

ORIGINAL RESEARCH ARTICLE

Investigation and the development of learning analytics dashboard in open and distance learning using big data mining

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ABSTRACT

The main aim of this study is to provide universities with a way of examining and predicting student performance. The fundamental aim and purpose of this study is to help academic institutions to analyse and predict student performance. The credibility and accuracy of the model was examined by comparing the predicted results of the model with the observed values. And educational data mining techniques were used to create student profiles. Weighted gain, classification analysis, decision tree and rule induction were used in this study. The results of the study showed that the level of students' academic performance varied according to criteria such as academic structure, faculty, mode of enrolment and gender. In order to determine the relative importance of variables, the information weight gain technique was used after generating rule induction parameters and hidden rules between data. Using data mining techniques, we can obtain both guidelines to instruct students and information to help us identify them.

Keywords: student performance; educational data mining; decision tree

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1. Introduction

In the twenty-first century, education, particularly higher education, has risen to the status of an absolute requirement. On average, a student spends fifteen years in school before graduating. In Malaysia, kids as young as seven may enroll in primary school, yet it takes the average Malaysian college student until they're 22 to get a degree. We can see from the fact that over a quarter of the typical lifespan was devoted to learning how important education is in today's world, both in terms of finding gainful employment and making it through daily living. Those without a college degree are at a disadvantage when applying for jobs. As a consequence, college students' academic performance may one day be the single most important factor in determining whether or not they are offered a job.

Most Malaysian parents enroll their four-year-olds in kindergarten, where they spend three years before moving on to primary school, then high school, and finally university. Education in Malaysia is funded and overseen by the government, namely the Ministry of Education (MOE). In doing so, the government is demonstrating its commitment to educating the public on the value of education. More skilled labor, competent employees, and educated experts in the science, technology, engineering, and mathematics areas

are needed as Malaysia transitions from a production-based society to a knowledge-based one. This shift gives one country an economic edge on a worldwide scale by increasing the availability of skilled workers, which in turn propels the nation's growth and hastens its progress. Singapore and other ASEAN countries have led the way in economic output while having landfills smaller than Pahang State on Peninsular Malaysia^[1]. A government's ability to attract top talent and encourage foreign investment results in a more skilled labor force that has had more opportunity to learn from experts in their field and participate in advanced levels of research and development. The examination-focused Malaysian education system is holding the country back from competing in the ASEAN market by not providing a well-rounded education to its future workers. To actualize the stated quality of a workforce, it is necessary to guarantee that the students are capable of high-order thinking processes and a problem-solving attitude. Human resource managers now consider a candidate's academic performance to be one of the most important criteria for hiring recent college graduates, which puts further pressure on students to excel in their coursework in order to meet employer expectations^[2,3]. Education in the sciences and technologies has never been more vital to a country's economic and social progress than it is in the twenty-first century, with new technologies springing up every day. There has been amazing progress in the use of technology in science and technology in Malaysia, and a great deal of interest has been shown in enrolling in the country's science and engineering institutions. This is encouraging, but only if the quality of graduates is guaranteed. Consequently, maintaining a high standard for graduates necessitates identifying the elements on which their success in school relies and putting such measures into place.

The purpose of this research was to construct and verify a mathematical model that may be used to analyze and forecast students' performance in higher education. In this light, the issue may be stated as follows:

- 1) The outcomes that kids get in the classroom are much too variable, and the disparities between them are far too large.
- 2) College students' outcomes cannot be analyzed mathematically.
- 3) Third, there are just too many unknowns to accurately predict with any proposed mathematical model.

2. Related work

2.1. Implication of academical results

On average, a kid in Malaysia will spend 15 years in school, between preschool, elementary school, middle school, high school, and college^[3]. Students will wait another fifteen years to join society after devoting their whole lives to learning. Students' academic outcomes are one metric used to evaluate their progress in class. This is combined with additional criteria like extracurricular involvement, shown leadership potential, etc. Students are considered to be in the upper tiers of the academic hierarchy if they have shown a commitment to their studies. Despite the intrinsic worth and soft skills being quantified, there is little proof that students with higher GPAs and participation in extracurricular activities have a major advantage in the workforce. Most findings were anecdotal, indicating that the parameters may change considerably. Examinations of any kind, even those administered by private institutions, have come to be seen as crucial in Malaysia to a student's ability to go further in their education or to find work. According to research conducted in the country, formal education is considered a gateway to higher-paying jobs and more prestigious careers in Malaysia. As a consequence, everyone involved in a child's education now looks only to test scores to gauge their child's academic success. In terms of one's own intellectual, emotional, spiritual, and physical growth, there are few things more vital than one's own attitudes and valuations; however, in the current national education system, these values are completely disregarded. However, there are a variety of elements that might influence a student's success in college. It may have to do with pressures, scheduling, habits, or views about one's own efficiency. One's productivity, happiness at work and in life, sense of role overload, and stress at work may all benefit from better time management^[4,5]. A student's intellectual curiosity and ability, motivation, environment, health, pre-university performance, and personality are not correlated with one another. It's

agreed upon that there's no one explanation for why pupils of identical academic aptitude may have such vastly diverse outcomes under the same conditions. Students' attendance, sleep habits, and extracurricular activities are more likely to be important predictors of individual variations in academic achievement than any other factor. The academic community has been a driving force behind the development of new policies in Malaysia, including the Malaysian Education Blueprint 2013–2025, the National Higher Education Action Plan 2007–2010, and the National Health Education Strategic Plan (NHESP) beyond 2020. The government is taking action to elevate the professions by setting more severe standards for professorship, and the goal of these efforts is to increase the number of lecturers with PhD qualifications in public higher education institutions. Over the course of the year, we've seen an increase in both the quality and quantity of our instructors thanks to R & D initiatives, Pillar, and MyBrain15. Predicting students' academic success is crucial because it enables teachers to tailor their teaching strategies to the needs of each individual student, particularly the lowest performers. A student may be considered at risk, for example, if the model predicts that their final grade point average (GPA) will fall below 3.0. Any instructional interventions, such as one-on-one tutoring, tutorials with solutions to help students review key concepts, assigning high-order thinking skill questions, remedial lessons, and asking students to summarize and review prior knowledge from the prerequisite course, can be incorporated into a lecturer's proactive approach to improving student learning. Students who are struggling academically might use the findings to motivate themselves to alter their approach to studying. Students are able to get insight on how they performed in a certain course, which compels them to reconsider how they studied in the past^[5,6].

2.2. Educational pathway in Malaysia

Centralized public exams serve as the foundation for the outcome-focused evaluation used across the Malaysian education system. In a system where graduation from each grade level was contingent on pupils' performance on standardized tests. From elementary school through pre-university, students must pass four standardized tests. These include the Primary School Achievement Test (UPSR), which will no longer be administered in 2021, the Form Three Assessment (PT3), which will be administered in 2022, the Malaysian Certificate of Education (SPM), and the pre-university certification, the Malaysian Higher School Certificate Examination (STPM), which will be administered in 2025. After formal schooling was established, several advancements were made. Over the course of the 1960s and 1970s, improvements were implemented at Malaysia's national schools. The reformations were heavily influenced by the west, but their outcomes were unexpected^[7]. Countries are increasingly under pressure from the globalization trend to accelerate their transition to a knowledge-based economy. In Malaysia, both governmental and private entities have developed to provide higher education, with the first being University Malaya, founded in 1959. There are around 500 private colleges in Malaysia, in addition to 20 public universities, 24 polytechnics, 37 public community colleges, 33 private universities, 5 foreign university branch campuses, and a total of roughly 500,000 students enrolled in higher education. Further, numerous universities and colleges in the United Kingdom, the United States, Australia, Canada, Germany, and New Zealand have partnered with their Malaysian counterparts to provide dual degree programs.

2.3. Quality assurance for tertiary education system

One of the issues schools encounter, as stated in the problem statements, is reproducing the same level of student achievement year after year. One reason why students' performances differ is because each person's skill set and potential are unique. On the other hand, inconsistency arises when the chasm is too wide. Inconsistency in a higher education platform might be disastrous since it is one of the factors that prospective students consider when deciding whether or not to enroll. Since this is the case, tertiary education institutions like colleges and universities need a tool that may assist them in maintaining continuity and relevance.

One way to do this is to ensure that all teachers have access to high-quality professional development

opportunities. Providing high-quality teaching, service, and research is essential for keeping the bar set by the institution at a consistently high level. Additionally, educational institutions should improve their infrastructure to provide equitable access to resources and materials for all students. However evident and perhaps inconsequential they may seem, the butterfly effect will bring about continuity in the institution's long-term strategy^[8]. Numerous methods for predicting academic success have been suggested in many nations. Predicting a student's grade point average (GPA) requires one to compile information from many educational institutions, and here is where neural network prediction algorithms come into play. Evidence suggests that both academic and extracurricular activities have significant effects on kids' yearly performance. Any conclusions drawn, however, would be profoundly impacted by the sheer size of the datasets^[9,10].

The National Higher Education Strategic Plan (NHEAP) of Malaysia, which spans the years 2007–2010, places a strong emphasis on classroom instruction and student learning. That's why we're laying the groundwork for a brighter, more robust future by implementing exciting, cutting-edge courses for our students. To prepare students for the competitive global market, a well-designed curriculum should emphasize the development of students' creative and innovative capacities as well as their leadership and entrepreneurial skills. Marketing Malaysian education places a premium on its profound cultural, religious, and political resonances; therefore, the curriculum must be strong enough to draw in foreign students. one that places a premium on culture, education, and healthy living. Malaysia's cabinet agreed to create the Malaysia Qualification Agency (MQA) in 2005^[11]. Its primary function is to ensure the quality of higher education programs, but it will also serve as a stepping stone towards the introduction of the Malaysian Qualification Framework (MQF). However, careful preparation is necessary for carrying out the aforementioned measures effectively.

2.4. Predictive model for student academic performance

Predictive models can be found everywhere, from the rankings of NBA players and college coaches to those of companies and political candidates. Even the PageRank algorithm is an example of a predictive model^[12,13]. Predictive analytics in this context tends to concentrate on individual learners rather than larger institutions. As a consequence of implementing the measurements, data collection, analysis, and reporting, the model's capacity to predict and enhance a student's performance and retention is shown. All these analyses can be conducted and gathered from student data, but they depend on the environment in which the data is obtained. Learning management systems (LMSs), which take into account learning activities, course administration, and tracking, are often used in educational settings to implement the analytics and reporting techniques for such data. Numerous learning management systems (LMSs) have been adopted by universities; they have the intelligence to detect and report on any academic problems that may arise. Student Advice Recommender Agent (SARA) and the MiGen teacher support tool, which was designed to display data and have alerting capabilities^[14], are only two examples of tools that may provide further interventions. However, LMSs' limited capacity to meet institutional demand rather than learning recommendations for students means that they do not contribute to optimal learning outcomes. Students need a clearer set of instructions or more data about the things they'll be doing in school, and they need to be flexible enough to adapt to new situations. By helping to identify students who are at risk in their studies and providing them with practical ideas on how to improve their outcomes for the semester, learning analytics has the potential to drastically alter the quality and value of higher education. One approach offered by Barker and Garvin-Doxas (2004) uses a hierarchical framework to facilitate communication between teachers and students on the latter's development. This research demonstrates that student rankings are a significant factor in shaping their actions. Predictive analytics' analysis and reporting phases might benefit from student rankings as a potential solution.

The proposed strategy and instrument are to create a model that can be used universally by all colleges and universities to predict and analyze the academic performance of students, specifically by forecasting their

cumulative GPA, which typically captures a continuous assessment of a student over the course of their college career in terms of the results from assignments, projects, quizzes, tests, and final examinations. Institutions may just need to enter their own data and information into a correct and precise model to evaluate their students' academic progress. Not only does this approach aid universities in the pre-planning stage, but it also proves useful in the post-mortem, particularly at Board of Directors' meetings when student academic achievement is discussed. The primary goal of this kind of methodology is to identify and address the underlying causes of kids' low and fluctuating performance in the classroom. Institutions may not only increase their understanding of such causes but also take preventative measures and adopt strategic planning to enhance their existing conditions. Otherwise, the university's and community's standings will be at stake. Many people have tried to analyze students' academic performance for various reasons (such as spotting students who are in danger of dropping out, ensuring their retention in school, allocating courses, determining which students need to retake courses, etc.). Such are some of the goals of the suggested paradigm. For instance, if a single student does poorly on a test, the appropriate division will be contacted so that their findings may be analyzed using the suggested mathematical model. Predicting a student's final test result in a given course may also be done with the use of mathematical models. Multivariate linear regression (MLR), multilayer perceptron (MLP) neural networks, radial basis function (RBF) neural networks, and support vector machines are some of the mathematical modeling tools (SVM). The predictor variables, such as a student's cumulative grade point average and performance in any prerequisite classes, are crucial inputs for these algorithms. Predicting students' success in their first year of college and then sorting them into low-, medium-, and high-risk groups based on their predicted performance are both examples of using neural networks and MLR approaches to predict students' performance in online learning environments.

The biggest obstacles encountered when developing this model were the factors that would change the outcomes. Both internal and external influences might have an impact on a student's academic achievement. Furthermore, there are a number of measurable and non-measurable elements, like motivational levels, emotional states, and so on. For instance, the social-cognitive career theory integrates both intelligence and character into a single framework. This theory uses separate but interconnected theoretical models to describe such phenomena as profession choice, interest development, and academic success. The theory contains a trifecta of basic tenets: self-efficacy, result expectancies, and objectives. Individual inputs, such as a student's gender, and contextual variables, such as financial or mental support from family, are also accounted for in the theory; together, they shape the student's learning experience, which is heavily influenced by a wide variety of factors that correlate with their sense of competence and their hopes for the future. Based on this hypothesis, a person's personality characteristics may serve as their contribution. There would be a significant degree of control, if not total control, by sociocognitive systems over the connection between personality and interest, decision-making, and academic success. The impact of sociocognitive and personality factors on academic success has received surprisingly little attention. The sociocognitive hypothesis hypothesizes that cognitive capacity will affect college students' performance both directly and indirectly. It's been shown that students' indirect performance is heavily influenced by their result expectations and self-efficacy. This means that students with lower outcome expectations and lower self-efficacy are more likely to set less challenging academic goals than students with higher outcome expectations and higher self-efficacy.

Therefore, certain characteristics that are excessively subjective, such as a student's emotional condition, will be disregarded by this model in order to reduce ambiguity. Additionally, various combinations of predictor variables may or may not produce different results, but they would certainly alter the model and the prediction procedure, so it's important to choose a combination that makes sense for predicting students' scores. Academic performance evaluations will be conducted using the suggested methodology in order to remove bias from the process. But other people say that self-efficacy doesn't really mean anything and is just a stand-in for actual performance. While it's true that self-efficacy may be used as a predictor of performance outcomes,

this fact is not novel; rather, it accounts for prior success.

In a nutshell, this will serve as a useful resource for educational institutions to analyze accessible data and get insight into their performance. This is a model that can help students understand themselves and address their deficiencies, and it will also help the school retain its standing and reputation.

3. Method

The primary purpose of this research is to help institutions analyze and anticipate the outcomes attained by college students by factoring in a variety of non-quantifiable elements that may be used to identify individuals who are in danger of failing in their academic programs. By comparing the model's projected values with the observed ones, its accuracy and dependability may be assessed.

The study's three goals are as follows:

- 1) Evaluate and choose suitable variables and independents, including quantitative and qualitative data, as inputs to the analytical model.
- 2) Build an analytical model using mathematics, and then choose the right kind of mathematics to use.
- 3) Use data acquired from at-risk college students to compare and evaluate the analytical model's correctness.

The collected data, a decision tree was constructed to help identify whether or not the pupils' health was improving. **Figure 1** shows the decision tree at a node where birth year and academic term are both taken into account.

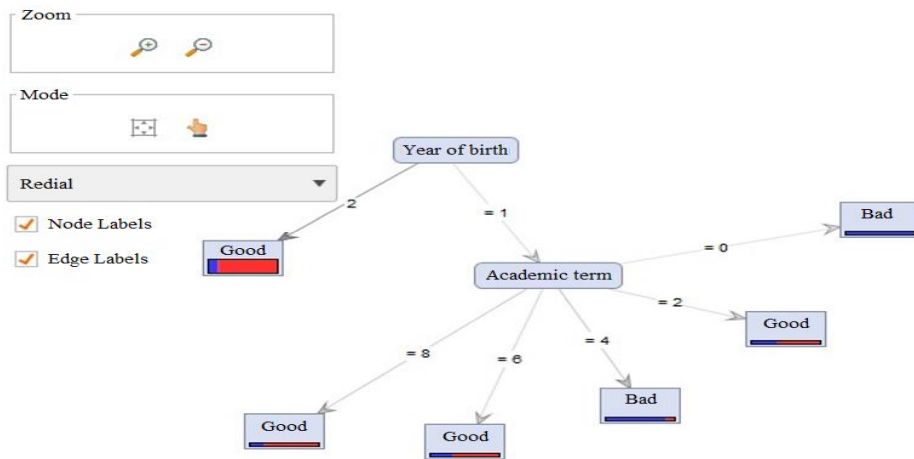


Figure 1. Decision tree.

There have been several breakthroughs in rule discovery since the Rule Extraction parameter was included into the Classification analysis setup (**Figure 2**). After analyzing the data set until a 50% error margin was reached, several surprising insights were uncovered.

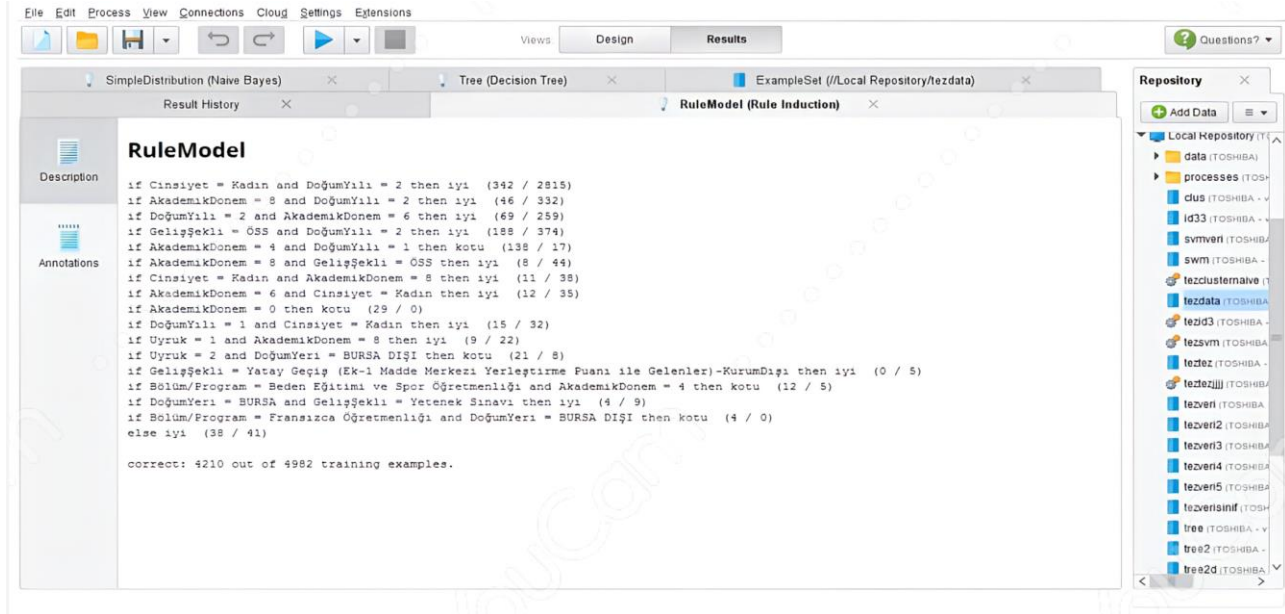


Figure 2. Rule inference.

4. Result and discussion

The findings presents the results of the analyses that address the first study question by demonstrating the connection between demographic factors and course performance. The outcomes of the categorization analysis are shown in the second section of the findings. Here we provide the results and new regulations that emerged from our investigation into issue two. The relative weights of the factors that influence students' performance in the classroom are shown in the third section of the results. Rapidminer's lowest and highest quantities of the dataset are included in its descriptive statistics, giving us a sense of what the data looks like as a whole.

The overall average grade point average is 2479. **Figure 3** displays the faculty's weighted average GPA distribution; the mean value for all 254 students seems to be zero. A female student has the highest GPA in the faculty at 3.97.

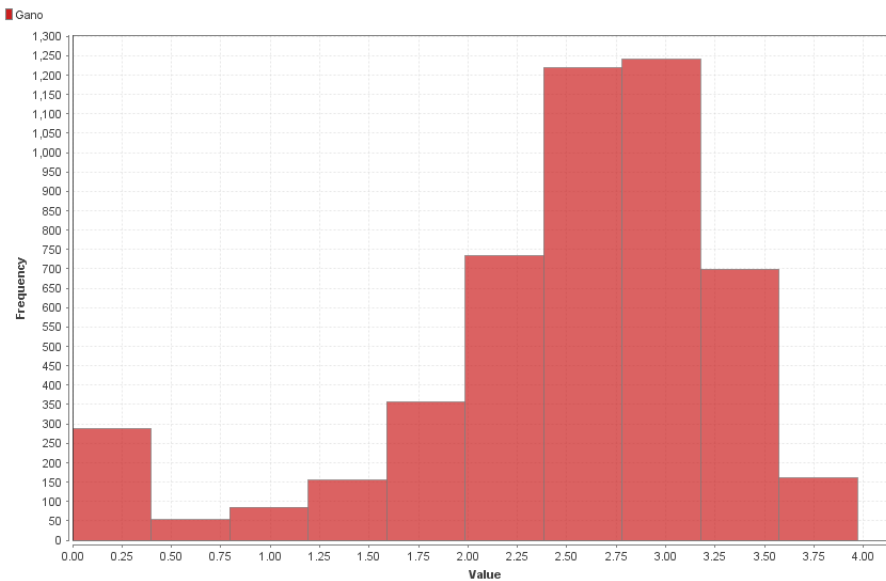


Figure 3. Grade point average variable.

Figure 4 shows that there are about twice as many female students as there are male students participating in the research. The student body is comprised of 3478 females and 1564 males.

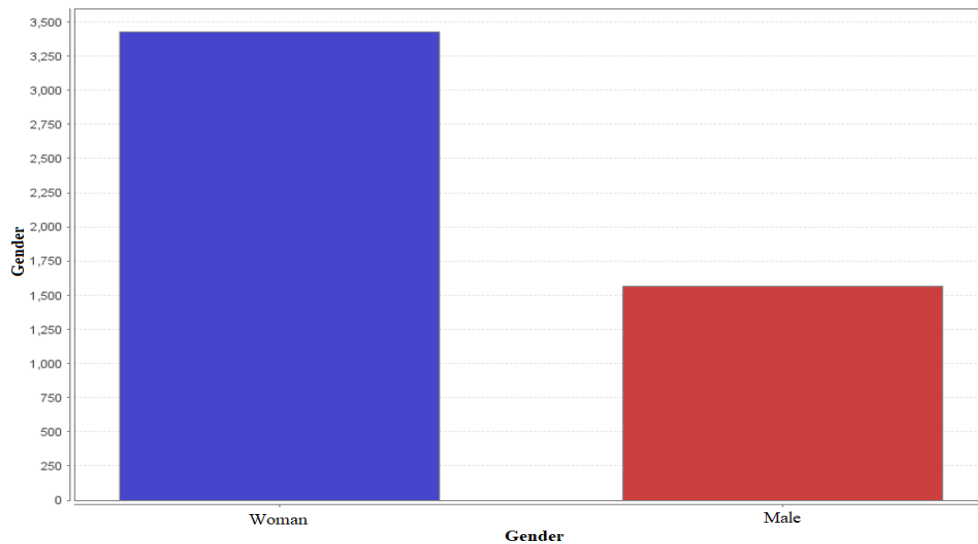


Figure 4. Gender variable.

There were 4527 students under the age of 27, whereas 465 students were born in the decades before 1990 and are thus older than 27 as shown in **Figure 5**.

Seventy-six percent of freshmen enrolled in college after taking the SAT/ACT, whereas twenty-four percent did so after taking an alternative test. Bulgaria, Turkmenistan, Greece, and Germany each have the highest percentage of international students at 2%. As many as 606 pupils are enrolled in secondary school. For whatever reason, 126 professors go by the name “Büşra,” making it the most popular surname. Merve, Elif, Kübra, Fatma, and Esra are in this sequence.

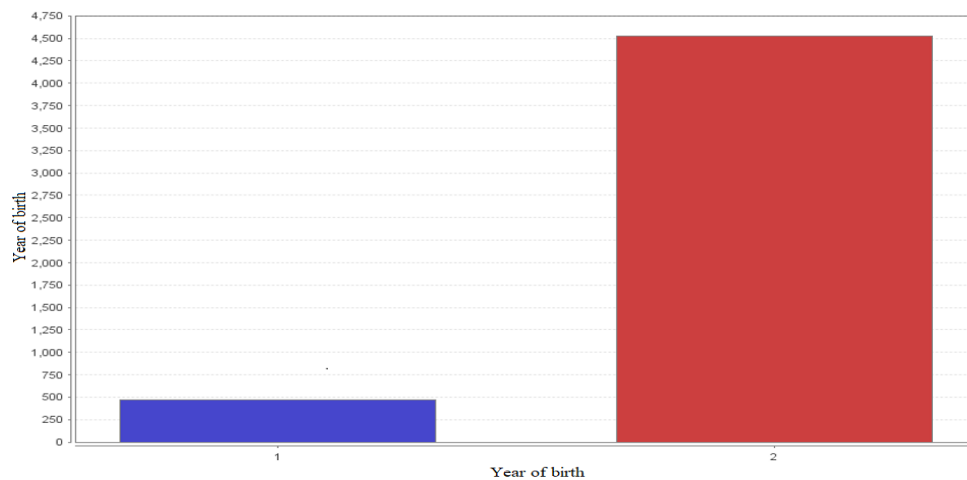


Figure 5. Birth year variable.

4.1. Student modeling (student modeling)

The analysis results are shown here, providing the answer to the first research question posed in the data analysis portion of the design screen by revealing the correlation between students' demographic traits and their average GPAs.

The link between the grade point averages of students born in Bursa and outside of Bursa is depicted in **Figure 6**. While the average of the students in the sample is grouped around 3, in the graph comprising the students in Bursa, there is a clustering around a grade point average, hasn't occurred.

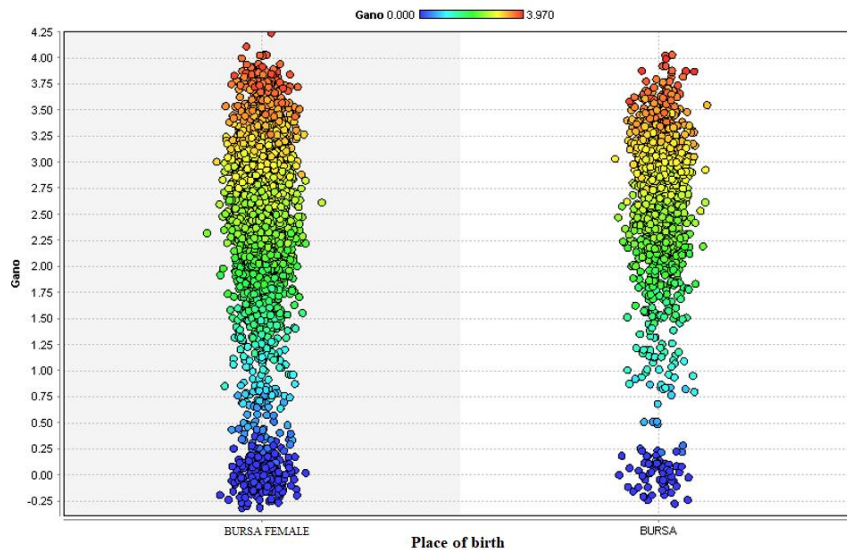


Figure 6. Student achievement place of birth relationship.

Figure 7 displays the correlation between academic term student achievement and grade level, showing that the majority of low-achieving students are found in grades 1 and 2, while those in grades 3 and 4 have averages over 2 and are therefore considered to be in good standing. When looking at failure rates throughout the faculty over time, the second year is the worst. Students in grades 1–4 tend to have an average grade point average of 2.25, whereas those in grades 3–5 tend to have an average grade point average of 2.75. Zero, since both the number of new students enrolled this semester and the average number of students registered overall are both logged in the system as zero.

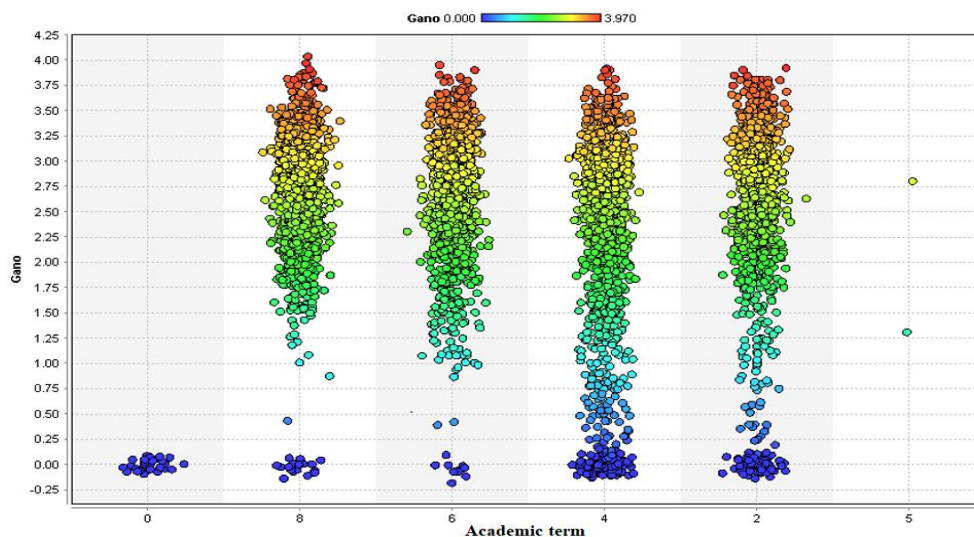


Figure 7. Student achievement academic term relationship.

Figure 8 is a graph showing the correlation between departmental and student performance. Interesting insights may be discovered in the graphic, where we can have a look at all the components visually at the same time. Success has been achieved.

Their GPAs show that how well they do in school varies a lot from one subject to the next.

It can be observed from the graph that the French department is set apart from the others in a unique fashion and that the sum of student accomplishments is rather low. The majority of students on the graph have GPAs below 2, while just a few have GPAs over 3. The students majoring in guidance and psychological counseling are following a successful, high, and growing curve, No one in the PE/SPT major has a GPA higher

than 3.25 and several students representations in the graph deviate significantly from one another.

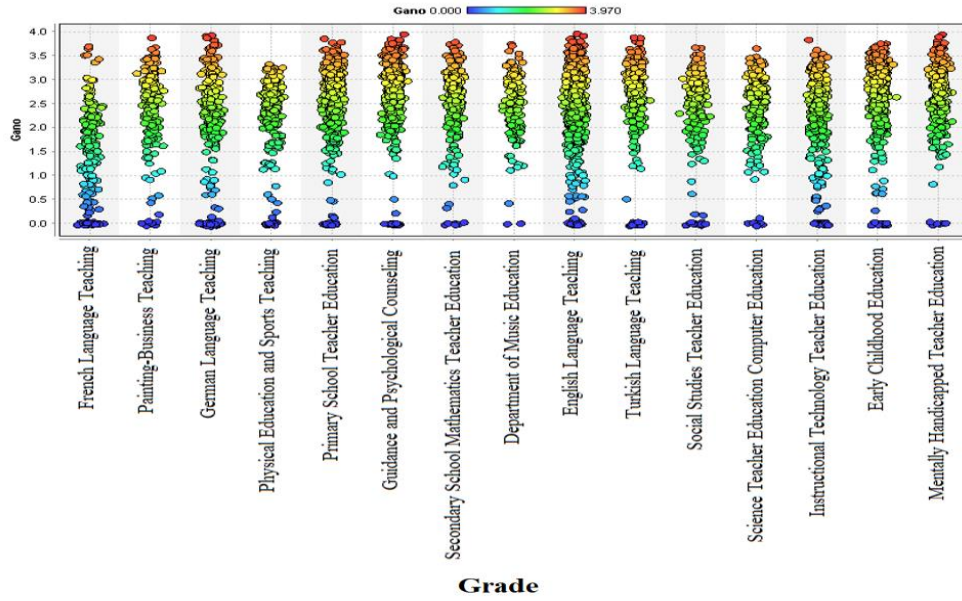


Figure 8. Student success department relationship 2.

Figure 9 displays the correlation between a student's degree of academic performance and the mode of admission using the path of development variable, we can see how students choose to continue their education. It shows that students who double major or who transfer across institutions have higher success rates than their peers, while those who get admission via amnesty do far worse. The success of students varies in relation to their arrival times. shows.

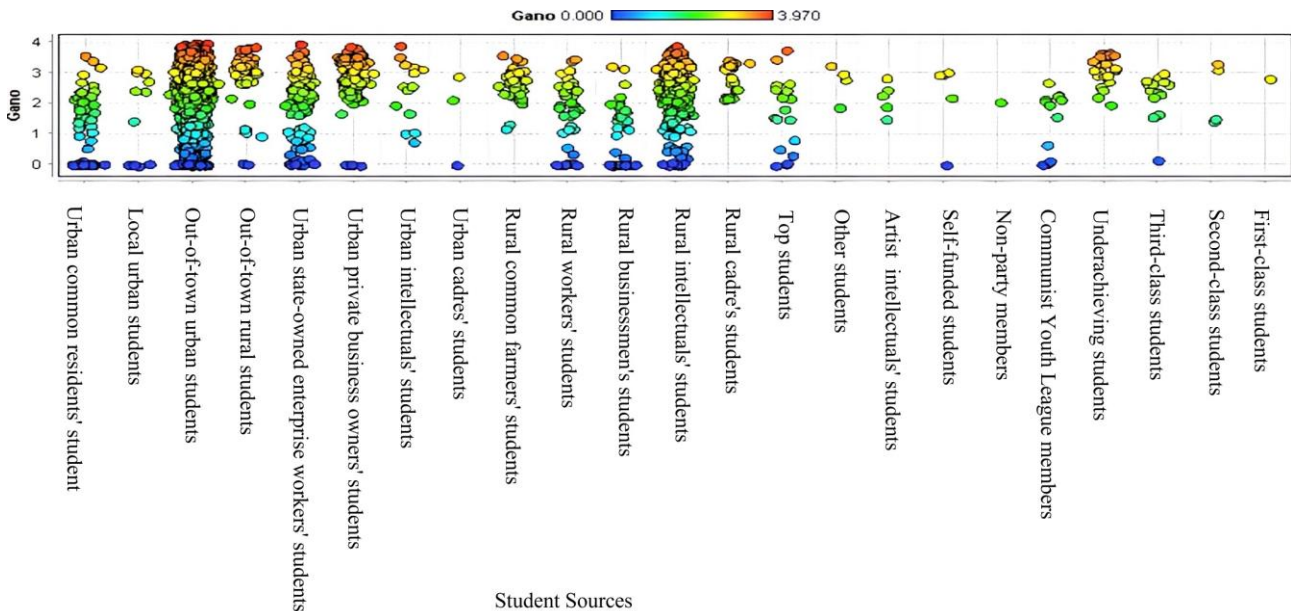


Figure 9. Student success and arrival type relationship 2.

In terms of academic performance, there is no discernible gap between those in their first and second years of schooling as shown in **Figure 10**. Second, academic success among schoolchildren does not follow a linear curve or peak in a single grade. In addition, data show that students in their second schooling had lower averages than those in their first.

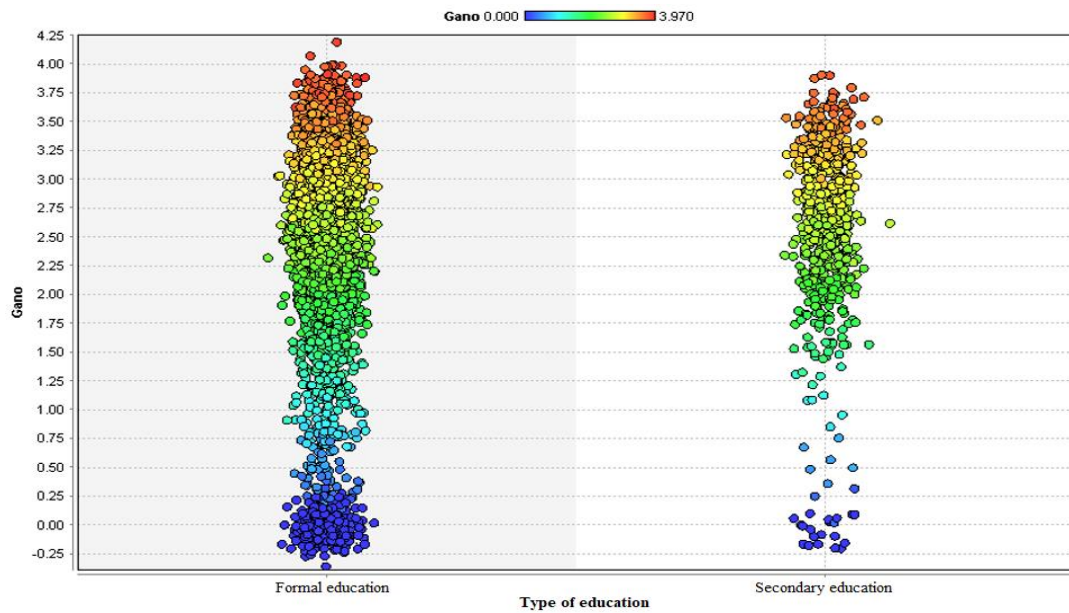


Figure 10. Student achievement teaching type relationship.

4.2. Classification analysis

The results from the Naive Bayes Classification Analysis are shown here. Students were categorized as good or terrible in terms of the circumstance variable and modeled accordingly using the Bayes method. A simple decision tree was constructed in this study, and the rule extraction technique was used to uncover previously unseen connections within the data. The pupils were roughly divided into two groups: good (81%), and poor (19%) as shown in **Figure 11**.

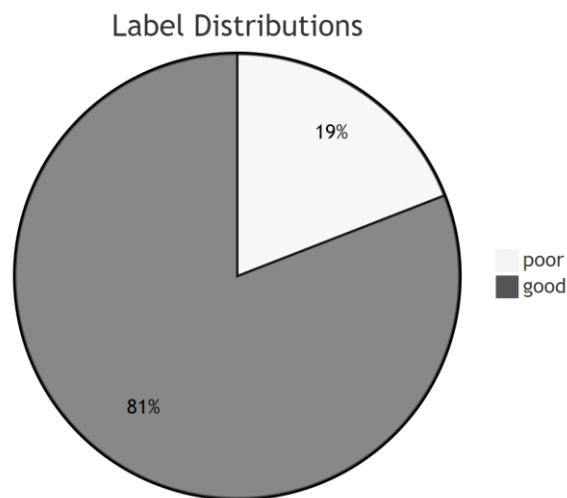


Figure 11. Naive Bayes method simple distribution.

The graph showing the number of good and bad students according to the nodal points determined in the decision tree is shown in **Figure 12**.

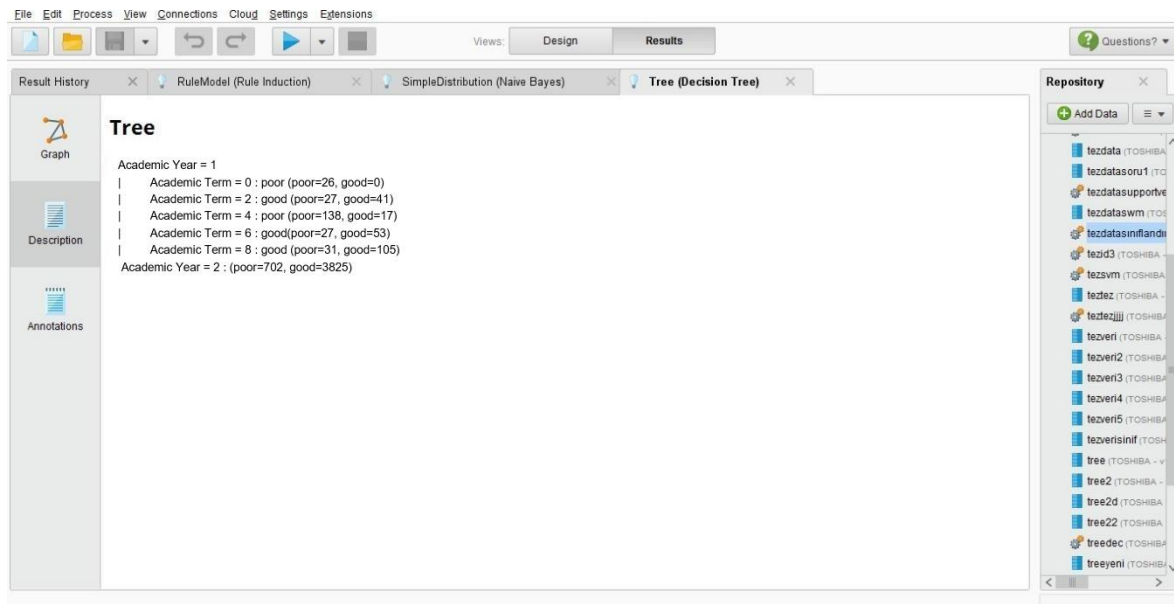


Figure 12. Decision tree nodes.

4.3. The importance of variables affecting academic achievement weights

The weight algorithm uses the knowledge growth ratio to decide how much weight each piece of data should carry when determining whether a student is good or terrible, and those results are shown here. **Figure 13** shows that the academic term is the second-most influential factor in determining a student's final grade point average, after the mode of entry. Other factors include the student's gender, age, country of birth, location of birth, and level of education.

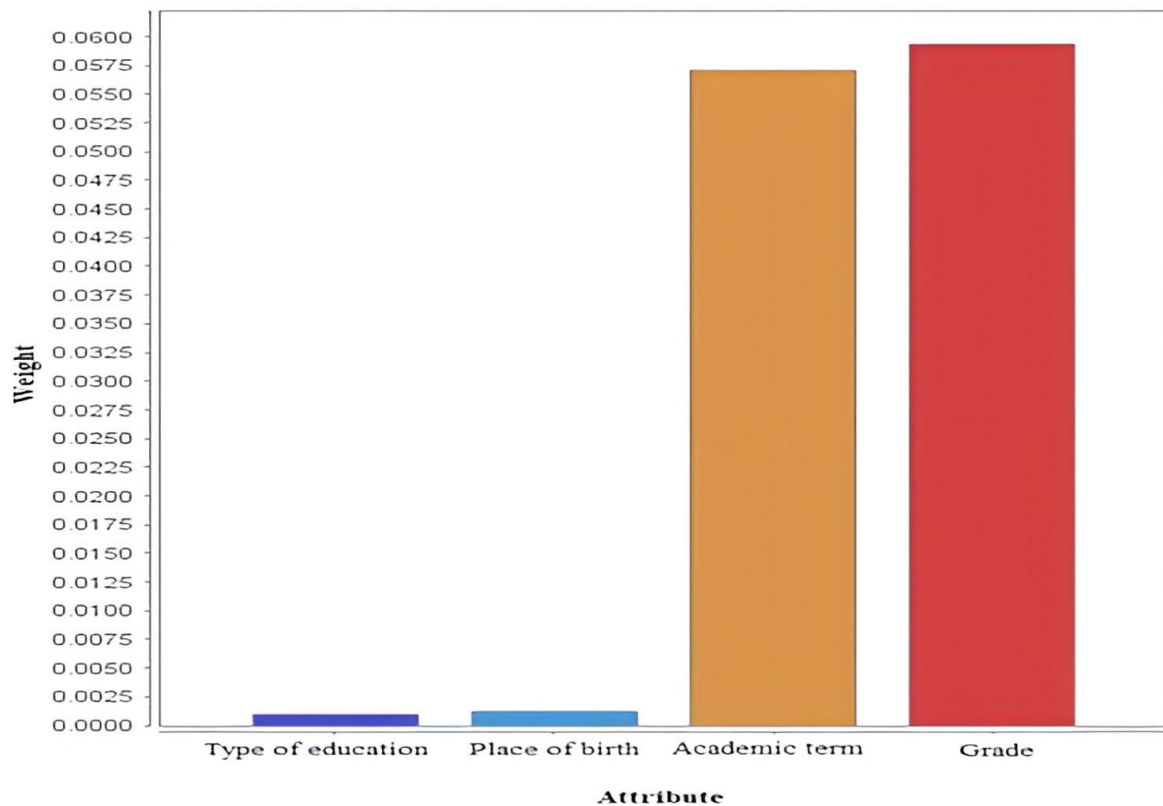


Figure 13. Significance weights of variables 2.

5. Conclusion

Data analysis is a computational discipline that may be approached in numerous ways but that requires extensive knowledge of a single topic. Numerous algorithms and mathematical methods exist for making predictions based on a given data set used for training. In addition, data analysts often need to pre-process obtained data in order to perform their research, whether the data is organized or unstructured. Depending on the organization of the information and the purpose of the research, pre-processing the data might either take a long time or be completed quickly. Reports, pictures, movies, files, sounds, and other media are only some of the types of data that may be gathered. Information gathered in this context may include everything from a student's profile and GPA to their history and high school records to their extracurricular activities, their whereabouts on campus, and the dates and times they checked out books from the library. Data processing may be difficult if done manually since accessible datasets might be large and unstructured. It is well known, for example, that students with a short sleep cycle are less likely to perform well in their studies; however, it could be that the students were spending time studying because studying at night is more effective for that student; this presents a challenge in determining which of the parameters can affect a student's CGPA. This prompted analysts to consider what factors may be measured in this study that have been shown to influence students' grade point averages. Or, do high achievers (those with a GPA of 3.5 or above) behave differently than poor performers (those with a GPA of 3.0 or below) in the same department? How can we quantify this difference to use it as a predictor of future success in school? There are a number of mathematical and nonmathematical aspects that may influence the accuracy of analyses and predictions of college students' academic success.

Author contributions

Conceptualization, YY and MZ; methodology, YY and MZ; software, YY and MZ; validation, YY and MZ; formal analysis, YY and MZ; investigation, YY and MZ; resources, YY and MZ; data curation, DW; writing—original draft preparation, YY and MZ; writing—review and editing, DW; visualization, NBH; supervision, NBH; project administration, NBH; funding acquisition, NBH. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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