likelihood of academic resilience?

Results of the logistic regression model showed the following indicators to be statistically significant ($p < 0.05$): (i) positively associated with academic resilience - intrinsic motivation for mathematics, mathematics self-efficacy and mathematics self-concept; and (ii) negatively associated with academic resilience - truancy (all three indicators), sense of belonging to school, self-responsibility for failing in mathematics, control of success in mathematics, mathematics anxiety and subjective norms in mathematics. The details of the logistic regression analysis are given in Table 2.

Table 2: Results of Logistic Regression Analysis

Indicator	Estimate	SE	t for H0: Parameter=0	Pr > t	Odds Ratio (OR)
Intercept	0.410	0.115	3.57	0.0004	
Control variables					
Economic, social and cultural status (ESCS)	-0.998	0.123	-8.09	<.0001	
ESCS squared	-0.124	0.035	-3.59	0.0003	
Gender (Female=1; male=0)	0.041	0.041	0.99	0.3205	
Immigration background (Yes=1; No=0)	0.009	0.054	0.16	0.8710	
Home language (is test lang=1; otherwise=0)	-0.331	0.055	-6.03	<.0001	
Grade (compared to modal grade)	0.674	0.030	22.3	<.0001	
Engagement with and in school					
Truancy - Late for school	-0.318	0.024	-13.27	<.0001	0.73
Truancy - Skip whole school day	-0.506	0.040	-12.69	<.0001	0.60
Truancy - Skip classes within school day	-0.211	0.040	-5.29	<.0001	0.81
Sense of Belonging to School	-0.149	0.029	-5.17	<.0001	0.86
Attitude towards School: Learning Outcomes	-0.026	0.034	-0.78	0.4444	0.97
Attitude towards School: Learning Activities	-0.003	0.029	-0.1	0.9211	1.00
Drive and motivation					
Perseverance	0.002	0.026	0.09	0.9303	1.00
Openness for Problem Solving	-0.046	0.026	-1.74	0.0922	0.96
Self-Responsibility for Failing in Math	-0.092	0.020	-4.51	<.0001	0.91
Control of Success in Mathematics	-0.154	0.033	-4.62	0.0004	0.86
Intrinsic Motivation for Mathematics	0.093	0.037	2.51	0.0178	1.10
Instrumental Motivation for Mathematics	0.043	0.027	1.61	0.1086	1.04
Mathematics self-beliefs					
Mathematics Self-Efficacy	0.724	0.029	24.6	<.0001	2.06
Mathematics Self-Concept	0.198	0.033	6.07	<.0001	1.22
Mathematics Anxiety	-0.101	0.027	-3.67	0.0005	0.90
Mathematics Intentions	0.030	0.023	1.31	0.1966	1.03
Subjective Norms in Mathematics	-0.165	0.023	-7.06	<.0001	0.85
Mathematics Behaviour	-0.014	0.024	-0.56	0.5752	0.99

Table 2 highlights that among the indicators, self-efficacy has the strongest positive association with academic resilience and is the only indicator of interest which has a moderate effect size (odds ratio, OR = 2.06). Students' self-concept (OR = 1.22) and intrinsic motivation (OR = 1.10) were also positively associated with resilience but the associations were weaker.

The results from the logistic model (Table 2) were in general agreement with the analysis on the mean differences between RES and DLA students (Table 1). Where RES students scored higher - e.g. in intrinsic motivation, mathematics self-efficacy and self-concept - the logistic model showed that these indicators were associated with higher probability of resilience. On the other hand, where DLA students scored higher - e.g. in truancy, self-responsibility for failing and mathematics anxiety - the logistic model showed these indicators were associated with lower probability of resilience. Possible explanations for indicators which appeared to be not in agreement between the two analyses - e.g. perseverance, openness for problem solving and control of success - would include the presence of other indicators in the model exerting confounding or mediating effects on the indicator of interest.

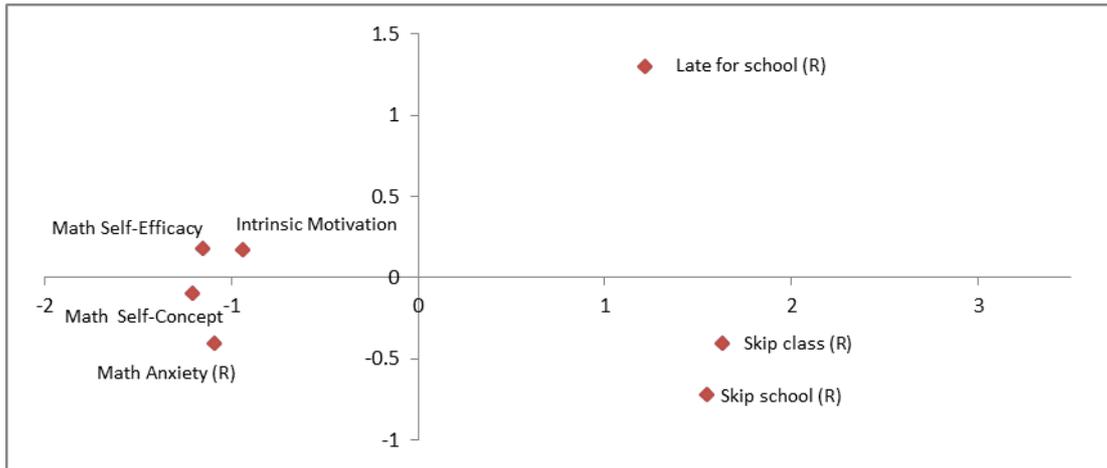
The results of the logistic model from this resilience study based on PISA 2012 (Mathematics) showed some similarities to that from PISA 2006 (Science). In both studies, students' confidence in their academic abilities was evidently associated to resilience, in particular, self-efficacy (strongest association in both) and self-concept. Similarly, intrinsic motivation was found to be statistically associated with resilience, though weaker, in both PISA 2012 and PISA 2006.

What were the similarities and differences of resilient students across countries?

The results of the logistic regression analysis showed that there were characteristics among resilient students, measured by the indicators, which were common across the countries being studied. In the following, an ordinal multidimensional scaling (MDS) analysis, based on the covariance matrix of the indicators, was used to study the relationship among these characteristics and to facilitate the classification of country profiles into clusters with similar characteristics exhibited by their resilient students.

For this purpose, indicators positively associated with resilience were examined. In addition, those of truancy and anxiety were included but the sign of these scores were reversed such that higher scores were now interpreted as being more favourable. The scores of indicators were ensured to be on the same scale.

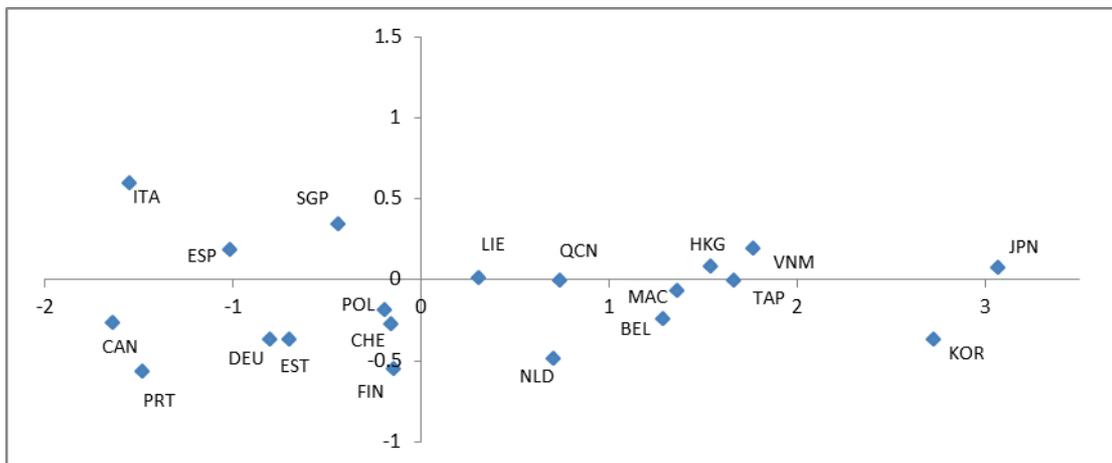
The fit of the resulting model to the data was acceptable with the measure, stress=0.03 (Kruskal, 1964). Figure 1 shows a visual representation of the structure of the indicators in a two-dimensional space where indicators close to one another tend to be more strongly correlated. The indicators of self-beliefs were posited at the negative or west end of dimension 1 while those of engagement were at the positive or east end of dimension 1. The sole indicator from the drive and motivation category i.e. intrinsic motivation was posited in close proximity to the indicators of self-beliefs. The data thus showed that the indicators concerned could be grouped roughly into two clusters – the self-beliefs and drive/motivation in one cluster and the engagement indicators in the other cluster.



(R) indicates that the sign of the values of the indicators have been reversed.

Figure 1: Visualizations of the positions of indicators on Dimensions 1 (x-axis) and 2 (y-axis)

Figure 2 shows the positions of the 21 countries corresponding to the indicator positions in Figure 1. In general, most of the European countries were clustered on the west side of dimension 1 where the prevalent indicators were those of self-beliefs and drive/motivation while most of the Asian countries were on the east end of dimension 1 where the prevalent indicators were those of engagement. There is a small cluster of countries near the middle of the map where the prevalent indicators were from both clusters. The data thus seemed to indicate that the geographical or cultural context has an influence on the prevalent indicators associated with resilience.



BEL(Belgium), CAN(Canada), CHE(Switzerland), DEU(Germany), ESP(Spain), EST(Estonia), FIN(Finland), HKG(Hong Kong-China), ITA(Italy), JPN(Japan), KOR(Korea), LIE(Liechtenstein), MAC(Macao-China), NLD(Netherlands), POL(Poland), PRT(Portugal), QCN(Shanghai-China), SGP(Singapore), TAP(Chinese Taipei), TUR(Turkey)(-4.8, 1.1), VNM(Vietnam)

Figure 2: Visualizations of the positions of 21 countries on Dimensions 1 (x-axis) and 2 (y-axis)

Discussions

Implications

The results of the study suggest that schools can play a role in promoting resilience by fostering disadvantaged students' self-beliefs, in particular self-efficacy. Fostering students' self-beliefs could involve, for example, restructuring learning to maximise opportunities for success (Martin & Marsh, 2003). Restructuring learning could

include breaking schoolwork into components so that students can experience small successes and individualising tasks to match students' capacities (McInerney, 2000). In addition, schools should also take steps to reduce truancy rate and anxiety as these were associated with lower likelihood of resilience.

Limitations

While the logistic regression analysis surfaced indicators associated with academic resilience, the associations do not imply causal relationships between these indicators and academic resilience. Furthermore, the indicators analysed were largely confined to the student domain. School, family and community factors could also influence the academic resilience of disadvantaged students (e.g. Siraj-Blatchford et al., 2011, Novotný, J.S., 2011). The findings should be interpreted with caution as by PISA 2012 design, information was available for only two thirds of students per question in the rotated parts of the student questionnaire (OECD, 2014), necessitating the need to impute missing data especially when the indicators were analysed simultaneously.

Conclusion

This study on PISA 2012 showed that students' self-efficacy has the strongest association with academic resilience. Students' self-concept and intrinsic motivation were also positively associated with resilience but the associations were weaker. In contrast, students' truancy rate and mathematics anxiety were associated with lower likelihood of resilience. The prevalent indicators associated with resilience were observed to be influenced by geographical or cultural context.

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