



## **Writing Assessment Tool (WAT) Project Final Report**

### **Prepared by:**

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### **Abstract:**

This report details the development and implementation of the Writing Assessment Tool (WAT), an innovative online platform designed to generate analytics on student writing and provide automated summative and formative feedback on various types of essays. The project applies Learning Engineering principles to address challenges in writing instruction and assessment, supporting students, teachers, and researchers in the writing process. The report covers the tool's purpose, functionality, development process, key features, benefits, challenges, and future directions. It also includes a comprehensive overview of the data visualization process, from initial exploration to the creation of final, interactive visualizations that offer insights into student performance across different dimensions.

**Code:** <https://github.com/cherrybalapurkar/DataAnalytics>

## **Introduction**

Learning Engineering is an emerging field that applies scientific principles and data-driven methodologies to improve educational outcomes. At the forefront of this innovative approach is the Writing Assessment Tool (WAT), developed by a team of researchers and educators to address the complex challenges of writing instruction and assessment.

The WAT project aims to create an online platform that generates analytics on student writing, providing automated summative and formative feedback on various types of essays. This tool is designed to support students, teachers, and researchers in the writing process, offering a data-informed approach to writing instruction and assessment.

## **The Need for Learning Engineering in Education**

Traditional educational models are increasingly challenged by the complexity of modern learning environments. Learning Engineering emerges as a solution, applying engineering principles to educational challenges. The field combines insights from learning sciences, human-centered design, and data analytics to create scalable, effective learning solutions.

Learning Engineering is particularly relevant in military contexts, where rapid skill acquisition and adaptability are crucial. The U.S. Army's Synthetic Training Environment (STE) is an example of Learning Engineering in action, providing virtual training that mimics real-world complexity while tracking performance data to tailor coaching and remediation.

## **The Writing Assessment Tool (WAT)**

### **Purpose and Functionality**

The WAT is designed to:

1. Provide automated summative and formative feedback on persuasive essays, summaries, and source-based essays.
2. Support teachers in administering and grading essay assignments.

3. Offer researchers indices and writing component scores for computational analyses.

## **Key Features**

1. Student Interface: Allows students to view assignments, write essays, and receive feedback.
2. Teacher Interface: Enables teachers to create assignments, review student work, and provide feedback.
3. Researcher Interface: Provides access to linguistic features and analytics for research purposes.

## **Benefits**

1. Reduced Teacher Workload: Automated feedback helps teachers focus on higher-level instruction.
2. Personalized Learning: Students receive timely, specific feedback to improve their writing.
3. Data-Driven Instruction: Teachers and researchers can use analytics to inform teaching strategies
4. Scalability: The tool can be applied across various educational contexts and large student populations.

## **WAT Development Process**

The WAT project employs a participatory design approach, involving teachers throughout the development process. This ensures that the tool meets real classroom needs and is user-friendly for both students and educators.

## **Key Steps in Development:**

1. Corpus Collection: Gathering a diverse set of student essays for analysis.
2. Algorithm Development: Creating NLP algorithms to assess various aspects of writing.

3. Feedback Refinement: Developing clear, actionable feedback based on algorithmic analysis.
4. Interface Design: Creating intuitive interfaces for students, teachers, and researchers.
5. Iterative Testing: Continuously refining the tool based on user feedback and performance data.

## **Improvements and Future Directions**

1. Enhanced Linguistic Analysis: Incorporating more sophisticated NLP techniques to provide deeper insights into writing quality.
2. Expanded Essay Types: Developing algorithms for additional types of writing assignments.
3. Integration with Learning Management Systems: Facilitating seamless use within existing educational technology ecosystems.
4. Adaptive Learning Paths: Using accumulated data to provide personalized learning recommendations.
5. Cross-Disciplinary Applications: Exploring the tool's potential in fields beyond traditional writing instruction.

## **Challenges and Considerations**

1. Ethical Use of Data: Ensuring student privacy and responsible use of collected information.
2. Balancing Automation and Human Instruction: Maintaining the crucial role of teachers in the writing process.
3. Addressing Bias: Continuously monitoring and adjusting algorithms to ensure fairness across diverse student populations.
4. Keeping Pace with Evolving Language: Regularly updating the system to reflect changes in language use and writing styles.

## **Conclusion**

The Writing Assessment Tool represents a significant advancement in the application of Learning Engineering principles to writing instruction. By combining insights from learning sciences, data analytics, and human-centered design, WAT offers a promising solution to the challenges of writing assessment and instruction.

As the field of Learning Engineering continues to evolve, tools like WAT will play an increasingly important role in shaping the future of education. The potential for personalized, data-driven learning experiences extends beyond writing instruction, offering exciting possibilities for transforming education across disciplines and contexts.

## **Initial Data Exploration and Understanding:**

We began by familiarizing ourselves with the dataset, which included information about students, essays, tasks, classrooms, and various scoring metrics. The primary goal was to gain insights into student performance and essay quality across different dimensions.

## **Identifying Key Entities and Relationships:**

We recognized the main entities in our data: students, essays, tasks, classrooms, and metrics. Understanding the relationships between these entities was crucial for creating meaningful visualizations.

## **Establishing Visualization Objectives:**

Our primary objectives were to:

- a) Analyze student performance across different tasks and drafts
- b) Evaluate the effectiveness of revisions (1st vs 2nd drafts)
- c) Identify trends in performance over time
- d) Compare performance across different metrics and categories

## **Iterative Development of Visualizations:**

*We developed our visualizations in stages, each building upon the last:*

### *a) Classroom-level Overview:*

Started with visualizations showing average scores by task, student performance distribution, and draft comparisons for an entire classroom.

This gave a broad perspective on how students were performing within a classroom context.

### *b) Task-specific Analysis:*

Narrowed focus to specific tasks within a classroom.

Introduced comparisons of student performance on individual tasks and metric-based analysis.

### *c) Student-centric Visualizations:*

Developed visualizations centered on individual student performance across tasks and drafts.

Introduced time-based analysis to track student progress.

*d) Category-based Analysis:*

Incorporated metric categories to provide a more nuanced view of performance in different areas (e.g., grammar, content, structure).

*e) Comprehensive Student Performance Overview:*

Created a holistic view of a student's performance across all tasks, submissions, and categories.

**Addressing Challenges and Refining Visualizations:**

*Throughout the process, we encountered and addressed several challenges:*

Handling missing data or scenarios where certain drafts or metrics were not available. Ensuring visualizations were meaningful and not cluttered when dealing with multiple dimensions (tasks, drafts, metrics, time). Balancing between detailed analysis and high-level insights.

**Incorporating Flexibility and User Input:**

*We evolved our approach to allow for more interactive analysis:*

Started with fixed visualizations for specific scenarios. Progressed to taking user inputs for classroom ID, task ID, student ID, and category ID. This allowed for more dynamic and targeted analysis based on user needs.

**Enhancing Interpretability:**

*Throughout the process, we focused on making the visualizations easily interpretable:*

Used appropriate chart types for different kinds of data (bar charts for comparisons, scatter plots for trends over time). Included clear labels, titles, and legends. Added statistical summaries to complement visual data.

## **Final Comprehensive Visualization:**

*Our final visualization focused on providing a complete picture of a student's performance:*

- Included average scores by task to show strengths and weaknesses.
- Incorporated a time-based performance trend to track progress.
- Showed category-wise performance to identify areas of expertise or improvement.
- Compared draft performances to evaluate the effectiveness of revisions.
- Added detailed statistics to provide context and highlight key performance indicators.

## **Continuous Refinement:**

*Throughout the process, we continuously refined our approach based on:*

- The need for more specific or broader insights.
- Challenges in data representation or interpretation.
- The goal of making the visualizations more informative and user-friendly.

## **Future Considerations:**

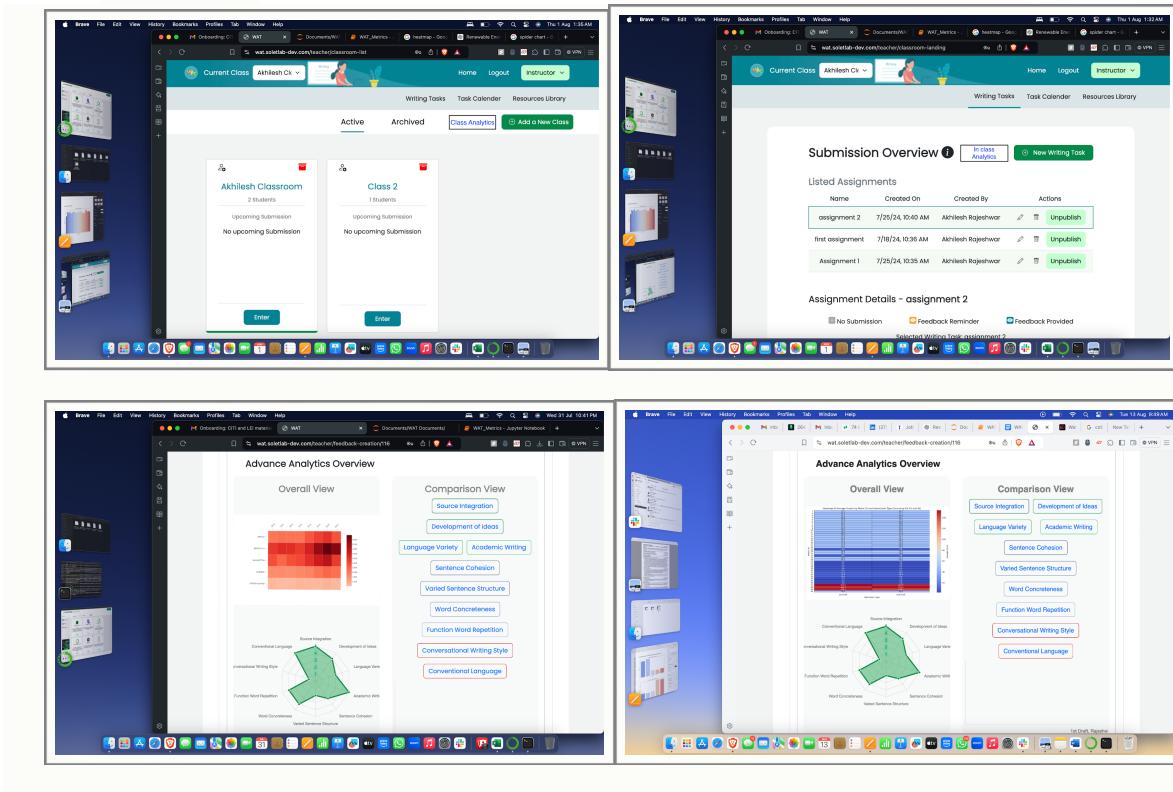
*While we developed a comprehensive set of visualizations, there's always room for further enhancement:*

- Incorporating more advanced statistical analyses.
- Developing predictive models based on the visualized data.
- Creating interactive dashboards for real-time analysis.

## 1. Initial Stages:

The project began with receiving raw data for visualization. The team conducted preliminary analysis and developed various visualization types. Key decisions made:

- Categorized visualizations into Classroom view, In-Class view, and Submission View.
- Proposed a heatmap for assignment-level visualization with metrics, drafts, and scores as variables.
- Decided to separate metrics into Basic Analytics, Advanced Analytics, and holistic scores.
- Planned to exclude metrics 41 and 42 (Content Quality and Wording Quality) from visualizations.
- Suggested progress tabs for student view and adding mentor texts for guidance.



## 2. Refining Approach:

The team refined their approach based on initial findings:

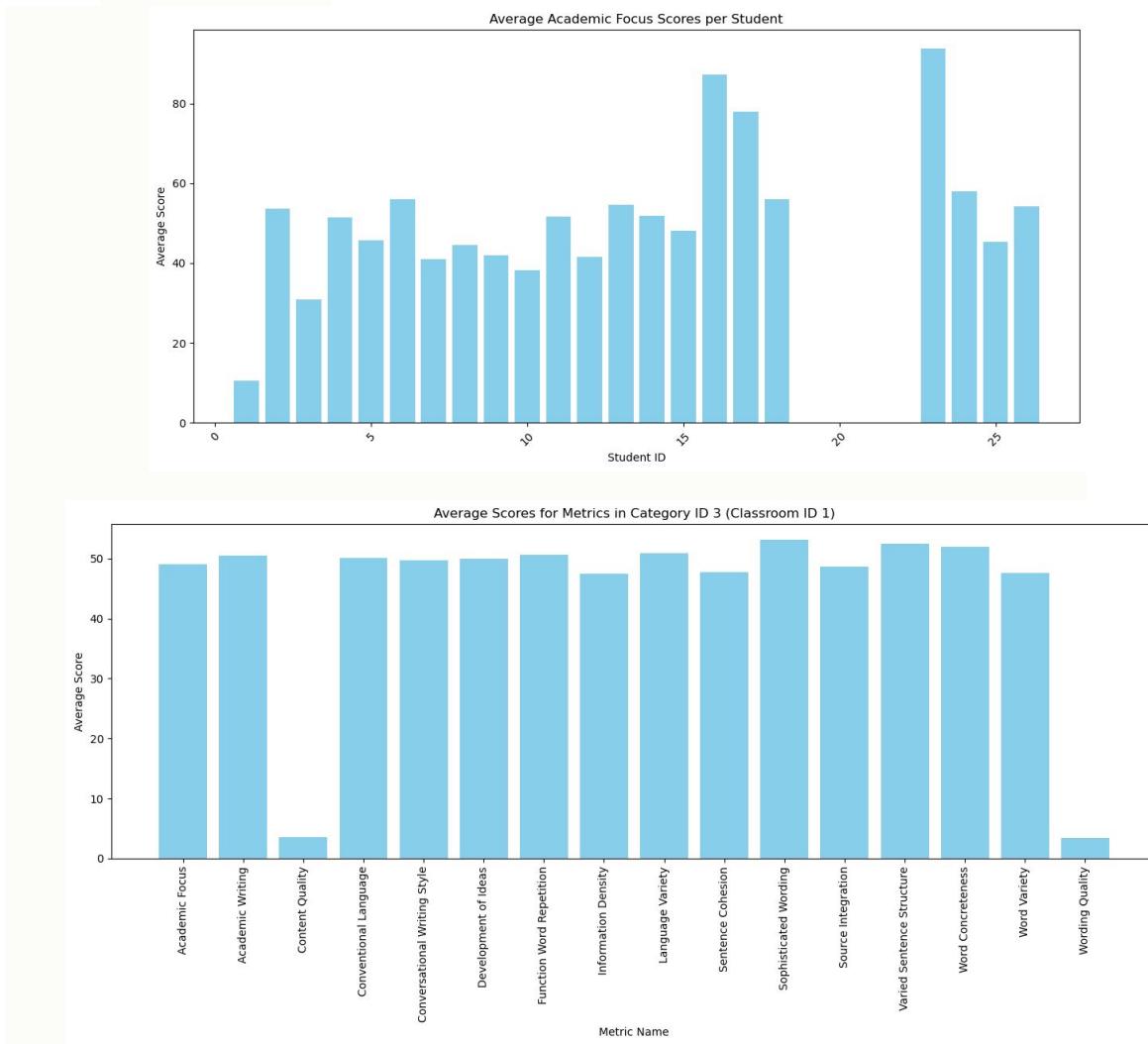
- Created visualizations segregating categories, metrics, and associated scores.
- Realized the need for different scales for each metric category due to varying score ranges.
- Proposed incorporating filters such as taskId and classroomId for more detailed visualizations.
- Focused on classroom IDs 1, 3, and 6 due to higher data density.
- Planned to improve visualizations for classroom ID and associated student scores.

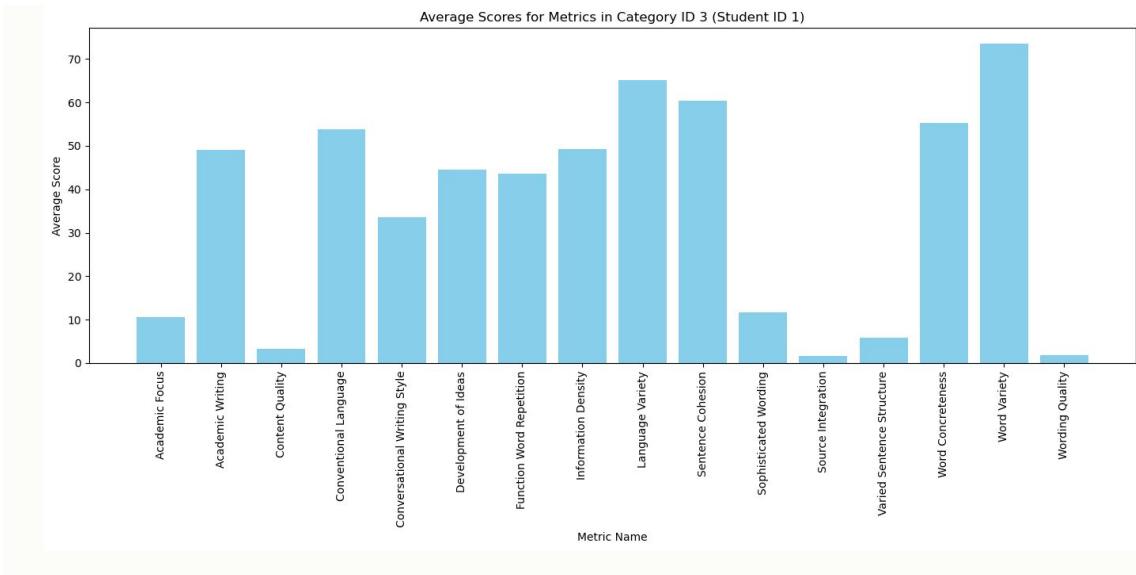


### 3. Developing Specific Visualizations:

The team developed more targeted visualizations:

- Created plots for classrooms across average scores for metrics in each category.
- Proposed three types of visualizations:
  - a) Metric-based: Average scores for each student across all classrooms.
  - b) Classroom-based: Averages for each metric within a classroom.
  - c) Student-based: Scores across metrics for a student in all classrooms.
- Decided to focus on 1-2 students for initial student-based visualizations.



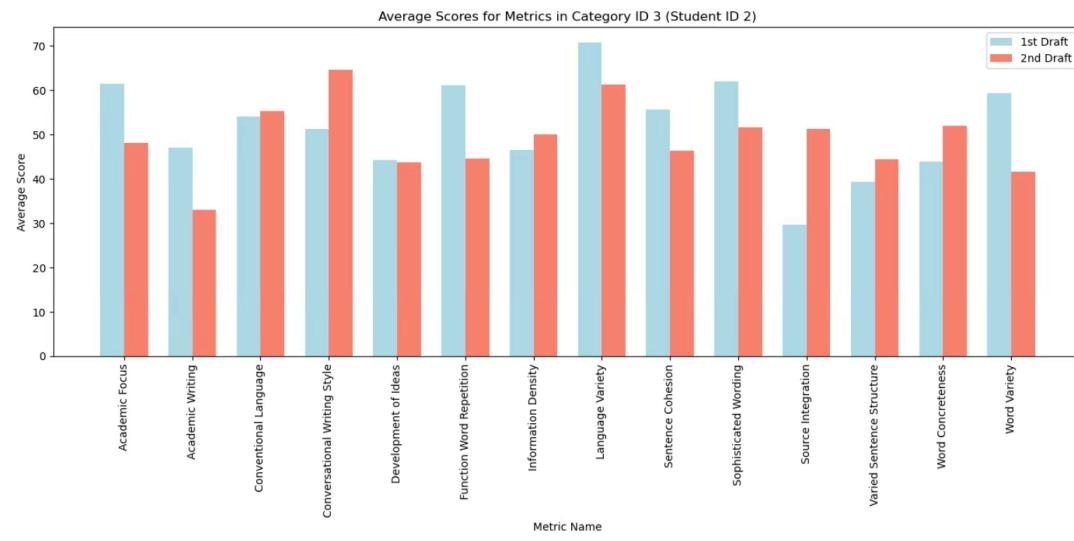


#### 4. Implementing Dynamic Visualizations:

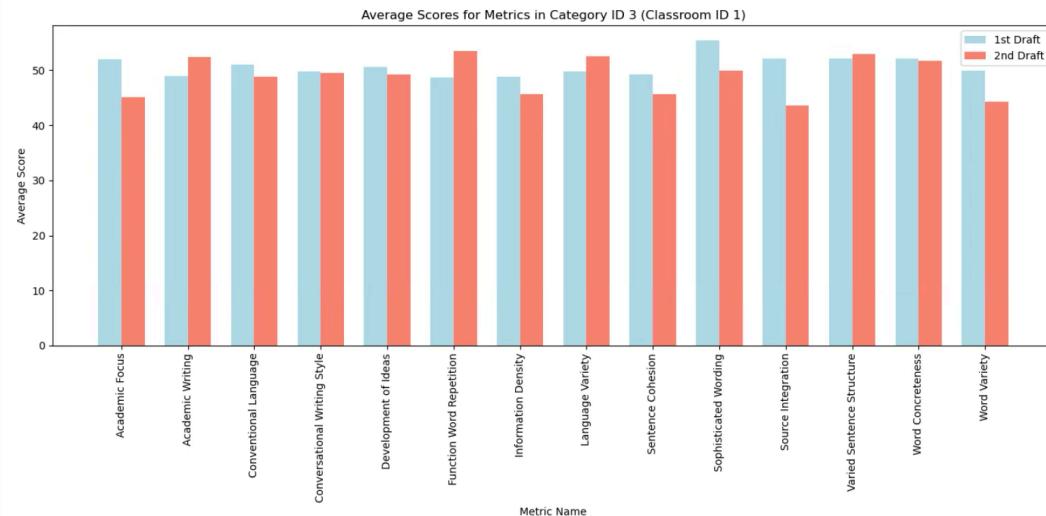
The team implemented more dynamic and interactive visualizations:

- Created input-based visualizations that change based on classroom ID or student ID.
- Incorporated draft variables into all visualizations.
- Added assignment ID as an input for more detailed insights.
- Developed visualizations for student performance across different assignments and drafts.

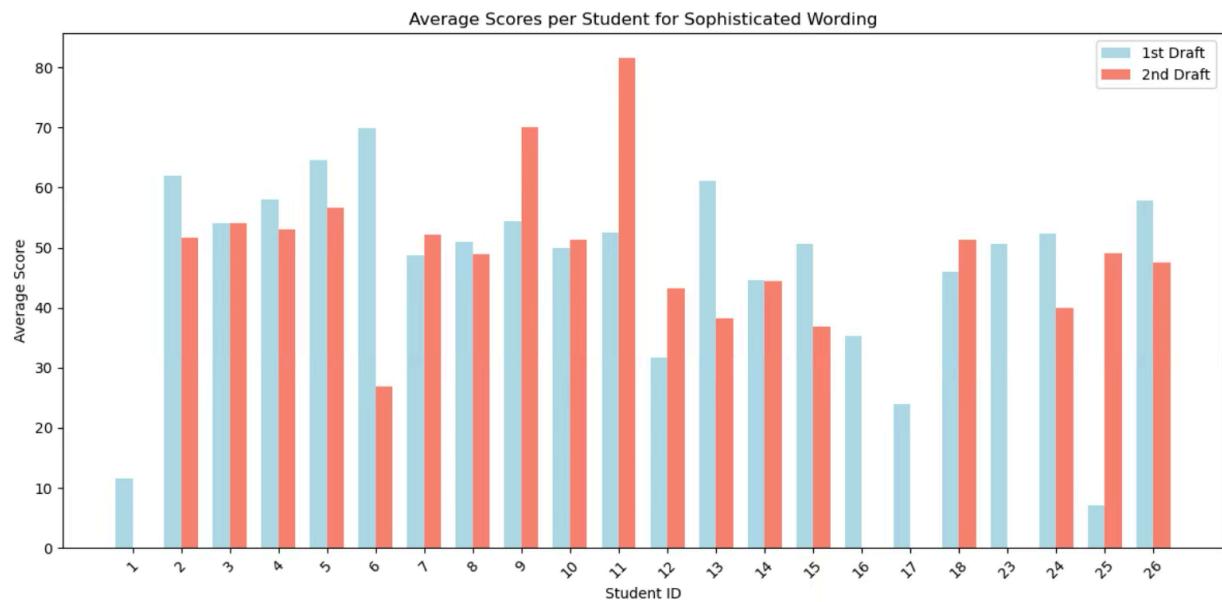
Enter a category ID (1, 2, or 3): 3  
Enter a student ID: 2



Enter a category ID (1, 2, or 3): 3  
Enter a classroom ID: 1



Enter a category ID (1, 2, or 3): 3



## 5. Exploring Diverse Visualization Types:

The team experimented with various visualization types:

- Stacked Bar Graph
- Line Plot with Markers
- Heat Map
- Grouped Bar Chart
- Box Plot
- Scatter Plot with Trend Lines
- Radar Chart
- Violin Plot

After evaluation, the team found Stacked Bar Chart, Line Plot with Markers, and Radar Chart most useful for their purposes.

The screenshot shows a web browser window titled "Assignment Details - first assignment". The URL is "wat.soletlab-dev.com/teacher/classroom-landing". The page displays three assignments:

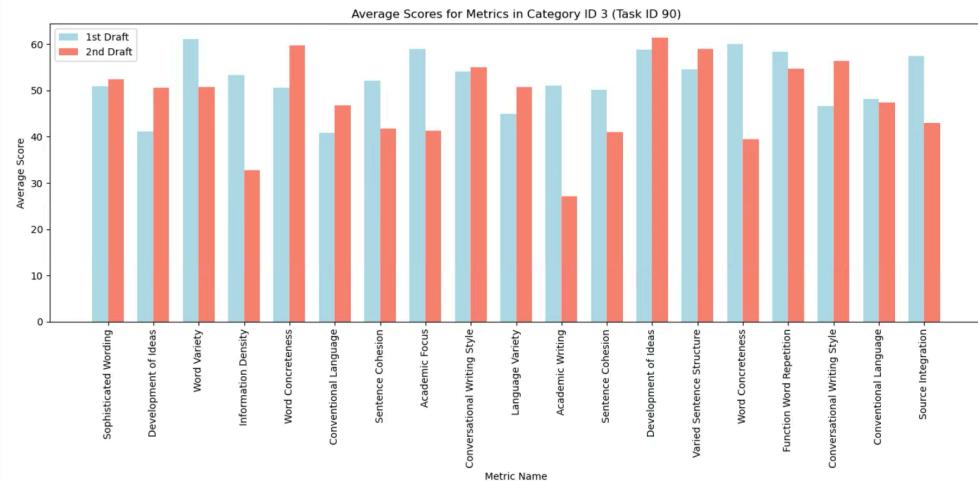
Name	Created On	Submitted By	Action
first assignment	7/18/24, 10:36 AM	Akhilesh Rajeshwar	<a href="#">Edit</a> <a href="#">Unpublish</a>
assignment 2	7/25/24, 10:40 AM	Akhilesh Rajeshwar	<a href="#">Edit</a> <a href="#">Unpublish</a>

Below the assignments, there is a search bar labeled "Search by Username" and a dropdown menu with the options "is" and "No Submission". To the right, there is a "Assignment Analytics" section with a bar chart titled "Average Scores for Metrics in Category 02 | Classroom 02\_L\_Score(0-100)". The chart compares scores across different categories and users.

At the bottom, there is a table showing user activity:

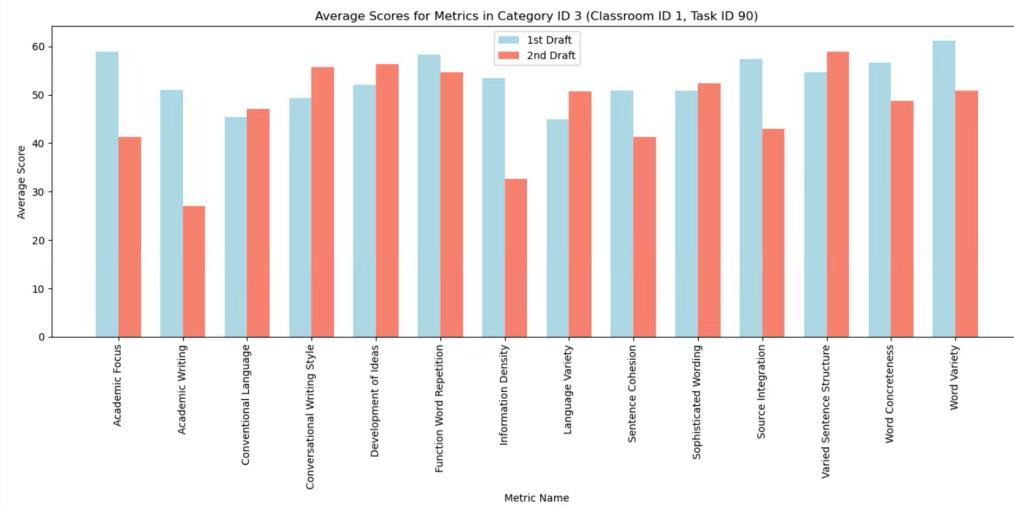
Username	Last Login	Assignment
student-7	7/11/24, 7:48 AM	<input type="checkbox"/>
abalapul	10/17/24, 4:36 PM	<input checked="" type="checkbox"/>

Enter a category ID (1, 2, or 3): 3  
Enter a task ID: 90

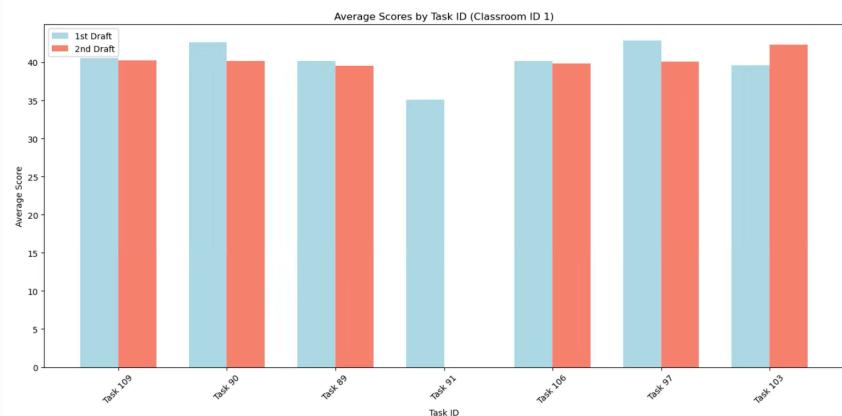


The screenshot shows a web browser window for a classroom management platform. The URL is wat.soleilab-dev.com/teacher/classroom-landing. The interface includes a top navigation bar with File, Edit, View, History, Bookmarks, Profiles, Tab, Window, Help, Home, Logout, and Instructor. Below the navigation is a sidebar with icons for assignment, calendar, and resources. The main content area is titled "Submission Overview" and shows a list of assignments. Assignment 1 was created on 7/25/24 at 10:35 AM by Akhilash Rajeshwar. Assignment 2 was created on 7/18/24 at 10:36 AM by Akhilash Rajeshwar. Both assignments have "Active" status and "Unpublish" buttons. Below the assignment list is a section for "Assignment Details - Assignment 1" which indicates "No Submission". At the bottom, there are buttons for "Feedback Reminder" and "Feedback Provided". A status bar at the bottom shows the date as Thu Oct 17 4:37PM.

Enter a category ID (1, 2, or 3): 3  
Enter a classroom ID: 1  
Enter a task ID: 90



Enter a classroom ID: 1



Brave File Edit View History Bookmarks Profiles Tab Window Help

Thu Oct 17 4:46 PM

wat.soleilab-dev.com/teacher/classroom-list

Instructor

Student Analytics

List of students

Search by username, first name or last name.

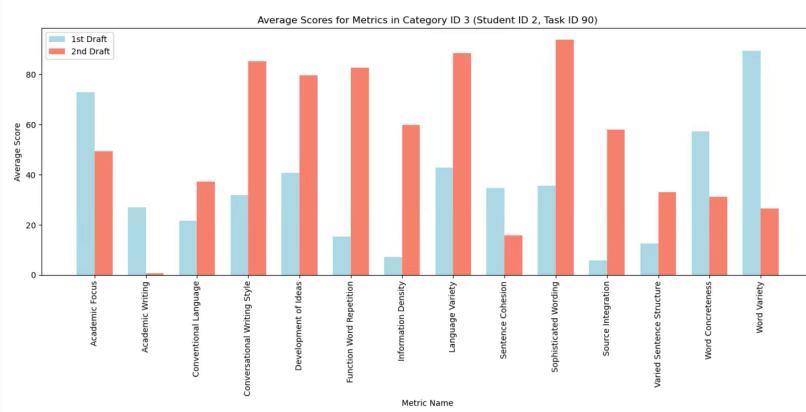
Sr. No.	Username	First Name	Last Name	Check to add <input type="checkbox"/>
1	student-7	SI	LN	<input checked="" type="checkbox"/>
2	student-2	SI	LN	<input type="checkbox"/>
3	student-6	SI	LN	<input type="checkbox"/>
4	Stud-2	SI	SI	<input type="checkbox"/>
5	student-14	SI	LN	<input type="checkbox"/>
6	student-17	SI	LN	<input type="checkbox"/>
7	student-4	SI	LN	<input type="checkbox"/>
8	Stud-1	SI	SI	<input type="checkbox"/>
9	student-12	SI	LN	<input type="checkbox"/>
10	student-1	SI	SI	<input type="checkbox"/>
11	student-13	SI	LN	<input type="checkbox"/>
12	student-15	SI	LN	<input type="checkbox"/>
13	student-16	SI	LN	<input type="checkbox"/>

New Class

Enter a category ID (1, 2, or 3): 3

Enter a student ID: 2

Enter a task ID: 90



## **6. Final Comprehensive Visualizations:**

The team developed a set of comprehensive visualizations:

a) Classroom Analytics:

- Visualization for overall classroom performance

b) Classroom and Assignment Analytics:

- Two-part visualization combining classroom and assignment-specific data

c) Student Analytics:

- Detailed view of individual student performance

d) Advanced Student Analytics:

- Comprehensive overview of a student's performance across all tasks

The team also demonstrated how these visualizations would be integrated into the WAT application interface.

### **Key Features of Final Visualizations:**

- Input-based: Users can enter specific classroom, task, student, and category IDs.
- Multi-level analysis: From classroom-wide trends to individual student performance.
- Draft comparison: Showing improvement between 1st and 2nd drafts.
- Category-based insights: Highlighting performance across different metric categories.
- Time-based analysis: Tracking performance trends over time.

### **Insights Provided:**

- Total tasks attempted and submissions
- Average scores across tasks and drafts
- Highest and lowest average task scores
- Improvement between drafts and Top and bottom performing categories.

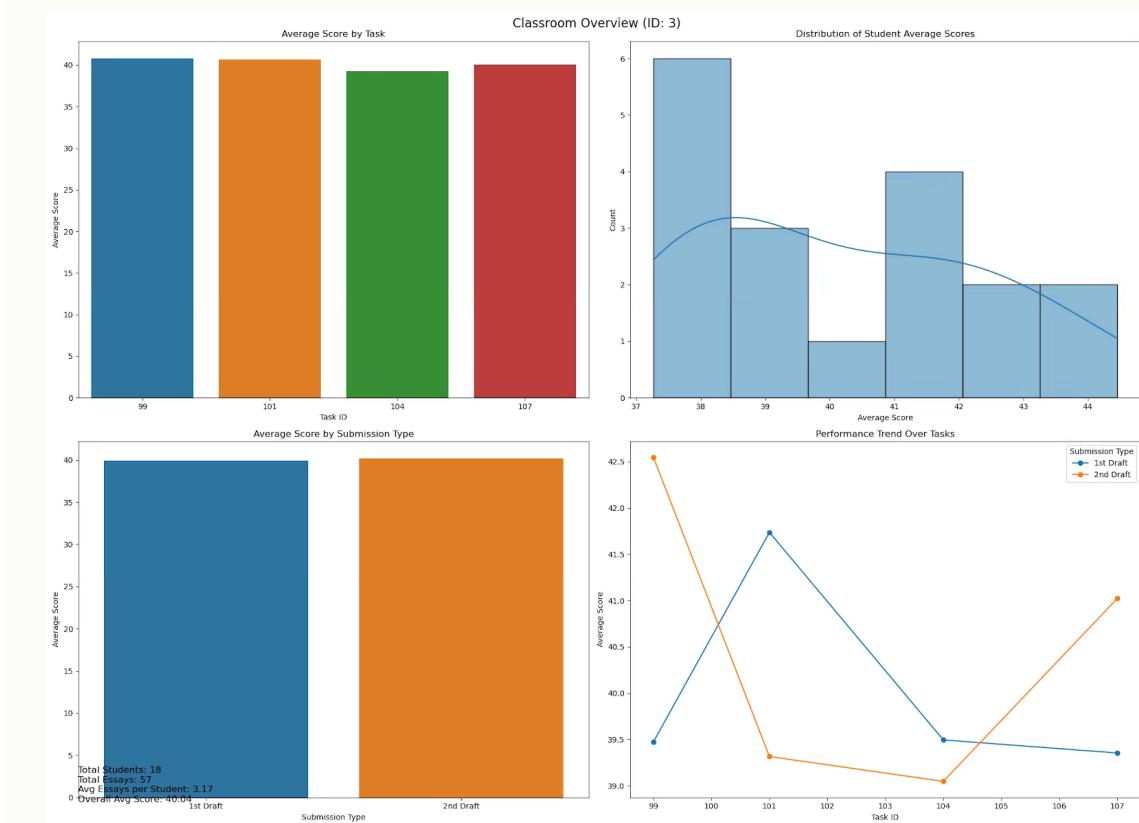
## Classroom Analytics:

The screenshot shows a web browser window for the Writing Analytics Tool (WAT) on a Mac OS X desktop. The URL is [wat.soletlab-dev.com/teacher/classroom-list](http://wat.soletlab-dev.com/teacher/classroom-list). The interface includes a sidebar with multiple windows previewed on the left and a main content area with two classroom cards.

**Akhilesh Classroom**  
2 Students  
Upcoming Submission  
No upcoming Submission  
[Enter](#)

**Class 2**  
1 Students  
Upcoming Submission  
No upcoming Submission  
[Enter](#) [Analytics](#)

At the bottom right of the main content area, there are three small charts: "Classroom Overview (ID: 3)", "Distribution of Student Average Scores", and "Performance Trend Over Tasks".



# Assignment Analytics 1

Brave File Edit View History Bookmarks Profiles Tab Window Help

Thu Oct 24 5:37 PM

Wat wat.soletlab-dev.com/teacher/classroom-landing

Current Class Class 2 Writing

Home Logout Instructor

Writing Tasks Task Calendar Resources Library

**Submission Overview** *i*

New Writing Task

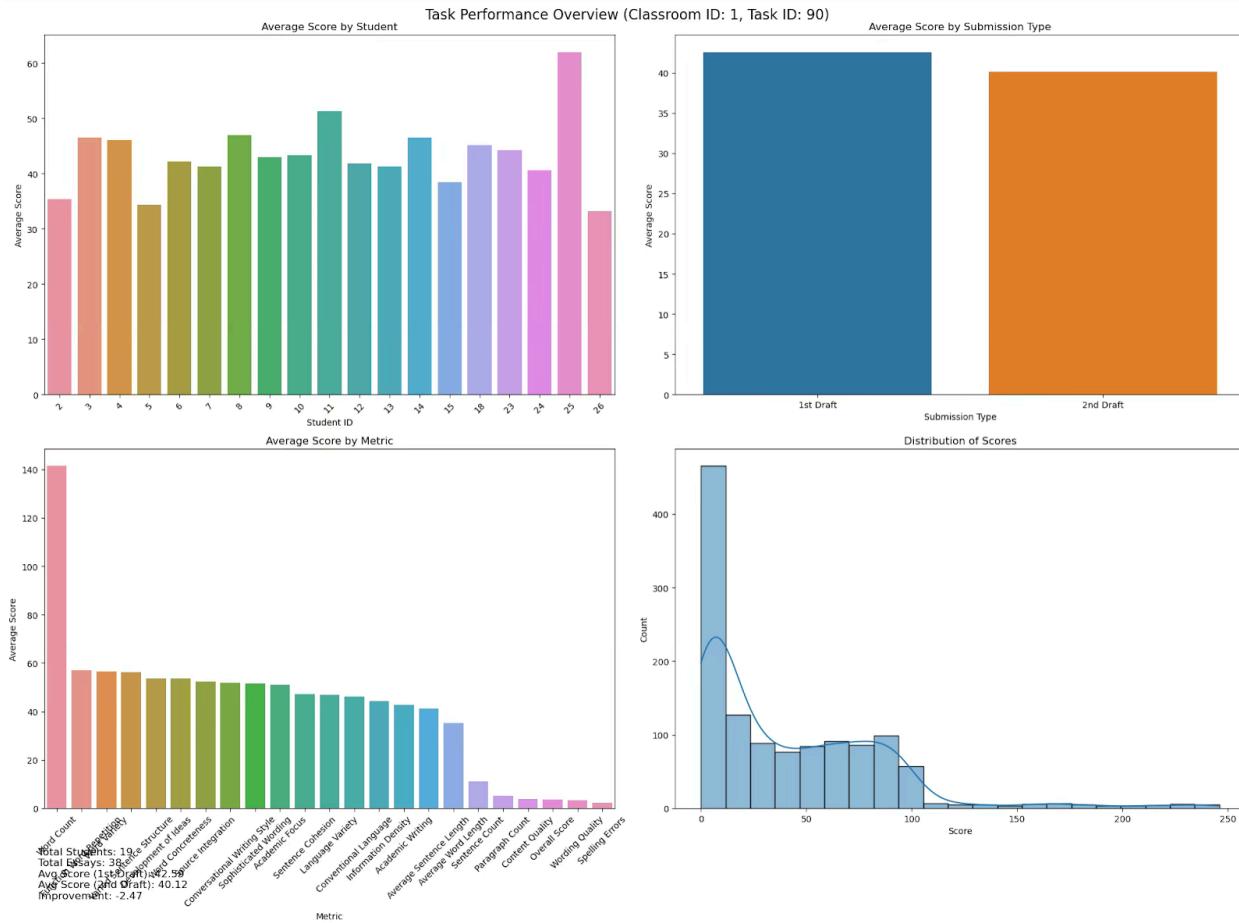
**Listed Assignments**

Name	Created On	Created By	Actions
Assignment 1	7/25/24, 10:35 AM	Akhilesh Rajeshwar Anyt	
first assignment	7/18/24, 10:36 AM	Akhilesh Rajeshwar	
assignment 2	7/25/24, 10:40 AM	Akhilesh Rajeshwar	

**Assignment Details - Assignment 1**

No Submission Feedback Reminder Feedback Provided

Selected Writing Task: Assignment 1



## Assignment Analytics 2

Brave File Edit View History Bookmarks Profiles Tab Window Help

WAT X Inbox (4,2) WAT Data Document WAT Analy... how to get + Thu Oct 24 5:46 PM

wat.soletlab-dev.com/teacher/classroom-landing

### Submission Overview

New Writing Task Classroom Analytics

#### Listed Assignments

Name	Created On	Created By	Actions
Assignment 1	7/25/24, 10:35 AM	Akhilesh Rajeshwar	
first assignment	7/18/24, 10:36 AM	Akhilesh Rajeshwar	
assignment 2	7/25/24, 10:40 AM	Akhilesh Rajeshwar	

#### Assignment Details - first assignment

No Submission Feedback Reminder Feedback Provided

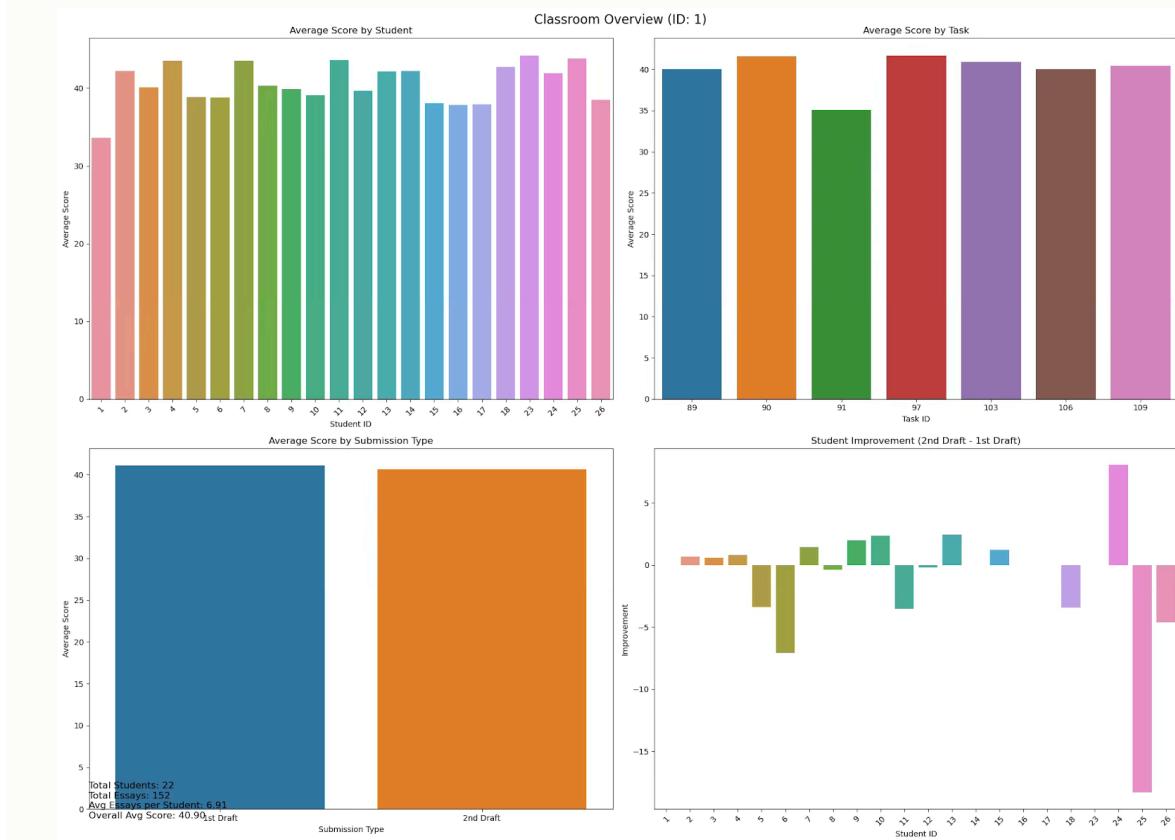
Selected Writing Task: first assignment

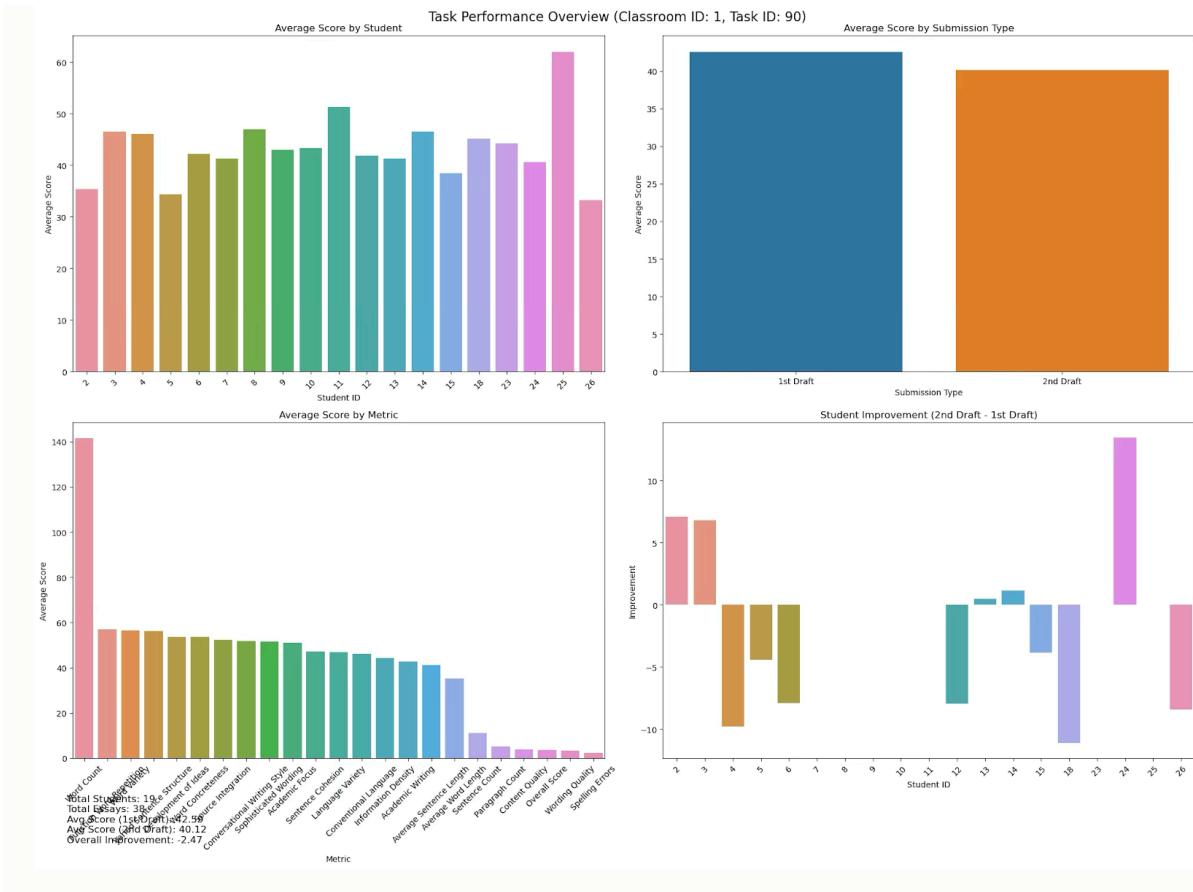
Search by Username

Username: first assignment

Last Login: Assignment Analytics

This screenshot shows the Assignment Analytics 2 interface. At the top, there's a navigation bar with tabs like 'File', 'Edit', 'View', 'History', 'Bookmarks', 'Profiles', 'Tab', 'Window', and 'Help'. Below the navigation is a header with 'Submission Overview' and a 'New Writing Task' button. To the right is a 'Classroom Analytics' link. The main area is divided into two sections: 'Listed Assignments' and 'Assignment Details - first assignment'. The 'Listed Assignments' section shows a table with three rows: 'Assignment 1', 'first assignment', and 'assignment 2'. Each row has a 'Created On' date, 'Created By' name, and a set of actions (edit, delete, unpublish). The 'Assignment Details' section is focused on 'first assignment'. It includes four bar charts: 'Average Score by Student', 'Average Score by Task', 'Average Score by Submission Type', and 'Student Improvement (2nd Draft - 1st Draft)'. There are also filters for 'No Submission', 'Feedback Reminder', and 'Feedback Provided'. A search bar for 'Username' is present, along with dropdowns for 'Last Login' and 'Assignment Analytics'. The bottom of the screen shows a Mac OS X dock with various application icons.





# Student Analytics

Assignment Details - Assignment 1

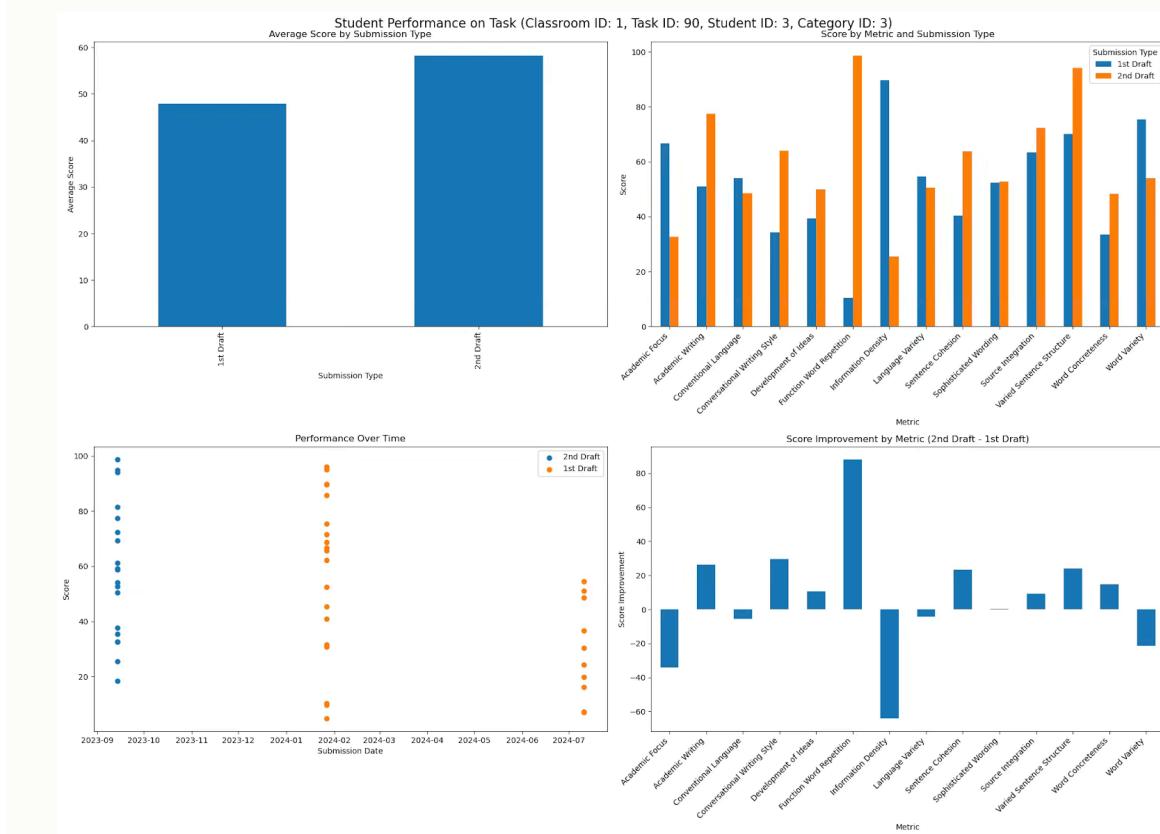
No Submission   Feedback Reminder   Feedback Provided

Selected Writing Task: Assignment 1

Search by Username:

Filter:

Username	Last Login	Assignment 1
student-7 Analytics	7/11/24, 7:48 AM	1st Draft
abalapul	10/24/24, 6:41 PM	2nd Draft



# Advanced Student Analytics

Overall Student Performance (Student ID: 2)

Average Score by Task

Average Score by Category

Performance Trend Over Time

Average Score by Submission Type

Search by username, first name or last name.

Sr. No.	Username	First Name	Last Name	Check to add <input type="checkbox"/>
1	student-7	SI	LN	<input type="checkbox"/>
2	student-2 Comp Anyt	SI	LN	<input type="checkbox"/>
3	student-6	SI	LN	<input type="checkbox"/>
4	Stud-2	SI	SI	<input type="checkbox"/>
5	student-14	SI	LN	<input type="checkbox"/>
6	student-17	SI	LN	<input type="checkbox"/>
7	student-4	SI	LN	<input type="checkbox"/>
8	Stud-1	SI	SI	<input type="checkbox"/>
9	student-12	SI	LN	<input type="checkbox"/>
10	student-1	SI	SI	<input type="checkbox"/>
11	student-13	SI	LN	<input type="checkbox"/>
12	student-15	SI	LN	<input type="checkbox"/>
13	student-16	SI	LN	<input type="checkbox"/>

