Analysis Report

This report is structured as follows.

Contents

Descriptive Statistics

The table below presents descriptive statistics for various variables across four different exams. The focus is on how these variables change from one exam to the next.

Exam Score: The average exam score starts high at 0.937 in Exam 1 and then shows a slight decrease in Exam 2 to 0.892. It marginally increases in Exams 3 and 4 to 0.903 and 0.913 respectively. This trend suggests a dip in performance in the second exam, followed by a slight recovery in subsequent exams.

Days Studied of 31: The mean days studied begins at 5.565 for Exam 1, decreasing significantly to 4.478 for Exam 2, and then further dropping to around 2.261 and 2.609 for Exams 3 and 4. This indicates a notable reduction in the number of days students spent studying as the exam series progressed.

Total Reviews: There is a fluctuation in the average total reviews, starting at 602.957 for Exam 1, peaking at 702.391 for Exam 2, then decreasing to 488.870 and 526.435 for Exams 3 and 4. This variable does not follow a clear trend across the exams.

Average for Days Studied: This variable also shows variation, starting at 100.174 for Exam 1, slightly decreasing in Exam 2, then increasing in Exams 3 and 4. The increase in later exams suggests a higher intensity or effectiveness of study per day.

Average Total: The mean value shows considerable variation across the exams, with the highest average total observed in Exam 2.

Cards: The variables Card_New, Card_Learning, Card_Relearning, Card_Young, Card_Mature, and Card_Suspended seem to represent different categories or types of study materials or methods. Each shows different patterns of usage across the exams. For example, Card_New usage peaks in Exam 2, while Card_Learning shows a significant increase in the same exam. Card_Relearning and Card_Mature have relatively low averages but show some increase by Exam 4.

Variable	**Exam 1**		**Exam 2**		**Exam 3**		**Exam 4**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Exam_Score	0.937	0.056	0.892	0.075	0.903	0.046	0.913	0.046
Days_studied_of_31	5.565	5.035	4.478	5.177	2.261	3.003	2.609	4.098
Total_reviews	602.957	598.675	702.391	1213.630	488.870	767.828	526.435	904.097
Average_for_days_studied	100.174	79.920	79.652	101.077	109.130	162.886	139.304	250.217
Average_total	19.478	19.278	25.652	44.829	15.739	24.735	17.043	29.049
Card_New	408.043	223.163	610.130	344.408	467.304	286.037	573.174	334.874
Card_Learning	14.870	26.755	47.652	177.491	4.217	9.244	6.696	10.814
Card_Relearning	0.652	2.288	0.000	0.000	0.261	1.251	1.304	6.041
Card_Young	235.870	227.481	174.304	267.239	189.565	267.099	218.174	320.214
Card_Mature	10.913	16.847	21.957	51.491	0.087	0.288	7.739	22.316
Card_Suspended	8.000	21.030	10.696	29.007	11.609	26.534	0.783	3.541

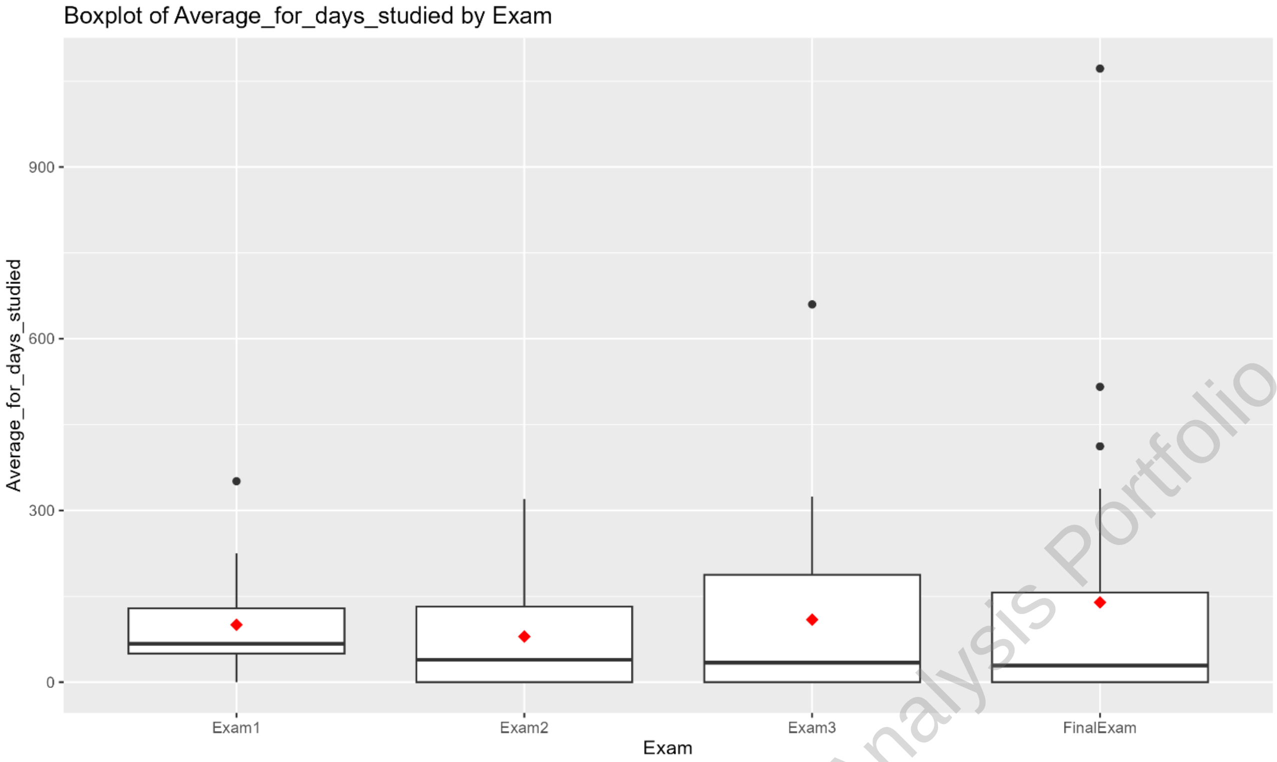
Descriptive Statistics – No Outliers

The table below contains descriptive statistics without considering Students 4 and 10.

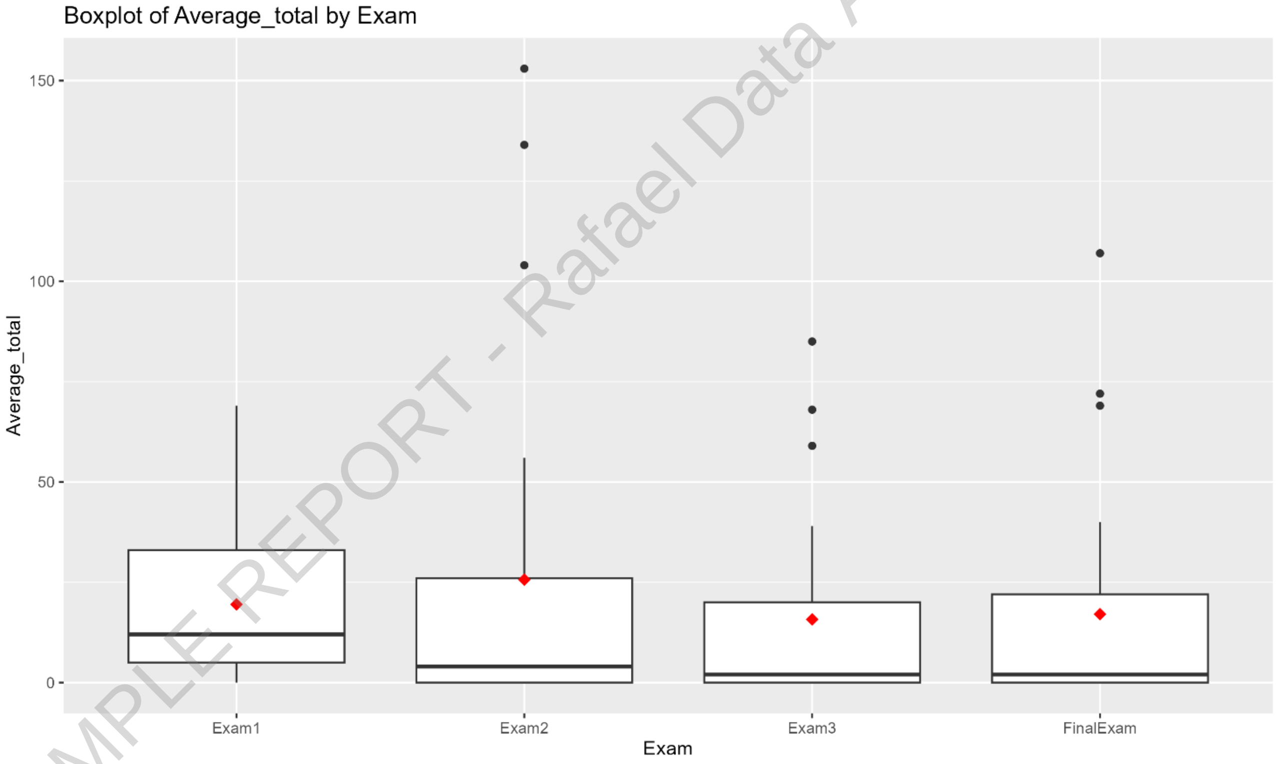
Variable	Exam 1		Exam 2		Exam 3		Exam 4	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Exam_Score	0.933	0.057	0.897	0.066	0.904	0.047	0.916	0.038
Days_studied_of_31	5.333	4.564	4.762	5.319	2.143	2.920	2.238	3.548
Total_reviews	558.762	506.774	761.000	1256.167	448.571	738.738	469.762	857.071
Average_for_days_studied	103.381	80.371	84.476	104.274	107.095	165.626	144.333	260.415
Average_total	18.048	16.280	27.810	46.405	14.429	23.775	15.238	27.555
Card_New	397.238	229.000	589.619	353.958	479.714	277.097	589.286	322.332
Card_Learning	16.190	27.681	50.714	185.785	4.619	9.594	7.333	11.124
Card_Relearning	0.714	2.390	0.000	0.000	0.286	1.309	1.429	6.321
Card_Young	227.333	213.184	189.190	275.409	176.667	256.719	204.762	312.619
Card_Mature	10.333	16.710	24.048	53.513	0.048	0.218	4.190	13.902
Card_Suspended	8.619	21.946	11.714	30.216	11.619	27.591	0.857	3.705

Boxplots

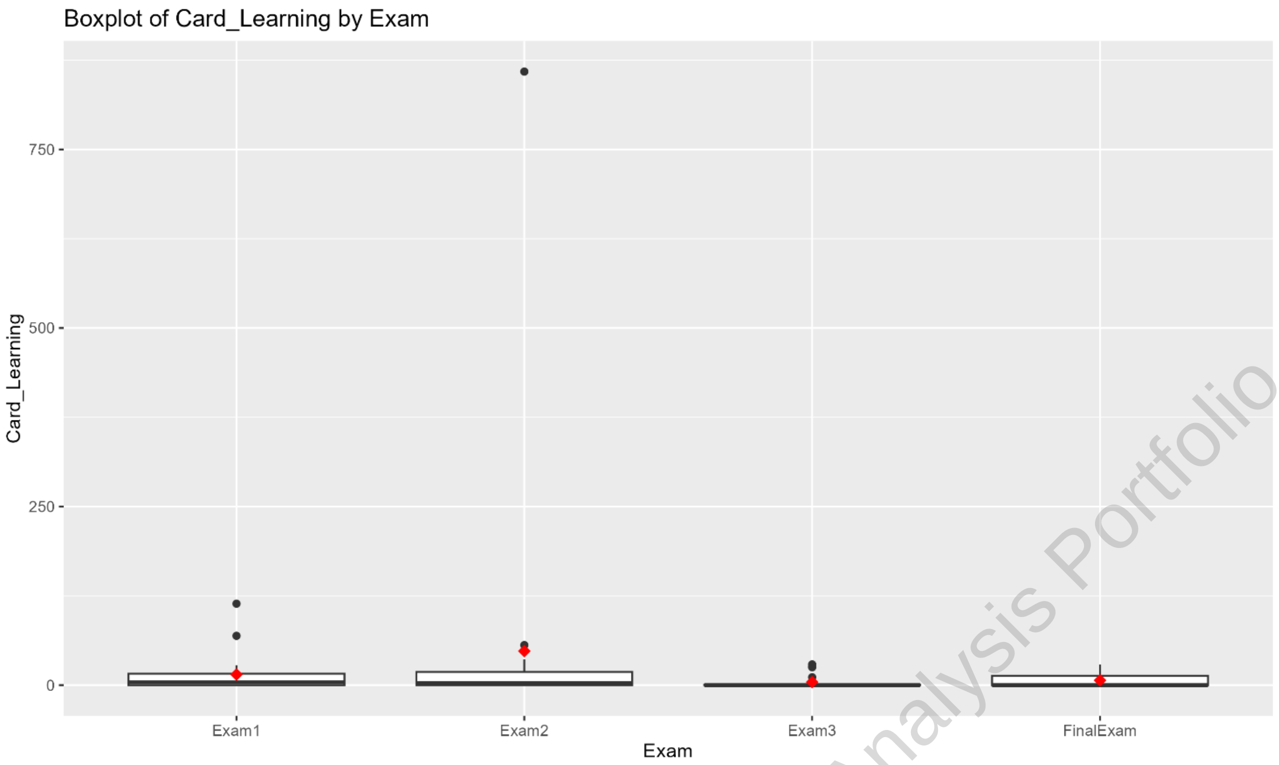
The boxplots on this section provide a visualization of the data distribution of different metrics on different exams. Some variables contain several outliers, which in some cases make the box barely visible in the graph.

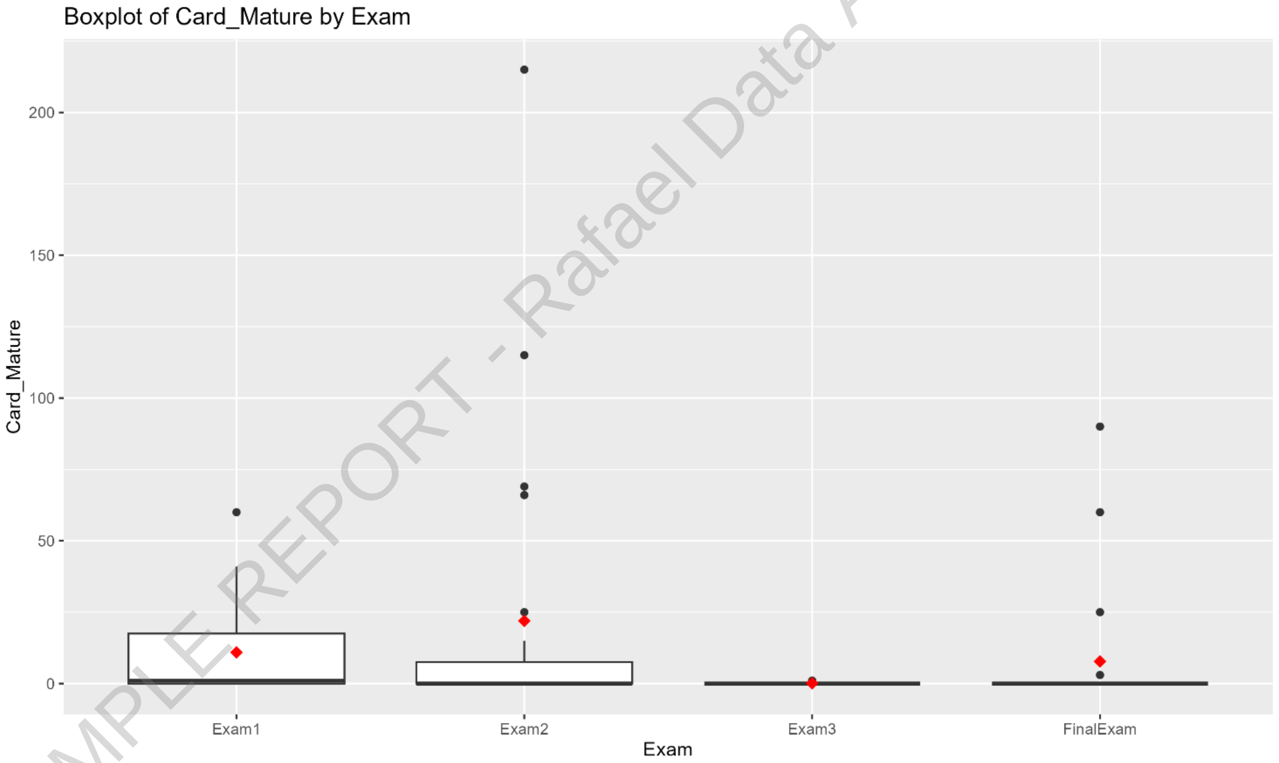


Boxplot of Average_for_days_studied by Exam

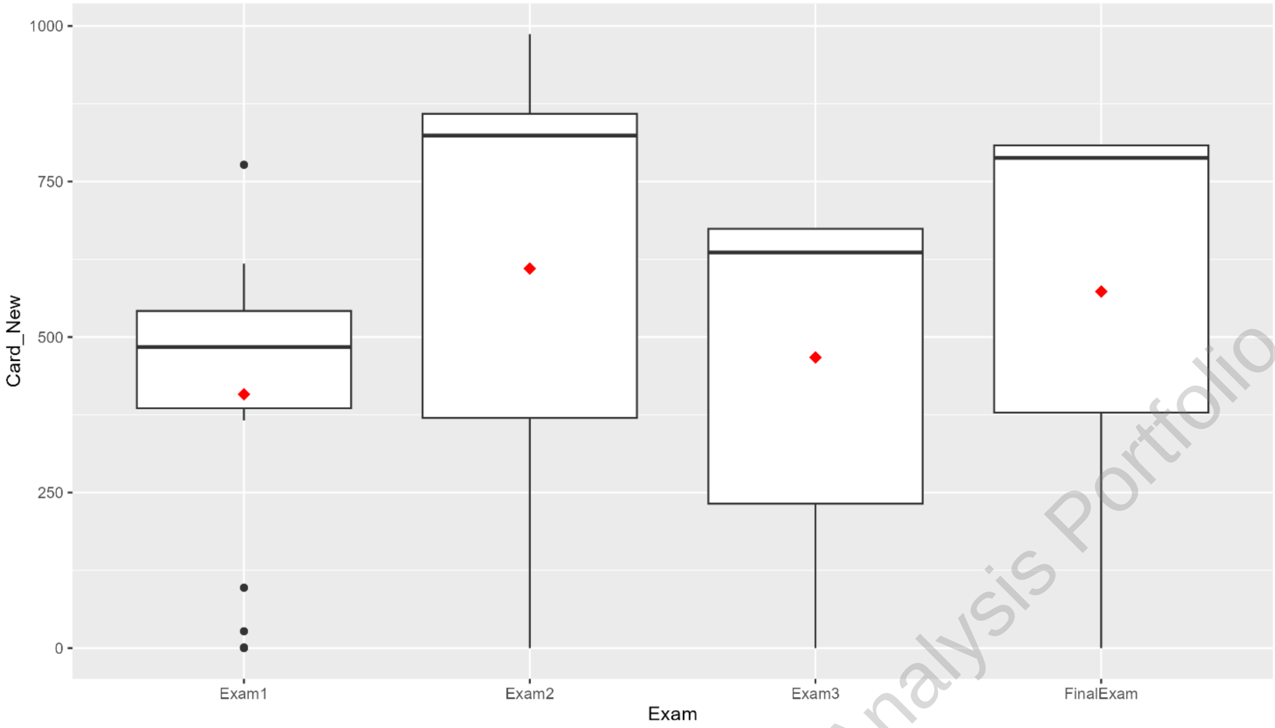


Boxplot of Average_total by Exam

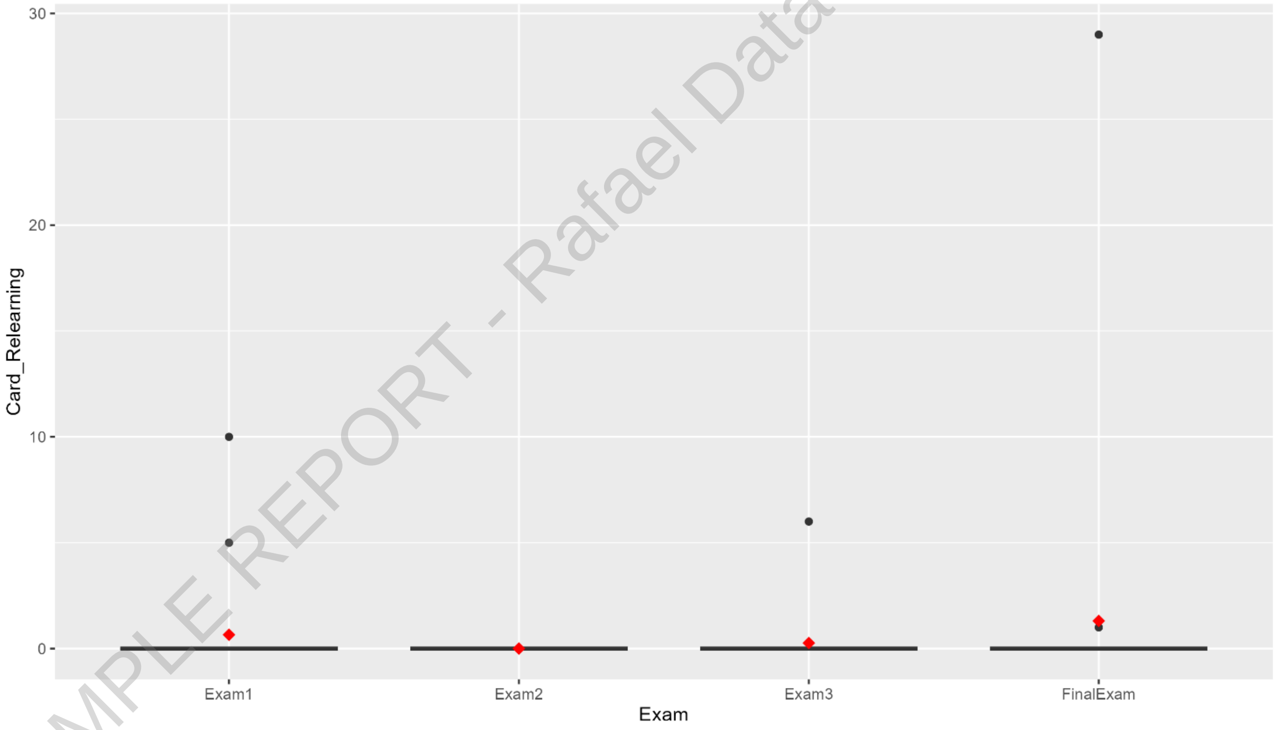

Boxplot of Card_Learning by Exam
Card_Learning
750
500
250
0
Exam1
Exam2
Exam3
FinalExam
Exam

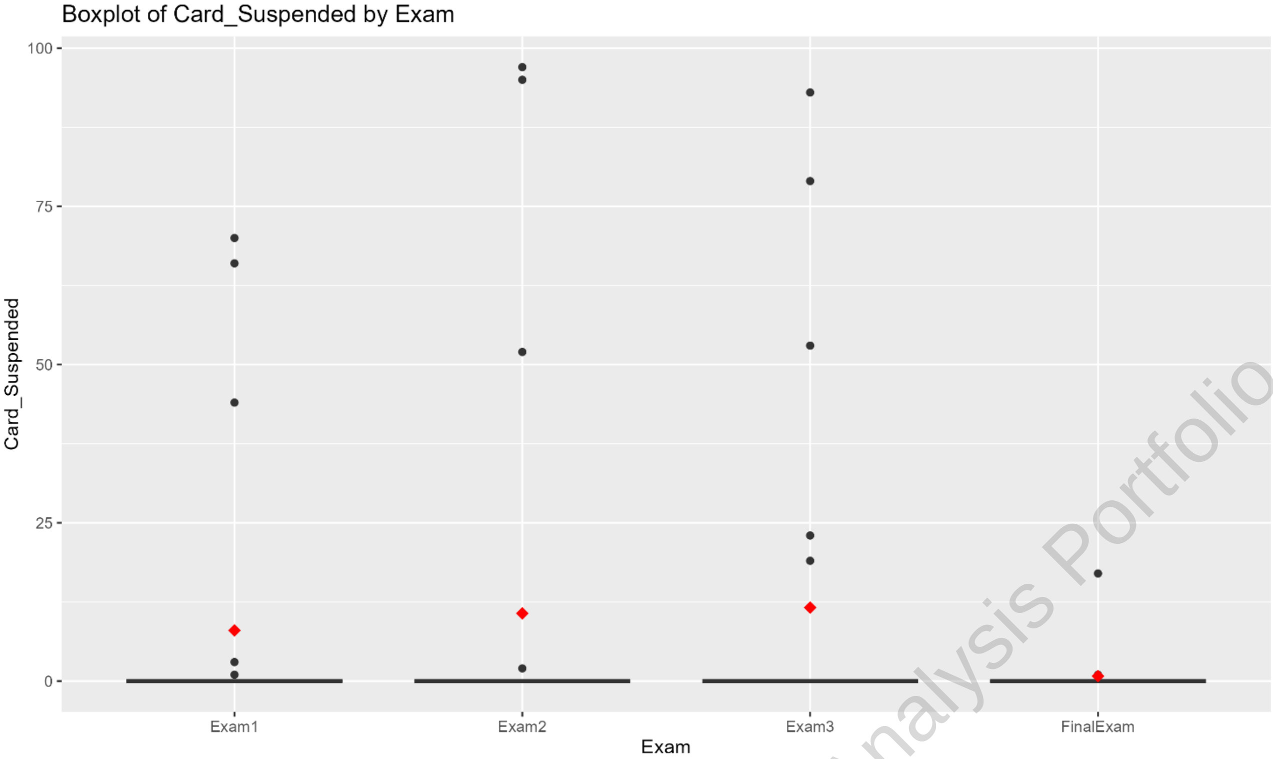

Boxplot of Card_Mature by Exam
Card_Mature
200
150
100
50
0
Exam1
Exam2
Exam3
FinalExam
Exam

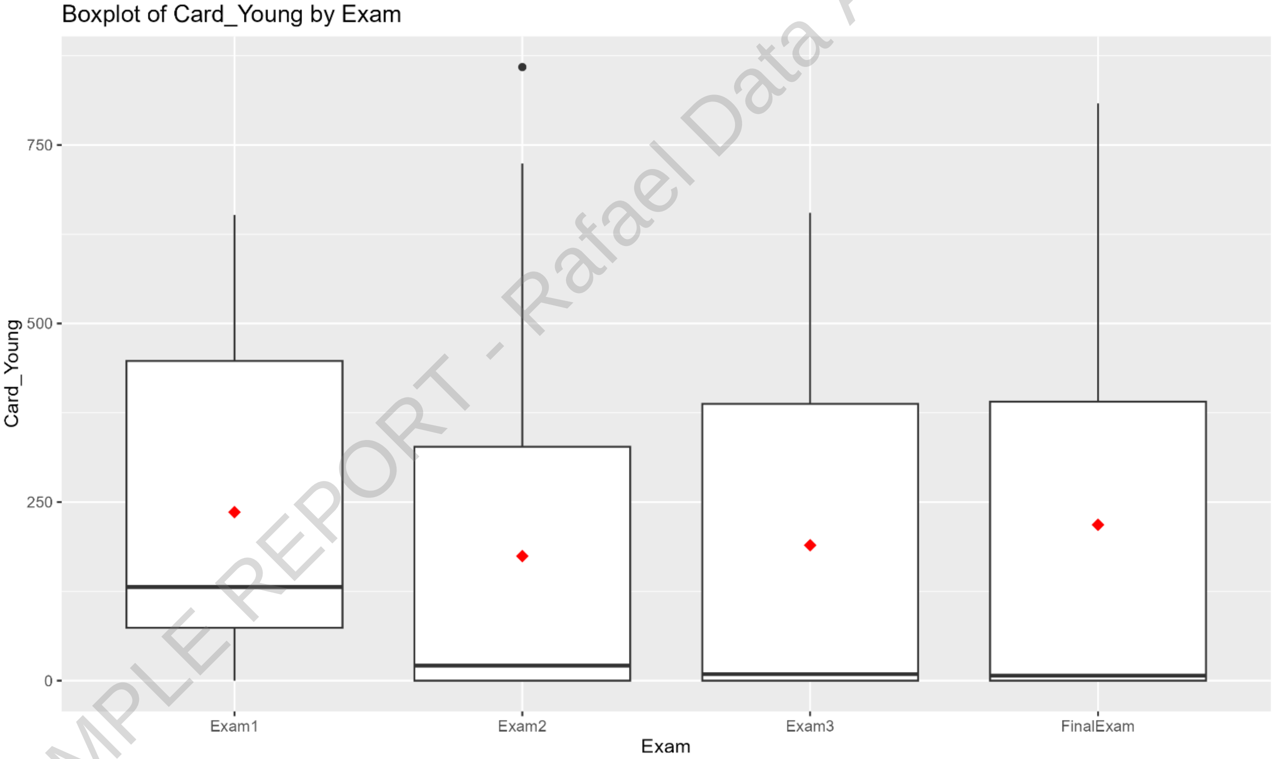
Boxplot of Card_New by Exam



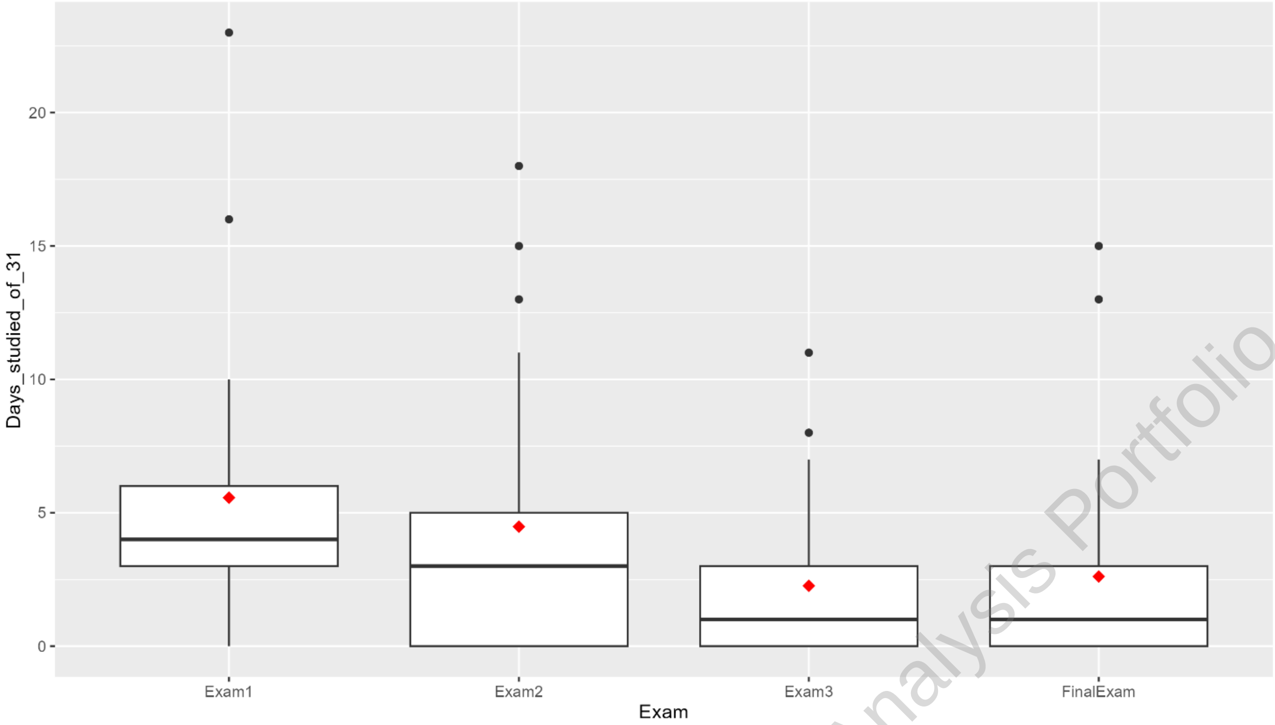
Boxplot of Card_Relearning by Exam



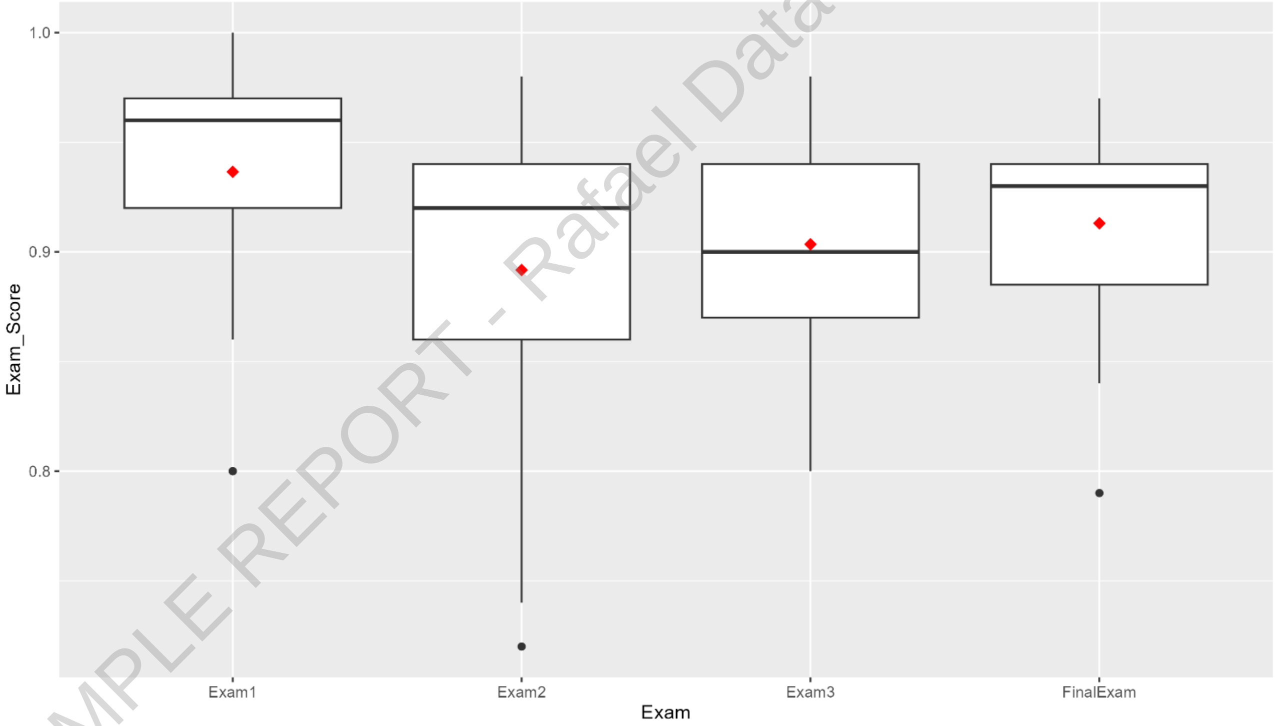

Boxplot of Card_Suspended by Exam
Card_Suspended
100
75
50
25
0
Exam1
Exam2
Exam3
FinalExam
Exam

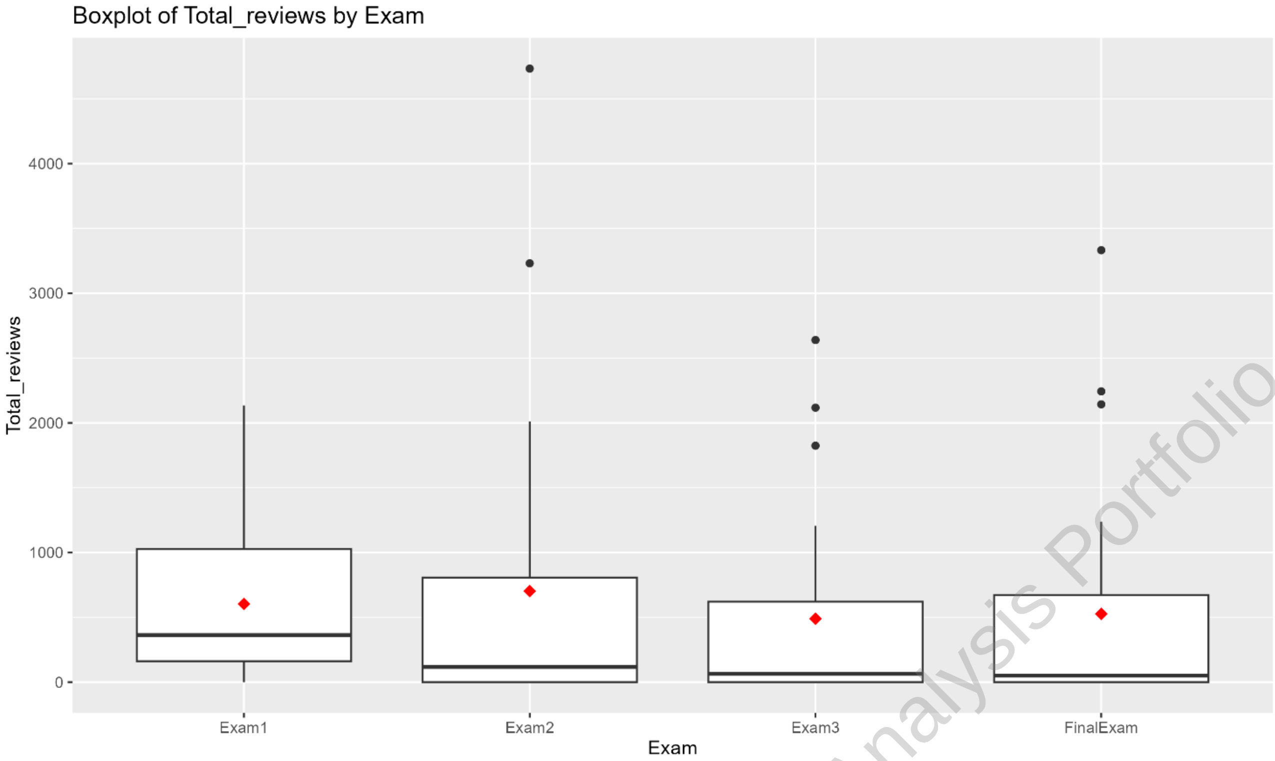

Boxplot of Card_Young by Exam
Card_Young
750
500
250
0
Exam1
Exam2
Exam3
FinalExam
Exam

Boxplot of Days_studied_of_31 by Exam



Boxplot of Exam_Score by Exam




Boxplot of Total_reviews by Exam
Total_reviews
4000
3000
2000
1000
0
Exam1
Exam2
Exam3
FinalExam
Exam

Correlation Analysis

The correlation table reveals several interesting relationships between "Exam_Score" and other variables, though it's important to note that these correlations, while statistically significant in some cases, are generally weak to moderate in strength. "Exam_Score" shows a positive correlation with "Days_studied_of_31" ($r = 0.173$, $p < 0.1$), indicating that students who spend more days studying tend to have slightly higher exam scores, although the correlation is weak. A similar relationship is observed with "Total_reviews" ($r = 0.185$, $p < 0.1$), suggesting that students who review more also tend to score slightly higher on exams.

However, for "Average_for_days_studied", the correlation with "Exam_Score" is positive ($r = 0.132$) but not statistically significant, implying that the average score per day studied does not have a clear relationship with overall exam scores. On the other hand, "Average_total" exhibits a positive correlation ($r = 0.185$, $p < 0.1$) with "Exam_Score", again indicating a weak association where higher averages are slightly related to better exam performance.

Interestingly, "Exam_Score" has negative correlations with "Card_New" ($r = -0.229$, $p < 0.05$) and "Card_Learning" ($r = -0.252$, $p < 0.05$), both significant at the 0.05 level. These correlations suggest that students who are more engaged with new cards or learning cards tend to score lower, although these relationships are not strong. Conversely, "Card_Young" shows a moderately positive correlation ($r = 0.246$, $p < 0.05$) with "Exam_Score", indicating that engagement with this category of cards is associated with higher exam scores.

For "Card_Mature" and "Card_Suspended", the correlations with "Exam_Score" are positive but relatively weak ($r = 0.090$ and $r = 0.221$, $p < 0.05$, respectively). These correlations suggest a slight association between these card types and exam scores, with higher engagement correlating with marginally higher exam scores.

	1	2	3	4	5	6	7	8	9	10	11
Exam_Score (1)	1.000	0.173*	0.185*	0.132	0.185*	-0.229**	-0.252**	0.080	0.246**	0.090	0.221**
Days_studied_of_31 (2)	0.173*	1.000	0.800***	0.249**	0.770***	-0.596***	-0.058	0.257**	0.647***	0.578***	0.461***
Total_reviews (3)	0.185*	0.800***	1.000	0.615***	0.973***	-0.757***	-0.067	0.313***	0.859***	0.393***	0.473***
Average_for_days_studied (4)	0.132	0.249**	0.615***	1.000	0.597***	-0.661***	-0.063	0.099	0.750***	0.068	0.247**
Average_total (5)	0.185*	0.770***	0.973***	0.597***	1.000	-0.748***	-0.064	0.287***	0.849***	0.379***	0.537***
Card_New (6)	-0.229**	-0.596***	-0.757***	-0.661***	-0.748***	1.000	-0.159	-0.224**	-0.889***	-0.305***	-0.526***
Card_Learning (7)	-0.252**	-0.058	-0.067	-0.063	-0.064	-0.159	1.000	-0.031	-0.090	-0.045	-0.036
Card_Relearning (8)	0.080	0.257**	0.313***	0.099	0.287***	-0.224**	-0.031	1.000	0.230**	0.050	0.081
Card_Young (9)	0.246**	0.647***	0.859***	0.750***	0.849***	-0.889***	-0.090	0.230**	1.000	0.293***	0.466***
Card_Mature (10)	0.090	0.578***	0.393***	0.068	0.379***	-0.305***	-0.045	0.050	0.293***	1.000	0.237**
Card_Suspended (11)	0.221**	0.461***	0.473***	0.247**	0.537***	-0.526***	-0.036	0.081	0.466***	0.237**	1.000

*: p < 0.1 **: p < 0.05 *** p < 0.01

Correlation Analysis – No Outliers

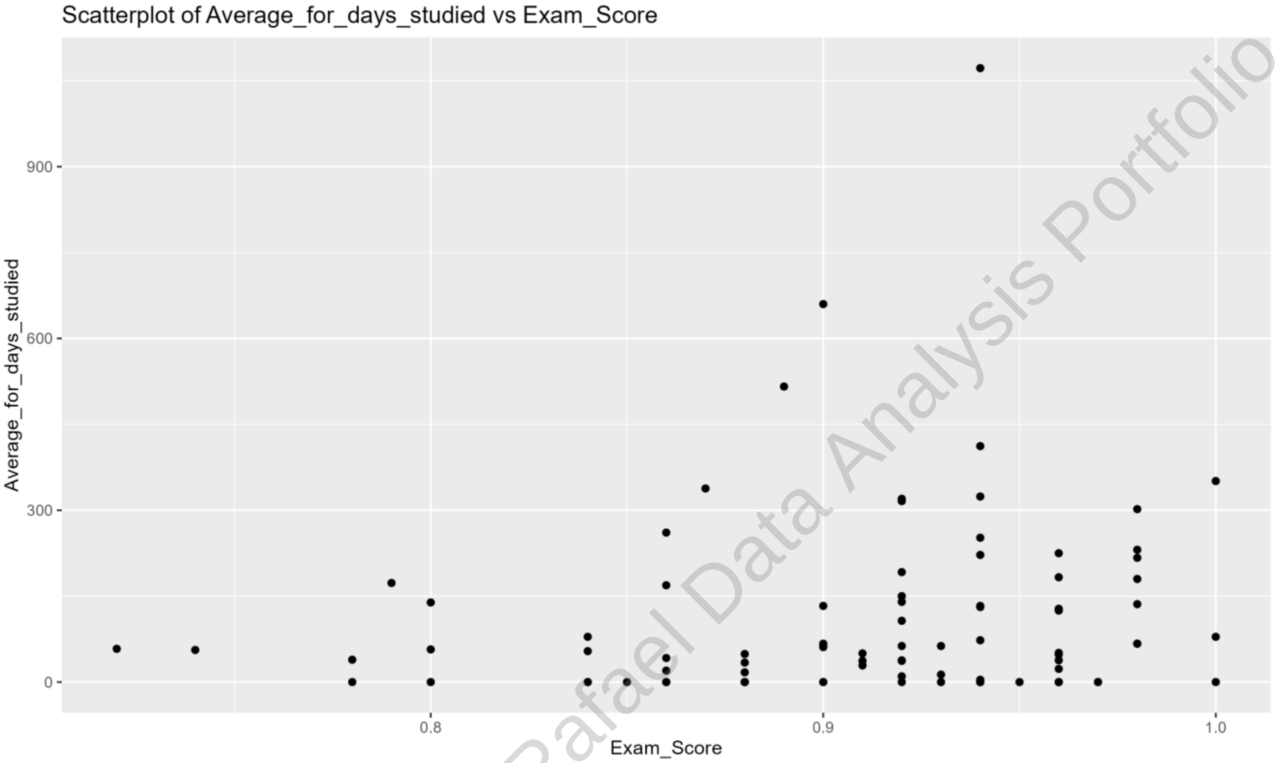
The matrix below presents correlation coefficients without Students 4 and 10. Now ‘Average for Days Studied’ is significantly positively correlated with Exam Scores ($r = 0.192$, $p < 0.10$). The magnitude of the correlations between exam scores and both total reviews and days studied have increased without the outliers.

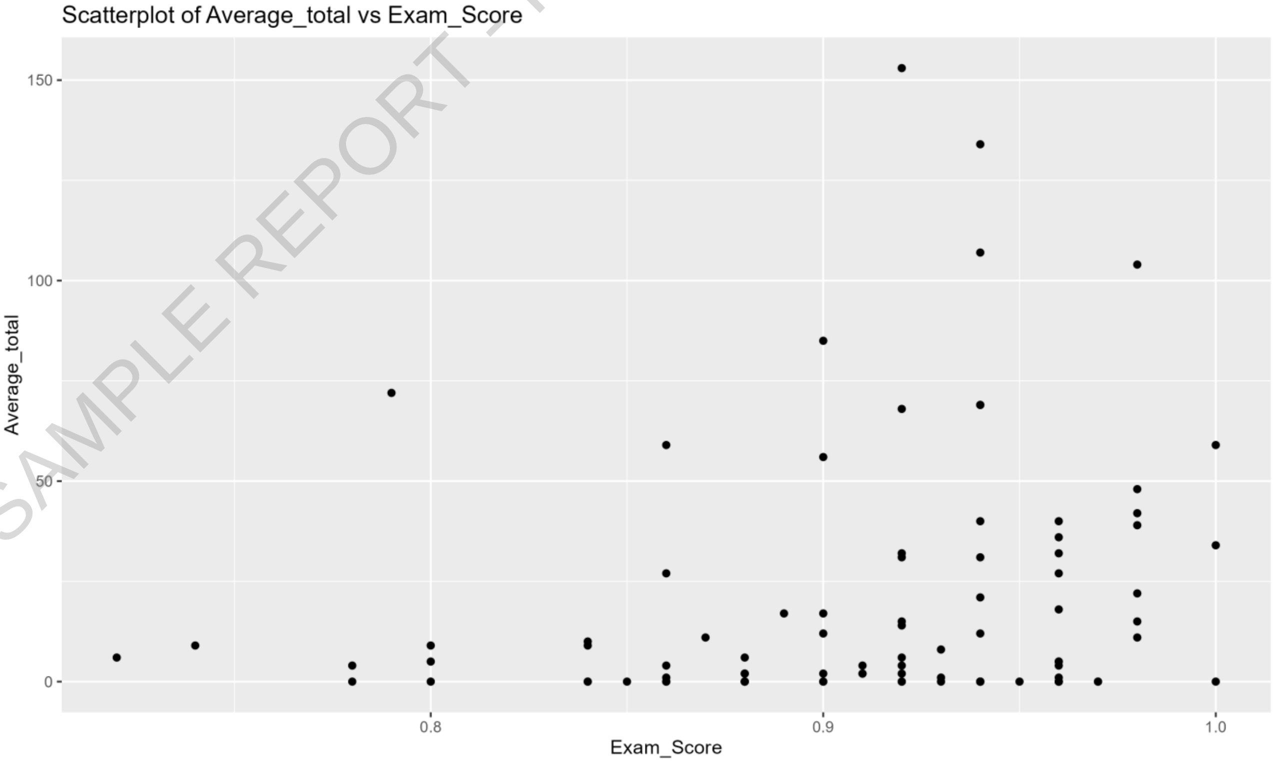
	1	2	3	4	5	6	7	8	9	10	11
Exam_Score (1)	1.000	0.298***	0.293***	0.192*	0.285***	-0.333***	-0.278**	0.086	0.373***	0.174	0.255**
Days_studied_of_31 (2)	0.298***	1.000	0.778***	0.226**	0.747***	-0.586***	-0.058	0.286***	0.601***	0.555***	0.503***
Total_reviews (3)	0.293***	0.778***	1.000	0.615***	0.970***	-0.746***	-0.065	0.338***	0.841***	0.353***	0.495***
Average_for_days_studied (4)	0.192*	0.226**	0.615***	1.000	0.592***	-0.655***	-0.066	0.098	0.760***	0.051	0.236**
Average_total (5)	0.285***	0.747***	0.970***	0.592***	1.000	-0.736***	-0.062	0.306***	0.832***	0.340***	0.559***
Card_New (6)	-0.333***	-0.586***	-0.746***	-0.655***	-0.736***	1.000	-0.171	-0.236**	-0.889***	-0.271**	-0.537***
Card_Learning (7)	-0.278**	-0.058	-0.065	-0.066	-0.062	-0.171	1.000	-0.034	-0.091	-0.042	-0.039
Card_Relearning (8)	0.086	0.286***	0.338***	0.098	0.306***	-0.236**	-0.034	1.000	0.250**	0.055	0.078
Card_Young (9)	0.373***	0.601***	0.841***	0.760***	0.832***	-0.889***	-0.091	0.250**	1.000	0.241**	0.488***
Card_Mature (10)	0.174	0.555***	0.353***	0.051	0.340***	-0.271**	-0.042	0.055	0.241**	1.000	0.259**
Card_Suspended (11)	0.255**	0.503***	0.495***	0.236**	0.559***	-0.537***	-0.039	0.078	0.488***	0.259**	1.000

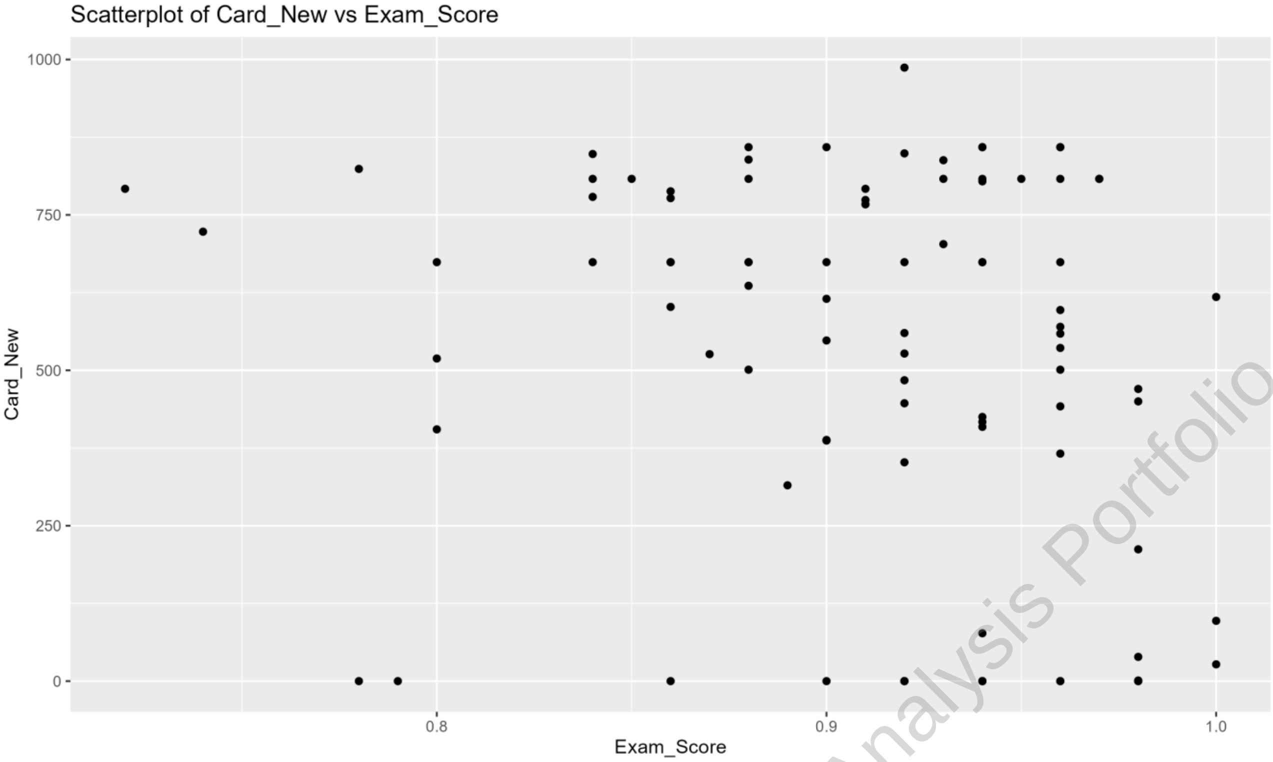
*: p < 0.1 **: p < 0.05 *** p < 0.01

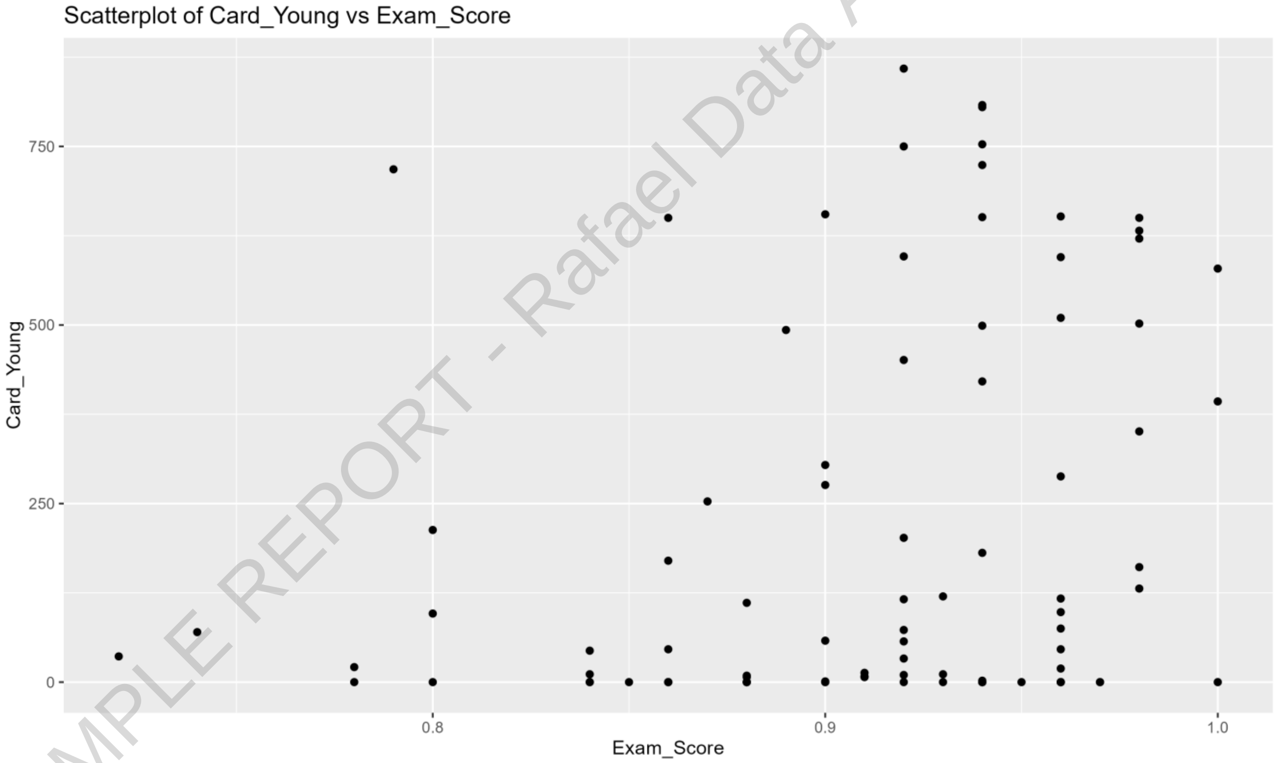
Scatterplots

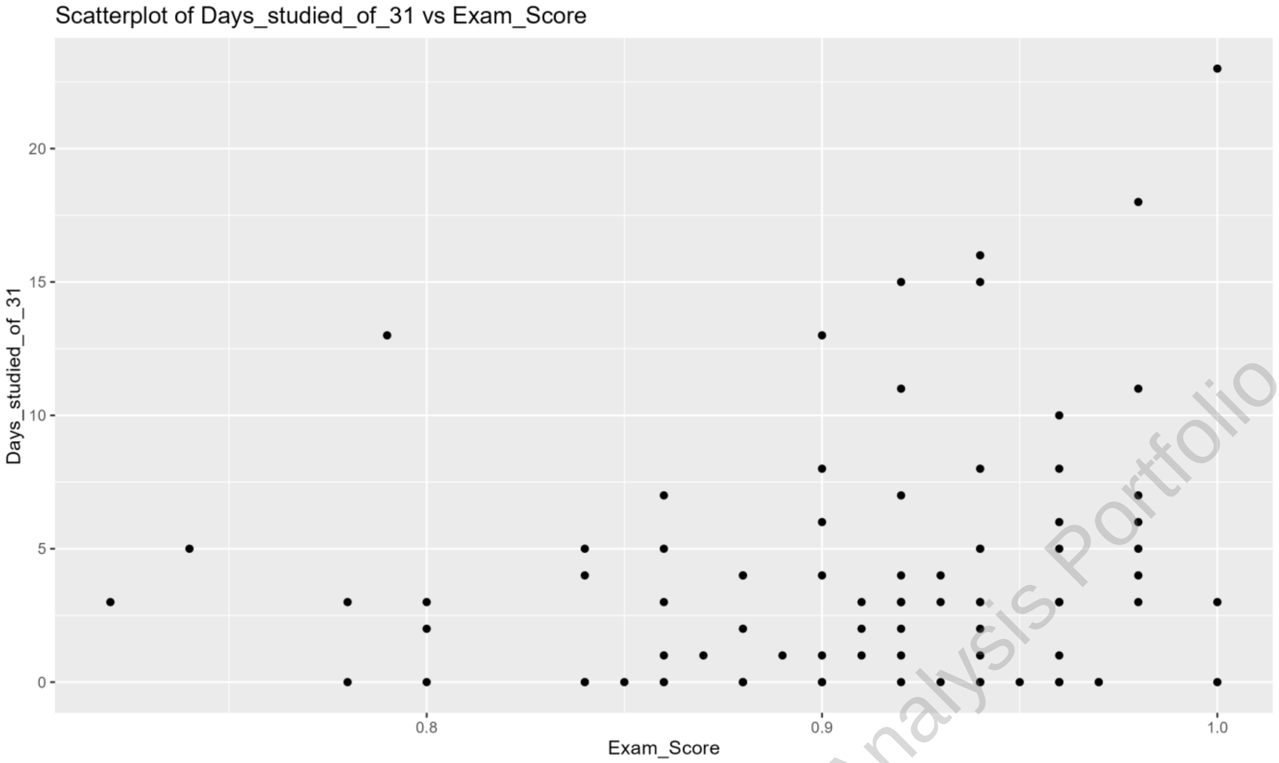
This section shows bivariate scatterplots between Exam Scores and other factors, which illustrate how they are correlated. In some cases such as the two figures below, it is noticeable that higher values of 'Exam_Score' tend to be associated with higher values of 'Days_Studied' or 'Average_Total'.



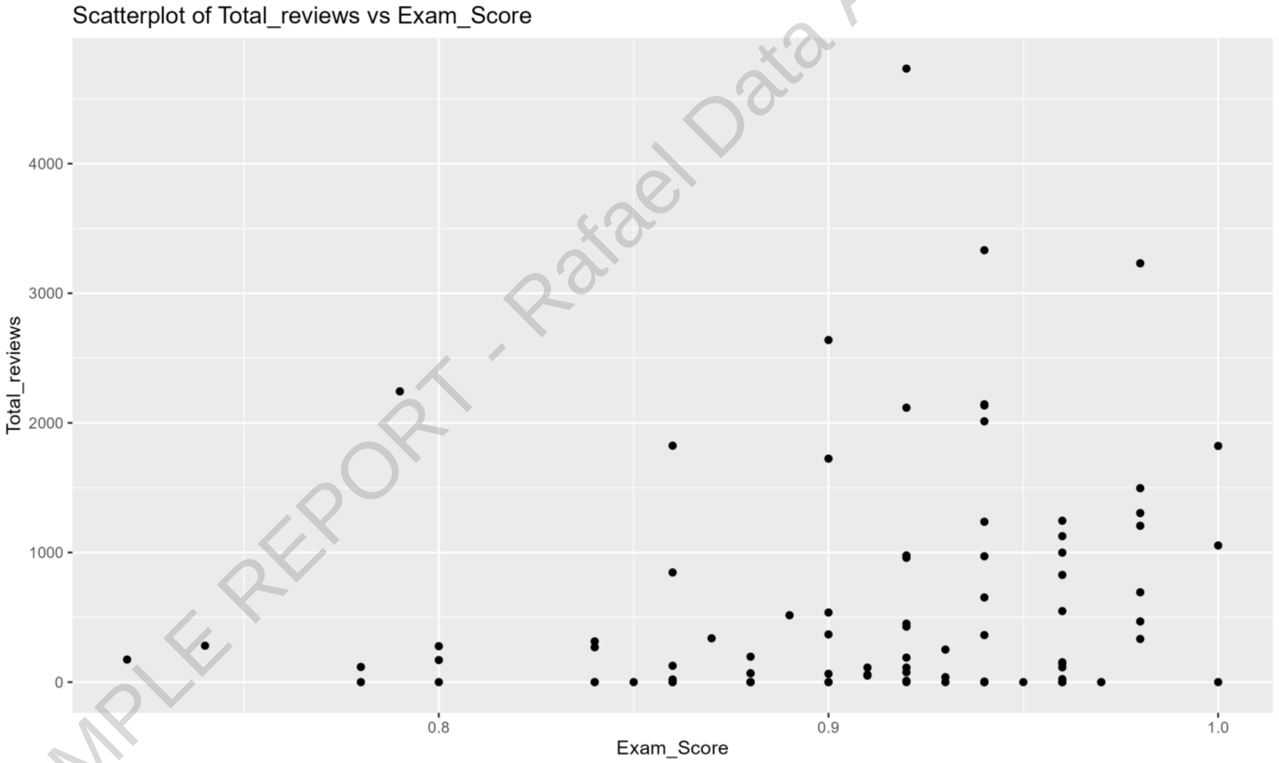



Scatterplot of Card_New vs Exam_Score


Scatterplot of Card_Young vs Exam_Score



Scatterplot of Days_studied_of_31 vs Exam_Score



Scatterplot of Total_reviews vs Exam_Score

Linear Mixed Model

Lastly, a Linear Mixed Model was fit to the data. Not all variables were inserted here due to their correlational nature. We chose the ‘Total_Reviews’ variable due to having the highest correlation with exam score. Nevertheless, several models were attempted in order to explore for significant results, which were not achieved.

A Linear Mixed Model (LMM) is a statistical model designed to handle complex data structures, particularly those involving hierarchical or nested data. It's commonly used when data points are not independent of each other, which is often the case in repeated measures, longitudinal studies, or when data are collected from clusters or groups (like schools, hospitals, etc.). The key feature of an LMM is its ability to model both fixed and random effects.

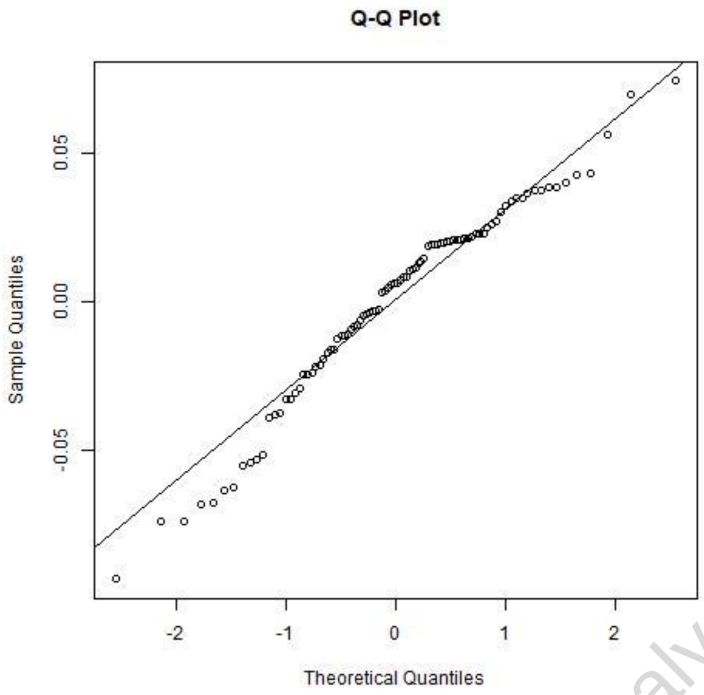
Fixed effects represent the average relationship between the predictor(s) and the response variable across all groups or levels in the data. In our model, "Total_reviews" is the fixed effect.

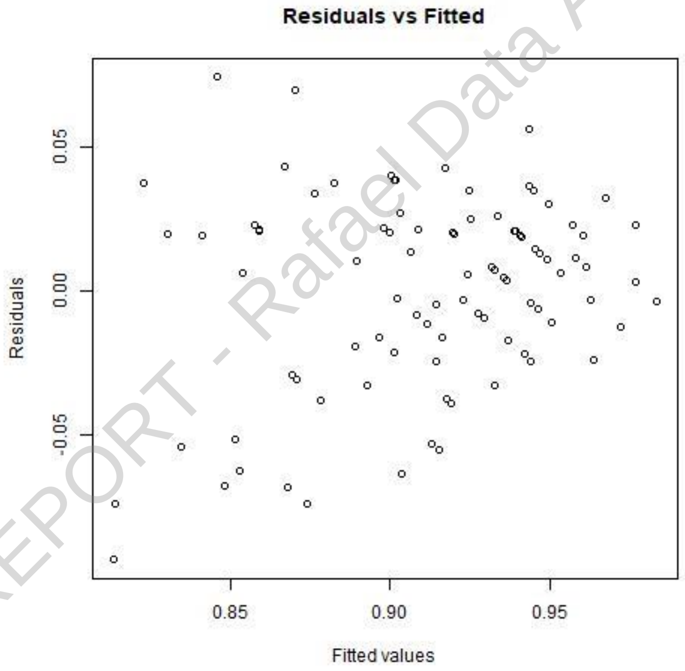
Random effects account for variations that are not captured by the fixed effects. They are used to model the impact of factors that vary across groups or levels, like individual differences or variations among clusters. In our model, "Exam" and "Student" are the random effects. This means the model accounts for the fact that exam scores might naturally vary from one exam to another and from one student to another, beyond what can be explained by the number of total reviews alone. The results are presented below.

Variable	estimate	std.error	statistic	df	p.value
(Intercept)	0.905	0.014	66.688	10.356	0.000
Total_reviews	9.85e-06	0.000	1.340	82.913	0.184

The estimate for Total_Reviews indicates the amount of change in the exam score expected for each one-unit increase in "Total_reviews". The estimate is very small (0.00000985), and with a p-value of 0.184, it's not statistically significant This implies that, after accounting for the variability in exams and students, the number of total reviews is not a strong predictor of exam scores within this particular dataset.

The figures below are used to assess the residual assumptions of the model. Both figures indicate that residuals follow a normal distribution, which makes the model valid and interpretable.


Q-Q Plot
Sample Quantiles
0.05
0.00
-0.05
-2
-1
0
1
2
Theoretical Quantiles


Residuals vs Fitted
Residuals
0.05
0.00
-0.05
0.85
0.90
0.95
Fitted values