

# Investigating Student Participation and Performance in Calculus I Courses that Utilize Standards-Based Grading

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## Background

- Standards-based Grading (SBG) focuses on **students' understanding** of the essential concepts of the course (standards).
- Standards are graded as Pass/Fail.
- Students are allowed to attempt each standard **multiple times** throughout the semester.
- Students' grades are assigned based on the number of checkpoints/standards passed by the end of the semester.

This project aims to understand how students' participation "buy-in" in the SBG method is related to their final grade in introductory calculus courses.

## Data Collection and EDA

### Data Collection

- Data were collected from three different sections of Calculus I courses during the Spring and Fall semester of 2021 taught by Dr. Jeff Ford.
- Recorded student performances during the course, including the information of each **checkpoint attempt**, **class activities**, and **final grades**. We also collected data on students' **mathematics background**.
- Students' final grades were assigned based on the **level achieved** by the end of the course. Levels were assigned based on the number of checkpoints passed, class activities, and participation (Table 1)

| Grade | Minimum Level | Grade | Minimum Level | Grade | Minimum Level |
|-------|---------------|-------|---------------|-------|---------------|
| A     | 25            | B-    | 21            | D+    | 17            |
| A-    | 24            | C+    | 20            | D     | 16            |
| B+    | 23            | C     | 19            | D-    | 15            |
| B     | 22            | C-    | 18            | F     | 14            |

Table 1. Level to Grade Conversion

### Data Analysis

Define "**buy-in**" as a student's ability to make consistent progress throughout the course. A **bought-in** student shows less variance in weekly level progress, while a **non bought-in** student shows large variability in their progress.

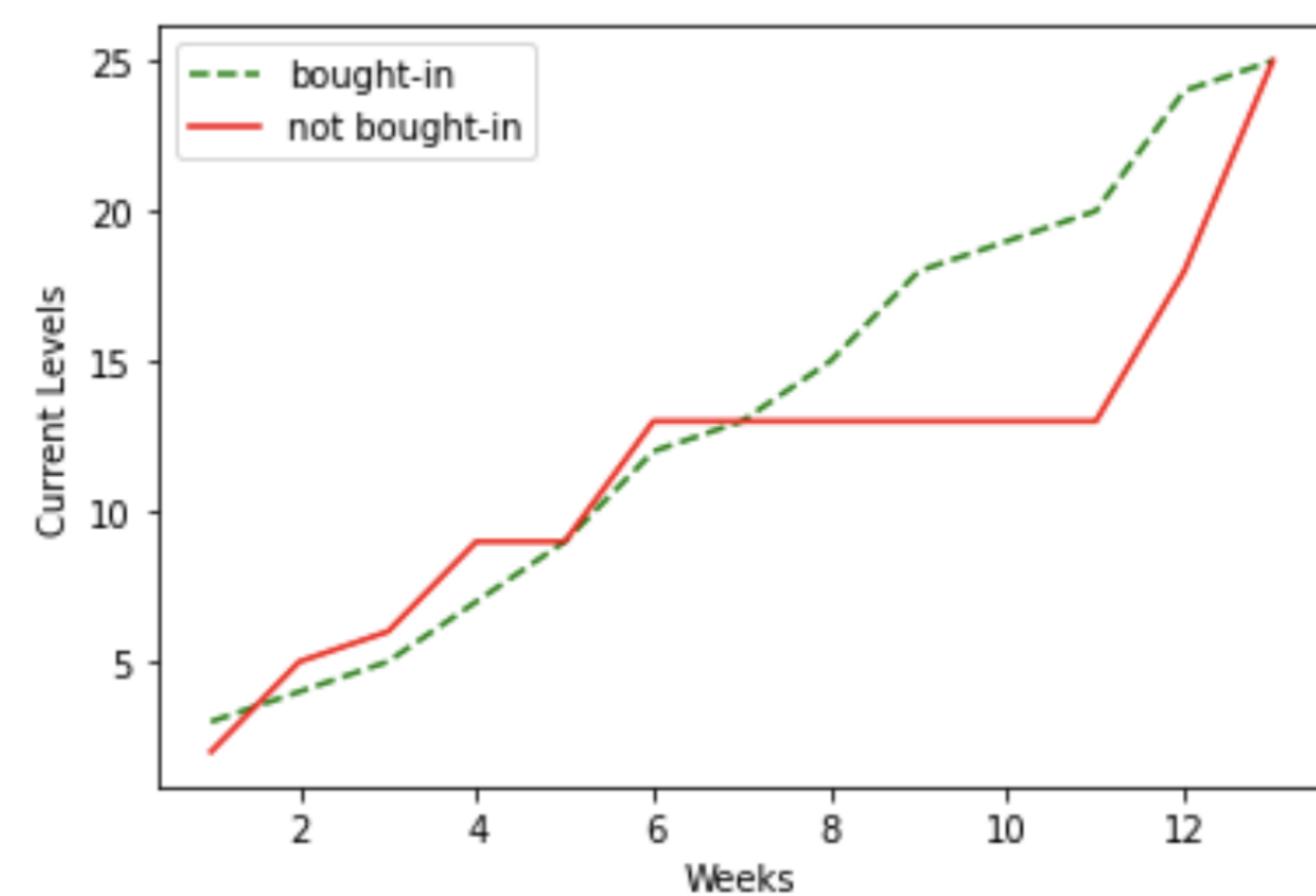


Figure 1. Example of a bought-in vs a non bought-in student

Figure 2 shows the distribution of the average number of levels a student progressed through per week.

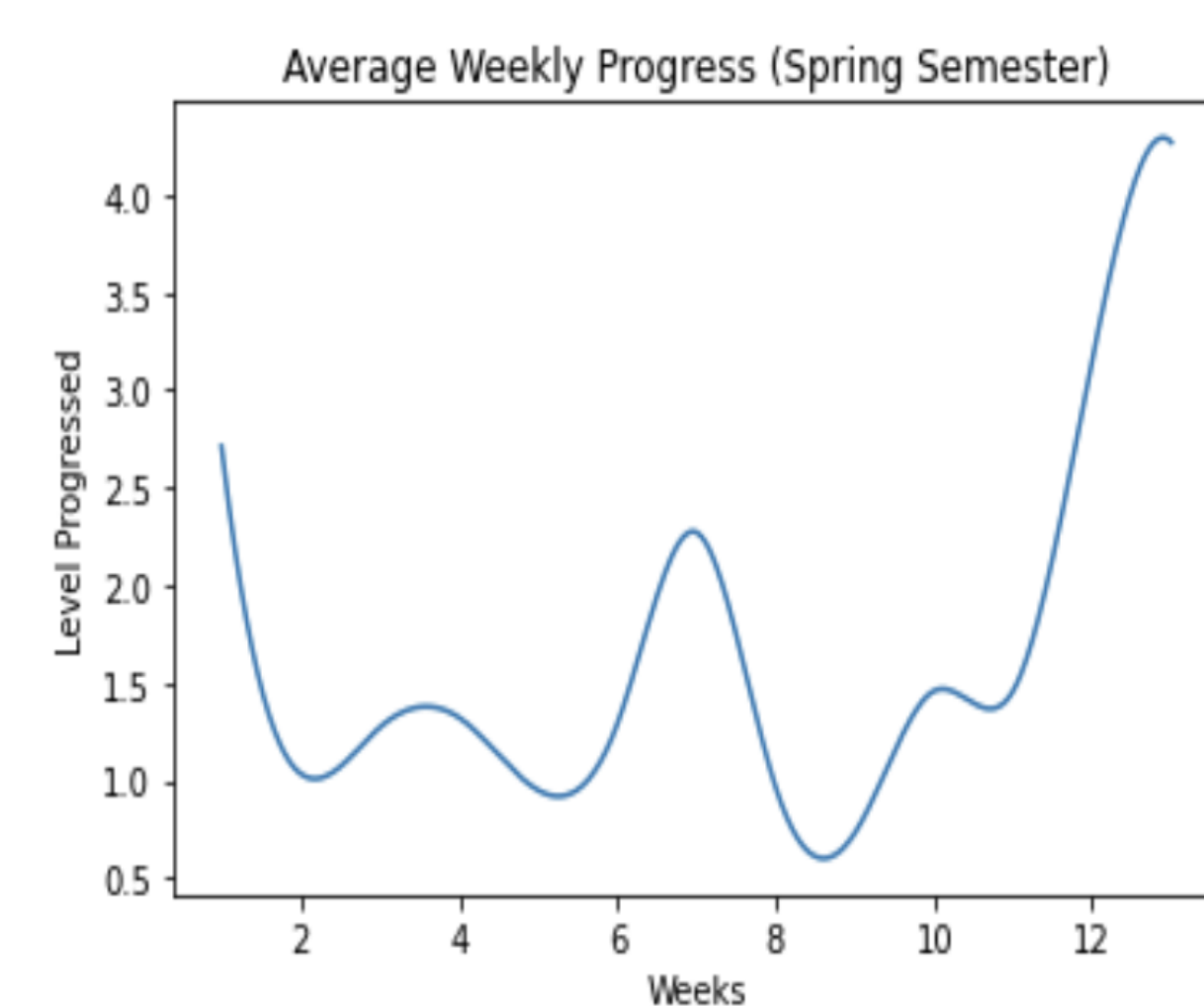


Figure 2. Distribution of Weekly Level Progress

## Clustering Students' Progress as Time Series

Students' weekly level progress presented as time series with entries indicating the student's level at a given week.

We used a **K-Means Clustering** [2] algorithm to categorize students into different groups based on patterns of weekly progress:

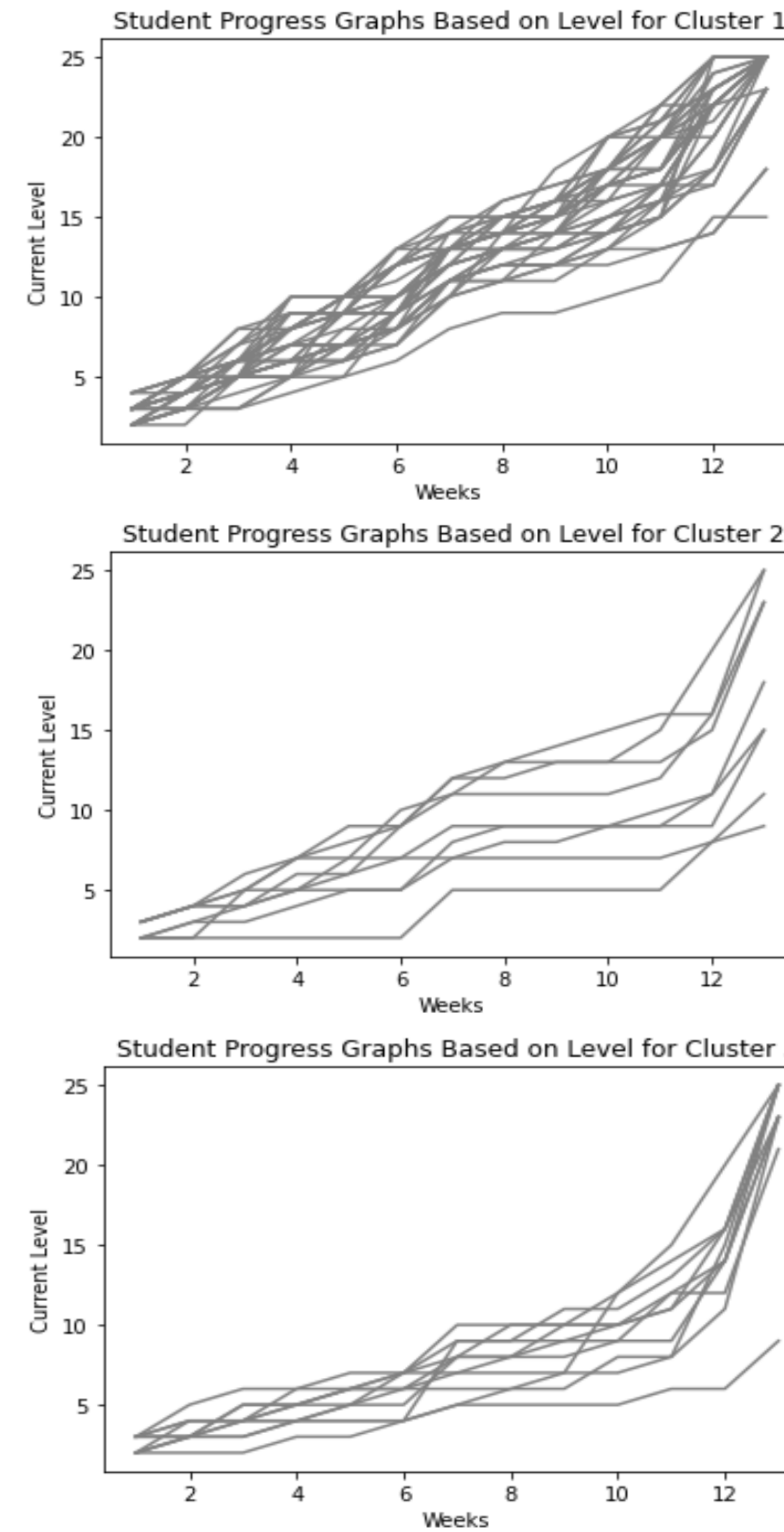


Figure 3. Distribution of Final Grades and Final Checkpoints Passed

### Clustering Results

Figure 3 shows the three groups of students clustered based on their weekly level progress:

- Cluster 1 consists of students with **consistent progress** throughout the semester.
- Cluster 2 consists of students with good **initial progress**, but ended up making **no progress** during 3-6 weeks in the middle of the semester.
- Cluster 3 consists of students who made **slow progress** throughout the semester, and **rapid** progress within the last two weeks.

Figure 4 shows the final grade and final checkpoints passed distribution among the three groups.

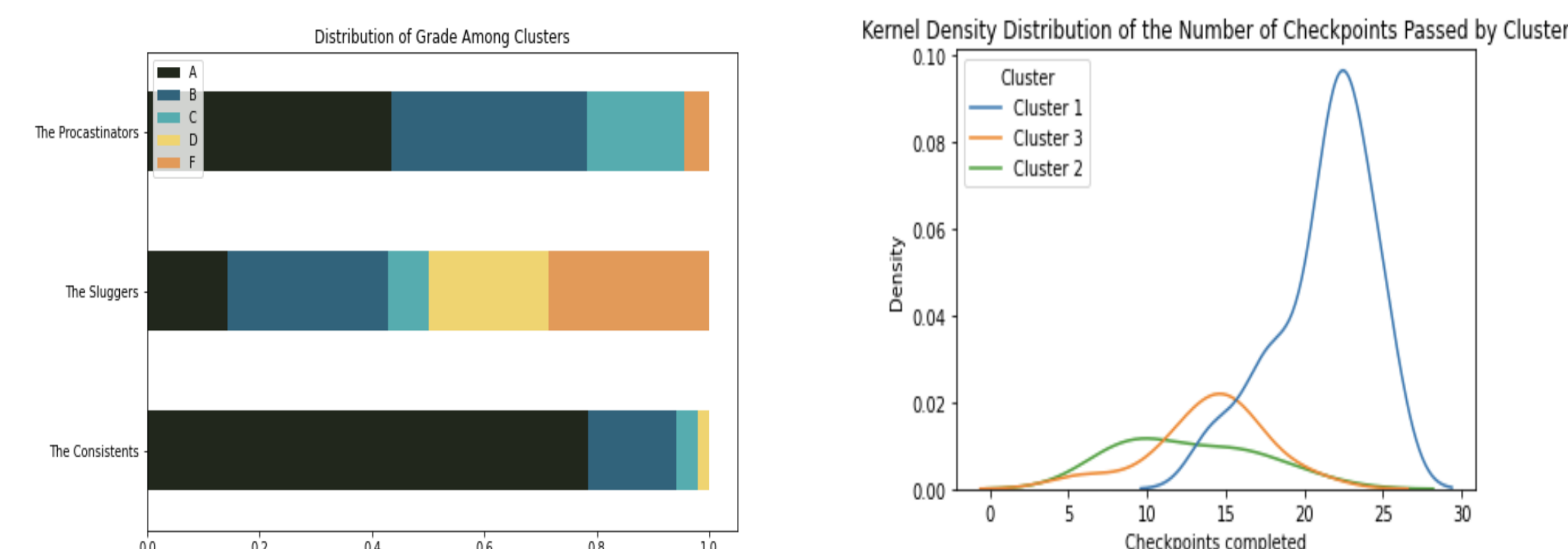


Figure 4. Distribution of Final Grade and Final Checkpoints Passed for the three groups

## Logistic Regression

Investigated whether trends in a student's weekly progress affected their final grade.

- Calculated each student's level at the end of each week throughout the semester.
- Progress was quantified as the increase in level per week
- Variance of students' progress** was calculated and summarized in Table 2.

| Final Grade | Mean Progress Variance | Median Progress Variance | Standard Deviation |
|-------------|------------------------|--------------------------|--------------------|
| A           | 2.295                  | 1.889                    | 1.323              |
| B           | 3.824                  | 2.806                    | 3.034              |
| C           | 4.209                  | 3.899                    | 2.682              |
| D           | 5.816                  | 5.243                    | 3.487              |
| F           | 1.602                  | 1.234                    | 0.861              |

Table 2. Summary of Weekly Progress Variance

Figure 5 shows the distribution of progress variance for students based on their final grade.

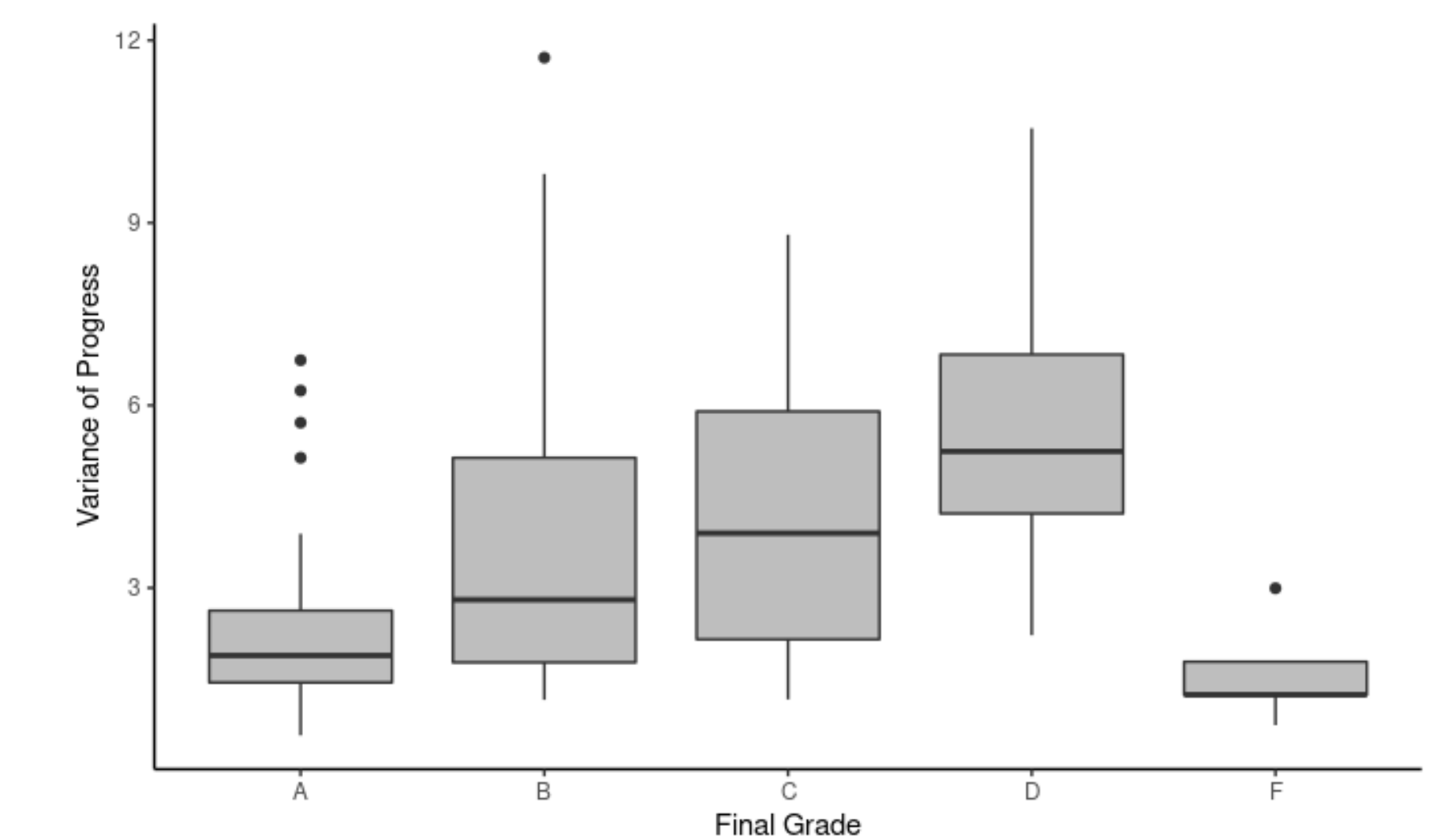


Figure 5. Relationship between weekly progress variance and final grade

**Logistic regression:** [1] predicts a student's grade using the variability of their weekly progress.

We found that progress variance is:

- Not a significant predictor** of whether a student receives a C or higher ( $p = 0.472$ )
- A moderately significant predictor** of whether a student receives a B or higher ( $p = 0.093$ )
- A very significant predictor** of whether a student receives an A ( $p = 0.005$ )

The results imply that a student's consistency in progress

- Significantly relates to** their ability to achieve an A in the course
- Moderately relates to** their ability to achieve a minimum of a B
- Weakly relates to** their ability to achieve a minimum of a C
- Students' mathematics background **does not** significantly relate to their performances.

## Discussion and Future Work

### Summary of Results

- There exists distinct patterns of behavior among students which are significantly related to final grades.
- Consistent weekly progress implies a higher chance to earn an A than inconsistent progress.
- Factors such as a student's year in college and their background in mathematics are not significantly related to final grades.

### Future Work

- Real-time intervention system to warn students with borderline behavior patterns.
- Analyzing other factors that are related to a student's buy-in and success in SBG courses.

## References

- Rudolf J Freund, William J Wilson, and Ping Sa. *Regression analysis*. Elsevier, 2006.
- James Douglas Hamilton. *Time series analysis*. Princeton university press, 2020.