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**Program Code: TU059 (Data Science), Full Time**

# **Section 1 – Research Questions**

**Question 1:** Can we predict the global score of the student using their Quantitative Reasoning and Critical Reading?

**Question 2:** Can we predict the global score of the student using their Quantitative Reasoning and Critical Reading with School Nature as dummy variable?

# **Section 2 – Dataset**

* **Representativeness:** The representativeness of the sample is determined by the randomness of the sample and its ability to represent the whole population
* **Statistics of variable of interest:** The dataset is analysed and some variables of interest for the understanding of the Research Questions are selected.

The summary statistics of the variables of interest are shown below:

* **Visualization of the Variables:** To further understand the data of the variables of interest, we do some visualizations to understand the distribution of the data.

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| Chart, bar chart  Description automatically generatedChart, bar chart  Description automatically generated  **School type analysis School Nature analysis**  Chart  Description automatically generated  **Gender wise analysis** |

* **School type analysis:** It shows an outlier ‘Not apply’ which is in very few number only 5 records, so we can ignore those outliers.
* **School Nature analysis:** It shows the classification of 12,411 records based on the school they attended before engineering. It can be observed there is only a slight difference between the public and private institutes.
* **Gender wise analysis:** It shows the classification of male and female pursuing engineering. It can be observed Females are considerably less compared to male.
* **Assessing Normality:** The normality of variables like ENG\_S11, ENG\_PRO, CR\_S11, CR\_PRO are determined as it is necessary for further analysis of the dataset and building a model.

**For eng\_s11:**

**Graphical Analysis:**

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* From the graphical analysis we cannot conclude the normality of eng\_s11 as it does not completely look normal to naked eye. So we resort to statistical analysis for confirmation

**Statistical Analysis:**

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| **> *pastecs::stat.desc(s\_perform$eng\_s11, basic=F)***  **median mean SE.mean CI.mean.0.95 var std.dev coef.var**  **59.0000000 61.8010636 0.1283409 0.2515681 204.4264163 14.2977766 0.2313516**  ***> eng\_s11skew[1]/eng\_s11skew[2]***  **skew (g1)**  **27.60265**  ***> eng\_s11kurt[1]/eng\_s11kurt[2]***  **Excess Kur (g2)**  **-8.432497**  ***> FSA::perc(as.numeric(zeng\_s11), 1.96, "gt")***  **[1] 5.648215**  ***> FSA::perc(as.numeric(zeng\_s11), 3.29, "gt")***  **[1] 0** |

* From the statistical analysis, we can confirm the normality of the eng\_s11 variable as it had no outliers outside the Z-value of 3.29 thus making it normal.

**For eng\_pro:**

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| Chart, histogram  Description automatically generated Chart  Description automatically generated  **Histogram Q-Q Plot** |

* From the graphical analysis we cannot conclude the normality of eng\_pro as it does not completely look normal to naked eye. So we resort to statistical analysis for confirmation

**Statistical Analysis:**

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| **> *pastecs::stat.desc(s\_perform$eng\_pro, basic=F)***  **median mean SE.mean CI.mean.0.95 var std.dev coef.var**  **59.0000000 61.8010636 0.1283409 0.2515681 204.4264163 14.2977766 0.2313516**  ***> eng\_proskew[1]/eng\_proskew[2]***  **skew (g1)**  **27.60265**  ***> eng\_prokurt[1]/eng\_prokurt[2]***  **Excess Kur (g2)**  **-8.432497**  ***> FSA::perc(as.numeric(zeng\_pro), 1.96, "gt")***  **[1] 5.648215**  ***> FSA::perc(as.numeric(zeng\_pro), 3.29, "gt")***  **[1] 0** |

* From the statistical analysis, we can confirm the normality of the eng\_s11 variable as it had no outliers outside the Z-value of 3.29 thus making it normal.
* **Missing Data:** The dataset is checked for any missing values and their influence on the normality of the dataset.

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| *> na\_count <-lapply(s\_perform, function(y) round((sum(length(which(is.na(y)))))/length(y)\*100))*  *> na\_count <- data.frame(na\_count)*  *> na\_count*  **cod\_s11 gender edu\_father edu\_mother occ\_father occ\_mother stratum sisben people\_house ...10 internet tv**  **1 0 0 0 0 0 0 0 0 0 100 0 0**  **computer washing\_mch mic\_oven car dvd fresh phone mobile revenue job school\_name school\_nat school\_type**  **1 0 0 0 0 0 0 0 0 0 0 0 0 0**  **mat\_s11 cr\_s11 cc\_s11 bio\_s11 eng\_s11 cod\_spro university academic\_program qr\_pro cr\_pro cc\_pro eng\_pro**  **1 0 0 0 0 0 0 0 0 0 0 0 0**  **wc\_pro fep\_pro g\_sc percentile X2nd\_decile quartile sel sel\_ihe**  **1 0 0 0 0 0 0 0 0** |

From the output above, we can conclude that the dataset doesn’t have any significant missing values except for one column “…10” which doesn’t have any significant meaning. So we ignore that as we are not interested in that column for our analysis.

# **Section 3 - Results**

## **Section 3.1 - Statistical evidence**

* **Checking for correlation between predictors and dependent variable.**

The predictors are chosen with the help of a correlation test, this is done to identify some kind of relationship between the predictor and the dependent variable. If there exists a moderate/high correlation then we can assume that variable to be a predictor.

* **Correlation between global score and Quantitative reasoning**

**Null Hypothesis:** The population correlation coefficient between g\_sc and qr\_pro is equal to a hypothesized value (=0 indicating no linear correlation)  
**Alternate Hypothesis:** The population correlation coefficient between g\_sc and qr\_pro is not equal (or less than, or greater than) the hypothesized value(indicating linear correlation)

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| ***> stats::cor.test(s\_perform$g\_sc, s\_perform$qr\_pro, method='pearson')***  Pearson's product-moment correlation  data: s\_perform$g\_sc and s\_perform$qr\_pro  t = 109.1, df = 12404, p-value < 2.2e-16  alternative hypothesis: true correlation is not equal to 0  95 percent confidence interval:  0.6906862 0.7086488  sample estimates:  **cor**  **0.6997781** |
| ***Chart, scatter chart  Description automatically generated*** |

We can observe from the graph that there is a moderate positive linear correlation, which implies we have satisfied our assumptions for pearson test they are:

* Correlation requires that both variables be quantitative.
* Correlation describes linear relationships.

From Pearson correlation,we get a correlation of 0.70, which means the effect size is medium(Acc. to cohen's effect size heuristic).  
Assuming our alpha level = 0.05, our p-value(0.001) < 0.05 => The correlation is statistically significant.  
And so we have evidence to reject null hypothesis in favour of the alternate which is there is a relationship between **g\_sc and qr\_pro.** So, we can use qr\_pro as one of the predictors

* **Correlation between global score and Critical Reading:**

**Null Hypothesis:** The population correlation coefficient between g\_sc and cr\_pro is equal to a hypothesized value (=0 indicating no linear correlation)  
**Alternate Hypothesis:** The population correlation coefficient between g\_sc and cr\_pro is not equal (or less than, or greater than) the hypothesized value(indicating linear correlation)

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| --- |
| ***> stats::cor.test(s\_perform$g\_sc, s\_perform$cr\_pro, method='pearson')***  Pearson's product-moment correlation  data: s\_perform$g\_sc and s\_perform$cr\_pro  t = 141.79, df = 12404, p-value < 2.2e-16  alternative hypothesis: true correlation is not equal to 0  95 percent confidence interval:  0.7796011 0.7930323  sample estimates:  **cor**  **0.7864097** |
| Chart, scatter chart  Description automatically generated |

We can observe from the graph that there is a high positive linear correlation, which implies we have satisfied our assumptions for pearson test they are:

* Correlation requires that both variables be quantitative.
* Correlation describes linear relationships.

From Pearson correlation,we get a correlation of 0.79, which means the effect size is large(Acc. to cohen's effect size heuristic).  
Assuming our alpha level = 0.05, our p-value(0.001) < 0.05 => The correlation is statistically significant.  
And so we have evidence to reject null hypothesis in favour of the alternate which is there is a relationship between **g\_sc and cr\_pro.** So, we can use cr\_pro as one of the predictors

* **T-test for differential variable.**

 The t test tells you how significant the differences between groups are; In other words it lets you know if those differences (measured in means) could have happened by chance.

**Hypothesis (Two-tailed):**

**Null Hypothesis H0:**There is no difference in mean g\_sc score between those who went to a private and public school.

**Alternate Hypothesis HA:**There is a difference in mean g\_sc score between those who went to a private and public school.

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| ***> car::leveneTest(g\_sc ~ school\_nat, data=s\_perform)***  Levene's Test for Homogeneity of Variance (center = median)  Df F value Pr(>F)  group 1 12.514 0.0004054 \*\*\*  12404 |

**Levene's Test: For homogeneity of variance**

**Null Hypothesis: All variances are equal.**  
**Alternate Hypothesis: All variances are not equal.**  
From the test, we can see Pr(>F) is 0.01,which is less than 0.05, so it is statistically significant, thus rejecting null hypothesis(Homogeneity).

Since homogeneity failed we are setting var.equal to FALSE as there is no equal means.

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| ***> res <- stats::t.test(g\_sc ~ school\_nat,var.equal=FALSE,data=s\_perform)***  ***> effcd=round((2\*res$statistic)/sqrt(res$parameter),2)***  ***> effectsize::t\_to\_d(t = res$statistic, res$parameter)***  ***d | 95% CI***  ***-------------------***  ***0.53 | [0.49, 0.56]***  ***> effes=round((res$statistic\*res$statistic)/((res$statistic\*res$statistic)+(res$parameter)),3)***  ***> effes***  ***t***  ***0.064*** |

* Cohens-d value = 0.53, which implies a medium effect size.
* eta value = 0.064, which implies a medium effect size.
* Since the test was statistically significant it implies that the variable school\_nat could act as a predictor for g\_sc.

## **Section 3.2 – Model 1**

Research Question : Can we predict the global score of the student using their Quantitative Reasoning and Critical Reading?

**Null Hypothesis:** The values of g\_sc cannot be predicted with the predictor variables(cr\_pro, qr\_pro) using Multiple linear Regression.

**Alternate Hypothesis:** **:** The values of g\_sc can be predicted with the predictor variables(cr\_pro, qr\_pro) using Multiple linear Regression.

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| > model1<-lm(s\_perform$g\_sc~s\_perform$qr\_pro+s\_perform$cr\_pro)  > stargazer(model1, type="text")  =================================================  Dependent variable:  -----------------------------  g\_sc  -------------------------------------------------  qr\_pro 0.380\*\*\*  (0.006)    cr\_pro 0.480\*\*\*  (0.005)    Constant 103.484\*\*\*  (0.398)    -------------------------------------------------  Observations 12,406  R2 0.712  Adjusted R2 0.712  Residual Std. Error 12.401 (df = 12403)  F Statistic 15,341.490\*\*\* (df = 2; 12403)  =================================================  > lm.beta(model1)  Call:  lm(formula = s\_perform$g\_sc ~ s\_perform$qr\_pro + s\_perform$cr\_pro)  Standardized Coefficients::  (Intercept) s\_perform$qr\_pro s\_perform$cr\_pro  0.0000000 0.3725515 0.5740398  > vifmodel  s\_perform$qr\_pro s\_perform$cr\_pro  1.481366 1.481366  > #Tolerance  > 1/vifmodel  s\_perform$qr\_pro s\_perform$cr\_pro  0.6750525 0.6750525 |

* The p-value indicates our model is significant, so we can reject the null hypothesis and accept the alternate hypothesis that the values of g\_sc can be predicted with the predictor variables(cr\_pro, qr\_pro) using Multiple linear Regression.
* Increase marks in qr\_pro and cr\_pro appears to be associated with increase marks in g\_sc.
* The F statistic looks at whether the model as whole is statistically significant.
* In our case adjusted r 2 value 0.712, which means around 71.2% of the variance g\_sc can be explained by cr\_pro and qr\_pro.
* Our linear regression model is **Predicted g\_sc = 103 + 0.38\*qr\_pro + 0.48\*cr\_pro**
* In our case using the standardised coefficents our model equation becomes: **Predicted g\_sc = 0 + 0.373\*qr\_pro + 0.574\*cr\_pro**

**Assumptions:**

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| Chart  Description automatically generatedChart, scatter chart  Description automatically generated  Cooks distance Leverage Plots  Chart, scatter chart  Description automatically generatedChart, scatter chart  Description automatically generated  Residual Fits  Chart, line chart  Description automatically generatedChart, histogram  Description automatically generated  Error Distribution |

* It can be observed that all the points are less than 1, So we don't have to worry about the outliers
* We can see that there is no pattern and points are equally distributed, therefore homoscedasticity is not an concern
* Minimum and Maximum value is within the acceptable range(-3.29,+3.29) hence we do not have outliers.  
  Though the red lines are slightly distorted but this is not a huge problem
* We can see that the errors are normally distributed
* Both collinearity and tolerance were with the acceptable limits (VIF <2.5 and tolerance > 0.4). So, we have no issues with Multi collinearity.

## **Section 3.3 – Model 2**

Research Question : Can we predict the global score of the student using their Quantitative Reasoning and Critical Reading with School Nature as dummy variable?

Differential effect

* We use the variable school\_nat as a predictor, since it is a categorical type we use it as a dummy variable to understand the differential effect of the global\_scores of students studied in Private and Public schools.
* Here, 0 (reference category, Private) and 1 (category of interest, Public)

**Null Hypothesis** The values of g\_sc cannot be predicted with the predictor variables(cr\_pro, qr\_pro, school\_nat) using Multiple linear Regression.

**Alternate Hypothesis:** **:** The values of g\_sc can be predicted with the predictor variables(cr\_pro, qr\_pro, school\_nat) using Multiple linear Regression.

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| > model2<-lm(s\_perform$g\_sc~s\_perform$qr\_pro+s\_perform$cr\_pro+s\_perform$school\_nat)  > stargazer(model2, type="text") #Tidy output of all the required stats  =================================================  Dependent variable:  -----------------------------  g\_sc  -------------------------------------------------  qr\_pro 0.368\*\*\*  (0.006)    cr\_pro 0.471\*\*\*  (0.005)    school\_natPUBLIC -5.134\*\*\*  (0.222)    Constant 107.329\*\*\*  (0.424)    -------------------------------------------------  Observations 12,406  R2 0.724  Adjusted R2 0.724  Residual Std. Error 12.141 (df = 12402)  F Statistic 10,847.740\*\*\* (df = 3; 12402)  =================================================  Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01  > lm.beta(model2)  Call:  lm(formula = s\_perform$g\_sc ~ s\_perform$qr\_pro + s\_perform$cr\_pro +  s\_perform$school\_nat)  Standardized Coefficients::  (Intercept) s\_perform$qr\_pro s\_perform$cr\_pro s\_perform$school\_natPUBLIC  0.0000000 0.3614803 0.5634178 -0.1109039 |

* The p-value indicates our model is significant, so we can reject the null hypothesis and accept the alternate hypothesis that the values of g\_sc can be predicted with the predictor variables(cr\_pro, qr\_pro,school\_nat) using Multiple linear Regression.
* Increased marks in qr\_pro and cr\_pro appears to be associated with increase marks in g\_sc.
* The F statistic looks at whether the model as whole is statistically significant.
* Our linear regression model is **Predicted g\_sc = 103 + 0.368\*qr\_pro + 0.471\*cr\_pro – 5.134\*school\_natPUBLIC**
* In our case using the standardised coefficients our model equation becomes: **Predicted g\_sc = 0 + 0.361\*qr\_pro + 0.563\*cr\_pro - 0.11\* school\_natPUBLIC**
* When we calculate the equation for Public and Private schools:

Public = 0+0.361+0.563-0.11=0.814  
Private=0+0.361+0.563 =0.924

* We can see a small difference between the group yes and no.
* We can see a slight change in the coefficent compared to model 1.
* In our case adjusted r 2 value 0.724, which means around 72.4% of the variance g\_sc can be explained by cr\_pro and qr\_pro when a dummy variable school\_nat is added. An increase compared to model 1.

**Assumptions:**

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* It can be observed that all the points are less than 1, So we don't have to worry about the outliers
* We can see that there is no pattern and points are equally distributed, therefore homoscedasticity is not an concern
* Minimum and Maximum value is within the acceptable range(-3.29,+3.29) hence we do not have outliers.  
  Though the red lines are slightly distorted but this is not a huge problem
* We can see that the errors are normally distributed
* Both collinearity and tolerance were with the acceptable limits (VIF <2.5 and tolerance > 0.4). So, we have no issues with Multi collinearity.
* The differential effect in the global scores can be see between the students who studied in Public and Private.

## **Section 3.3 – Model comparison**

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| > stargazer(model1, model2, type="text")  ===============================================================================  Dependent variable:  -----------------------------------------------------------  g\_sc  (1) (2)  -------------------------------------------------------------------------------  qr\_pro 0.380\*\*\* 0.368\*\*\*  (0.006) (0.006)    cr\_pro 0.480\*\*\* 0.471\*\*\*  (0.005) (0.005)    school\_natPUBLIC -5.134\*\*\*  (0.222)    Constant 103.484\*\*\* 107.329\*\*\*  (0.398) (0.424)    -------------------------------------------------------------------------------  Observations 12,406 12,406  R2 0.712 0.724  Adjusted R2 0.712 0.724  Residual Std. Error 12.401 (df = 12403) 12.141 (df = 12402)  F Statistic 15,341.490\*\*\* (df = 2; 12403) 10,847.740\*\*\* (df = 3; 12402)  ===============================================================================  Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01 |

* Both the models are significant.
* The adjusted R2 has changed by 1% after adding the dummy variable.
* Adding the "students\_nat" variable decreased the F-statistic of the model 1 and thus making model 2 more reliable

# **Section 4 – Discussion/Conclusion**

The prediction of global score using different predictors yielded two different models which upon testing was able to predict almost 70% of the values.

* Research question 1, was successfully answered by creating a model to predict the global scores and the necessary steps required to build said model are followed and the model is tested.
* Research question 2, was successfully answered by creating a model to predict the global scores and the differential effect of school\_nat has been analysed and added to the model and the model is tested.
* New research questions can be developed using other variables in the dataset like

the eng\_s11, qr\_s11, mat\_s11 can be used to predict the eng\_pro, qr\_pro.