Using AutoML to Analyze the Effect of Attendance and Seat Choice on College Student Grades

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Abstract. The students at Southern Adventist University (USA) submit valuable attendance data daily through an attendance-tracking system once used for COVID-19 contact tracing. This study organizes some of this data and employs machine learning to analyze the claim that class attendance and sitting at the front of a classroom may improve student grades. We performed a correlation analysis in Microsoft Azure's Machine Learning workspace by training regression models. No correlation was found between student attendance and seat choice and final course grades. Next we used the K-means clustering algorithm to train clustering models in Microsoft Azure. At $k = 2$ clusters, a cluster with perfect attendance shows a higher average grade than a cluster with a late attendance average. Seat choice within the classroom does not prove important to the clustering models.

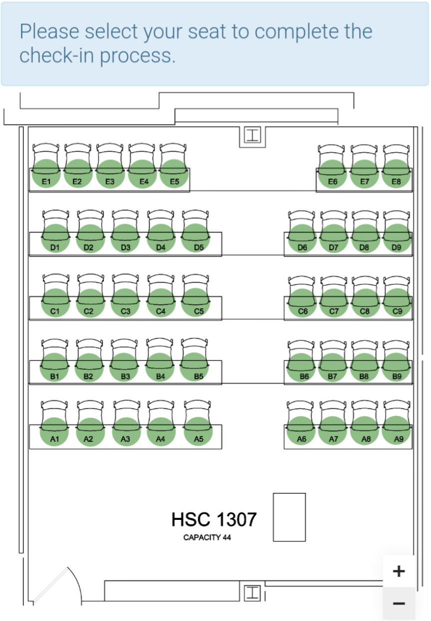
Keywords: Microsoft Azure, Machine Learning, Workspace, Regression, K-means clustering, Class attendance, Seat selection, Grade prediction

1 Introduction

In 2020, the rapid spread of the SARS-CoV-2 virus, which causes the disease commonly known as COVID-19, changed institutions and systems all around the Earth. While some of these changes made daily life more difficult, others presented unforeseen opportunities.

Southern Adventist University (SAU), located in Tennessee, USA, like many other educational institutions, implemented strict quarantines and contact tracing to allow their students to attend classes in person during the pandemic [1,2]. Using the web interface shown in Figure 1, SAU required thousands of students to select their seat in every class they attended all semester. This data allowed for digital contact tracing (DCT) whenever a new case of COVID-19 was identified.

As campus activity returned to normal and concern over Covid subsided over the next few semesters, the new attendance system remained. Many professors simply found the system much more convenient than manually taking note of



Please select your seat to complete the check-in process.

Fig. 1. The ATS interface in one of the many classrooms on campus.

absent or late students. Not only did the new system allow professors to discuss course material sooner, but it continued collecting attendance and seating data which could be useful for more than just contact tracing.

Upon identifying the opportunity this data held, faculty and students at the campus asked two primary questions:

1. Does class attendance and punctuality foreshadow higher course grades?
2. Do students that sit in the front of class receive higher marks than those that choose to sit near the back?

Our contribution is the application of two ML techniques, namely regression and clustering, to answer these two questions. To this end, we made use of the Automated Machine Learning (AutoML) functionality of Microsoft Azure.

This paper is organized as follows. Section 2 presents the state of the art. Section 3 presents the methodology. Section 4 presents the results. Section 5 presents the conclusions and future work.

2 State of the Art

School websites arguing for the importance of class attendance can be found quite easily.[3], [4] According to academic research, regular attendance promises

[3] fondafultonvilleschools.org

[4] egcsd.org

many benefits for students. Some schools even quote Woody Allen, arguing that "80% of success is just showing up."[5]

The National Center for Education Statistics explains that, starting in kindergarten and progressing through high school, commonly absent students miss out on learning opportunities [3]. As a result, even the best teacher's ability to enable student success is limited. Moreover, after leaving school, absentees "exhibit a history of negative behaviors."

Moreover, during the data collection phase of this project, one of the attendance system managers recalled a high school course in which their instructor announced that students would be graded based on where they sat. Students in the front rows would receive higher marks than those who chose to sit further away. In this way, the instructor was hastening what he assumed to be an inevitable outcome. Several studies, including our project, test this hypothesis.

Researchers and scientists in various departments have conducted studies concerning some aspect of student attendance and course performance. In their 2015 study of first-year psychology courses, Alexander and Hicks analyzed whether class attendance was linked to increased student performance in modern classrooms with online lectures [4]. Their results featured significant ($p < 0.001$ and $p < 0.05$) correlations between student attendance and performance on assignments.

Furthermore, several studies have been done concerning seat choice and student grades. In a 1973 issue of *Sociometry*, Becker et al. demonstrate that students sitting nearer to their instructor not only received higher grades than those further away, but also liked their professor more ($p < 0.01$) [5]. However, other studies present contradictory conclusions [6].

Others have conducted experiments using machine learning to predict grades or analyze groups of students in classrooms. For example, Zabriskie et al. studied which pieces of information best predicted a student's grade in physics courses as the semester progressed [7]. At first, a student's GPA was the strongest predicting factor, but eventually the first test grade surpassed this measure with homework performance in second place.

3 Methodology

The first step to performing successful data science experiments is obtaining good data. Therefore, this section first describes where data was obtained, how it was organized, and what precautions were practiced to avoid potential problems. Next the tools used are introduced along with the procedures and experiments performed.

[5] marktomforde.com

3.1 Data Collection

For this study, all data was gathered from one institution, SAU. Because the driving questions concern a typical classroom setting, the data collected needed to reflect only this setting.

Some courses at SAU only contained a handful of students per a semester. Additionally, several classrooms had movable desks. Because stickers on these desks indicated the seat row and column (as shown in Figure 1), adjustable desks could have introduced systematically flawed data in a study where seat placement is critical. To eliminate both of these issues, only physically large classrooms with bolted desks were selected.

Some faculty raised further concerns that the attendance system had changed as the university relaxed its COVID-19 restrictions. For instance, during its first semester of use, the attendance tracking system (ATS) only permitted students to sit in every other seat, thus restricting student seat choice. However, in following semesters, ATS allowed students to sit in any seat in a classroom. In favor of consistency, only the latter of these systems was used, resulting in two semesters of data (Fall 2021 and Winter 2022).

Once locations and times were chosen for data collection, all other entities followed naturally as shown in Figure 2. 159 course sections with twenty or more students enrolled were found using the seventeen chosen classrooms over the two semesters. 2,067 students were enrolled in one or more of these sections, which were taught by sixty-three professors representing thirteen departments.

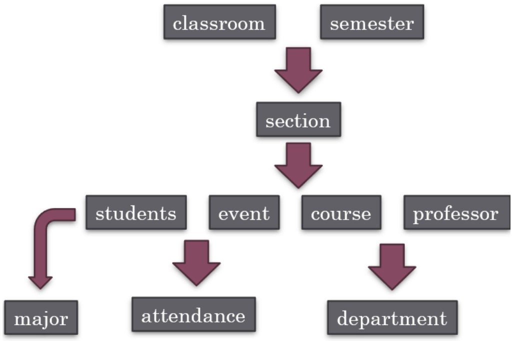


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Fig. 2. The natural progression of entities in data collection.

Each section had associated events that represented one class period. The ATS stored data for each student that was present, but it did not always specify if a student was absent from a class. Thus, using several structured query language (SQL) scripts, this data was imputed. If a student was enrolled in a section but had no record of attending any one of its events, they were assumed absent.

3.2 Data Organization and Tools

Separating the above entities into relations was the most natural way of storing and organizing the data. Because the data was pulled from a data warehouse partially external to the university, it was not separated into the various entities described in the previous subsection. Thus, Tableau Prep Builder was used to segregate and clean the data.[6]

Because Microsoft Azure was to be used for the data science experiments, it was also chosen to store and serve the data. Using an Azure SQL Database on an Azure SQL Server, we constructed a relational database from the outputs of Tableau Prep Builder. After resolving all the bugs encountered during data collection, the cleaned comma-separated values (CSV) files provided by Tableau Prep Builder were simply imported as tables into the database using Microsoft SQL Server Management Studio (SSMS). Primary and foreign keys were also configured in SSMS. The resulting schema for this database can be seen in Figure 3. All entities are transitively related using primary/foreign keys.

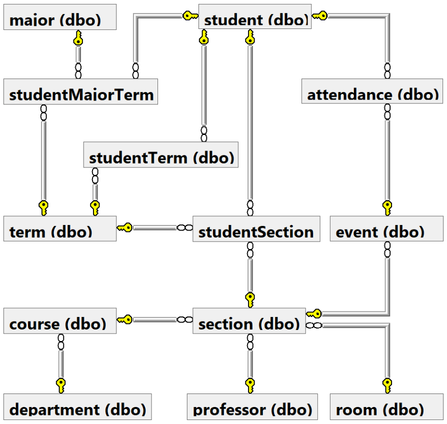

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Fig. 3. An abbreviated form of the database schema as visualized by Microsoft SQL Server Management Studio.

its

The initial reasons for using Microsoft Azure were its advertized ease of use and Automated Machine Learning (AutoML) workspace. AutoML is an emerging technology that offers automatic training of various machine learning models without the need for coding.

In a typical solution, data is first supplied to a model training component. The component trains a prediction model, often even automatically choosing which algorithm is best for solving a given classification, regression, clustering, or forecasting problem. It may also tune the model's hyperparameters.

[6] tableau.com/products/prep

All experiments were run on Microsoft Azure's cloud computing platform. The specific machine configuration selected, Standard D2 v2, had the following specifications: Cores ...

I think this flows better

The following Microsoft Azure's Standard D2 v2 machine was used in the experiments: Cores: 2; RAM: 7 GB; disk: 100 GB; temporal storage (SSD): 100 GiB; NICs: 2; network bandwidth: 1500 Mbps; throughput IOPS: 8x500; maximum data disks: 8; and maximum temporal storage throughput: IOPS/Read MBps/Write MBps: 6000/93/46.

3.3 Experiment Plan

The general plan for regression and clustering experiments was to connect the Microsoft Azure AutoML workspace to the Microsoft Azure SQL Database so that the AutoML components could automatically extract the latest data from the database. Using these two platforms, we created automatic pipelines that built machine learning models for student grades. Finally, various subsets of attributes were provided to the AutoML pipeline to run experiments on.

After producing a model, Microsoft Azure supplied various metrics associated with that model. For regression, these included error scores and correlation coefficients, allowing for a simple correlation analysis of any subset of attributes. For clustering, metrics included cluster densities and diameters as well as each record's cluster assignment. Using this information, the model could provide the average values of each attribute in each cluster, which could give insight into how the algorithm naturally organized the data.

To perform logistic regression and clustering, class data first needed to be transformed into a numerical format. The twelve grade categories "A-F" were converted to the numbers 1-12, respectively. Also, "I" (incomplete) and "IP" (incomplete passing) were assigned values of 13 and 14.[7]

Other categorical variables were converted in a similar manner. For example, there were five categories for attendance status. The labels "Present," "Online," "Late," "Excused," and "Absent" were assigned the values 0-4 respectively.

Further, as shown in the ATS interface in Figure 1, students selected their seat using a numerical column and a *row letter*. Most training models would perform better with a *row number* rather than a letter. Also, the number of rows and spacing between those rows in each classroom varied, rendering any categorical row data inconsistent. To provide the most useful data to the algorithms that would train the models, the row letters were extracted, aggregated for each classroom, and converted to a normalized distance from the front of the classroom. This new attribute, called "distanceToFront," measured how far a student's chosen seat was from the front of the classroom. Values closer to "0" indicate seats closer to the front row of a classroom while those closer to "1" represent seats at the back of a classroom.

The final query fetches the attributes of interest for this project (shown in Listing 1.1).[8] These attributes included student demographic information, credit

[7] This assumes that not completing a class is a less favorable outcome than failing it. Also "Incomplete Passing" is marked as lower than "Incomplete," but it is not a cause for concern as this represents less than 0.1% of the data.

[8] Notice that courses in the Nursing (NRSG) and Physical Education (PEAC) departments were filtered out. Nursing courses were removed because students were often

load, hours worked during the semester, distance to the front of the classroom, attendance status, and final grade. This query was run against the Azure SQL database and the resulting data was used as a starting point for Azure's AutoML experiments.

```
select s.isFemale, s.isHispanic, s.race,
  st.housing, st.gradeLevel, st.credits,
  st.tensOfHoursWorked,
  a.distanceToFront, a.seatColumn, a.statusCode,
  sn.finalGradeCode
from attendance a
  join student s on a.studentID = s.studentID
  join studentTerm st on s.studentID = st.studentID
  join studentSection sn on s.studentID = sn.studentID
    and sn.termID = st.termID
  join section n on sn.sectionID = n.sectionID
  join event e on n.sectionID = e.sectionID and e.eventID = a
   .eventID
  join course c on n.courseID = c.courseID
where c.departmentID != 'NRSG'
  and c.departmentID != 'PEAC';
```

Listing 1.1. Query to fetch the attributes of interest.

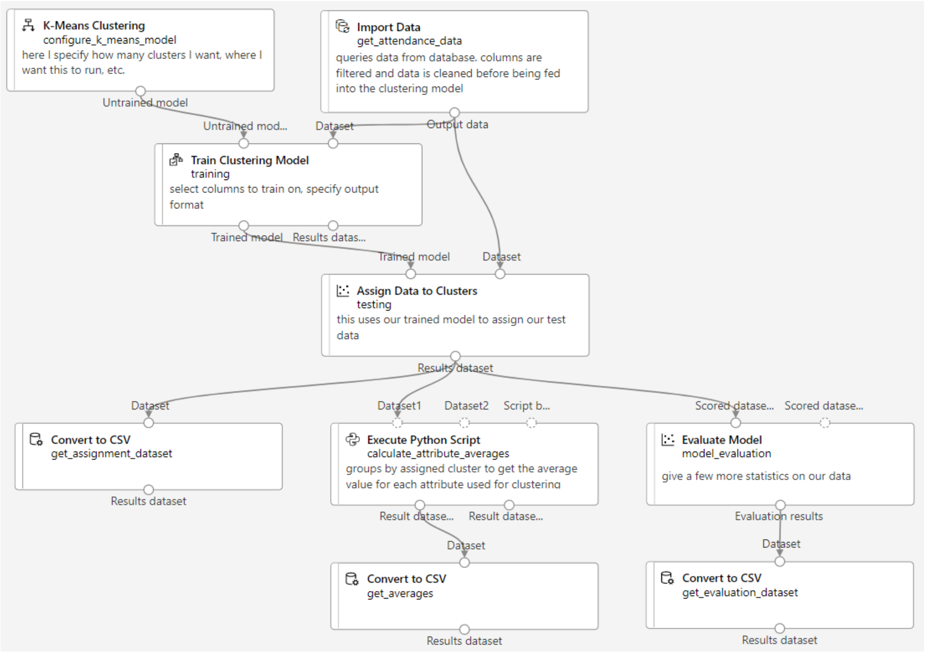
Correlation Analysis Regression experiments were configured as "jobs" and started in Microsoft Azure's Machine Learning workspace. To analyze correlation across different groups of attributes, the experiment was run multiple times with different subsets of the columns shown in the query shown in Listing 1.1.

Clustering Rather than telling the algorithm how the data should be fit, unsupervised learning allows the model to try to group the data based on all the given attributes. After the algorithm has formed clusters of data that minimize some cost function, the clusters can be assessed to form conclusions.

Microsoft Azure's AutoML platform can perform popular clustering algorithms such as K-means. In order to approach this approach, our solution was to created as a pipeline. In a pipeline, several components can be "wired together" to create a single process. This process is capable of gathering data, processing it, training machine learning models, testing those models, and generating result data in automatic succession. The machine learning pipeline shown in Figure 4 was used to perform clustering for this project. Note that to make this image fit better on paper, a data cleaning step and a column selection step were removed from the pipeline. The cleaning step simply imputed missing values using column means.

The best way to use clustering in Microsoft Azure is to create a pipeline.

assigned seats in these courses, thus removing the student's ability to choose their seat. Physical education courses, on the other hand, were not considered a "normal classroom setting."



K-Means Clustering
configure_k_means_model
here I specify how many clusters I want, where I want this to run, etc.

Import Data
get_attendance_data
queries data from database, columns are filtered and data is cleaned before being fed into the clustering model

Train Clustering Model
training
select columns to train on, specify output format

Assign Data to Clusters
testing
this uses our trained model to assign our test data

Convert to CSV
get_assignment_dataset

Execute Python Script
calculate_attribute_averages
groups by assigned cluster to get the average value for each attribute used for clustering

Evaluate Model
model_evaluation
give a few more statistics on our data

Convert to CSV
get_averages

Convert to CSV
get_evaluation_dataset

Fig. 4. The clustering pipeline created in this project.

In the **Import Data** component (top right of Figure 4), the pipeline fetches data dynamically from the Microsoft Azure SQL Database. Different attributes can be selected within or after the query that this component performs. Initially, numerical, textual, and categorical data was being returned. However, after several experiments and database adjustments, only numerical data was fetched using the query shown in Listing 1.1.

On the top left of Figure 4, the **K-Means Clustering** component is used to initialize and configure an untrained clustering model. Several parameters can be set here: the number of clusters desired in the output, the feature normalization option, a model weight initialization algorithm, and a multi-dimensional distance metric.[9] The **Train Clustering Model** component then trains this model using the imported data.

The **Assign Data to Clusters** component takes all the provided data and assigns it to a cluster using the trained model. Using this data, the model can be evaluated in the **Evaluate Model** component, which measures average distances between all clusters.

Microsoft Azure provides a mechanism for executing Python code in a pipeline. A custom Python script only needs to contain an `azureml_main()` function that

[9] In our experiments, the number of clusters varied from two to fourteen, normalization was enabled, weights were initialized with the "K-Means++" algorithm, and a Euclidean distance metric was used.

receives and returns up to two dataframes. To generate the necessary data, the **Execute Python Script** component receives all the records along with their cluster assignments and calculates the average value of every feature for each cluster (see Listing 1.2).

```
import pandas as pd
def azureml_main(dataset, optional_data = None):
    return dataset.groupby("Assignments").mean()
```

Listing 1.2. Function to calculate the avaerage value of every feature for each cluster.

Finally, all the data generated by these components is converted into CSV format as described in the following section.

4 Results

This section presents the results of the correlation and clustering analyses.

4.1 Correlation Analysis

In the first experiment, all of the attributes of interest mentioned in the previous section were fed into the regression model.[10] The Root Mean Squared Error (RMSE), Explained Variance (EV), Spearman Correlation Coefficient, and R^2 Score are presented in Table 1. This configuration provided a fairly accurate regression model. The Spearman correlation coefficient was over 0.9, suggesting a high correlation between all the input and target attributes. As a visual representation of its accuracy, the regression graph is shown in Figure 5.

Table 1. Regression Performance Metrics

Attributes Used	RMSE	EV	Spearman	R^2 Score
All shown in SQL query	1.110	0.859	0.906	0.859
statusCode, distanceToFront	2.314	0.043	0.186	0.043
statusCode	2.923	0.020	0.107	0.020
distanceToFront	2.922	0.020	0.140	0.020

Microsoft Azure also provides insight into which attributes were most important to the accuracy of the model. As shown in Figure 6, the model relied heavily on class standing, term information, and demographic information. The distance to the front of the classroom falls in fifth place and attendance status in seventh.

Figure 6 is 2 pages down. Is it against the conference formatting rules to get figures 5 and 6 both on the next page?

Based on the composition of other highly-accurate models, we suspect that the automated machine learning algorithm may have trained the regression

[10] This included demographics, course and work amounts, attendance information, and *finalGradeCode*, which is the target variable.

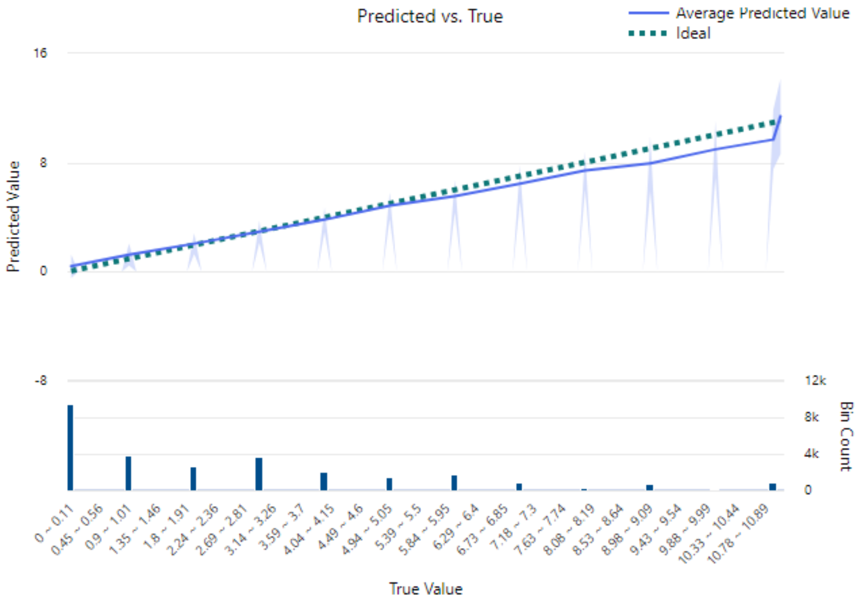


Fig. 5. The predicted values approximate the true values very well.

model to recognize individual students and predict grades based on that student's historical performance.

To avoid this issue, the following experiment only retained two attributes, attendance status (*statusCode*) and distance to the front of the classroom (*distanceToFront*). After trying to correlate these attributes with the students' final grades for forty-eight minutes, the best model that Microsoft Azure trained offered a mean absolute error that was nearly a fifth of the entire range. Very little of this error was explained by the variance in attendance data. Additionally, both correlation metrics suggested no correlation between the attendance data and student grades. In fact, the R^2 score suggests that there is a 95.7% chance of getting this correlation from unrelated attributes.

Isolating the attendance status and seat row attributes even further did not improve results. Both prediction models produced separately by these two attributes yielded even lower correlation values.

Overall, the results of the correlation analysis showed that attendance and seat choice could not be used to accurately or precisely predict student grades in the data obtained from Southern Adventist University.

4.2 Clustering

Before other hyperparameters were tuned, the number of clusters, k, had to be decided. To this end, we made use of the Elbow Method. As shown in Figure 7, the inflection point is slightly unclear. Thus, experiments were first performed

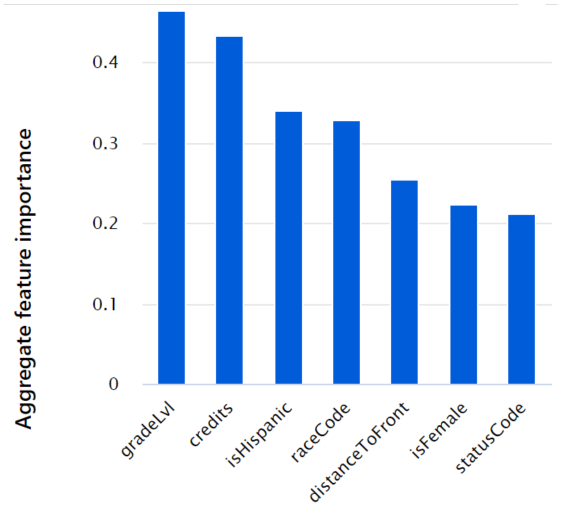


Fig. 6. The top seven attributes used by the first regression model, ranked in order of predictive importance.

with $k = 5$ clusters. The first experiment used all the queried columns. However, the clustering algorithm grouped data primarily using demographic information.[11]

After limiting the number of attributes available, K-Means grouped the data primarily based on attendance status and distance to the front of the classroom. However, five clusters proved too many for this set of attributes so the count was reduced to $k = 3$.

represents

Tables 2 and three are too far down from this point to easily reference. This may be fixed if the images above them were higher up in the paper.

The averages in Table 2 were obtained using three clusters and two input attributes. Data placed in Cluster 0 represented a mostly "Present" attendance status and a seat choice roughly halfway from the front of the classroom. Nearly all of the attendance records in this cluster had perfect scores of "A". Cluster 1 has similar averages, but with grades much closer to "C+" and "C". Finally, the cluster with chronically late attendance and a seating preference slightly beyond the halfway point has an average grade around a "B+" or "B".

have

The experiment was repeated with three clusters and no results wavered. Although Cluster 2 does show a group of students that is often late and performs worse than average, the three clusters together are inconclusive.

Finally, the experiments were repeated with only two clusters. The results are displayed in Table 3. As seen before, distance to the front of the classroom is nearly the same for both clusters. However, Cluster 1 specifically represents records where a student was, on average, late to class. This cluster has an average

[11] For example, four of the five clusters would be entirely based on a student's gender and Hispanic status.

[12] This feature was originally named "Average Distance to Cluster Center" and has been scaled so that the largest value is 1.

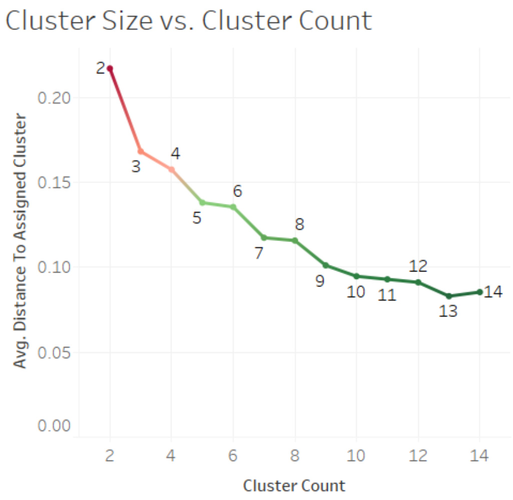


Fig. 7. The average distance to a cluster compared across various number of clusters.

Table 2. Average Attribute Values in Three Clusters

	status	distanceToFront	grade	radius[12]	point count
Cluster 0	0.020	0.575	1.004	0.404	104833
Cluster 1	0.030	0.613	6.384	0.569	42212
Cluster 2	2.922	0.610	3.618	1.000	18143
Total	0.341	0.589	2.666	0.512	165188

grade between ”B+” and ”B”. Cluster 0, on the other hand, displays much better attendance and grades on average between “A-” and “B+”.

Table 3. Average Attribute Values in Two Clusters

	status	distanceToFront	grade	radius[13]	point count
Cluster 0	0.022	0.586	2.548	0.689	147033
Cluster 1	2.921	0.610	3.624	1.000	18155
Total	0.341	0.589	2.666	0.651	165188

Though interesting, these clusters are still far from ideal. One major issue is that they are unbalanced. One includes 89% of the attendance data and the other only 11%. A more balanced dataset is desirable.

[13] This feature was originally named “Average Distance to Cluster Center” and has been scaled so that the largest value is 1.

To further validate Microsoft Azure's automated clustering algorithm, clustering was also performed in Weka 3.[14] The results from this experiment were identical to those obtained from Microsoft Azure's K-Means clustering.

5 Conclusions and Future Work

The correlation analysis did not support any correlation between a student's attendance and their performance in class. With correlation coefficients as low as $R^2 = 0.020$, the lack of any relationship between the independent and dependent variables is easier to argue than a correlation or causation between them.

Clustering provided more insight. A cluster of data was identified that represented tardiness or absence along with lower grades. With further work and more balanced data, this machine learning approach holds the most promise.

No experiments showed that sitting nearer to the front of the classroom positively impacted a student's grades. Instead, this attribute seemed generally unimportant. It only seemed useful for identifying particular students (assuming students often sat in the same seat throughout the semester).

Overall, this study does not conclusively prove correlation between student attendance and grades, nor does it prove that student seating is irrelevant to grades. Therefore, as future work we will work in the following aspects: First, Microsoft Azure's AutoML promised an easy-to-use automated machine learning process, but proved very difficult to navigate and configure. Thus, in future work, a different tool would be used.

Secondly, the experiments might benefit from having data that has been balanced to include the similar amounts of high and low scores. More data with final grades below "B" should be collected and combined with the current dataset. Also, a better balance is needed between the different attendance categories. Currently, "Late," "Absent," and "Excused" attendance records represent only 11.6% of attendance data.

Other assumptions remain untested. For instance, *"distanceToFront"* was relative for each classroom. Thus, some students in the back of one classroom may be farther away from their instructor than students in the back of another classroom that contains fewer rows. If physical distance has a significant impact, that factor is lost in this process, as both seats in the rear of any classroom would be assigned values of "1". Also, data about the horizontal placement of a student within a classroom was not processed or converted into a numerical format.

partially

Moreover, correct data entry cannot be guaranteed unless researchers or their representatives ensure that a student's self-reported attendance matches reality. For example, if one student accidentally selects the wrong seat in the ATS, they cannot change their selection.

Finally, in this project models were trained on records of every piece of attendance information with a final grade attached. This results in a system where

[14] cs.waikato.ac.nz/ml/weka

courses that meet many times during a week have more influence on machine learning models than courses that meet fewer times. Classes that meet four times a week should not have this type of privilege over courses that meet once or twice a week for the same total hours.

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A better method might calculate average metrics such as "distanceToFront" and attendance for each student in each course. This data could then be provided to the AutoML platform, avoiding the "meeting times" issue. It could even be systematically scaled by the number of credits offered in the course to further even out the weight of the information.

Other variables, such as a professor's teaching style, adjustable tardiness thresholds, and time of day were not controlled. To mitigate this, a more structured study needs to be planned and documented.

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