



An Analysis Of Singapore's School Performance In The PISA Global Education Survey

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Agenda



**Project
Overview**



**Data
Preparation**



Data Analysis

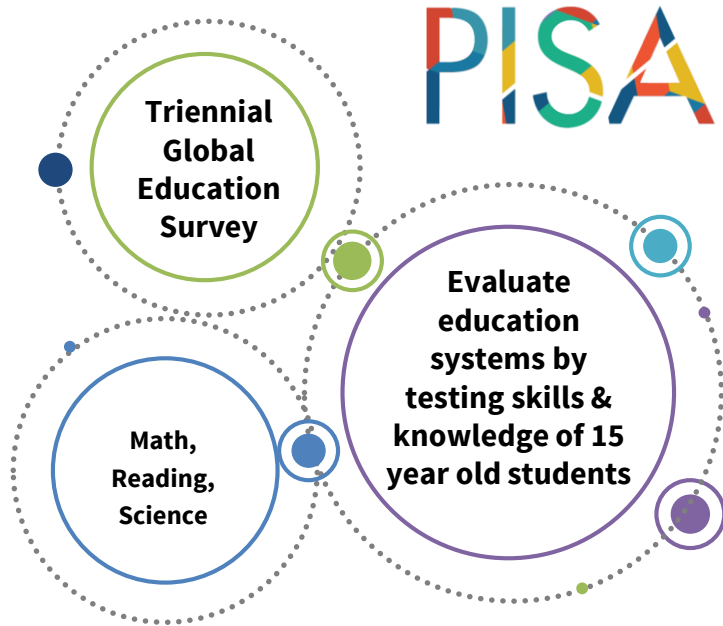


Insights



Conclusion

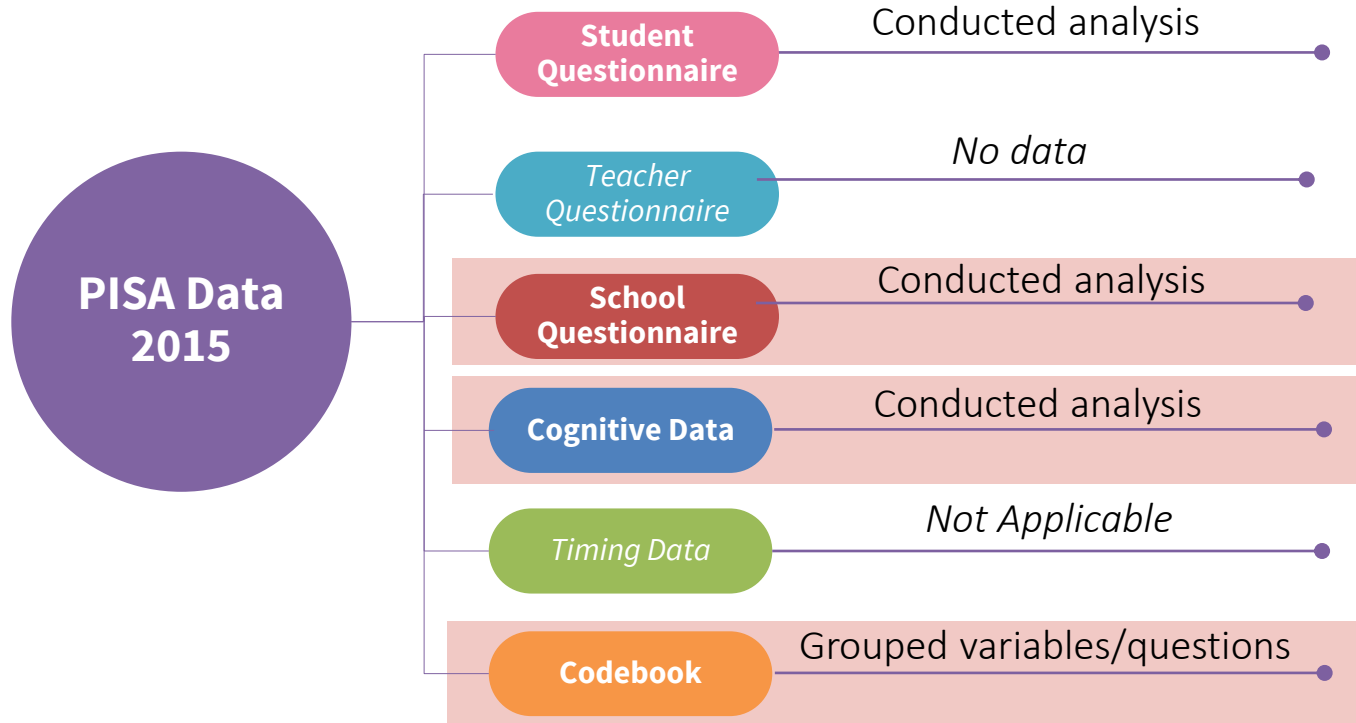
Introduction



HOW DID SINGAPORE STUDENTS FARE?

#1 Reading
Math
Science

Introduction





Background & Motivation



Ministry of Education
SINGAPORE

“Every school a good school”

HOWEVER,
the public sentiment is that **students do not start on an equal footing**



Background & Motivation

Past research findings:

Socioeconomically advantaged students tend to perform better than their disadvantaged peers regardless of countries and economies

Our finding:

There are indeed differences across schools



Background & Motivation



What determines the differences in results across schools in Singapore?

Should more support be given to students from less privileged backgrounds?





Background & Motivation

Past Research Finding

A student's performance is generally better when their socioeconomic status is higher, *regardless of countries and economies*



Hypothesis

Schools with **greater percentage of disadvantaged students** from a socioeconomic perspective tend to **perform more poorly** overall



Objective

We seek to explore the factors contributing to the differences in overall scores and science scores across all schools

Booklet ID	Reading	Math	Science
31 - 42	✓		✓
43 - 54		✓	✓
55 - 66	✓	✓	✓
67 - 78		✓	✓
79 - 90	✓		✓
91 - 96			✓



Methodology



Data Preparation

- 1 Sorting Explanatory Variables by Type
- 2 Excluding Variables with Missing Values



Data Analysis

- 1 Standard Least Squares Regression – Removing Correlated Variables
- 2 Decision Tree Analysis – Feature Selection for Categorical Variables
- 3 Stepwise Multiple Linear Regression – Identifying Variables that Matter



Insights & Recommendations



Methodology

- A regression model will be developed to explain why certain schools score better than others
- Multiple linear regression is the technique selected for our analysis as it allows us to use both continuous and categorical variables.

Explanatory variables:

- Derived from questions posted to the school

Response variables:

- Schools' mean overall score
- Schools' mean science score

Data Preparation

Sorting variables by type

Using the codebook (OECD), questions from the school questionnaire were sorted into:

1. Continuous,
 2. Ordinal, and
 3. Nominal
- variables by observing the question types

SC018Q01TA0 Teachers in TOTAL: Full-time	NUM	5.0	138	0 - 1327
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Figure: Example of continuous explanatory variable

SC009Q08TA Frequency of <the last academic year>. I pay attention to disruptive behaviour in classrooms.	1	Did not occur
	2	1-2 times during the year
	3	3-4 times during the year
	4	Once a month
	5	Once a week
	6	More than once a week

Figure: Example of ordinal explanatory variable

SC059Q06NA We have enough laboratory material that all courses can regularly use it.	1	Yes
	2	No

Figure: Example of nominal explanatory variable



Data Preparation

Excluding variables with missing values

Response Variables:

School ID 29 was removed due to missing values for majority of the questions

Explanatory Variables:

Arbitrary threshold created – no more than 20%, or 35.4 out of 177 missing data points should exist

“SC014Q01NA” was excluded

Data Analysis

STANDARD LEAST SQUARE REGRESSION

1 Removing Correlated Variables – Continuous Variables

- 3 iterations of standard least squares regression were conducted
- Variables removed conservatively
- Observed Correlation of Estimates (Threshold: +/- 0.7)

Multivariate							
Correlations							
	SC002Q01TA	SC002Q02TA	SC003Q01TA	SC004Q01TA	SC004Q02TA	SC004Q03TA	SC004Q04NA
SC002Q01TA	1.0000	-0.2327	0.0286	0.2784	-0.0267	-0.0268	-0.1190
SC002Q02TA	-0.2327	1.0000	0.1203	0.2068	0.2119	0.2084	0.1523
SC003Q01TA	0.0286	0.1203	1.0000	0.3660	0.2635	0.2746	0.2101
SC004Q01TA	0.2784	0.2068	0.3660	1.0000	0.3320	0.3311	0.2281
SC004Q02TA	-0.0267	0.2119	0.2635	0.3320	1.0000	0.9972	0.8678
SC004Q03TA	-0.0268	0.2084	0.2746	0.3311	0.9972	1.0000	0.8630
SC004Q04NA	-0.1190	0.1523	0.2101	0.2281	0.8678	0.8630	1.0000
SC004Q05NA	0.0261	-0.0735	-0.3623	-0.2836	-0.2188	-0.2208	-0.1549
SC004Q06NA	0.3575	0.1784	-0.0648	0.2362	0.2830	0.2849	0.1796

Figure: Table showing correlation of estimates of sampled variables from the first iteration of standard least square regression of overall scores given all continuous variables

Data Analysis

STANDARD LEAST SQUARE REGRESSION

1 Removing Correlated Variables

- Variance Inflation Factors (VIF) is useful in determining multicollinearity within variables
- Final check for multicollinearity by ensuring VIFs are less than 8

Response Mean(Standardized Scoring)

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t	VIF
Intercept	0.3916704	0.071393	5.49	<.0001*	.
SC004Q01TA	7.2371e-5	0.000101	0.72	0.4748	1.7009541
SC004Q02TA	-2.17e-5	0.000154	-0.14	0.8880	3.58459
SC004Q04NA	0.0001028	0.000132	0.78	0.4404	3.0475662
SC004Q05NA	-0.002128	0.001008	-2.11	0.0380*	1.5680619
SC004Q06NA	0.0001241	0.000362	0.34	0.7325	2.0557817
SC004Q07NA	6.2143e-5	0.000106	0.59	0.5584	1.2586255
SC016Q01TA	0.0001582	0.000547	0.29	0.7732	1.7319271
SC018Q05NA01	-4.167e-5	0.000493	-0.08	0.9329	2.3554889
SC018Q05NA02	0.0059182	0.002708	2.19	0.0320*	1.3912684
SC018Q06NA01	0.0015814	0.000842	1.88	0.0644	3.2680948
SC018Q06NA02	-0.009765	0.007533	-1.30	0.1988	1.7459349
SC018Q07NA02	0.1366489	0.047398	2.88	0.0051*	1.3756713
SC019Q03NA01	0.0037439	0.001626	2.30	0.0241*	3.3178211
SC019Q03NA02	-0.001898	0.009111	-0.21	0.8355	1.4323192
SC048Q01NA	0.0004739	0.000281	1.69	0.0956	1.2995682
SC048Q02NA	-0.000291	0.001847	-0.16	0.8752	1.5322895
SC048Q03NA	-0.004281	0.000873	-4.90	<.0001*	1.7201939
SC064Q01TA	0.0001316	0.000306	0.43	0.6684	1.1726238
SC064Q02TA	-0.000193	0.000316	-0.61	0.5423	1.248144
SC064Q03TA	-0.000432	0.000907	-0.48	0.6347	1.4140444
SC064Q04NA	0.0012861	0.000794	1.62	0.1096	1.4411688
SC025Q01NA	2.5281e-5	0.000327	0.08	0.9386	1.2461476

Figure: Table showing Variance Inflation Factor (VIF) of variables from the final iteration of standard least square regression of overall scores given selected continuous variables



Data Analysis

DECISION TREE ANALYSIS

2 Feature Selection

- Feature selection conducted due to the excessive number of categorical explanatory variables
- Determining number of splits:
 - R-square value continued rising and the split history graph did not reach a plateau
 - Saturation point reached

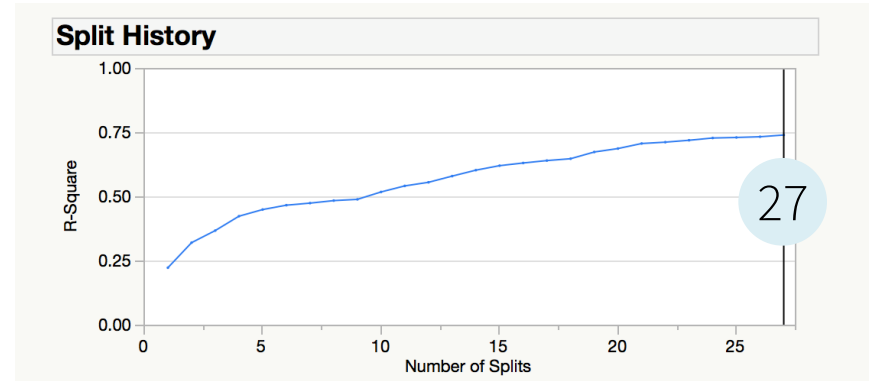


Figure: Graph showing number of splits against R-square for decision tree (Overall Scores)

Data Analysis

DECISION TREE ANALYSIS

2 Feature Selection

- All variables with positive logworth (greater than zero) will be selected

Column Contributions			
Term	Number of Splits	SS	Portion
SC012Q06TA	1	0.68262638	0.3032
SC053Q05NA	1	0.296485	0.1317
SC035Q10TB	1	0.16964001	0.0753
SC061Q01TA	1	0.14294961	0.0635
SC063Q04NA	2	0.10781184	0.0479
SC010Q06TC	2	0.10367029	0.0460
SC034Q04TA	2	0.08628422	0.0383
SC009Q05TA	1	0.07864303	0.0349
SC053Q07TA	1	0.07335942	0.0326
SC012Q02TA	1	0.07142401	0.0317
SC010Q04TE	1	0.07023804	0.0312
SC010Q12TE	1	0.05318189	0.0236
SC010Q02TE	1	0.05165119	0.0229
SC059Q08NA	1	0.04238636	0.0188
SC010Q01TC	1	0.04081201	0.0181
SC032Q04TA	1	0.03176841	0.0141
SC010Q02TA	1	0.02975941	0.0132
SC009Q10TA	2	0.0287976	0.0128
SC037Q09TA	1	0.02434131	0.0108
SC017Q01NA	1	0.02246203	0.0100
SC010Q09TE	1	0.02199972	0.0098
SC035Q11NB	1	0.0147574	0.0066
SC010Q10TB	1	0.006368	0.0028

Figure: Table showing categorical variables with positive logworth values (Overall Scores)

3 Identifying Variables that Matter

Selection of Direction for Stepwise Regression Model

(Selection Criteria for Variables: p -value < 0.05)

- Backward, forward and mixed stepwise regression models were generated
- Backward stepwise resulted in the highest adjusted R-square

Fit Group	
Response Mean(Standardized Scoring)	
Summary of Fit	
RSquare	0.740088
RSquare Adj	0.705586
Root Mean Square Error	0.071246
Mean of Response	0.521251
Observations (or Sum Wgts)	129

Figure: Summary of Fit for backward stepwise regression model (Overall Scores)

Fit Group	
Response Mean(Science %)	
Summary of Fit	
RSquare	0.733729
RSquare Adj	0.690935
Root Mean Square Error	0.071291
Mean of Response	0.513482
Observations (or Sum Wgts)	131

Figure: Summary of Fit for backward stepwise regression model (Science Scores)

Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

3 Identifying Variables that Matter

Variables explain 70.56% of the variation in the mean school overall scores

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RSquare	0.740088
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Root Mean Square Error	0.071246
Mean of Response	0.521251
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Figure: Summary of Fit for backward stepwise regression model (Overall Scores)

Variables explain 69.09% of the variation in the mean school science scores

Fit Group	
Response Mean(Science %)	
Summary of Fit	
RSquare	0.733729
RSquare Adj	0.690935
Root Mean Square Error	0.071291
Mean of Response	0.513482
Observations (or Sum Wgts)	131

Figure: Summary of Fit for backward stepwise regression model (Science Scores)



Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Overall Scores

Fit Group				
Response Mean(Standardized Scoring)				
Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.5241833	0.029769	17.61	<.0001*
SC018Q07NA02	0.0782989	0.038733	2.02	0.0456*
SC053Q07TA{1}	0.0322451	0.009551	3.38	0.0010*
SC053Q05NA{1}	0.0233774	0.007737	3.02	0.0031*
SC063Q04NA{1}	0.0135695	0.006594	2.06	0.0419*
SC009Q05TA{3&4-5&6}	0.0122029	0.007147	1.71	0.0905
SC034Q04TA{2&1-4&3&5}	0.0058602	0.007109	0.82	0.4115
SC019Q03NA01	0.0044681	0.000794	5.63	<.0001*
SC035Q11NB{1}	-0.001072	0.006711	-0.16	0.8733
SC004Q05NA	-0.0024	0.000721	-3.33	0.0012*
SC048Q03NA	-0.004258	0.000614	-6.93	<.0001*
SC034Q04TA{2-1}	-0.01131	0.009707	-1.17	0.2464
SC009Q05TA{2-3&4&5&6}	-0.017561	0.01426	-1.23	0.2207
SC010Q01TC{0}	-0.018819	0.008205	-2.29	0.0237*
SC009Q05TA{3-4}	-0.020274	0.008714	-2.33	0.0218*
SC037Q09TA{1-3&2}	-0.025456	0.015931	-1.60	0.1129

Figure: Table showing variables from backward stepwise regression model sorted by parameter estimates in descending order (Overall Scores)

Term	Question	Response Options	Estimate (Overall)
SC063Q04NA{1}	School includes parents in school decisions.	1 Yes 2 No	0.0135695
SC018Q07NA02	Teachers with an <ISCED Level 6> qualification: Part-time	(continuous variable)	0.0782989

Schools should increase parents involvement in school decisions

- In line with recent trends – schools aim to engage parents beyond the “superficial” purposes (i.e. fundraising)
- Potential explanation – parents feel more ownership when they get to participate in school decisions as it encourages them to contribute their valuable knowledge, skills and viewpoints

Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Overall Scores

Fit Group				
Response Mean(Standardized Scoring)				
Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.5241833	0.029769	17.61	<.0001*
SC018Q07NA02	0.0782989	0.038733	2.02	0.0456*
SC053Q07TA{1}	0.0322451	0.009551	3.38	0.0010*
SC053Q05NA{1}	0.0233774	0.007737	3.02	0.0031*
SC063Q04NA{1}	0.0135695	0.006594	2.06	0.0419*
SC009Q05TA{3&4-5&6}	0.0122029	0.007147	1.71	0.0905
SC034Q04TA{2&1-4&3&5}	0.0058602	0.007109	0.82	0.4115
SC019Q03NA01	0.0044681	0.000794	5.63	<.0001*
SC035Q11NB{1}	-0.001072	0.006711	-0.16	0.8733
SC004Q05NA	-0.0024	0.000721	-3.33	0.0012*
SC048Q03NA	-0.004258	0.000614	-6.93	<.0001*
SC034Q04TA{2-1}	-0.01131	0.009707	-1.17	0.2464
SC009Q05TA{2-3&4&5&6}	-0.017561	0.01426	-1.23	0.2207
SC010Q01TC{0}	-0.018819	0.008205	-2.29	0.0237*
SC009Q05TA{3-4}	-0.020274	0.008714	-2.33	0.0218*
SC037Q09TA{1-3&2}	-0.025456	0.015931	-1.60	0.1129

Term	Question	Response Options	Estimate (Overall)
SC063Q04NA{1}	School includes parents in school decisions.	1 Yes 2 No	0.0135695
SC018Q07NA02	Teachers with an <ISCED Level 6> qualification: Part-time	(continuous variable)	0.0782989

Schools should increase the number of part-time teachers with a degree from a second stage of tertiary education (i.e. doctorate)

Figure: Table showing variables from backward stepwise regression model sorted by parameter estimates in descending order (Overall Scores)



Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Science Scores

Fit Group				
Response Mean(Science %)				
Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.5779303	0.040173	14.39	<.0001*
SC053Q07TA[1]	0.0300571	0.009734	3.09	0.0025*
SC053Q05NA[1]	0.0269779	0.007604	3.55	0.0006*
SC009Q10TA{2-3&4&5&6}	0.0240565	0.02022	1.19	0.2367
SC009Q05TA{3&4-5&6}	0.011446	0.007746	1.48	0.1423
SC019Q03NA01	0.004913	0.001129	4.35	<.0001*
SC034Q04TA{2&1-4&3}	0.0036358	0.008263	0.44	0.6608
SC035Q07TB[1]	0.0026934	0.009043	0.30	0.7664
SC064Q04NA	0.0012142	0.000683	1.78	0.0783
SC025Q02NA	0.0004049	0.000209	1.93	0.0557
SC018Q05NA01	-0.00047	0.000393	-1.20	0.2345
SC034Q04TA{2&1&4&3-5}	-0.001012	0.007837	-0.13	0.8975
SC064Q03TA	-0.001452	0.0008	-1.82	0.0721
SC004Q05NA	-0.002504	0.000741	-3.38	0.0010*
SC048Q03NA	-0.004568	0.000633	-7.22	<.0001*
SC009Q05TA{2-3&4&5&6}	-0.009155	0.015953	-0.57	0.5672
SC009Q05TA{3-4}	-0.012872	0.008621	-1.49	0.1382
SC010Q01TC[0]	-0.023162	0.008623	-2.69	0.0083*
SC034Q04TA{2-1}	-0.02366	0.010456	-2.26	0.0256*

Term	Question	Response Options	Estimate (Overall)
SC025Q02NA	Teaching staff in your school has attended a programme of profess dev? Science teaching staff	(continuous variable)	0.0004049
SC064Q04NA	<the last academic year>, what proport. of parents part. school-related activities? Volun\phys, or extra-curricular act	(continuous variable)	0.0012142
SC009Q10TA{2-3&4&5&6}	Frequency of <the last academic year>. I engage teachers to help build a school culture of continuous improvement.	1 Did not occur 2 1-2 times during the year 3 3-4 times during the year 4 Once a month 5 Once a week 6 More than once a week	0.0240565

Schools should increase participation in professional development programmes for teachers

- Programmes are effective in preparing the teachers to become better educators, allowing the students to learn more effectively

Figure: Table showing variables from backward stepwise regression model sorted by parameter estimates in descending order (Science Scores)



Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Science Scores

Fit Group				
Response Mean(Science %)				
Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.5779303	0.040173	14.39	<.0001*
SC053Q07TA[1]	0.0300571	0.009734	3.09	0.0025*
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SC009Q05TA{3&4-5&6}	0.011446	0.007746	1.48	0.1423
SC019Q03NA01	0.004913	0.001129	4.35	<.0001*
SC034Q04TA{2&1-4&3}	0.0036358	0.008263	0.44	0.6608
SC035Q07TB[1]	0.0026934	0.009043	0.30	0.7664
SC064Q04NA	0.0012142	0.000683	1.78	0.0783
SC025Q02NA	0.0004049	0.000209	1.93	0.0557
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SC048Q03NA	-0.004568	0.000633	-7.22	<.0001*
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SC034Q04TA{2-1}	-0.02366	0.010456	-2.26	0.0256*

Term	Question	Response Options	Estimate (Overall)
SC025Q02NA	Teaching staff in your school has attended a programme of profess dev? Science teaching staff	(continuous variable)	0.0004049
SC064Q04NA	<the last academic year>, what proport. of parents part. school-related activities? Volun\phys, or extra-curricular act	(continuous variable)	0.0012142
SC009Q10TA{2-3&4&5&6}	Frequency of <the last academic year>. I engage teachers to help build a school culture of continuous improvement.	1 Did not occur 2 1-2 times during the year 3 3-4 times during the year 4 Once a month 5 Once a week 6 More than once a week	0.0240565

Schools should increase proportion of parents' participation in school-related activities

Figure: Table showing variables from backward stepwise regression model sorted by parameter estimates in descending order (Science Scores)

Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Science Scores

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SC064Q04NA	<the last academic year>, what proport. of parents part. school-related activities? Volun\phys, or extra-curricular act	(continuous variable)	0.0012142
SC009Q10TA{2-3&4&5&6}	Frequency of <the last academic year>. I engage teachers to help build a school culture of continuous improvement.	1 Did not occur 2 1-2 times during the year 3 3-4 times during the year 4 Once a month 5 Once a week 6 More than once a week	0.0240565

*Principals should engage teachers to create a school culture of continuous improvement **1 - 2 times a year***

Figure: Table showing variables from backward stepwise regression model sorted by parameter estimates in descending order (Science Scores)

Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Both Overall & Science Scores

Term	Question	Response Options	Estimate (Overall)	Estimate (Science)
SC010Q01TC[0]	Selecting teachers for hire: <School governing board>	0 Not checked 1 Checked	-0.018819	-0.023162
SC048Q03NA	Est. percent. <national modal grade for 15-year-olds>. Students from socioeconomic disadvantaged homes	(continuous variable)	-0.004258	-0.004568
SC019Q03NA01	<School science> teachers<ISCED Level 5A or higher> qualification <with a major> in <school science>: Full-time	(continuous variable)	0.0044681	0.004913
SC053Q05NA[1]	<This academic year>,follow. activities\school offers<national modal grade for 15-year-olds>? Science club	1 Yes 2 No	0.0233774	0.0240565
SC053Q07TA[1]	<This academic year>,follow. activities\school offers<national modal grade for 15-year-olds>? Chess club	1 Yes 2 No	0.0322451	0.0269779

Schools with a higher percentage of students from socioeconomic disadvantaged homes tend to do more poorly for the PISA survey

Data Analysis

STEPWISE MULTIPLE LINEAR REGRESSION

Insights – Variables Affecting Both Overall & Science Scores

Term	Question	Response Options	Estimate (Overall)	Estimate (Science)
SC010Q01TC[0]	Selecting teachers for hire: <School governing board>	0 Not checked 1 Checked	-0.018819	-0.023162
SC048Q03NA	Est. percent. <national modal grade for 15-year-olds>. Students from socioeconomic disadvantaged homes	(continuous variable)	-0.004258	-0.004568
SC019Q03NA01	<School science> teachers<ISCED Level 5A or higher> qualification <with a major> in <school science>: Full-time	(continuous variable)	0.0044681	0.004913
SC053Q05NA[1]	<This academic year>,follow. activities\school offers<national modal grade for 15-year-olds>? Science club	1 Yes 2 No	0.0233774	0.0240565
SC053Q07TA[1]	<This academic year>,follow. activities\school offers<national modal grade for 15-year-olds>? Chess club	1 Yes 2 No	0.0322451	0.0269779

Schools should do/have more:

- Students participating in the extra-curricular activities (Chess Club and Science Club)
- Involvement of school governing board in selection process of teachers for hire
- Number of teachers with minimally a bachelor's degree

Conclusion

To ensure that all schools can provide the same support to their students, schools and relevant authorities can consider recommendations in the following three broad areas:

1. Training and Development for teachers

- Send more teachers for professional development courses
- ↑ grants to schools with greater percentage of less privileged students

2. Fine-tuning the hiring process for teachers

- Fair allocation of teachers with tertiary education
- School governing body to play a role in the selection process of teachers

3. Increasing parents' involvement through meaningful engagement

- Encourage parents to be more involved with school activities and decisions

A blurred classroom scene with students raising their hands. A large, black, cursive text overlay reads "Thank You".

Thank You