Measures of Success: Determining the most significant predictors of student achievement

An analysis of student achievement data in secondary education of two Portuguese schools courtesy of UC Irvine Machine Learning Repository

Seth Dalmacio, Rachel Brown, Talibah Timothy, Liliana Perez Diaz, Nedal Rashid

Project Overview

*In this project we sought to answer, **what are the most important predictors that will determine whether a student passes or fails?***

Our Methodology:

1. Clean data
2. Use a classification algorithm (Logistic regression, K-Means Clustering, etc) to determine the variables that appear to have the most impact on student achievement
3. Create and train a model to predict student outcomes
4. Visualize findings
5. Evaluate model performance

Dataset Used: https://archive.ics.uci.edu/dataset/320/student+performance

Tools Used: Pandas, Matplotlib, Seaborn, Scikit learn

Data cleaned to ensure consistency and usability

Purpose: Ensure the dataset is consistent, understandable, and ready for analysis by removing irrelevant or redundant data and handling missing values.

1. **Remove**

   Remove unnecessary columns identity those that do not contribute to analysis

2. **Rename**

   Make column names more consistent and descriptive

3. **Address inconsistencies**

   Handle missing or inconsistent values; check for missing data and either fill in with suitable value or drop

4. **Scale**

   Normalize and scale numerical features

5. **Export**

   Export cleaned dataset for use in analysis

Data cleaned to ensure consistency and usability

Before cleaning

```
school;sex;age;address;famsize;Pstatus;Medu;Fedu;Mjob;Fjob;reason;guardian;traveltime;studytime;failures;schoolsup;famsup;paid;activities;nursery;h
GP;"F";18;"U";"GT3";"A";4;4;"at_home";"teacher";"course";"mother";2;2;0;"yes";"no";"no";"no";"yes";"yes";"no";"no";4;3;4;1;1;3;6;"5";"6";6
GP;"F";17;"U";"GT3";"T";1;1;"at_home";"other";"course";"father";1;2;0;"no";"yes";"no";"no";"no";"yes";"yes";"no";5;3;3;1;1;3;4;"5";"5";6
GP;"F";15;"U";"LE3";"T";1;1;"at_home";"other";"other";"mother";1;2;3;"yes";"no";"yes";"no";"yes";"yes";"yes";"no";4;3;2;2;3;3;10;"7";"8";10
GP;"F";15;"U";"GT3";"T";4;2;"health";"services";"home";"mother";1;3;0;"no";"yes";"yes";"yes";"yes";"yes";"yes";"yes";3;2;2;1;1;5;2;"15";"14";15
GP;"F";16;"U";"GT3";"T";3;3;"other";"other";"home";"father";1;2;0;"no";"yes";"yes";"no";"yes";"yes";"no";"no";4;3;2;1;2;5;4;"6";"10";10
GP;"M";16;"U";"LE3";"T";4;3;"services";"other";"reputation";"mother";1;2;0;"no";"yes";"yes";"yes";"yes";"yes";"yes";"no";5;4;2;1;2;5;10;"15";"15";15
```

After cleaning

school	sex	age	Parent_sta	Mother_Ec	Father_Ed	Mjob	Fjob	reason	traveltime	Study_Tim	failures	schoolsup	famsup	paid	activities	nursery	higher	internet
GP	F	18	A	4	4	at_home	teacher	course	2	2	0	1	0	0	0	1	1	0
GP	F	17	T	1	1	at_home	other	course	1	2	0	0	1	0	0	0	1	1
GP	F	15	T	1	1	at_home	other	other	1	2	3	1	0	1	0	1	1	1
GP	F	15	T	4	2	health	services	home	1	3	0	0	1	1	1	1	1	1
GP	F	16	T	3	3	other	other	home	1	2	0	0	1	1	0	1	1	0
GP	M	16	T	4	3	services	other	reputatior	1	2	0	0	1	1	1	1	1	1
GP	M	16	T	2	2	other	other	home	1	2	0	0	0	0	0	1	1	1

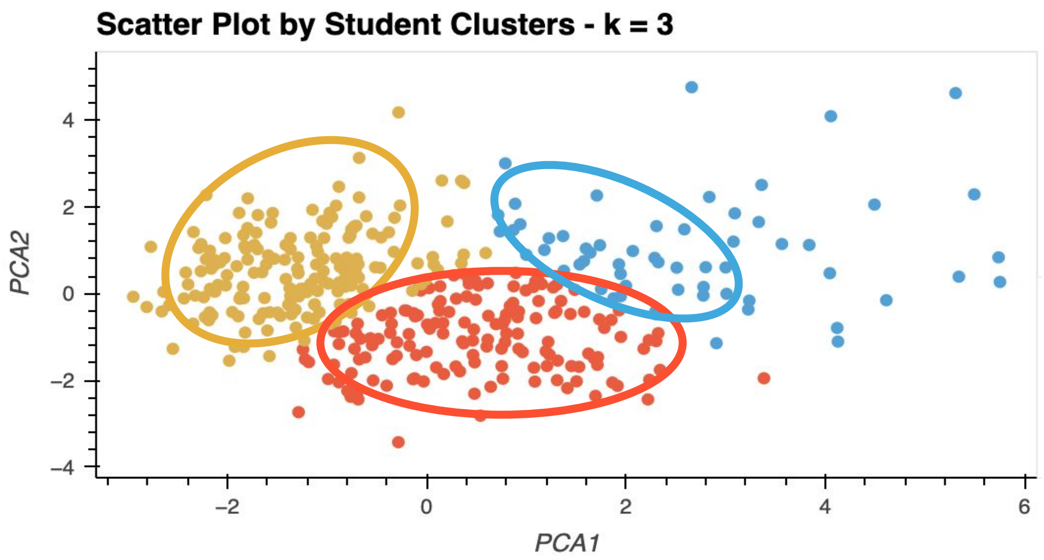
Data cleaned to ensure consistency

```
[1]: import pandas as pd
     from sklearn.preprocessing import MinMaxScaler

[2]: # Load the dataset
     data = pd.read_csv('Resources/student-mat.csv', delimiter=';')

[3]: # Remove unnecessary columns
     columns_to_remove = ["G1", "G2", "Walc", "address", "famrel", "Dalc", "guardian", "famsize"]
     data.drop(columns=[col for col in columns_to_remove if col in data.columns], errors='ignore', inplace=True)

[4]: # Rename columns
     data.rename(columns={"G3": "final_grade", "studytime": "Study_Time_Hours", "Fedu": "Father_Edu", "Medu": "Mother_Edu", "Pstatus"

[5]: # Convert 'yes'/'no' to 0's and 1's
     binary_columns = ['schoolsup', 'famsup', 'paid', 'activities', 'nursery', 'higher', 'internet', 'romantic']
     for col in binary_columns:
         if col in data.columns:
             data[col] = data[col].map({'yes': 1, 'no': 0})

[6]: # Handle missing values: Fill with mean for 'absences'
     if 'absences' in data.columns:
         data['absences'].fillna(data['absences'].mean(), inplace=True)
```

- Clean Data
- Rename columns
- Remove columns
- Prepare data for for rest of the steps

And more

Clusters only explain ~20% of variance



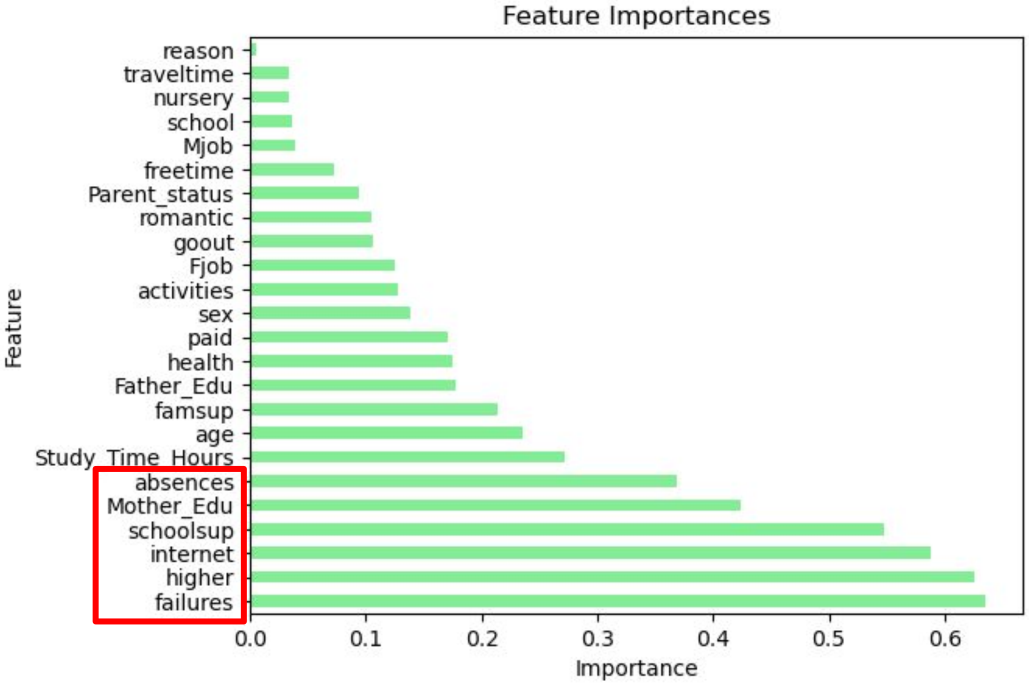
Variance

- PCA 1: 13.10%
- PCA 2: 7.36%

Highest homogeneity with students in cluster 2

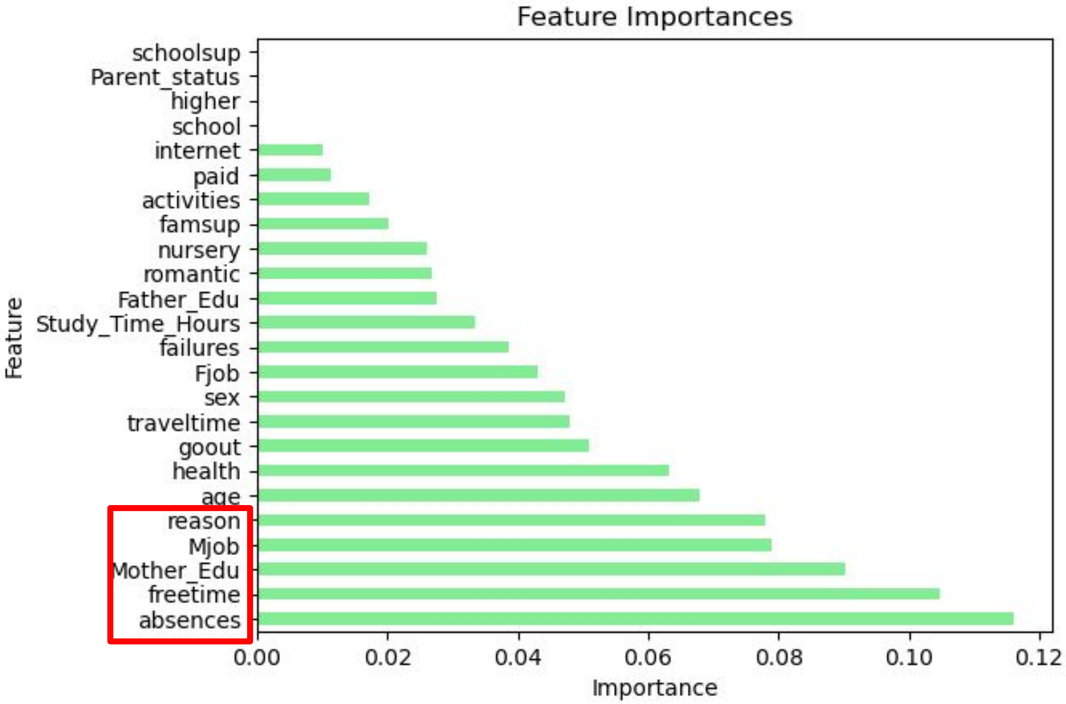
Clusters overlap

Logistic regression shows past failures, desire for higher ed, internet access may be predictors of success



	Feature	Coefficient
11	failures	0.637093
17	higher	0.625623
18	internet	0.586423
12	schoolsup	0.546977
4	Mother_Edu	0.424645
23	absences	0.368176
10	Study_Time_Hours	0.272150
2	age	0.235348
13	famsup	0.214005
5	Father_Edu	0.177268
22	health	0.175581
14	paid	0.170889
1	sex	0.138447
15	activities	0.127860
7	Fjob	0.125328
21	goout	0.106399
19	romantic	0.104248
3	Parent_status	0.093528
20	freetime	0.073369
6	Mjob	0.039472
0	school	0.035761
16	nursery	0.033901
9	traveltime	0.033049
8	reason	0.005652

Decision Trees reveal absences, free time, and mother's education level to be potential predictors of success



	Feature	Importance
23	absences	0.116200
20	freetime	0.104882
4	Mother_Edu	0.090366
6	Mjob	0.079067
8	reason	0.077947
2	age	0.067986
22	health	0.063255
21	goout	0.050796
9	traveltime	0.048039
1	sex	0.047128
7	Fjob	0.043158
11	failures	0.038519
10	Study_Time_Hours	0.033431
5	Father_Edu	0.027494
19	romantic	0.026718
16	nursery	0.026166
13	famsup	0.020151
15	activities	0.017273
14	paid	0.011335
18	internet	0.010087
0	school	0.000000
17	higher	0.000000
3	Parent_status	0.000000
12	schoolsup	0.000000

Model correctly classified around 71% of cases, may be some bias toward positive predictions

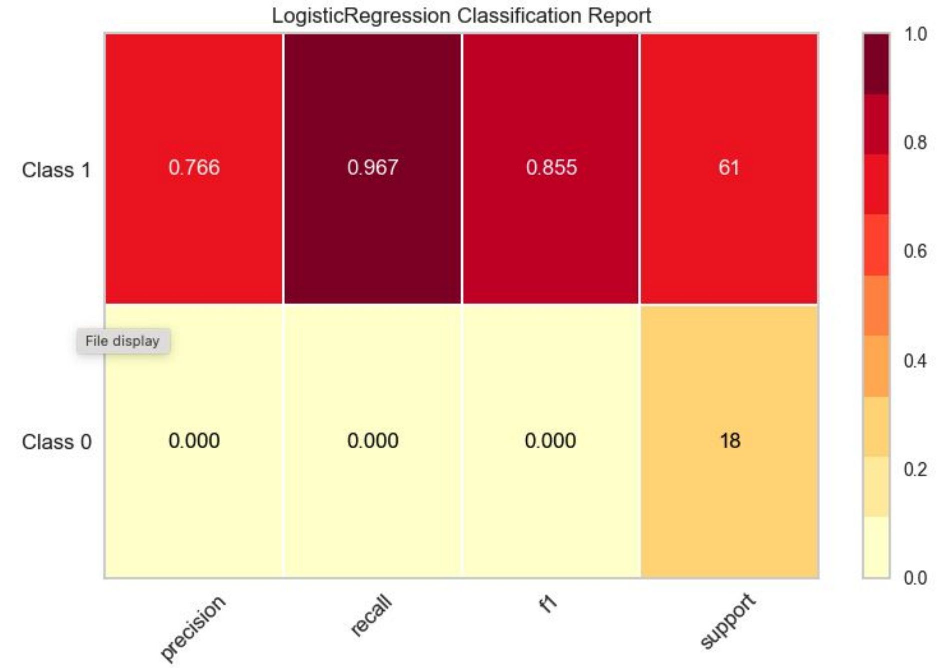
Confusion Matrix

	Predicted 0	Predicted 1
Actual 0	5	16
Actual 1	13	65

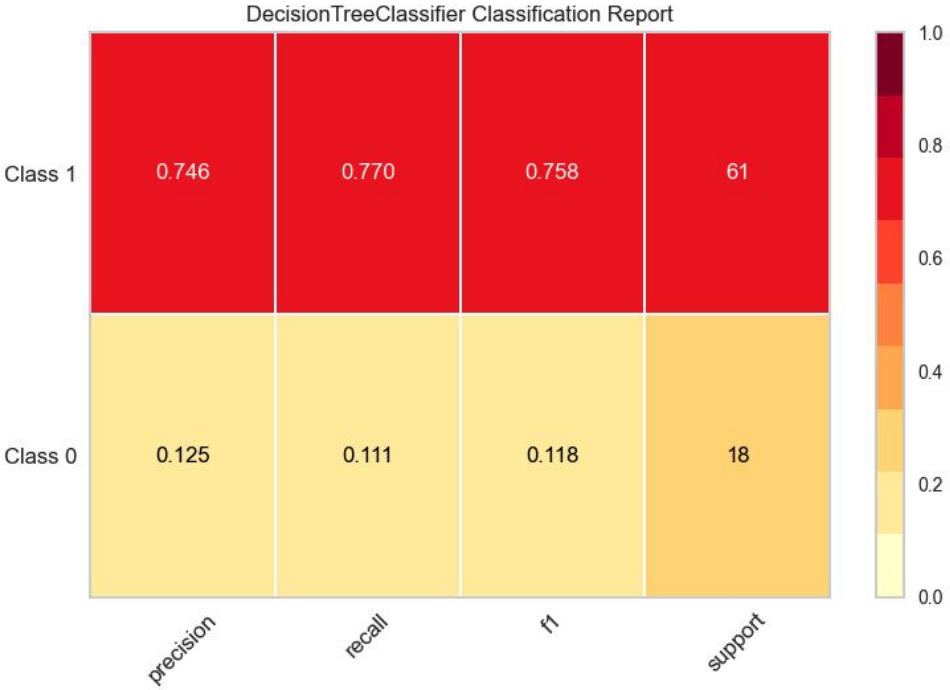
0 = low success
1 = high success

```
Accuracy Score : 0.7070707070707071
Classification Report
              precision    recall  f1-score   support

           0       0.28      0.24      0.26        21
           1       0.80      0.83      0.82        78

    accuracy                           0.71        99
   macro avg       0.54      0.54      0.54        99
weighted avg       0.69      0.71      0.70        99
```

Model shows strong bias toward predicting positive cases but struggles significantly with negative cases suggesting potential imbalance issues in the training data



Decision Tree shows slightly more balanced performance between classes, though still poor for Class 0



Thank you!

Questions?

Resources

Data

- https://archive.ics.uci.edu/dataset/320/student+performance