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Early Warning System for At-Risk Students: Leveraging Data to Reduce Drop-Out Rates

Ethan

Project Proposal

- ★ Our goal is to create an **Early Warning System for At-Risk Students**.
- ★ The education dataset, collected via school reports and questionnaires, consists of over 600 individual data instances from two Portuguese classes including attributes such as
  - demographics
  - grades
  - social factors
  - support
- ★ We're hoping to identify problem areas within students' environments and potentially reduce the total drop-out rate.

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Key Questions: Potential Risk Factors

- extra educational support
- higher-educated parents
- health
- social tendencies

Methodology

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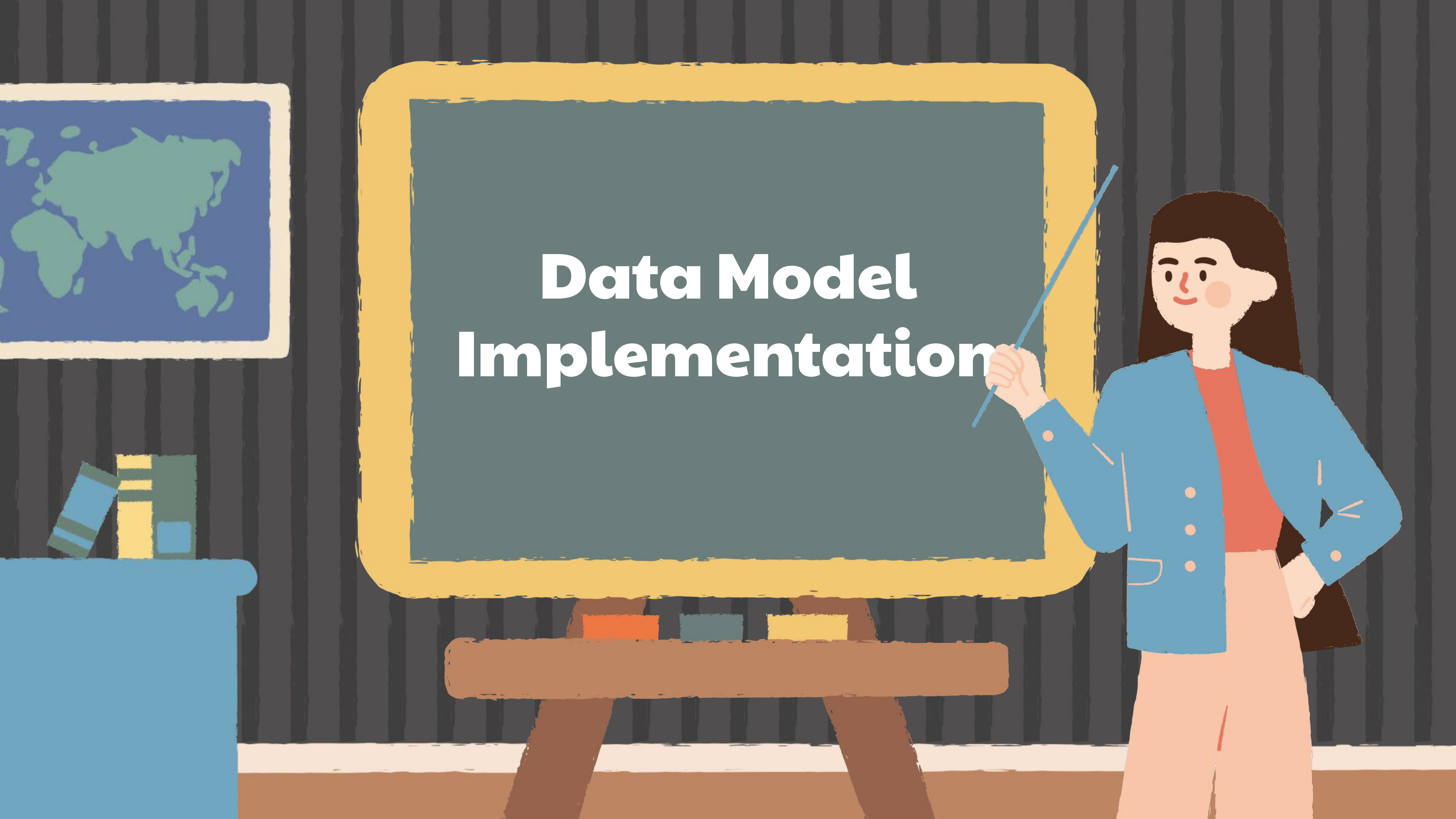
Data Model Implementation

- cleaned two CSVs (math class data, Portuguese class data)
- SQLite database creation

Data Model Optimization

- feature engineering
- multilabel classification
- modifying target
- experimenting with model type

Prediction & Visualization


Data Model
Implementation

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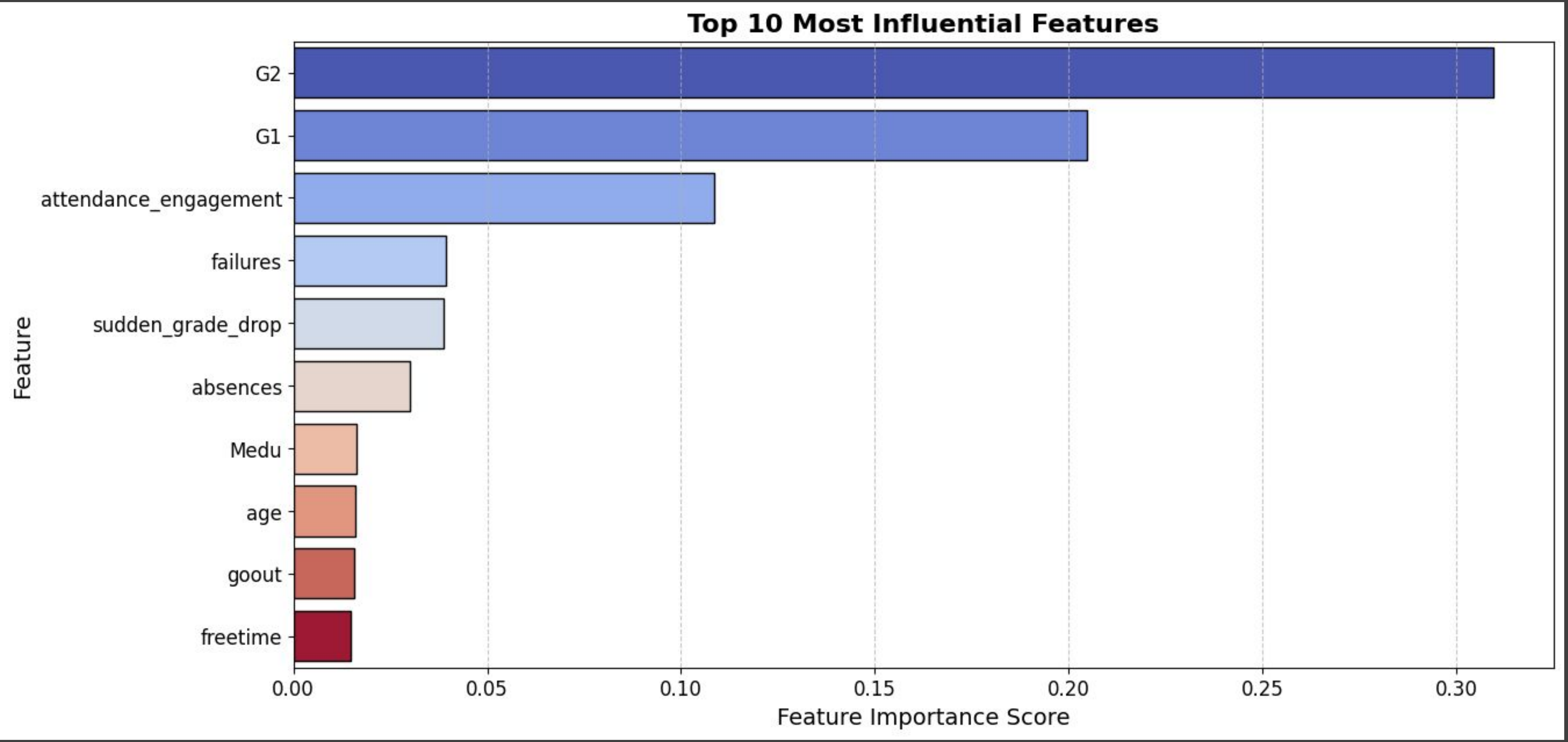
Process

- **Minimal cleaning**
- **Feature Engineering**
  - Attendance Engagement (Balances absences with grades)
  - Sudden Grade Drop (from G1 to G2)
  - Low Engagement Flag (Flags students whose engagements levels are in the highest quartile)
- **Model Types**
  - Logistic Regression - Baseline
  - Decision Tree - Baseline
- **Predictions**



Top 10 Most Influential Features
G2
G1
attendance_engagement
failures
sudden_grade_drop
absences
Medu
age
goout
freetime
Feature
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Feature Importance Score

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Classification Report for Baseline

```
Baseline Decision Tree Model Evaluation:
Accuracy: 0.8038277511961722
Classification Report:
              precision    recall  f1-score   support

           0       0.71      0.78      0.74        46
           1       0.84      0.82      0.83       122
           2       0.82      0.78      0.80        41

    accuracy                           0.80       209
   macro avg       0.79      0.79      0.79       209
weighted avg       0.81      0.80      0.80       209
```


```
              precision    recall  f1-score   support

           0       0.71      0.78      0.74        46
           1       0.84      0.82      0.83       122
           2       0.82      0.78      0.80        41

    accuracy                           0.80       209
   macro avg       0.79      0.79      0.79       209
weighted avg       0.81      0.80      0.80       209
```


```
Baseline Logistic Regression Model Evaluation:
Accuracy: 0.84688995215311
Classification Report:
              precision    recall  f1-score   support

           0       0.74      0.87      0.80        46
           1       0.90      0.83      0.86       122
           2       0.84      0.88      0.86        41

    accuracy                           0.85       209
   macro avg       0.83      0.86      0.84       209
weighted avg       0.85      0.85      0.85       209
```


```
              precision    recall  f1-score   support

           0       0.74      0.87      0.80        46
           1       0.90      0.83      0.86       122
           2       0.84      0.88      0.86        41

    accuracy                           0.85       209
   macro avg       0.83      0.86      0.84       209
weighted avg       0.85      0.85      0.85       209
```

Hannah

Data Model Optimization

Hannah

Process

- **Feature Engineering**
  - Extra Support
  - Health
  - Parent Education
  - Social Tendencies
- **Experimenting with different targets**
  - G3 (final grade)
  - creating a risk category (multiclass labels)
- **Experimenting with Model Types**
  - Logistic Regression
    - ✓ Highest accuracy (99%)
  - Decision Tree
    - ✓ Highest accuracy (100%)
  - Random Forest
  - Pruned Forest
    - ✓ Highest accuracy (85.65%)

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Optimizations 1-3 focused on engineering features, yielding 90%+ accuracy.

Optimization 4 focused on modifying the multiclass labels (based on final grades) from three to **four risk categories** and making this the **new target**.

0 - 'at risk'

1 - 'low risk'

2 - 'moderate risk'

3 - 'not at risk'

```
Logistic Regression Model Evaluation:
Accuracy: 0.9904306220095693
Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.96      0.98        46
           1       0.97      1.00      0.98        61
           2       1.00      1.00      1.00        61
           3       1.00      1.00      1.00        41

    accuracy                           0.99       209
   macro avg       0.99      0.99      0.99       209
weighted avg       0.99      0.99      0.99       209
```

- performs well at classifying 'moderate risk' and 'not at risk' students
- missed some 'at risk' students leading to false-positives for 'low risk' students.

Hannah

Decision Tree Model Evaluation:

Accuracy: 1.0

Classification Report:

	precision	recall	f1-score	support
0	1.00	1.00	1.00	46
1	1.00	1.00	1.00	61
2	1.00	1.00	1.00	61
3	1.00	1.00	1.00	41
accuracy			1.00	209
macro avg	1.00	1.00	1.00	209
weighted avg	1.00	1.00	1.00	209

The 100% accuracy here may reflect a complex or non-linear dataset.

Extra support features didn't make a significant difference.

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Extra Supports

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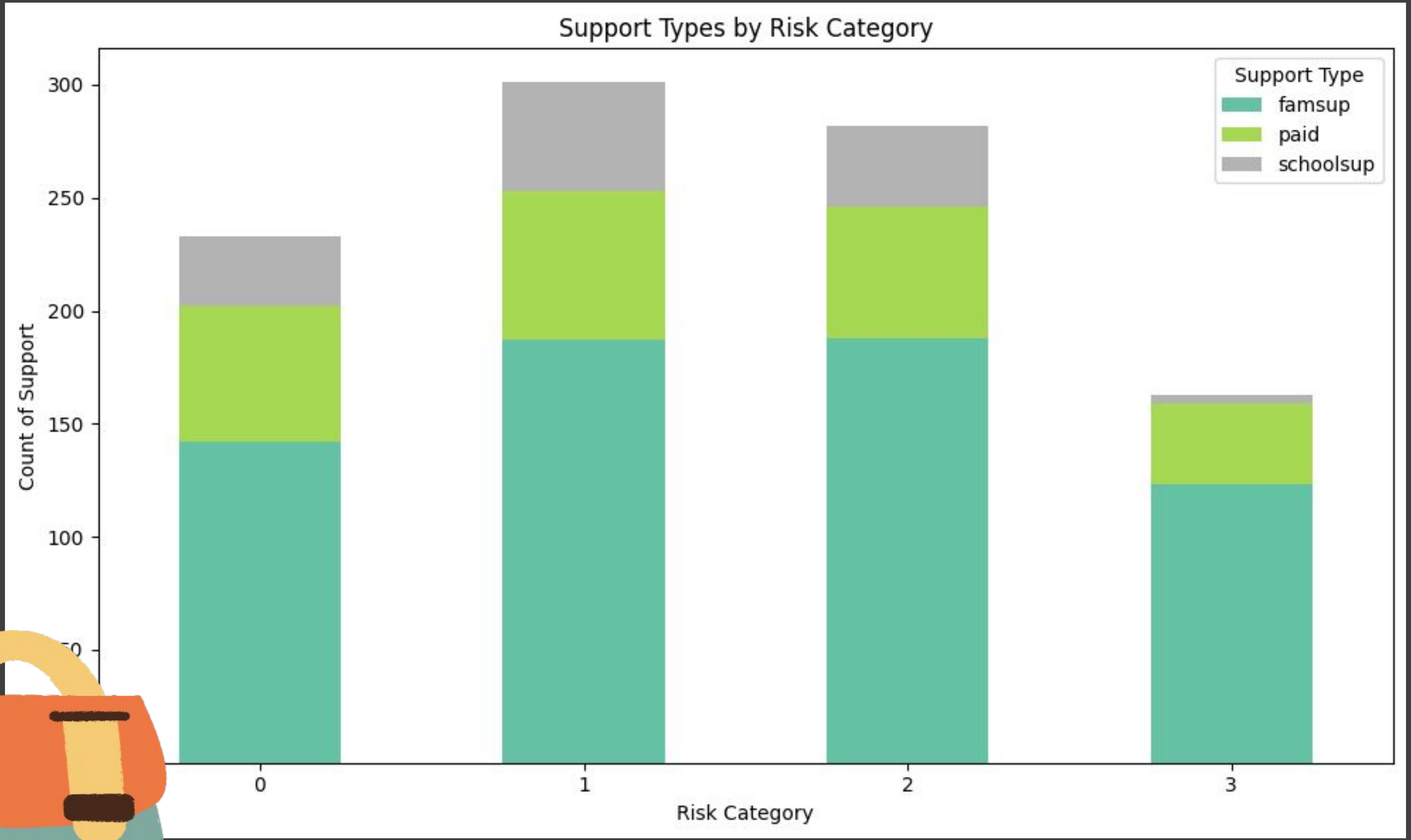
Is there a relationship between a student being at-risk and access to extra educational support, family educational support, or extra paid classes within the course subject?



Students identified as being **'at risk'** receive

- more total support than **'not at risk students'**
- less than **'moderate'** and **'low risk'** students.

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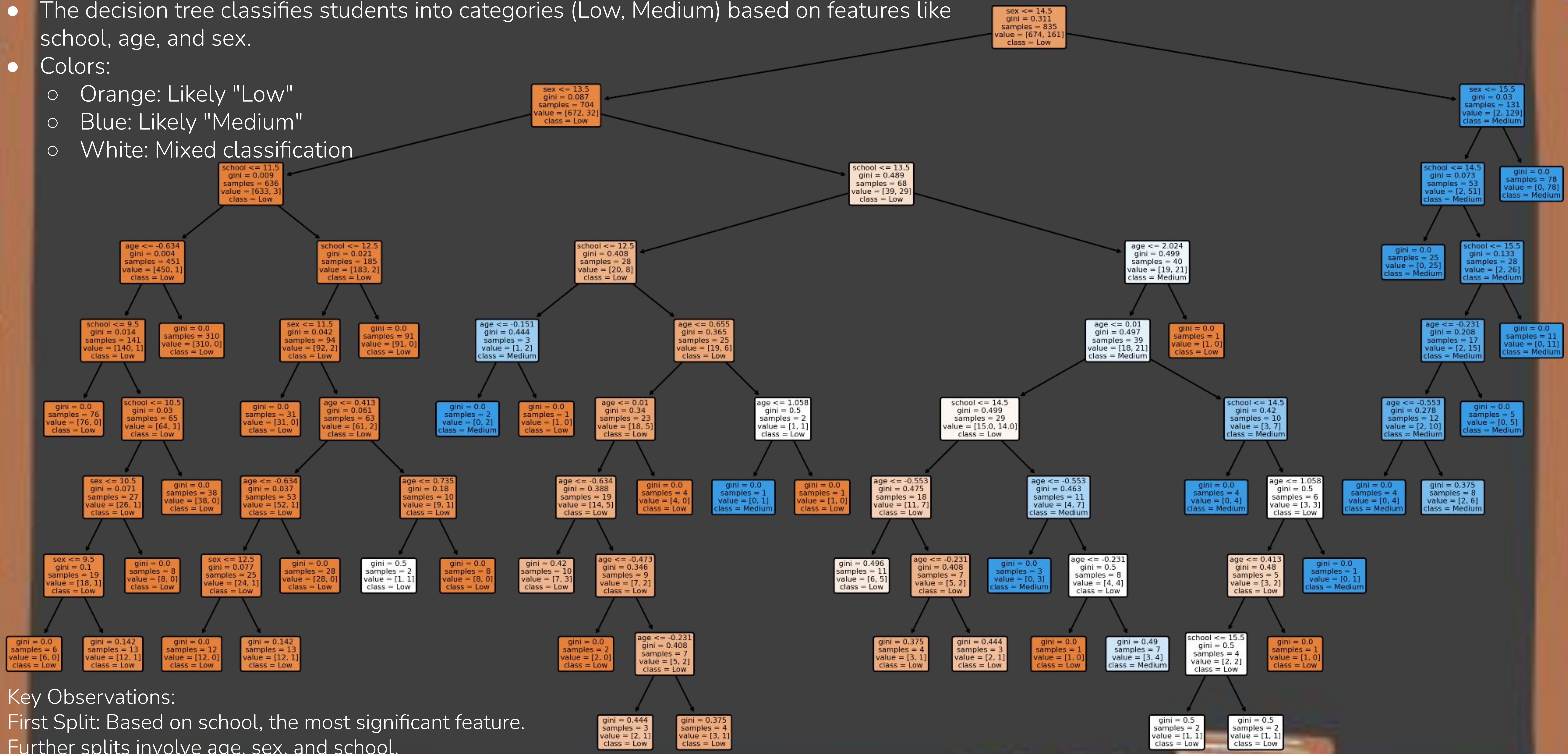
Influence of Parental Education on Student Performance and Higher Education Interest

Decision Tree Model for Predicting Student Outcomes

Victoria

Visualization Overview:

- The decision tree classifies students into categories (Low, Medium) based on features like school, age, and sex.
- Colors:
  - Orange: Likely "Low"
  - Blue: Likely "Medium"
  - White: Mixed classification



Key Observations:

First Split: Based on school, the most significant feature.

Further splits involve age, sex, and school.

Nodes with a Gini index of 0 indicate perfect classification.

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Do students with higher-educated parents perform better in final exams (G3)?

Do they show stronger interest in higher education?

Key Takeaways:

- ❖ Class 0 (Not Pursuing Higher Education):
  - ➢ 100% precision & recall – no false negatives 🚀
- ❖ Class 1 (Pursuing Higher Education):
  - ➢ 100% precision – all predicted students belong to this class 🎓
  - ➢ 86% recall – some students may be missed (false negatives) ⚠️
- ❖ F1-Score Insights:
  - ➢ High F1-scores for both classes 🔥
  - ➢ Slight preference for precision in predicting higher education students 📊

Higher parental education levels (likely contributing to students' higher academic performance) are strongly associated with students' interest in pursuing higher education.

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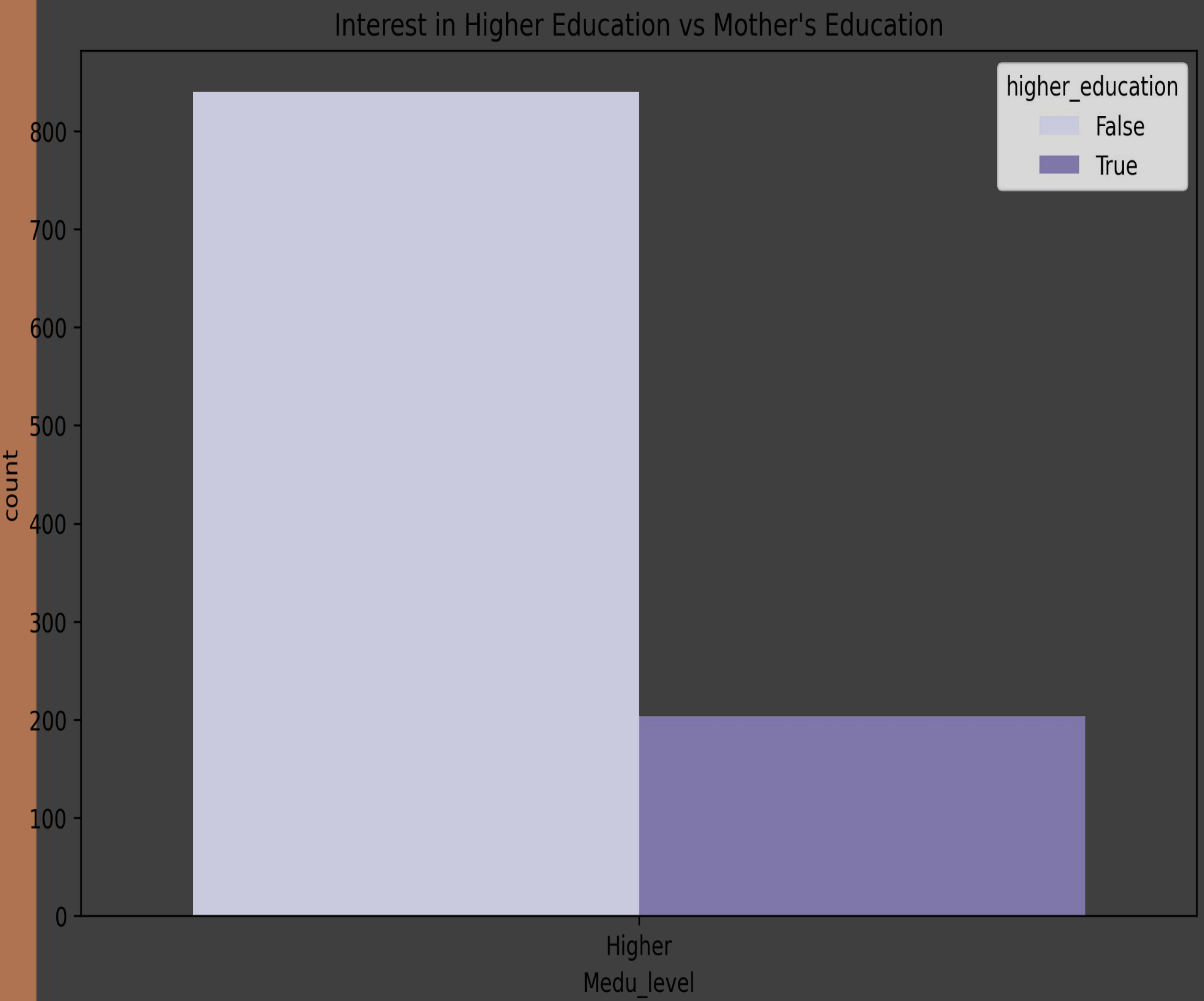

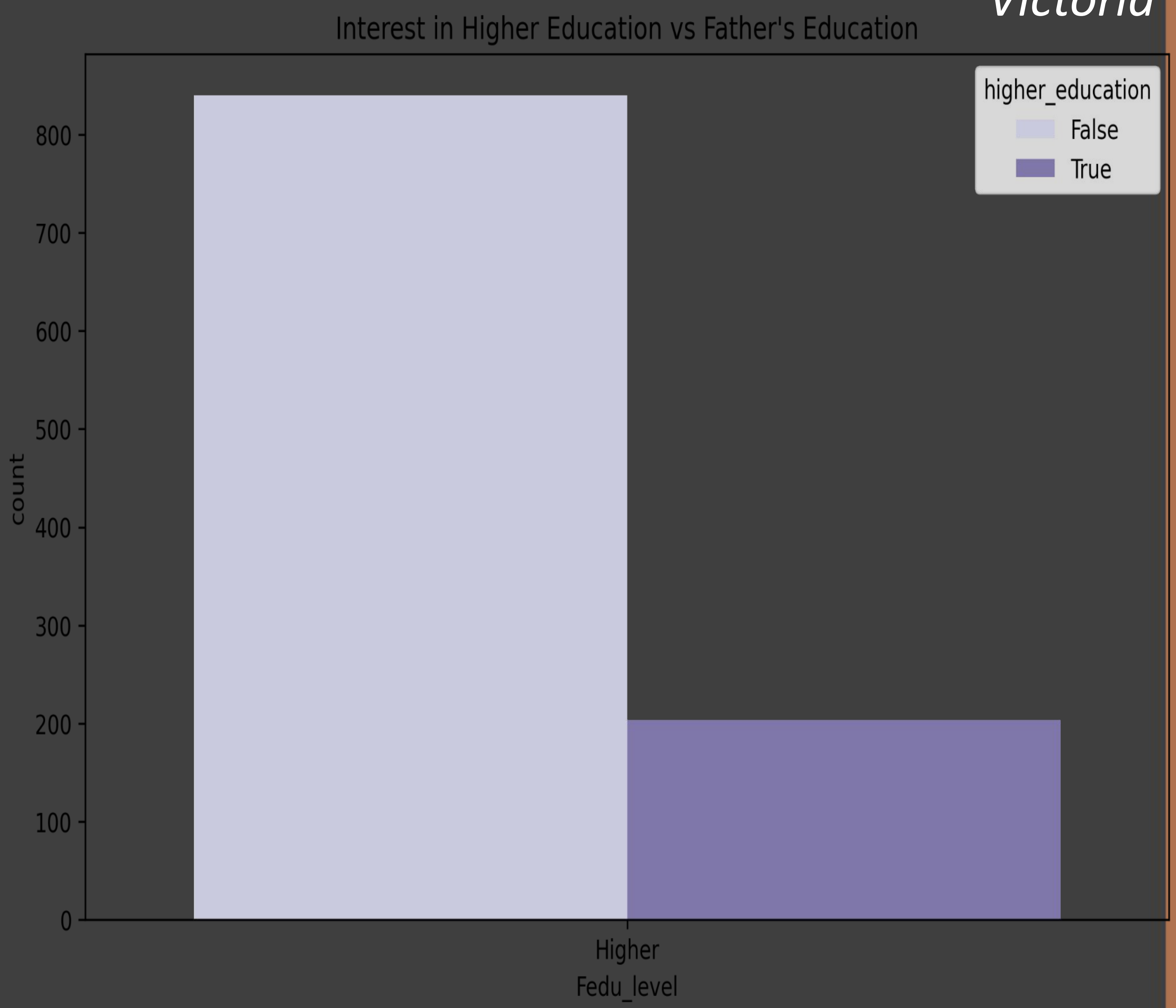

- A large proportion of students whose parents have lower education levels are not pursuing higher education (lighter bars dominate).
- In contrast, students with more highly educated parents show a greater interest in continuing their education (darker bars increase).
- This suggests a strong correlation between parental education and a student’s likelihood of seeking higher education.

Ethan

Social Tendencies

Social Tendencies and their correlations

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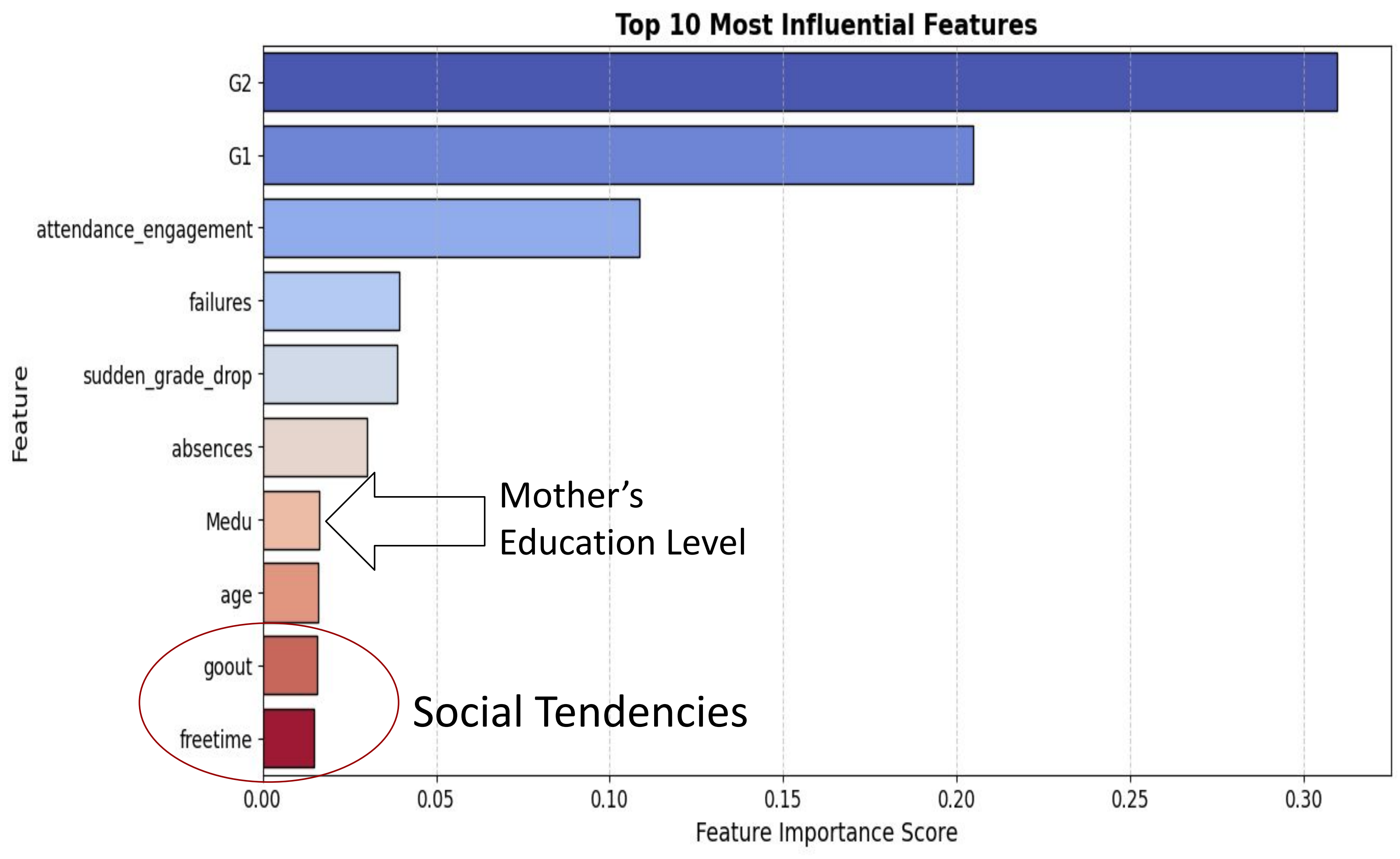
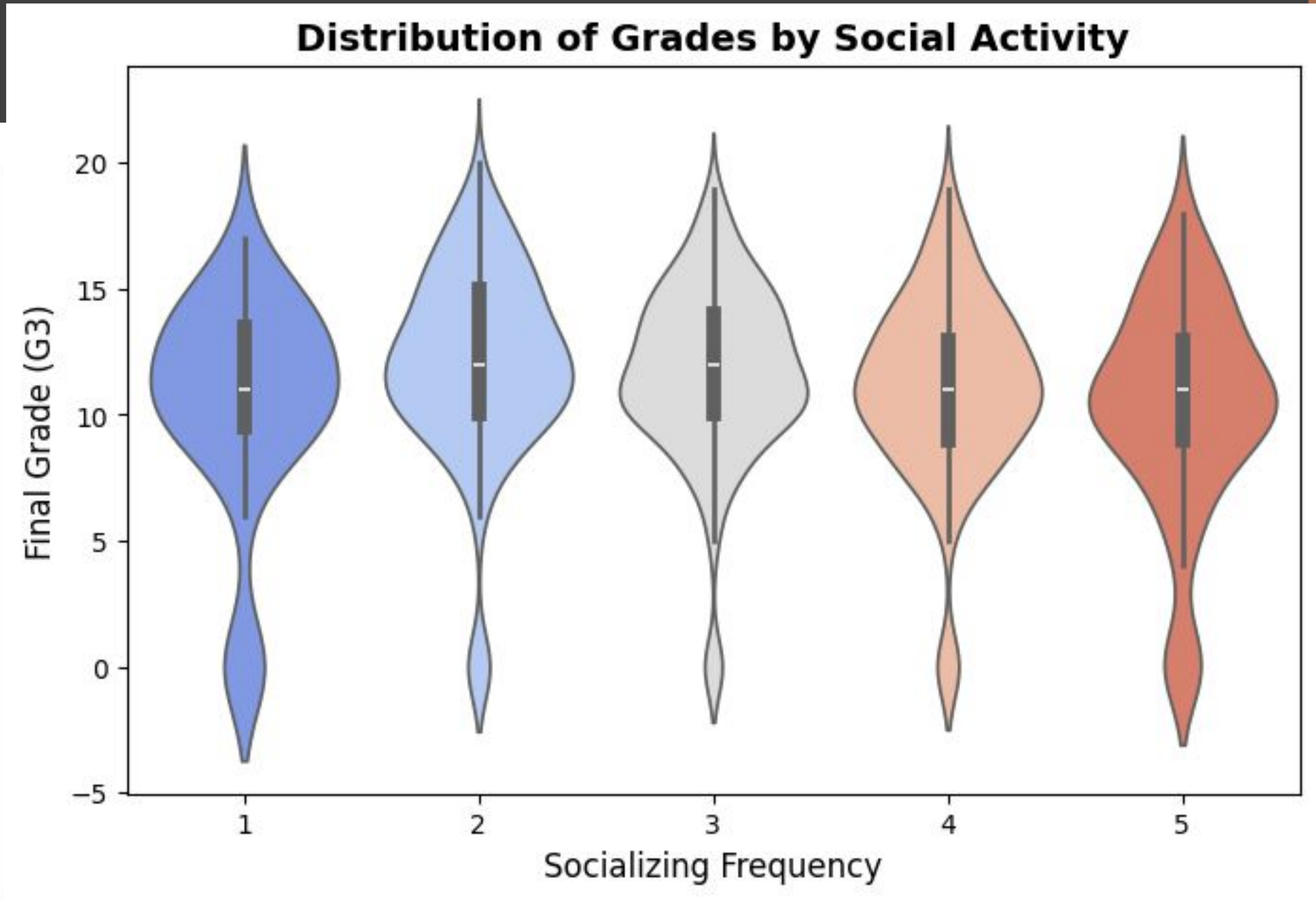
What impact do certain **social tendencies** have on the students' likelihood to succeed? (e.g. Frequency of alcoholic consumption, social lives, extracurricular activities, romantic relationships, etc.)





Social Tendencies and their correlations

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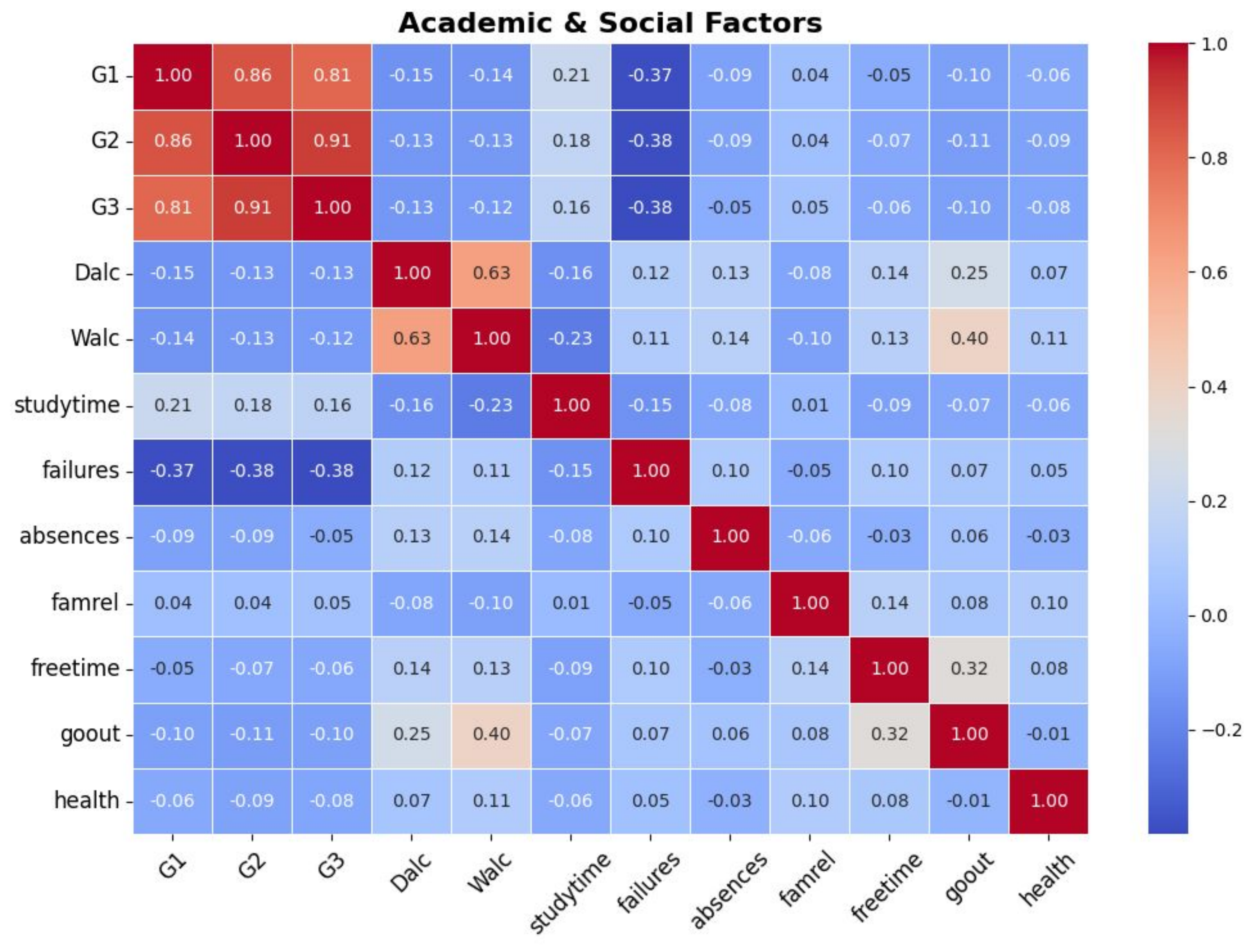

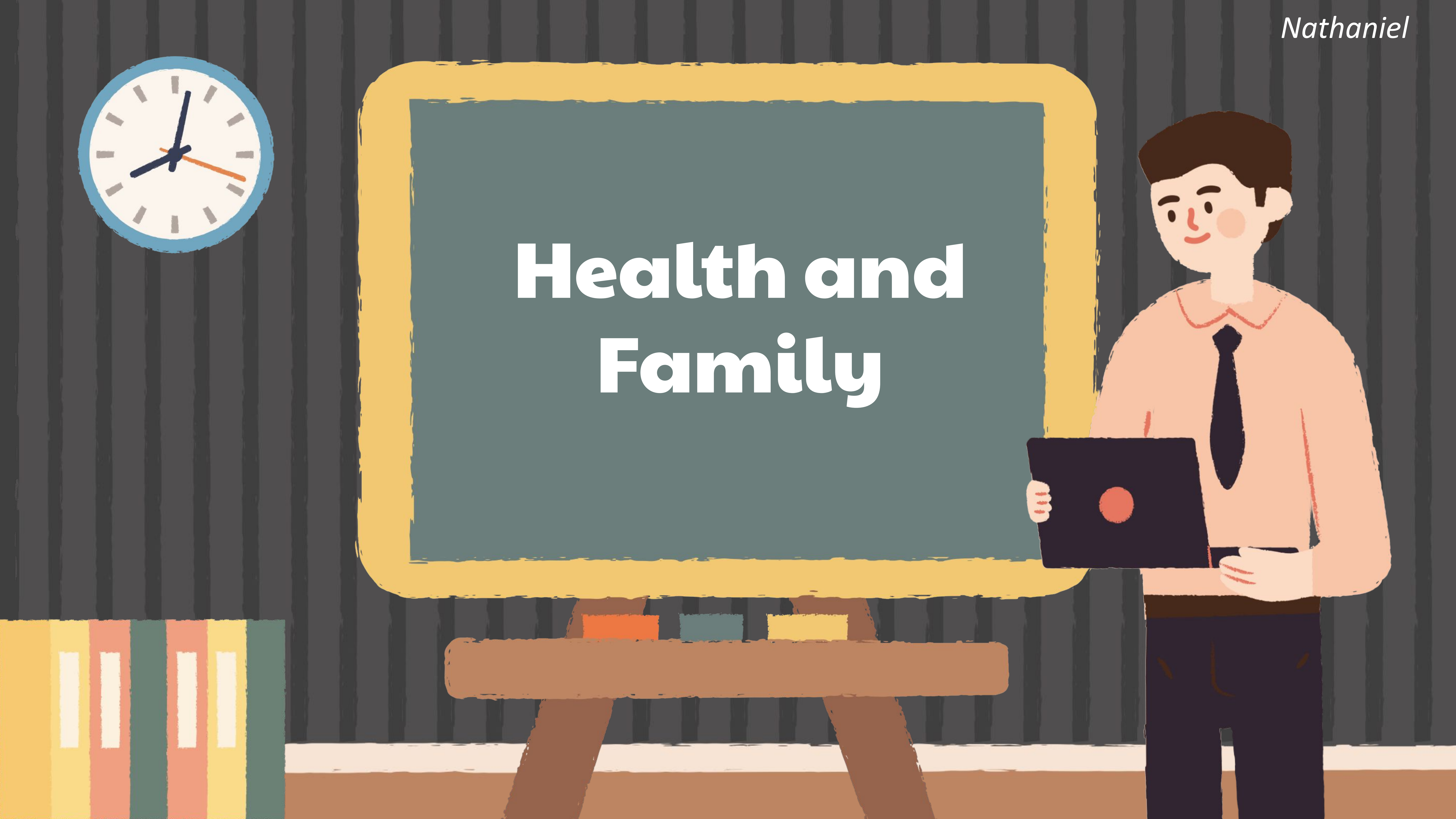
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Health and Family

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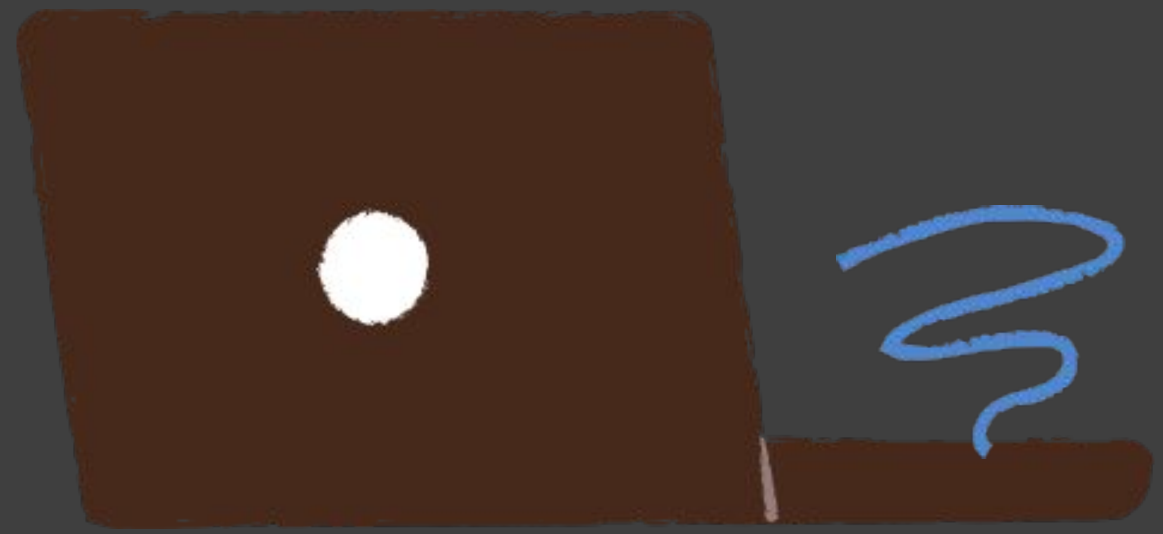
How does health impact a person's likelihood to succeed?



01 Does poor health often result in more absences and poorer grades?

02 Is there a high incidence of absence and failure among students classified in poor health?

03 Is there a correlation between health and quality of family relationships?

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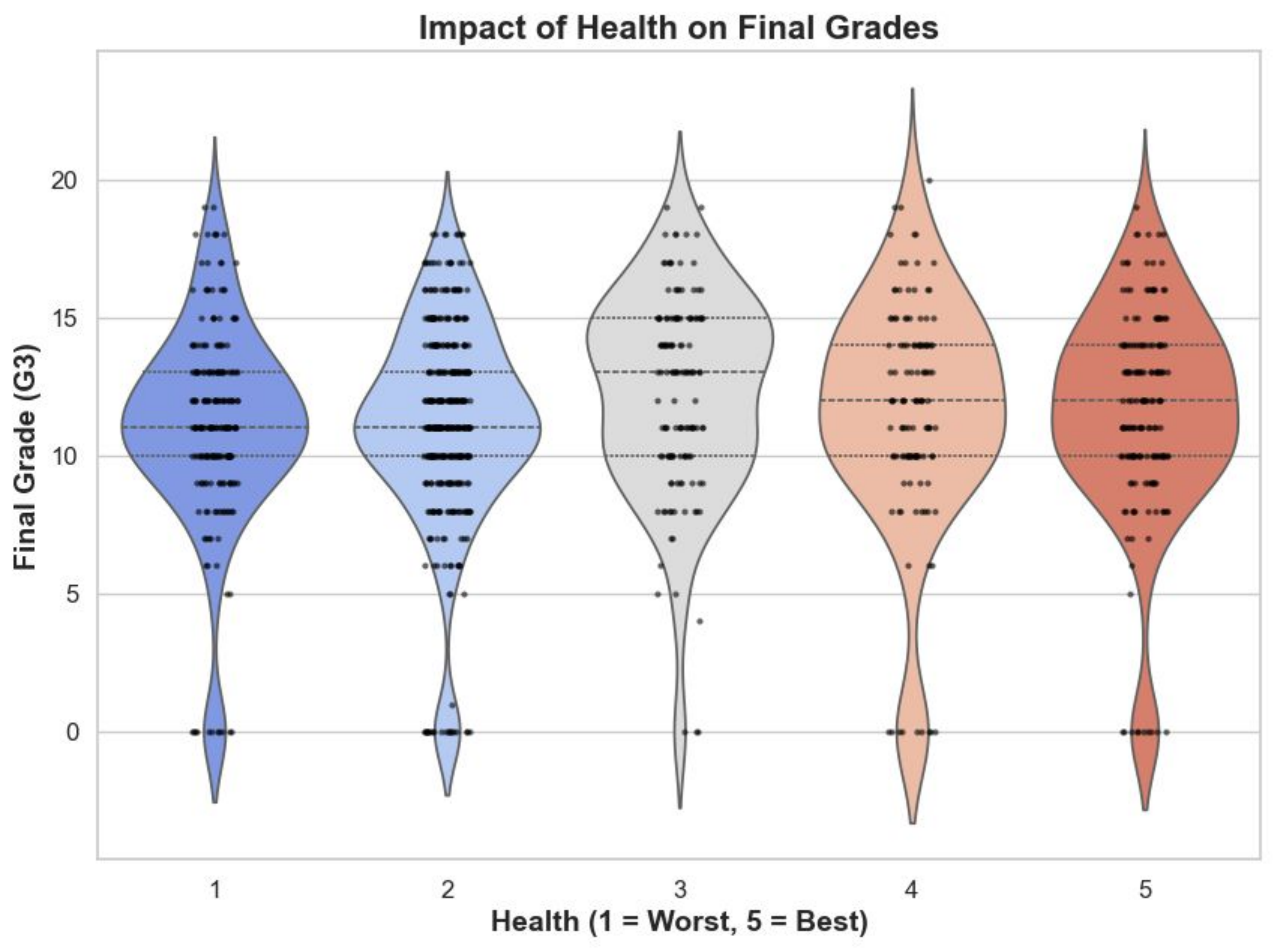

Health & Success

- There is a weak negative correlation with grades ($\rho = -0.081$, $p = 0.009$), suggesting that poor health slightly lowers grades.
- Conclusion: While health may have some impact, it is not the main predictor of success.

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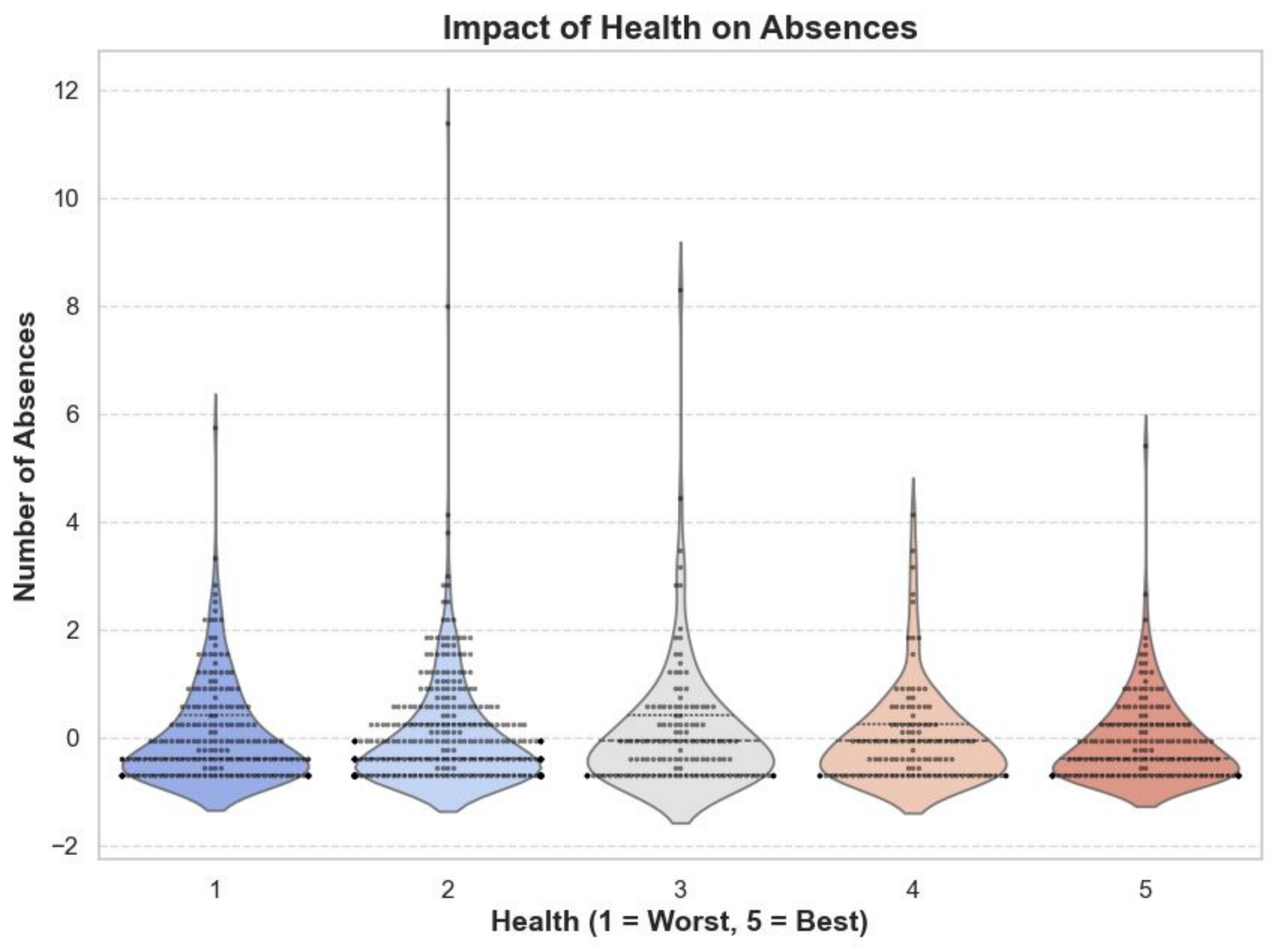

Health and Absences

- No strong correlation **(ρ = -0.034, p = 0.267)** → Poor health **does not** increase absences.
- **Conclusion:** Health **affects grades more than attendance**.

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```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 famrel   R-squared:                       0.011
Model:                            OLS   Adj. R-squared:                  0.010
Method:                 Least Squares   F-statistic:                     11.42
Date:                Tue, 18 Mar 2025   Prob (F-statistic):           0.000755
Time:                        18:31:13   Log-Likelihood:                -1475.7
No. Observations:                1044   AIC:                             2955.
Df Residuals:                    1042   BIC:                             2965.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const      -3.469e-17      0.031  -1.13e-15      1.000      -0.060       0.060
health         0.1041      0.031      3.379      0.001       0.044       0.165
==============================================================================
Omnibus:                      155.627   Durbin-Watson:                   1.952
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              240.357
Skew:                          -1.008   Prob(JB):                     6.41e-53
Kurtosis:                       4.207   Cond. No.                         1.00
==============================================================================
```

Health & Family Relationships

- Weak positive correlation **(ρ = 0.090, p = 0.0037)** → Healthier students report better family relationships.
- **Conclusion:** Family support may contribute to both **better health and academic success**.

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Implications

If schools want to identify at risk students, they should be looking at:

- ✓ grades
- ✓ attendance
- ✓ mother's education

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Summary & Conclusions

- ★ Successfully optimized our baseline model
- ★ A Decision Tree Model was most accurate
  - Less linear relationships
  - Some features heavily skewed the chances of a student being at risk
- ★ We realized that we could have made a features prediction earlier on to ensure we were analyzing the most impactful features


Thank you!