

# Predicting Learning Commons Usage: Duration and Occupancy A Statistical Learning Approach

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MATH 7550 Statistical Learning || BGSU

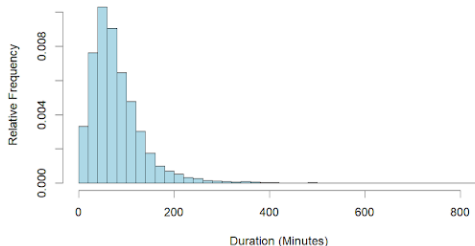
December 4, 2024

# Distribution Statistics

## Duration (minutes):

Statistic	Value
Minimum	6.00
1st Quartile	44.00
Median	68.00
Mean	81.78
3rd Quartile	103.00
Maximum	822.00

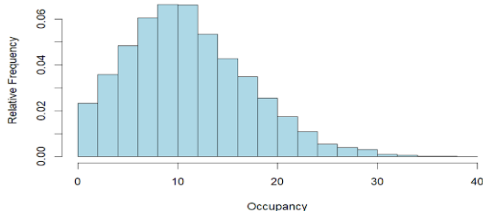
Distribution of Duration (in Minutes)



## Occupancy (students):

Statistic	Value
Minimum	1.00
1st Quartile	7.00
Median	11.00
Mean	11.62
3rd Quartile	15.00
Maximum	40.00

Distribution of Occupancy



# Feature Categories Overview

Category	Key Features
Temporal	Time of day, Day of week, Week of semester
Academic	Course level, GPA categories, Credit load
Visit	Duration patterns, Group sizes, Visit frequency
Course	Subject areas, Level progression, Course mix
Student	Major groups, Class standing, Academic progress

## Engineering Approach

- Temporal patterns
- Academic context
- Student behavior
- Group dynamics

## Dropped Raw Features

Raw Feature	Engineered Into
Student_IDs	Total_Visits, Semester_Visits, Avg_Weekly_Visits
Class_Standing	Class_Standing_Self_Reported, Class_Standing_BGSU
Major	Major_Category, Has_Multiple_Majors
Expected_Graduation	Expected_Graduation_Date, Months_Until_Graduation
Course_Name	Course_Name_Category
Course_Number	Unique_Courses, Course_Level_Mix
Course_Type	Course_Type_Category
Course_Code_by_Thousands	Course_Level, Advanced_Course_Ratio

### Feature Engineering Strategy

Raw features were transformed into more informative derived features, capturing higher-level patterns and relationships in the data.

# Complete Feature List (~50 Pre-Dummied)

Category	Features
Student Demographics	<b>Student_IDs</b> , Gender, <b>Class_Standing</b> , Class_Standing_Self_Reported, Class_Standing_BGSU, Has_Multiple_Majors, <b>Major</b> , Major_Category, Degree_Type
Academic Performance	<b>Total_Credit_Hours_Earned</b> , Term_Credit_Hours, Credit_Load_Category, Term_GPA, Cumulative_GPA, Change_in_GPA, GPA_Category, GPA_Trend
Course Information	<b>Course_Name</b> , <b>Course_Number</b> , <b>Course_Type</b> , Course_Type_Category, Course_Level, <b>Course_Code_by_Thousands</b> , Course_Name_Category, Course_Level_Mix, Advanced_Course_Ratio, Unique_Courses
Temporal Features	<b>Check_In_Time</b> , <b>Check_Out_Time</b> , <b>Check_In_Date</b> , Check_In_Hour, Check_In_Day, Check_In_Month, <b>Semester</b> , Semester_Week, Check_In_Week, Is_Weekend, Time_Category
Visit Metrics	<b>Duration_In_Min</b> , Group_Size, Group_Size_Category, Group_Check_In, Total_Visits, Semester_Visits, Week_Volume, Avg_Weekly_Visits, <b>Occupancy</b>
Graduation	<b>Expected_Graduation</b> , Expected_Graduation_Date, Months_Until_Graduation

## Common Models for Both Tasks

Model	Hyperparameters
Ridge	$\alpha \in [10^0, 10^2]$
Lasso	$\alpha \in [10^{-2}, 10^0]$
Penalized-Splines	<b>knots:</b> {9, 11, 13, 15}, <b>degree:</b> 3, <b>ridge:</b> $\alpha \in [10^0, 10^2]$
KNN	<b>neighbors:</b> {15, 17, 19, 21}, <b>weights:</b> {uniform, distance}

### Implementation Details

- **Duration:** Log-normal
- **Occupancy:** Poisson & Weibull
- Integer rounding for occupancy
- Grid search optimization
- Feature selection
- Cross-validation

# Model Pipeline Configurations

CV Method	Description	Pipeline	Implementation
kfold	Random k splits	vanilla	Scaling → Model
rolling	Fixed-size window moving forward	interact _select	Scaling → Interactions → SelectKBest → Model
expanding	Growing window with fixed start point	pca_lda	Scaling → PCA/LDA → Interactions → SelectKBest → Model

## Scaling Methods

- **StandardScaler:**  $(x - \mu)/\sigma$  - sensitive to outliers
- **RobustScaler:**  $(x - Q_2)/(Q_3 - Q_1)$  - resistant to outliers
- **MinMaxScaler:**  $(x - x_{min})/(x_{max} - x_{min})$  - preserves zeros

# Best Model Configurations

## Duration Prediction:

Component	Value
Model	PenalizedSplines
Pipeline	vanilla
CV Method	kfold
RMSE	59.47
R <sup>2</sup>	0.059
Ridge $\alpha$	14.38
Spline degree	3
Spline knots	15
Scaler	RobustScaler

## Occupancy Prediction:

Component	Value
Model	PenalizedSplines
Pipeline	vanilla
CV Method	rolling
RMSE	3.64
R <sup>2</sup>	0.303
Ridge $\alpha$	29.76
Spline degree	3
Spline knots	15
Scaler	RobustScaler

### Key Insight

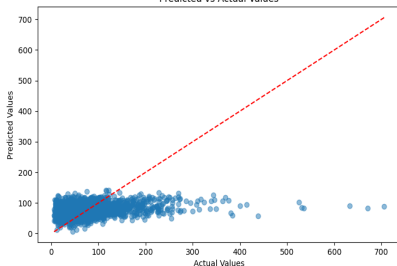
Both tasks achieved best results with PenalizedSplines and vanilla features, though with different CV methods & regularization.



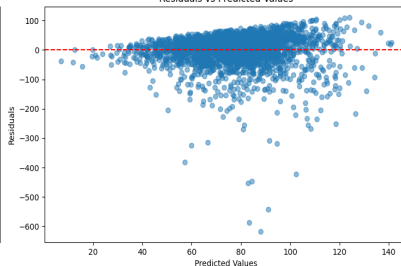
# Duration: Best Model Diagnostics

Prediction Analysis for PenalizedSplines\_vanilla\_kfold

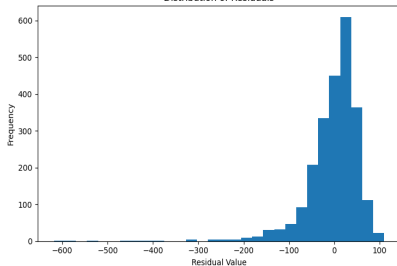
Predicted vs Actual Values



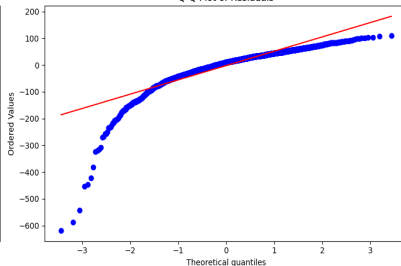
Residuals vs Predicted Values



Distribution of Residuals

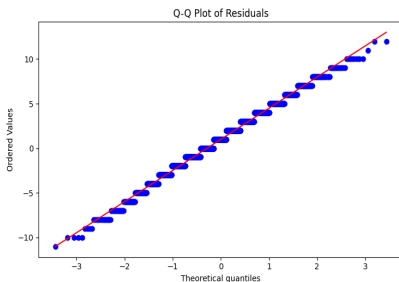
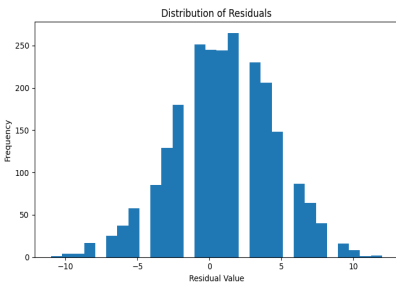
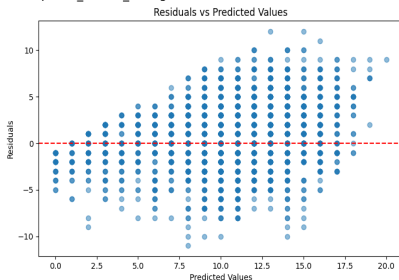
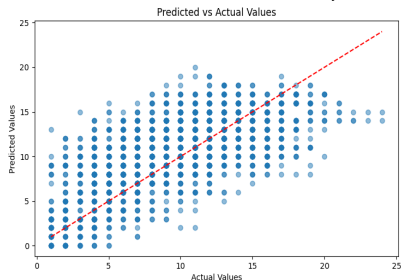


Q-Q Plot of Residuals

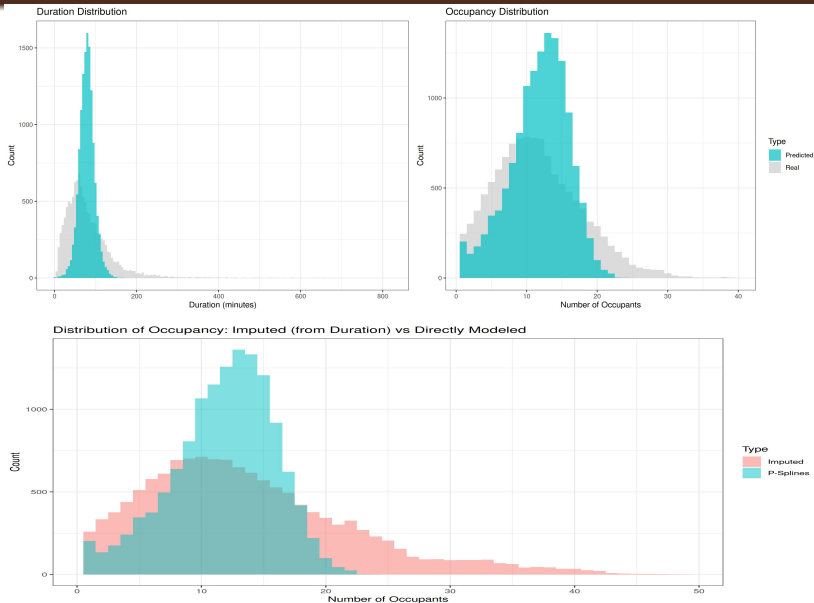


# Occupancy: Best Model Diagnostics

Prediction Analysis for PenalizedSplines\_vanilla\_rolling



# Sanity Check



# Key Findings

## Main Results:

- **PenalizedSplines** with *vanilla* features performed best
- **Occupancy** prediction shows promise ( $R^2 = 0.303$ )
- **Duration** prediction remains challenging ( $R^2 = 0.059$ )

## Future Directions:

- Incorporate *weather* data
- Explore *non-linear* relationships further
- Investigate *time series* approaches

## Impact

While duration prediction remains difficult, our occupancy model shows strong potential for a victory **#CautiousOptimism**

*Thank You*

*For Your Attention*

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Questions & Discussion Welcome