learningtower: an R package for Exploring Standardised Test Scores Across the Globe

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Abstract Reproducibility enables a key aspect of data analysis. Furthermore, it adds context to scientific results, increasing public confidence and laying the groundwork for future study. The Programme for International Student Assessment (PISA) is a well-known open data set that is freely available. This data has the ability to provide meaningful results and insights that can help with various decisions in the fields of education and research. This experiment has a direct influence on society for the benefit of people's lives. In this R journal article, we introduce the `learningtower` package, which provides a user-friendly easy accessibility to a subset of variables from PISA data gathered by the Organization for Economic Cooperation and Development (OECD) from 2000 to 2018. This is an excellent dataset for data exploration and visualisation. This dataset can also be utilised for various analytical and statistical analysis. In addition, we present a few example anlaysis utilizing this dataset addressing some research questions regarding the gender gap noticed in these students', the effect of different socioeconomic factors on the students' performance, and we go further to study the Australia's PISA scores.

Introduction

The Organization for Economic Cooperation and Development OECD is a global organization that aims to create better policies for better lives. Its mission is to create policies that promote prosperity, equality, opportunity, and well-being for all. (Authors, 2021) PISA is one of OECD's Programme for International Student Assessment. PISA assesses 15-year-old students' potential to apply their knowledge and abilities in reading, mathematics, and science to real-world challenges. OECD launched this in 1997, it was initially administered in 2000, and it currently includes over 80 nations. (for Economic Cooperation and Development, 2021a) The PISA study, conducted every three years, provides comparative statistics on 15-year-olds' performance in reading, maths, and science. This paper describes how to utilize the `learningtower` package, which offers OECD PISA datasets from 2000 to 2018 in an easy-to-use format. This dataset comprises information on their test results and other socioeconomic factors, as well as information on their schools, infrastructure and the countries participating in the program.

What is PISA?

PISA assesses the extent to which children approaching the end of compulsory school have learned some of the information and abilities required for full participation in modern society, notably in maths, reading, and science. The examination focuses on reading, mathematics, science, and problem solving. It also assesses students capacity to replicate information and extrapolate from what they have learned and apply that knowledge in unexpected circumstances, both inside and outside of school. This approach reflects the fact that individuals are rewarded in modern economies not for what they know, but for what they can accomplish with what they know.

This evaluation which is carried out every three years, assists in identifying students' development of knowledge and skills throughout the world, which can provide actionable insights and therefore assist education policymakers. PISA is well known for its distinctive testing characteristics, which include policy orientation, an innovative notion of literacy, relevance to lifelong learning, regularity, and breadth of coverage. PISA is now used as an assessment tool in many regions around the world. In addition to OECD member countries, the survey has been or is being conducted in East, South and Southeast Asia, Central, Mediterranean and Eastern Europe, and Central Asia, The Middle East, Central and South America and Africa. (for Economic Cooperation and Development, 2014)

For each year of the PISA study, one domain subject is thoroughly examined. In 2018, for example, reading was assessed alongside mathematics and science as minor areas of assessment. The 2012 survey concentrates on mathematics, with reading, science, and problem solving serving as minor evaluation topics. PISA targets a certain age group of students in order to properly compare their performance worldwide. PISA students are aged between 15 years 3 months and 16 years 2 months at the time of the assessment, and have completed at least 6 years of formal schooling. They can enroll in any sort of institution, participate in full-time or part-time education, academic or vocational programs, and attend public, private, or international schools inside the country. Using this age across nations and throughout time allows PISA to compare the knowledge and abilities of people born

in the same year who are still in school at the age of 15, irrespective of their diverse schooling. (for Economic Cooperation and Development, 2014)

The PISA test is primarily computer-based and lasts around 2 hours. The examination comprises both multiple choice and free entry questions. Some countries that were not ready for computer-based delivery carried out the testing on paper. Each student may have a unique set of questions. An example of the test may be seen here. PISA assessment areas seek to measure the following aspects of students' literacy in math, reading, and science. The goal of mathematical literacy is to assess students ability to grasp and interpret mathematics in a variety of settings. Reading literacy assesses students' capacity to absorb, apply, analyze, and reflect on texts in order to attain required goals and participate in society. Science literacy is described as the ability to engage with science-related issues and scientific concepts as a reflective citizen. (for Economic Cooperation and Development, 2021c)

PISA data is publicly accessible for download. Furthermore, reading the data documentation reveals that the disclosed PISA scores are generated using a sophisticated linear model applied to the data. For each student, several values are simulated. (for Economic Cooperation and Development, 2021b) This is known as synthetic data, and it is a popular technique to ensuring data privacy. The data can still be deemed accurate within the mean, variance, and stratum used in the original data's modelling. In addition, the PISA website provides the data in SPSS and SAS format, which can limit accessibility due to the commercial nature of these software. Furthermore, all questions are assigned with unique IDs within each year of the PISA study, but do not always agree across the different years. This data has now been curated and simplified into a single R package called learningtower, which contains all of the PISA scores from the years 2000 to 2018.

Data Compilation

Each developer at the ROpenSci OzUnconf was assigned to curate a specific year of the PISA study. Data on the participating students and schools were first downloaded from the PISA website, in either SPSS or SAS format. The data were read into an R environment with the exception of the year 2000 and 2003. Due to formatting issues, the data for these two particular years were first read using SPSS and then exported into compatible .sav files. After some data cleaning and wrangling with the appropriate script, the variables of interest were re-categorised and saved as RDS files. One major challenge faced by the developers was to ensure the consistency of variables over the years. For example, a student's mother's highest level of education was never recorded in 2000, but it was categorised as "ST11R01" between 2003 and 2012 and "ST005Q01TA" between 2015 and 2018. Such a problem was tackled manually by curating these values as an integer variable named "mother_educ" in the output data. These final RDS file for each PISA year were then thoroughly vetted and made available in a separate GitHub repository.

What is learningtower?

'learningtower' (Wang et al., 2021) is an easy-to-use R package that provides quick access to a variety of variables using OECD PISA data collected over a three-year period from 2000 to 2018. This dataset includes information on the PISA test scores in mathematics, reading, and science. Furthermore, these datasets include information on other socioeconomic aspects, as well as information on their school and its facilities, as well as the nations participating in the program.

The motivation for developing the learningtower package was sparked by the announcement of the PISA 2018 results, which caused a collective wringing of hands in the Australian press, with headlines such as "Vital Signs: Australia's slipping student scores will lead to greater income inequality" and "In China, Nicholas studied maths 20 hours a week. In Australia, it's three". That's when several academics from Australia, New Zealand, and Indonesia decided to make things easier by providing easy access to PISA scores as part of the ROpenSci OzUnconf, which was held in Sydney from December 11 to 13, 2019. The data from this survey, as well as all other surveys performed since the initial collection in 2000, is freely accessible to the public. However, downloading and curating data across multiple years of the PISA study could be a time consuming task. As a result, we have made a more convenient subset of the data freely available in a new R package called learningtower, along with sample code for analysis.

The learningtower package primarily comprised of three datasets: student, school, and countrycode. The student dataset includes results from triennial testing of 15-year-old students throughout the world. This dataset also includes information about their parents' education, family wealth, gender, and presence of computers, internet, vehicles, books, rooms, desks, and other comparable factors. Due to the size limitation on CRAN packages, only a subset of the student data can be made available

in the downloaded package. These subsets of the student data, known as the `student_subset_yyyy` (yyyy being the specific year of the study) allow uses to quickly load, visualise the trends in the full data. The full student dataset can be downloaded using the `load_student()` function included in this package. The `school` dataset includes school weight as well as other information such as school funding distribution, whether the school is private or public, enrollment of boys and girls, school size, and similar other characteristics of interest of different schools these 15-year-olds attend around the world. The `countrycode` dataset includes a mapping of a country/region's ISO code to its full name.

learningtower developers are committed to providing R users with data to analyse PISA results every three years. Our package's future enhancements include updating the package every time additional PISA scores are announced. Note that, in order to account for post COVID-19 problems, OECD member nations and associates decided to postpone the PISA 2021 evaluation to 2022 and the PISA 2024 assessment to 2025.

Example Analysis

In this section we will illustrate how the learningtower package can be utilized to answer some research questions by applying various methodologies and statistical computations on the learningtower datasets.

We will solely utilize the 2018 PISA data and scores for illustrative purposes throughout the example analysis section. During the post-development phase, the learningtower developers collectively decided to answer a few intriguing questions on the PISA data and see if we could identify any interesting trends or insights utilizing this dataset. Some of these questions include if there is any significant gender difference between girls and boys and explore their performance in the areas of mathematics, reading, and science. Furthermore, we will inspect the various socioeconomic characteristics reflected in the student data and investigate if they have any substantial impact on the scores of these 15-year-olds. We will delve into Australia's score history and study the temporal trends to uncover some noteworthy trends that Australia has observed as a result of its participation in the PISA experiment.

Gender Analysis

Gender gaps have always been a topic of interest among researchers, and when it comes to PISA data and scores of 15-year-old students around the world, uncovering patterns based on their gender would help gain meaningful insights in the field of education for various education policymakers around the world. Based on the 2018 PISA results, let us see if there is a major gender disparity between girls and boys throughout the world in mathematics, reading, and science. To begin, we will create a 'data.frame' that stores the weighted average maths score for each nation as well as the various regions of the countries grouped by country and gender, in order to create this `data.frame` and represent data in the tidy format we use the **tidyverse** (Wickham et al., 2019) and **dplyr** (Wickham et al., 2021) R packages. Survey weights are critical and must be used in the analysis to guarantee that each sampled student accurately represents the total number of pupils in the PISA population. In addition, we compute the gender difference between the two averages. To demonstrate the variability in the mean estimate, we use bootstrap sampling with replacement using the `map_dfr` function on the data and compute the same mean difference estimate. For each country, the empirical 90 percent confidence intervals are presented. The same process is used for reading and science test scores.
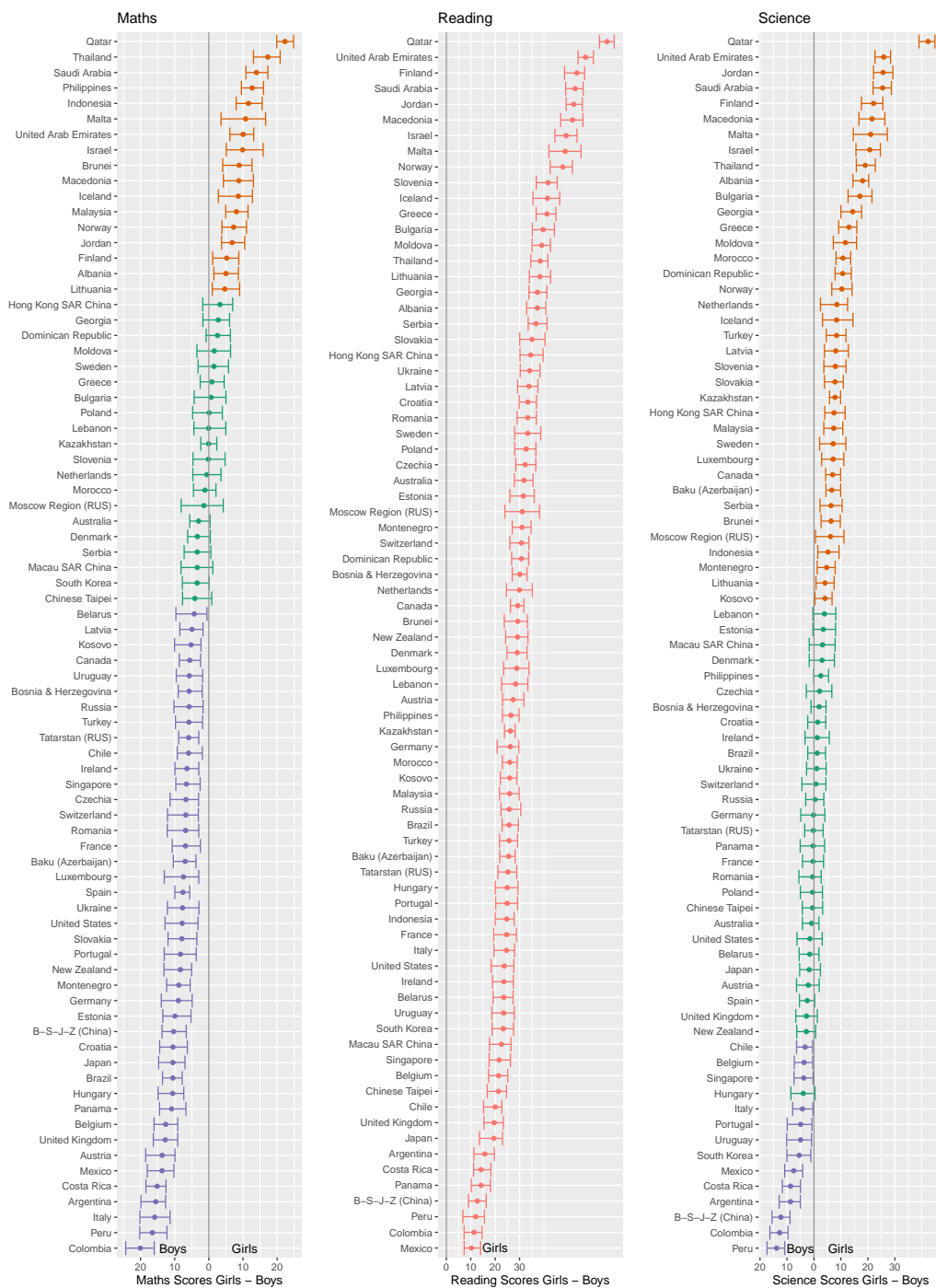
Figure 1: The chart above depicts the gender gap difference in 15-year-olds' in math, reading, and science results in 2018. The scores to the right of the grey line represent the performances of the girls, while the scores to the left of the grey line represent the performances of the boys. One of the most intriguing conclusions we can get from this chart is that in the PISA experiment in 2018, girls from all countries outperformed boys in reading.

Figure 1 illustrates the global disparities in mean math, reading, and science outcomes, before we get to the plot conclusion, let's have a look at the variables that have been plotted. The grey line here indicates a reference point, and all of the scores to the right of the grey line show the scores of girls in math, reading, and science. Similarly, the scores on the left side of this grey line indicates the scores of boys in the three disciplines. Based on figure 1, because most math estimates and confidence intervals lie to the left of the grey line, we may conclude that most boys outperformed girls in math. In nations such as Morocco, Netherlands, Slovenia, Poland, Bulgaria, and Greece, there is almost no gender difference in average math scores. When we look at the reading scores, we notice a really interesting detail which is all girls outpaced boys in reading in all countries in 2018. The highest reading scores

were achieved by girls from Qatar, United Arab Emirates, and Finland. Looking further into the science plot, we see an unexpected pattern here where most countries have very little gender difference in science scores, implying that most boys and girls perform equally well in science. Boys from Peru, Colombia, and regions of China perform really well in science and girls from Qatar, the United Arab Emirates, and Jordan are the top scores for science. Figure 1 helps us depicts the gender gap in math, reading, and science for all nations and regions that took part in the 2018 PISA experiment.

We gathered meaningful insights about the gender gap between girls and boys across the world from the above figure 1 because this is a geographical research communication topic, the findings will help us better comprehend the score differences in the three educational disciplines using world maps. Let us continue to investigate and discover patterns and correlations using map visualisation. To illustrate the gender gap difference between girls and boys throughout the world, we utilize the `map_data` function to get the latitude and longitude coordinates needed to construct a map for our data. We connect these latitude and longitude coordinates to our PISA data and render the world map using `geom_polygon` function wrapped within **ggplot2** (Wickham, 2016), **plotly** (Sievert, 2020) and **patchwork** (Pedersen, 2020) packages in R.

World Map displaying Gender Gap Scores in Math, Reading and Science
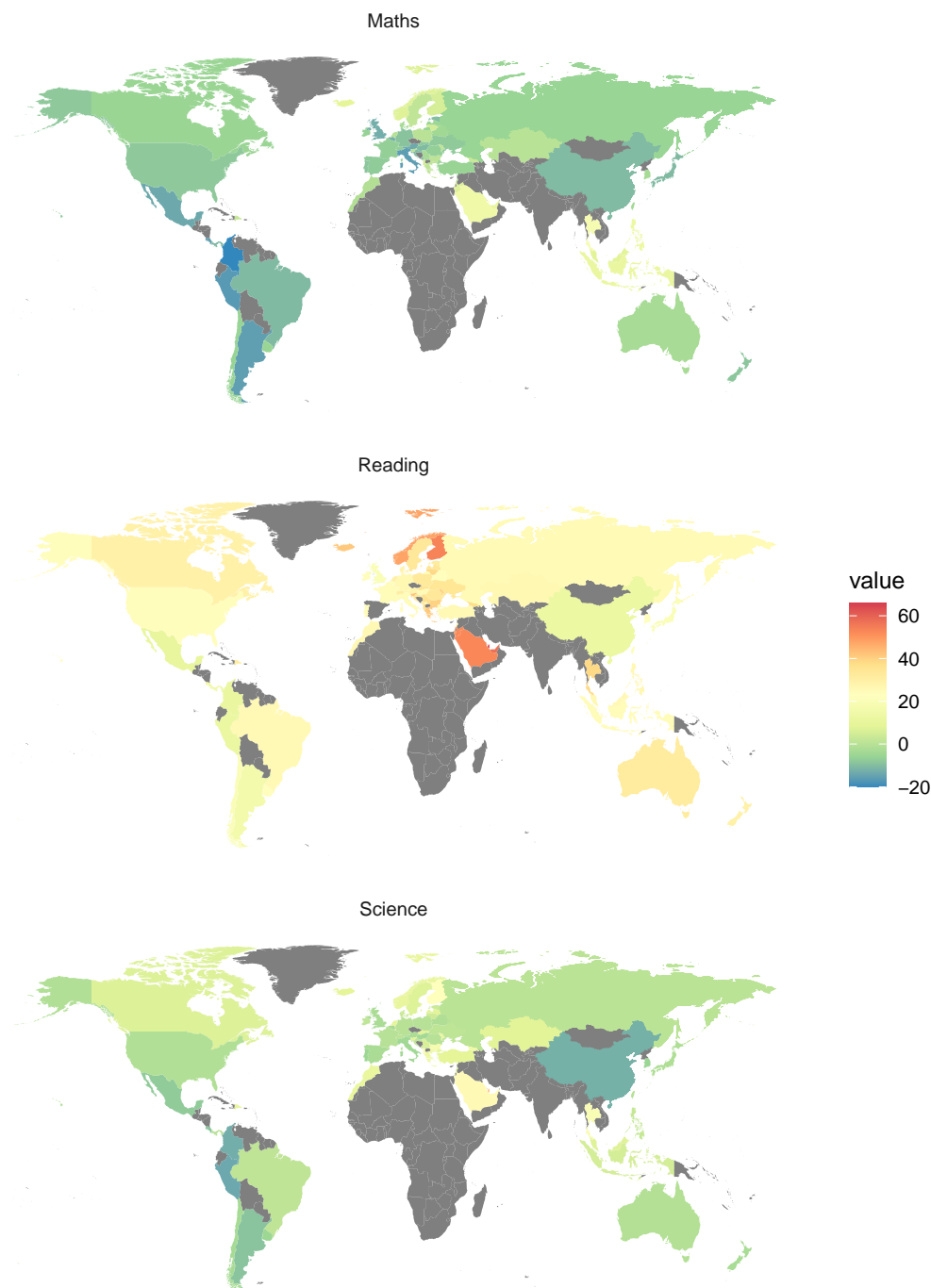

Figure 2: Maps showing the gender gap in math, reading, and science results between girls and boys throughout the world. The diverging colour scale makes it possible to interpret the range of scores and it also helps us intrepret the gender gap difference among these students across the globe. The legend displayed enables interpretation of the score differential for each subject across all maps. A positive score for a country indicates that girls outperformed boys in that country, whereas a negative score for a country difference indicates that boys outperformed girls in that country.The reading scores are all positive, suggesting that girls outperform boys globally in the year 2018.

In the graphic 2, we have shown the gender gap difference between girls and boys in math, reading, and science in 2018. Map visualization aids in the comprehension of large volumes of data in a more efficient manner. Increases the ability to compare outcomes across many geographies at a glance. In the illustration, we see both positive and negative score difference scale ranges in all three maps. A positive country score indicates that girls outperformed boys in that country, whereas a negative

country score shows that boys outscored girls in that country. The diverging spectral color scale and the legend of these maps makes it possible for us to deduce and identify regions across the globe showing large gender discrepancy between girls and boys, we can see that the most gender difference can be seen in the reading and maths scores, where most boys around the world outperform girls in the subject of mathematics, whereas all positive reading scores indicate that all girls around the world outperformed boys in reading in 2018. We see that there is less of a gender disparity seen in the science scores. In addition, the color scale for scores of each subject aids in identifying the countries that took part in the PISA experiment. The grey colour for different geographic locations across the maps in figure 2 indicates that these regions were not a part of the PISA experiment in year 2018.

As a result, in this section, we have seen the gender gap scores and striking trends between 15-year-old girls and boys in math, reading, and science. Our main conclusion from this gender study is the performance of girls in reading. The fewer gender disparity evident in science scores, and the majority of boys perform better than girls in mathematics.

Socioeconomic Factors Analysis

Socioeconomic status is an economic and sociological complete measure of a person's work experience, economic access to resources, and social standing in relation to others. Do these socioeconomic factors influence students' academic performance? In this section, we will investigate if different socioeconomic factors owned by a family have a significant impact on a student's academic performance. The student dataset in the **learningtower** package is comprises scores of 15-year-olds from triennial testing across the world. This dataset also includes information about their parents' education, family wealth, gender, and ownership of computers, internet, cars, books, rooms, desks, and dishwashers. In this section, we will mainly explore intriguing figures and derive some fascinating aspects of the influence of a few socioeconomic factors on student performance in math, reading, and science. Before we go on to our socioeconomic determinants and their impact on students, figure 3 shows how the math, reading, and science scores are strongly positively correlated to one another.
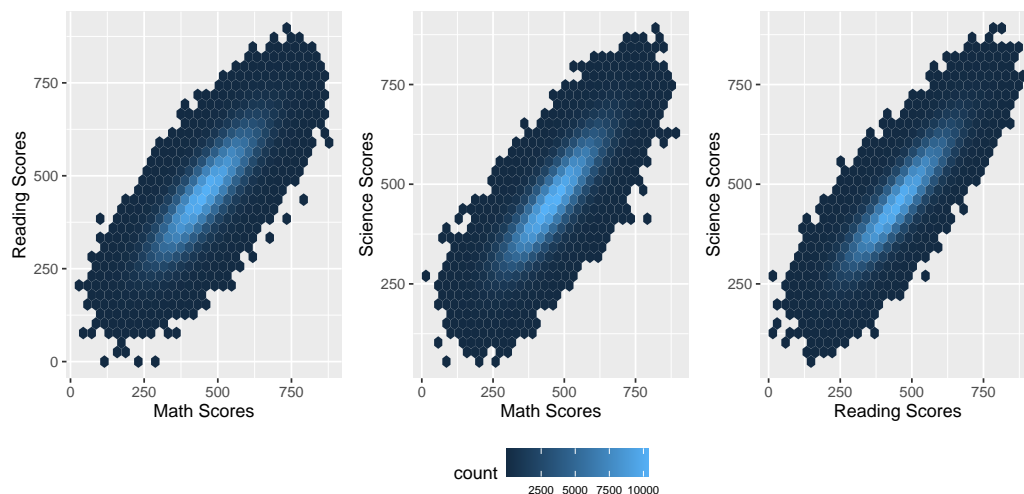

Figure 3: The scatterplot displays the relationship between math, reading, and science scores for all PISA countries that participated in the experiment in 2018. This scatterplot shows that all three subjects have a significant and positive correlation with one another.

We plotted all three scores against each other using the geom_hex() function available under the **ggplot2** (Wickham, 2016) package in R. The figure 3 help us us reveal the relationship between these three subjects allowing us to deduce that math, science, and reading scores are positively and significantly correlated with one another, implying that when we inspect and analyse the many socioeconomic determinants, we would get comparable outcomes with each subject math, reading or science along with the influence of desired socioeconomic factor. As a result of seeing this substantially positive association between all three subjects for all the countries that participated in the PISA experiment in 2018, the developers decided to show the effect of socioeconomic variables on average math scores only due to highly positive correlation since the other two subjects will show similar patterns as well. Let us further explore the impact of a few socioeconomic factors on the students' score.

Parents qualification is and will always be a vital element of childhood development. As previously stated, the student dataset in the package includes information regarding the parents qualification. In this section, we will investigate if both the mother's and father's qualifications have a significant impact on the child's performance. The mother's education and father's education variables are originally recorded in the student dataset in the **learningtower** package at distinct levels which are less than ISCED1 equivalent to ISCED 0, ISCED 1, ISCED 2, ISCED 3A and ISCED 3B, C. The International Standard Classification of Education, (ISCED) decides and classifies these levels, where level 0 indicates pre-primary education or no education at all, level 1 indicates primary education or the first stage of basic education, level 2 indicates lower secondary education or the second stage of basic education, and level 3 indicates upper secondary education. ISCED level 3 have been further classified into three distinct levels, with ideally very little difference in their classification. This may also be found in the publication Classifying Educational Programmes (for Economic Cooperation and Development, 1999) published by ISCED. To determine the impact of parents qualification we first create data.frames that are categorized by the various countries and regions and grouped by the father's and mother's qualification. We next compute the weighted mean average of math scores while accounting for student weights. Furthermore, we refactored the parents qualification variable based on the multiple levels of classification, dividing it into four unique levels of education, namely early childhood, primary, lower, and secondary education. Furthermore, we display the weighted math average versus qualification colored by the refactored qualifications levels for both the mother and father using the geom_quasirandom function wrapped within **ggplot2** (Wickham, 2016), **viridis** (Garnier et al., 2021) and **patchwork** (Pedersen, 2020)
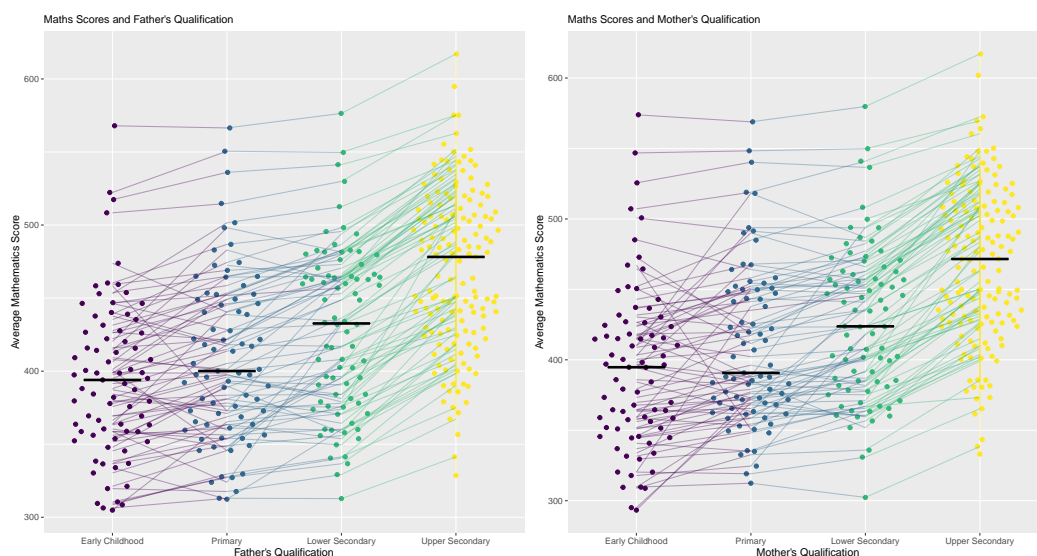

Figure 4: The impact of parents' education on their children's academic progress is depicted in this graph. When the parents have greater levels of education, we see a considerable rise in scores and an increase in the median of scores for each category, as shown in the figure. In comparison to parents with lower levels of education qualifications. Parents who have tend to have upper secondary qualification or equivalent credentials their children are more likely to perform better in academics when compared with parent having lesser levels of qualifications.

The figure 4 depicts the impact of mothers' and fathers' qualifications on students academic performance. The figure 4 allows us to deduce a very important and remarkable insight in which we see a constant increase in the students' academic performance when both mother and father qualifications shift towards higher levels of education. The bold horizontal black lines that we see in each category for mother's and father's qualification here represent the category's median score. As the parent attains better qualifications, we notice an increasing trend in these medians for each category. Taking a closer look at the figure 4, we can see that there is a considerable boost in scores when both the mother and father have upper secondary education. Furthermore, utilizing the geom_quasirandom function available in the **ggbeeswarm** (Clarke and Sherrill-Mix, 2017)ggbeeswarm makes this plot more accessible and understandable by providing a way to offset points inside categories to prevent overplotting. Thus, we can clearly see that both the mother's and father's qualifications have a significant influence on the student's academic performance, with the more educated the parent, the more likely their offspring are to perform well academically.

Television is one of humanity's greatest inventions; it is one of the assets that has had a significant

impact and influence on humans. In this segment of the article, we investigate the influence of television in many countries, as well as whether this technology has a significant impact on students' academic performance. The television variables that are recorded in the student dataset is a factor variable that records whether or not the students participating in this study have a television and, if they do, the quantity of televisions per family is recorded via the PISA survey. Furthermore, because we are interested in researching the impact of these television on the students' scores, we have re factored the television variables and designated four levels: No TV, 1 TV, 2 TVs, or 3+TVs. We are also interested in visualising the confidence intervals for each of these levels in order to determine the uncertainty of the results at each level. We begin with initially creating a data.frame that is grouped by country and the number of television per household for each country. Next we fitted a linear model to the math average and distinct refactored television categories for each country in the 2018 PISA data and finally plot the television impact for all countries sorted as per the slope with the help of the functions available in the **ggplot2** (Wickham, 2016) package.
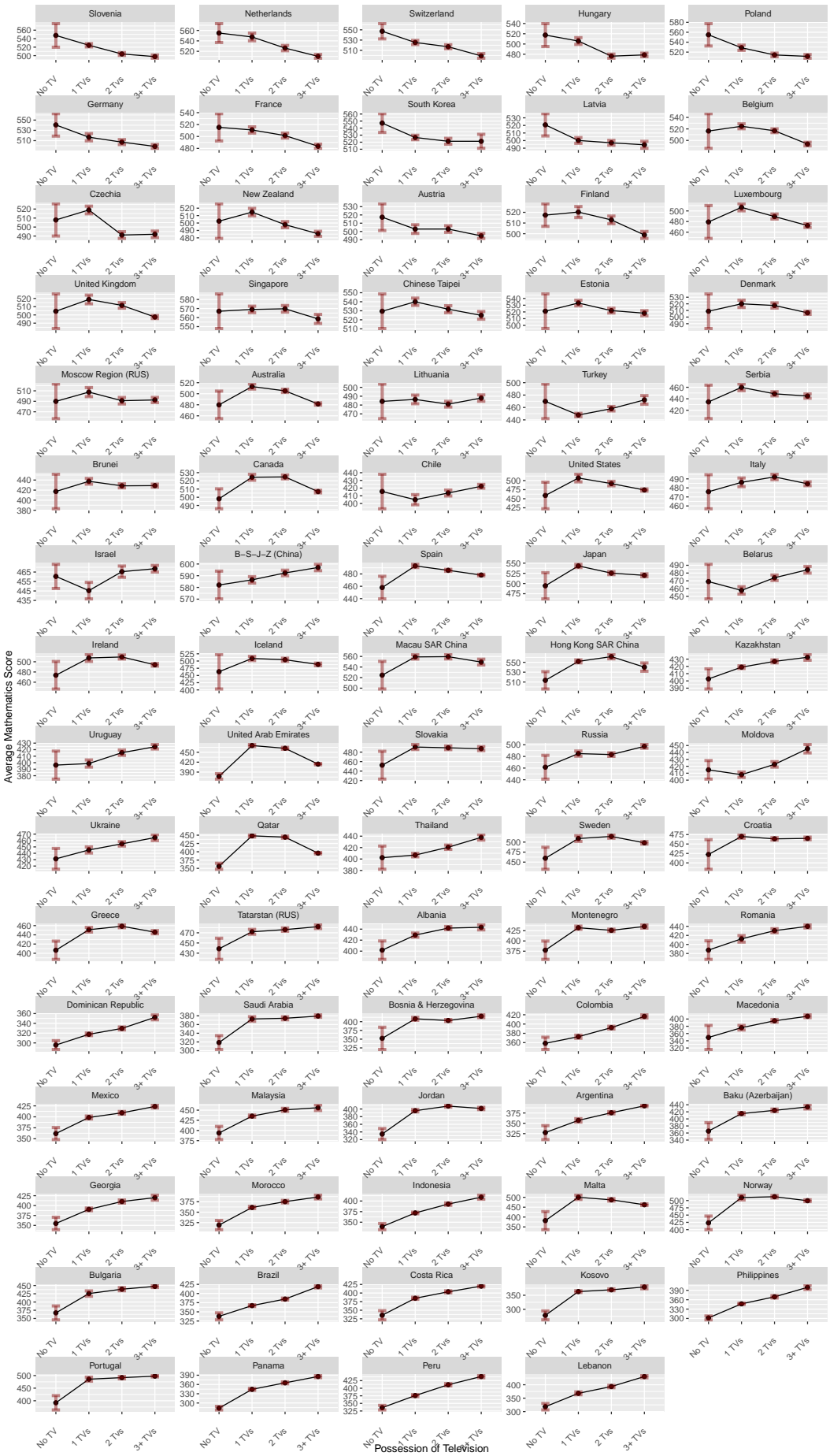
Figure 5: The impact of television on student performance is a contentious issue, however in this figure, we examine the effects of television on student performance using statistical methods. The counties are arranged according to the slope of the linear model fitted for the math average score against the various levels of television. We observe that television has the greatest influence on performance in a select countries, such as Lebanon, whilst it has the least impact in Slovenia. The confidence interval suggests that there is an uncertainty of the scores when a household does not own a television in the majority of the nations that participated in the PISA experiment in the year 2018.

In the figure 5, we can see highly striking patterns as well as a significant influence of television on students' academic performance. We have arranged the nations in the figure 5 according to the slope of math average scores fitted against the different levels of television described previously. Slovenia, Netherlands, Switzerland, Hungary, and Poland have a lower influence of television on student performance, whereas Portugal, Panama, Peru, and Lebanon have a rising tendency and therefore a larger impact of television on students' performance. Furthermore, the confidence interval plotted in the figure 5 show that there is a lot of uncertainty in the level of scores when a household does not possess a TV in the majority of the countries. Taking a closer look at the figure 5 we observe that when the slope of television increases in countries, the confidence interval of such countries becomes narrower. Hence depending on your wealth and where you live, television can be a valuable asset. since it has a notable effect on a student's academic performance.

We've always heard and read that books play an important role in early childhood because they assist learners develop emotional intelligence and creativity. However, the developers of **learningtower** package intended to invest if books, has a significant influence on the students score. The book variable is initially recorded in the student dataset has been categorized in the following levels 0-10, 11-25, 26-100, 101-200, and more than 500 books. We will do a similar investigation as we did when we investigated the effect of television. First, we construct a `data.frame` that is grouped by the different levels of books and countries. In addition, we calculated the confidence interval using the method to account for the uncertainty associated with the scores for the different categories of books. We subsequently fit a linear model with the average math score and each level of book categories to derive a coefficient or slope for each country. Finally, plot the country and score estimations for each country, ordered according to slope with help of the functions available in the **ggplot2** (Wickham, 2016) package.
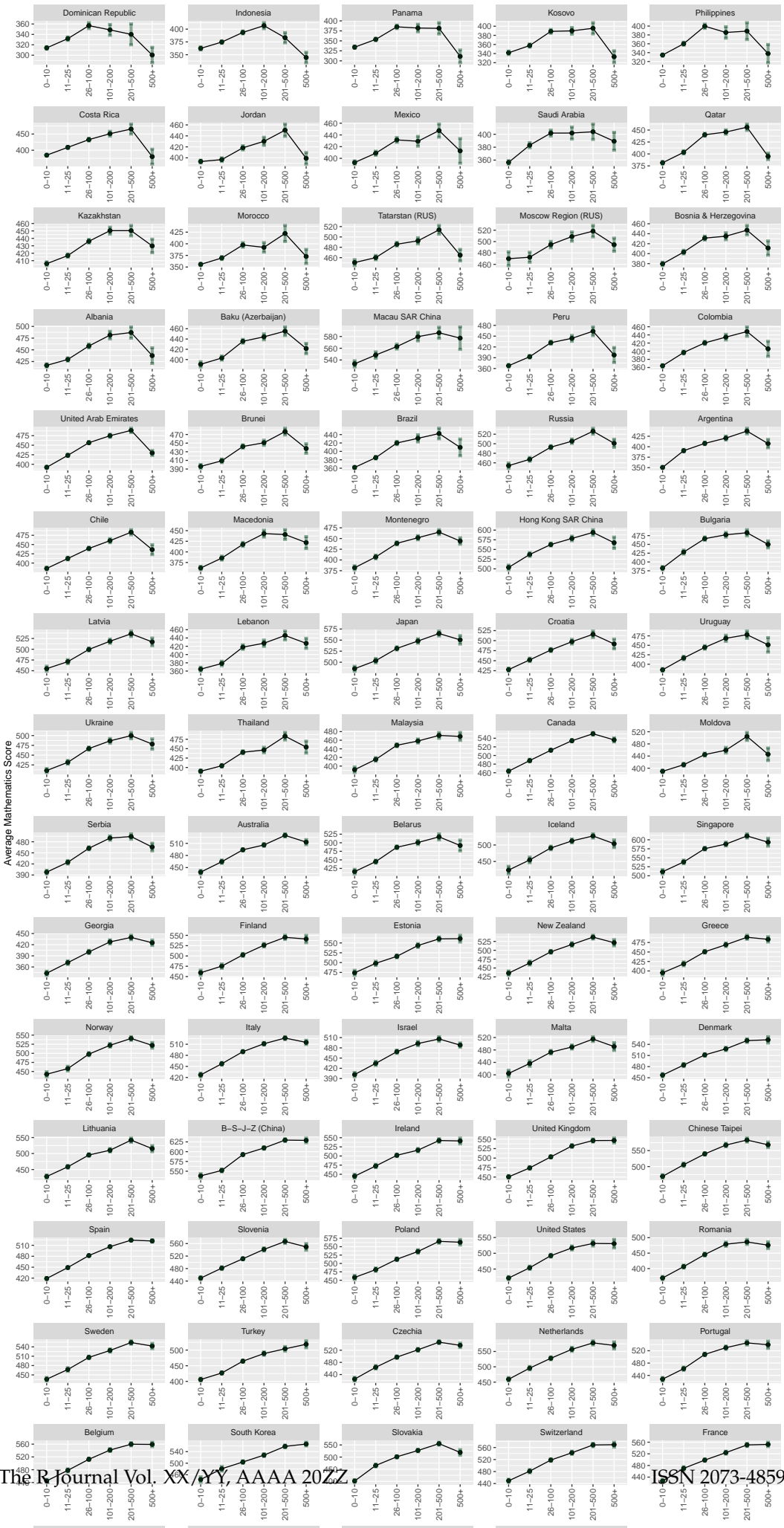
In the figure 6, we can see the different countries arranged by slope and their correlation with math score estimation for each of the book categories. Taking a detailed look at the figure 6, we deduced that the more books a family possesses, the more likely it is that its children will perform well academically. Looking at the graph, we can notice a rising tendency as the quantity of books per household increases. Furthermore, we see a decline in the score when the category contains more than 500 books, owing to the lack of data in such categories. Because ideally there are extremely few households that own more than 500 books. In this scenario, we also examine the confidence intervals of our plots to better understand the lower and upper bounds of the math score estimation. The confidence intervals in each of the categories are not particularly very broad. In addition, arranging the graph by slope allows us to understand the impact of books in different countries. Despite the fact that most countries have a significant influence on books per home, we can see in this graph that most countries have a significant impact on books per household. We may state that the Dominican Republic, Indonesia, and Panama have witnesses a slightly lower impact of owing books than the countries of Luxembourg, Germany, and Hungary. As a result, we may conclude that having a greater quantity of books in a home will undoubtedly benefit a student's academic performance.

Students are becoming autonomous, adept members and researchers as they advance in technology and usage of computers and the internet. However, let us investigate if having a computer with internet access at the age of 15 has a positive or negative impact on student academic achievement. We will plot the average math results of the several nations that participated in the PISA experiment in 2018 to determine the effect of owning a computer and having access to the internet. This necessitates the creation of a `data.frame` that is grouped by the nations and the frequency of or whether the student possesses a computer or not, as well as a students' access to the internet or not. We will plot this result against the weighted average mathematical score to determine the influence of various of television and internet on the student academic performance using the several functions available in the **ggplot2** (Wickham, 2016) package.
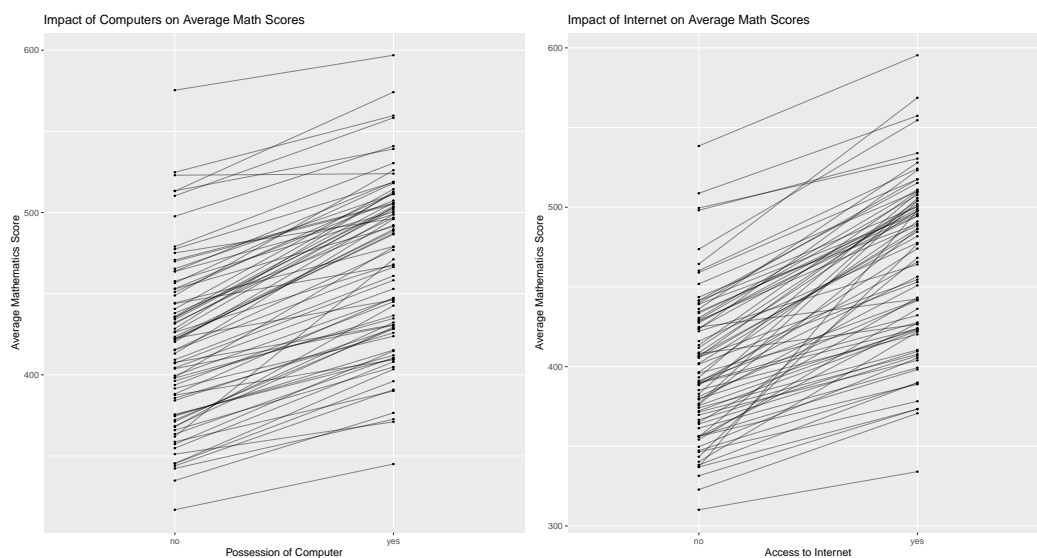

Figure 7: Computers and the Internet are two of the most important inventions in the history of technology. In this figure, we observe the impact of owning a computer and having access to the internet on 15-year-old students all over the world. A remarkable finding from the plot is that all nations have higher scores in student performance when they own a computer and have access to the internet.

In the figure 7, we see some absolutely fascinating and astonishing insights that might help education policymakers make decisions. This data allows us to conclude that students who own a computer and have access to the internet consistently outperform students who do not own a computer or have access to the internet at all. Interestingly, we regard these as actionable information for all countries participating in the PISA study in 2018. No country has exempted from this findings. Thus, a 15-year-old student's access to a computer and the internet is unquestionably has significant positive influence on their academic performance.

Temoral Trend Australia

In this section of analysis, we look at the temporal trends noticed in Australia. The release of PISA results in 2018 also led several headlines on the decline in scores recorded in Australia. In this section, we will determine whether this decrease is indeed significant or whether there are any other aspects to consider when comparing country rankings. To better comprehend Australia's scores and trends since 2000, the developers of the learningtower package, feel it is appropriate to illustrate the temporal trend of Australia in comparison to a few other nations. We evaluate these nations' ratings using a statistical procedure bootstrap with replacement using the map_dfr function which resamples a single dataset to generate a large number of simulated samples. In this situation, we have decided to apply this strategy to a few selected countries whose scores are compared to Australia's. In this context, we have chosen three additional countries: New Zealand, Qatar, and Indonesia. Using these three countries, the score of Australia will be compared throughout all years since the PISA experiment was implemented.
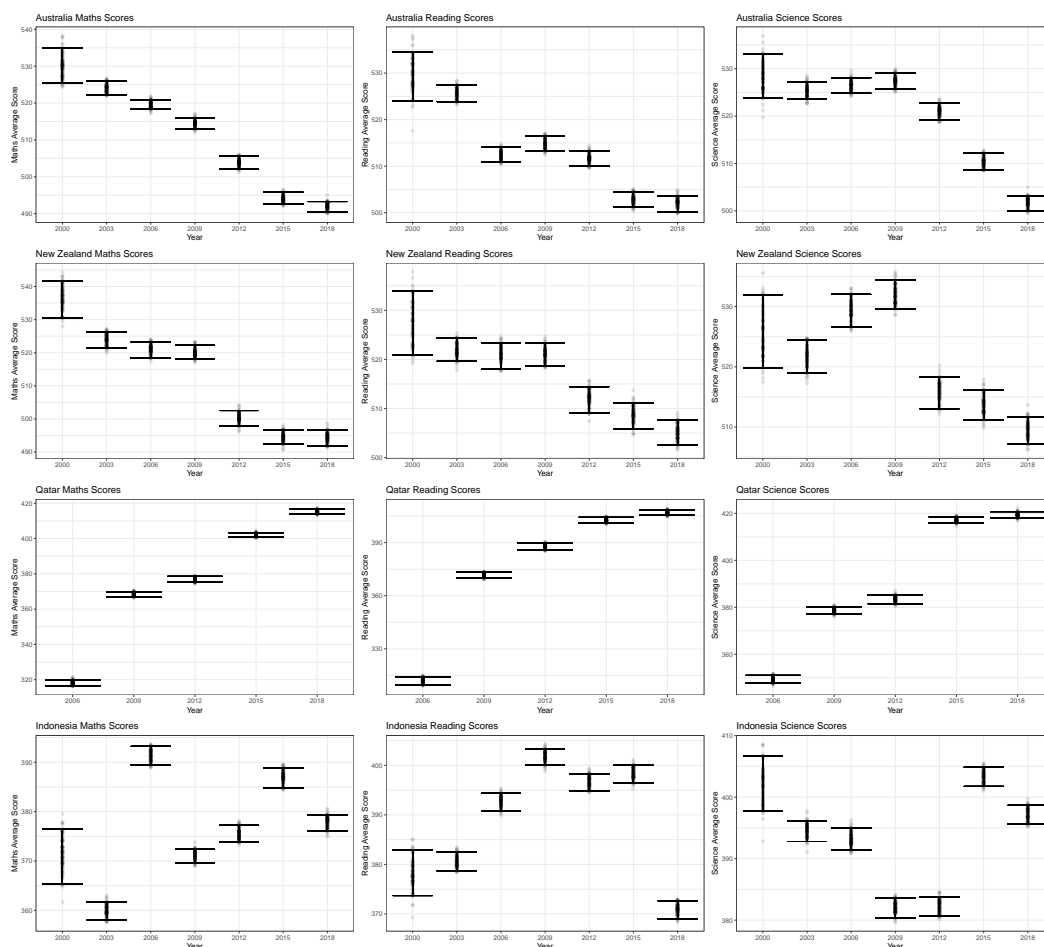

Figure 8: Bootstrap

Taking a deeper look at the figure 8 and comparing the Australia scores to those of New Zealand, Qatar, and Indonesia, we conclude that New Zealand and Australia follow a similar trajectory in the areas of math, reading, and science scores throughout all the years. Whereas on observing Australia's scores with respect to Qatar's, we notice the changing scales of their scores in all three plots of math, reading, and science and we infer that Australia's performance has been is much better than Qatar's across all the years but one could argue about an increasing pattern seen in the scores for Qatar and a decreasing pattern for Australia. To deepen our understanding of the topic, we compare Indonesia's results to those of Australia. In Indonesia, there is occasionally a growing and decreasing trend over the years. However, if on closely examining the average maths, reading and science score, we see that the highest score for Indonesia or even for Qatar is initially a very low score, and this increases further. However, Australia's performance in the PISA was initially a top achievement, and it has only drops by a few points. Though the temporal trend of Australia displays a declining tendency, this is due to the fact that Australia initially performed very well in the PISA experiment and has only

decreased it scores by a few points each year, remaining in one of the top scores of the PISA research until the year 2018. As a result, we infer that Australian's performance has declined over time but the country has remained on the list of top scores countries for all of the years this PISA research has been done. Using a similar notion, we conclude that countries with lower initial PISA results have a tendency to increase their score each time the PISA exam is taken whilst countries that have previously established a standard with great score results may witness a decreasing trend in the scores but optimally the scores has decrease by a few points only thus not making the the declining trend a significant measure of performance. In addition, to understand this better, we have a animation plotted using **gganimate** (Pedersen and Robinson, 2020) the that explains how performance can only be compared among scales and not based on scores or any other characteristics with respect to several other countries that participated in the PISA experiment.

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