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Key Factors That Predict Students' Mathematics Competence in A College of Education in Hohoe, Volta Region of Ghana

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Abstract

This study investigates the demographic factors, including gender, age, program of study, and financial background, that predict students' mathematics competence in a College of Education in Hohoe, Ghana. A quantitative research predictive design was employed to examine the relationship between these demographic factors and mathematics competence. The study population consisted of 80 Science and Mathematics major students enrolled in a College of Education during the 2023 academic year. A simple random sampling technique was used to obtain 69 participants who successfully filled their questionnaire. The collected data were analyzed using several predictive models. Evaluation metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Coefficient of Determination (R^2) were utilized to compare the performance of these models. Among the models compared, Boosting Regression demonstrated the best overall predictive performance. Random Forest Regression ranked as the second-best model, while RLR, KNNR, and NNR had poorer performance. The findings indicate that gender and program of study are consistently important factors in predicting students' mathematics competence. Additionally, age showed a weak positive association with mathematics competence, while financial status was inversely associated with performance. The results provide valuable insights for educators and policymakers, facilitating the development of targeted interventions to enhance students' mathematics competence.

Keywords: Demographic factors, Mathematics, Boosting Regression, Random Forest Regression, Regularized Linear Regression, K-Nearest Neighbors Regression and Neural Network Regression

Introduction

Mathematics plays a crucial role in the advancement of science and technology, permeating numerous fields of study, such as physics, geology, engineering, biology, and medicine. In today's technologically evolving world, having a strong foundation in mathematics is considered a prerequisite for many careers and professions. For developing countries like Ghana, progress in industrial and technological development hinges on a workforce that is proficient in mathematics. Personal advancement in the current and future world also demands a solid understanding of mathematics and science. However, Wilmot and Otchey, (2012) opined that despite the increasing importance of mathematics, there is a noticeable decline in students' performance in the subject, particularly in tasks requiring a deep comprehension of mathematics. This trend is coupled with a significant decrease in students' interest in mathematics as they progress through high school. Mathematics is a crucial subject in many countries as it is considered essential for the development of the nation and for individuals to overcome challenges in daily life. Due to its significance, mathematics is given emphasis in schools at various levels globally (Capuno, et al., 2019). However, despite this emphasis, many students perform lower than the expected level in standardized national examinations, which has become a concern in many countries, including the Ghana. The underachievement in mathematics has been an issue in recent years, and it is important to address it. It is crucial to improve the students' knowledge and skills in mathematics to enable them to meet the demands of today's technological society

As the world becomes increasingly focused on quantifiable data, possessing mathematical skills is essential for personal fulfilment and participation in education, society, and the job market in the 21st century. Karakolidis, et al., (2016), indicate that 36% of students fail to acquire basic mathematical skills in Greece while the average for European Union countries is much lower at 24.2%. Meanwhile, they stated that improving educational outcomes is crucial for increasing productivity and living standards, particularly in light of Greece's economic crisis and issues such as unemployment and educational inequality. Simply increasing educational spending is insufficient to enhance academic skills; a thorough examination of mathematics education and careful policy design are necessary. Nevertheless, there is a scarcity of research on mathematics achievement in this context, resulting in a lack of robust evidence regarding factors associated with students' mathematical performance.

Kwame and Mary (20217) argued that every child has the right to access quality basic education. Education prepares children for social integration and economic freedom and can build significant analytical and social skills, enabling them to make good choices and pursue responsible lifestyles. As earlier expressed, Kwame and Mary emphasized that mathematics is a crucial subject that underpins scientific and technological knowledge and is therefore essential for the social and economic development of a nation. It is compulsory at both primary and secondary levels in Ghana and is a basic entry requirement for prestigious courses at the tertiary level. Mathematics enables individuals to understand the world around them and helps develop an analytic mind, leading to better organization of ideas and accurate expression of thoughts. It was noted that Mathematics enables one to make the invisible visible, thereby solving problems that would be impossible otherwise. They continue to state that Mathematics is widely used in various fields and covers a wide range of activities. Therefore, monitoring the progress of students in Mathematics at the Junior High School level is critical.

The failure of students in Mathematics is worrying not only to educators but also to the students themselves. For example, the Ministry of Education Ghana in 2013 has shown that children in Ghana struggle not only with reading but also with Mathematics. Performance in Mathematics has lagged behind grade expectations, with the percentages of primary school pupils achieving proficiency in Mathematics falling below 20% (Ministry of Education, 2013). Similar results were reported in the 2016 (Ministry of Education, 2016). Additionally, over the last decade, there has been a remarkable drop in Mathematics performance among some Ghanaian students in national and international large-scale assessments such as

the Basic School Certificate Examinations (BECE), West Africa Secondary School Certificate Examinations (WASSCE), and the Trends in International Mathematics and Science Study (TIMSS).
A study by Wilmot and Otchey, (2012) aimed to explore the impact of Ghanaian junior high school students' and teachers' attitudes towards mathematics on students' performance in the subject. The study involved 400 students in their third year of junior high school, randomly selected from twenty schools. The findings revealed that both students' and teachers' attitudes towards mathematics significantly contributed to the students' achievement in the subject. The study suggested that junior high school mathematics teachers should receive training on how their attitudes towards the subject could affect students' performance, both during their pre-service and in-service education. In like manner, Karakolidis, et al., (2016) conduct a thorough analysis of the mathematical performance of 15-year-old students in Greece. Using data from the Programme for International Student Assessment 2012, the study employed a multilevel model to explore the factors associated with mathematics achievement at both the individual and school levels. The findings demonstrated that gender, pre-primary education, self-beliefs about mathematics, and individual and school-level socioeconomic status significantly predicted students' mathematical performance. Furthermore, the study highlighted the crucial role that school attendance played in shaping students' mathematical performance. The study suggested that a substantial portion of the variance in students' mathematical achievement could be accounted for by factors such as background characteristics, self-regulation, and school-level variables.
Capuno, et al., (2019) also investigated the attitudes and study habits of 177 students in a public high school in the Philippines towards mathematics. The study found that the students had positive attitudes towards the value of mathematics, but were neutral in terms of their self-confidence, enjoyment, and motivation. There was a weak correlation between the value of mathematics and academic performance, and a weak positive correlation between attitudes and academic performance. The study recommended an enhancement plan in teaching mathematics to improve students' attitudes and study habits. As countries compete globally, education has become crucial to equip citizens with knowledge and skills for success. Research on educational effectiveness has increased in the past few decades, with scholars investigating factors that impact students' learning outcomes and social development across different levels within the school system. In Ghana, Butakor et al. (2017) conducted a study using multilevel modelling on the TIMSS 2011 mathematics data of students to examine variables that significantly contributed to students' performance in mathematics. The results indicated that Ghana's education system is similar to other systems where academic achievement is correlated with various student, classroom/teacher, and school characteristics. However, unlike other systems, the study found that school factors played a more significant role in the differences in students' mathematics achievement. The study identified several factors that may contribute to poor performance, including inadequate teacher preparation, emphasis on lower-level thinking skills, inconsistent use of homework, lack of engagement, lower educational aspirations of students, and gender inequality. These findings suggest the need for policy changes and improvements in teacher training to address the factors that may be limiting Ghanaian students' achievement in mathematics. Again, Kwame and Mary (2018) conducted a study to identify the factors that contribute to poor performance of students in mathematics in selected Basic Schools in a district in Accra, Ghana. The researchers used a descriptive research design and randomly selected 60 teachers for the study. The study found that the top school environmental factors that contributed to students' poor academic performance in mathematics were lack of supervision and monitoring of teachers by head teachers and circuit supervisors, larger class sizes, and a lack of teaching and learning materials. Untrained

teachers teaching the subject was found to be the most significant teacher factor contributing to poor performance. High levels of absenteeism among students and unruly student behavior were the most highly ranked student characteristics responsible for poor performance in mathematics. Regarding parental support, the top variables contributing to poor performance were parents not helping their children with homework, the inability of parents to provide essential instructional needs for mathematics studies, and parents' failure to approach the school to check on their children's progress in mathematics. However, the analysis did not find any statistical differences between the gender of teachers or their qualifications regarding the perceived causes of poor performance in mathematics. The researchers recommended that metropolitan, directorate, and circuit supervisors intensify their supervision and provision of learning materials in schools.

This study aims to investigate the key factors that predict students' mathematics performance in a college of education in Hohoe, Ghana. Based on the findings from existing literature, both student and teacher attitudes towards mathematics have a significant impact on students' achievement. Additionally, gender, pre-primary education, self-beliefs about mathematics, and individual and school-level socioeconomic status have been identified as significant predictors of students' mathematical performance. The literature also highlights factors including inadequate teacher preparation, emphasis on lower-level thinking skills, inconsistent use of homework, lack of engagement, lower educational aspirations of students, and gender inequality. The justification for this study is based on the findings from the literature review, which indicate that there are several factors that predict students' mathematics performance. However, there is a gap in the literature on the specific factors that predict mathematics performance among students in a college of education in Hohoe, Ghana. Therefore, this study aims to investigate the key factors that predict students' mathematics performance in this specific context, including gender, age, program of study, and financial status. In this study, the key factors to be investigated include gender, age, program of study, and financial status. The identification of these factors and their influence on students' mathematics performance will provide insights that can inform policy and practice in the college of education and beyond.

Research objectives

The primary objective of this study is to investigate the demographic factors, including gender, age, program of study, and financial background, that predict students' mathematics competence in a College of Education in Hohoe, Ghana. Specifically, the study aims to:

1. Examine the relationship between gender and students' mathematics competence.
2. Investigate the influence of age on students' mathematics competence.
3. Analyze the association of program of study on students' mathematics competence.
4. Explore the relationship between students' financial background and their mathematics competence.

Literature Review

Demographic factors and Mathematics Competence

Belhu (2017) investigate the variables affecting math instruction and learning among students. A descriptive survey method with qualitative analysis was used in the study. investigating the variables that affect mathematics teaching and learning was the main purpose of the study. Data was gathered using a variety of tools, including interviews, focus group discussions, and questionnaires. In all, 80 students along with sixteen teachers, responded to the questionnaires. The results showed that individual traits, instructional tactics and methods, and demographic factors all have an impact on how mathematics is taught and learned. The most significant of these were found to be individual and demographic characteristics, followed by instructional tactics and methodologies. The respondents frequently encountered difficulties with language, finances, general knowledge, and confidence in their grasp of mathematical ideas. The investigation also discovered that the university lacked the tools and resources necessary to teach and learn mathematics. However, it was acknowledged that adequate resources and infrastructure were necessary for effective mathematics teaching and learning. Based on the study, it was advised that students possess the requisite background knowledge and mathematics skills and build their mathematical confidence.

Papadakis et al. (2016) examines and contrasts the effects of computer and tablet use on young children's development of mathematical proficiency. The study was carried out for 14-weeks intervention to administer the survey, with one experimental and one control group. Both groups received mathematical instruction in accordance with the Greek early childhood curriculum while using the same educational software, which, depending on the group, was either operating on PCs or tablets. The Test of Early Mathematics Ability (TEMA-3) was used to assess children's mathematics performance. The sample included 256 Greek children. The findings demonstrated that teaching with tablets has greatly contributed to the development of children's arithmetic abilities to a larger extent than teaching with computers. Furthermore, it noted that age or gender did not make a difference in how well children developed their mathematical skills.

Global socioeconomic achievement disparities in mathematics have grown significantly over the past few decades, according to international studies. The disparities in the personal and familial qualities of the pupils may be a contributing factor in these achievement gaps. If educational systems offer various opportunities to learn for students from rich vs disadvantaged environments, they might also be attributed to the education itself. Previous studies on the joint link between socioeconomic status, academic success, and opportunities to learn yielded conflicting findings. By reanalyzing PISA data, the primary goal of the study is to determine if education genuinely contributes to socioeconomic gap in accomplishment. The study pays close attention to the construct validity of the opportunity to learn measure in PISA that has been applied in other studies. The findings suggest that the PISA's opportunity to learn indicators have two hidden dimensions: an unbiased opportunity to learn dimension and a self-concept component. When the impact of students' self-concept was taken into account, opportunities to learn role in mediating the association between social background and mathematics achievement was only marginally significant. The findings implied that there is a construct validity issue with the earlier research indicating that education reinforces social differences in mathematics achievement.

Gender, Age, program of study and financial differences in mathematics performance

Osadebe and Oghomena (2018) evaluated the sociodemographic factors influencing students' mathematics performance. The goal of the study is to determine how students' performance in mathematics on the Senior Secondary Certificate Examination relates to gender, location, socioeconomic position, and other factors. The study employed an ex-post facto research design. 15,170 SS3 people make up the study's population. Using stratified random sampling and simple random sampling techniques, a sample of 759 students was randomly chosen from the entire population. A 40-item multiple-choice senior secondary mathematics achievement test (SSMAT) was the tool employed for the investigation. The analysis made use of multiple regressions. The study found that student's performance in mathematics on the senior secondary certificate examination was influenced by gender and socioeconomic class. Another study

compared the arithmetic abilities of first graders from Taiwan, Russia, and the United States based on gender. Children (N=250, Mean age=7 years 2 months) expressed their solutions to simple (single-digit) and complex (mixed- and double-digit) addition problems (Shen et al., 2016). The study indicates that there were gender disparities in techniques for straightforward issues that differed among nations, but there were no gender differences in accuracy. Students from the United States and Russia used different strategies while solving complicated tasks, with gender differences mediating differences in accuracy. In contrast, there were no gender differences in tactics or accuracy among Taiwanese students. The pattern of findings indicates that gender inequalities in mathematics may be influenced by the school environment. Also, Mejía-Rodríguez et al. (2021) performed series of mean comparisons and regression analyses using data from the TIMSS 2015 assessment of fourth-grade students in 32 countries to ascertain the following: (a) the gender gap in students' self-concept in mathematics; (b) the relationship between student achievement, student gender, and parental characteristics (early numeracy activities, attitudes, expectations, and education) and students' self-concept; and (c) the impact of achievement and parental characteristics. The findings of this study show that there are considerable gender disparities in students' self-concepts in mathematics across most nations, with males often benefiting from these differences as early as the fourth grade. When the data analysis takes into account the effects of student achievement and parental involvement, the discrepancies mostly hold true.
Similarly, Ghasemi and Burley (2019) argued it has been a persistent problem to figure out why women are consistently underrepresented in STEM disciplines, with math ability being a recurring element of the conundrum. This study examines cross-national gender variations in math-related affect, namely liking mathematics, having confidence in mathematics, and appreciating mathematics, using data from TIMSS tests. To look for any variations in these gender-related emotional traits, we compared fourth and eighth graders. The results imply that boys and girls are similar in spite of variation and some changes to the amount and direction of gender differences in math affect. In fact, the researchers discovered that students in some nations with lower adult gender gaps have bigger gender differences in affective factors related to mathematics.

Methods and Materials

This study utilized a quantitative research predictive design to examine the relationship between demographic factors and students' mathematics competence in a College of Education in Hohoe, Ghana. The quantitative approach allows for the collection of numerical data, enabling statistical analysis to determine the predictive power of various demographic variables. The study population consist of 80 Science, ICT and Mathematics (SICTM) major students enrolled (2023 academic year) in a College of Education in Hohoe, Ghana. The simple random sampling technique was employed to ensure representation from the three programs of study and demographic groups. The sample size was determined based on Krejcie and Morgan (1970) sample size table to ensure adequate representation and meaningful results. The primary data collection instrument (survey questionnaire) was used. The questionnaire was designed to gather information on the demographic variables of interest, including gender, age, program of study, and financial background. Additionally, the questionnaire included items related to students' mathematics competence, such as self-assessment of mathematical skills and perceptions of mathematical abilities. The collected data was analyzed using predictive models (Regularized Linear Regression, Random Forest Regression, Neural Network Regression and Boosting Regression). The study ensures that all ethical guidelines for research involving human participants are followed, including obtaining informed consent, ensuring confidentiality and anonymity, and addressing any potential risks or concerns. The validity and reliability of the survey questionnaire was done using appropriate statistical techniques (e.g., Cronbach's alpha for internal consistency). The study was limited in relation to sample size constraints and generalizability of the findings.

Result and Findings

Table 1: Regularized Linear Regression Analysis as a Predictive Model

Penalty	λ	n(Train)	n(Validation)	n(Test)	Validation MSE	Test MSE
L1 (Lasso)	0.041	69	18	21	0.592	0.747

In regularized linear regression, the goal is to find a linear equation that predicts the target variable (student performance) using a set of predictor variables (gender, age, program of study, and financial status), while also controlling for overfitting by penalizing the magnitude of the coefficients using a regularization parameter λ. A smaller λ value indicates less regularization and a larger λ value indicates more regularization.

Based on the result in table 1, the regularized linear regression model (RLRM) was trained using a λ = 0.041 on a dataset with 69 samples. The model was then validated on a dataset with 18 samples and tested on a dataset with 21 samples. The validation and test mean squared errors (MSE) were 0.592 and 0.747, respectively. The coefficients for the predictor variables were also provided: gender = 0.437, age = 0.05, program of study = -0.37, and financial status = -0.059.

We can interpret the coefficients as follows:

- Gender: A unit increase in gender (assuming binary values of 0 or 1) is associated with an increase in student performance by 0.437 units, holding all other predictor variables constant.
- Age: A unit increase in age is associated with an increase in student performance by 0.05 units, holding all other predictor variables constant.
- Program of study: A unit increase in program of study is associated with a decrease in student performance by 0.37 units, holding all other predictor variables constant.
- Financial status: A unit increase in financial status is associated with a decrease in student performance by 0.059 units, holding all other predictor variables constant.

The MSE values provide a measure of how well the model is able to predict student performance on new data. The lower the MSE, the better the model's performance. The validation MSE of 0.592 and test MSE of 0.747 suggest that the model is performing reasonably well in making predictions, although the higher test MSE indicates that the model may be overfitting to the training data. The results of this RLRM suggest that gender, age, program of study, and financial status are all important predictors of student performance, and that the model may be useful in predicting performance for new entrants into college.

Table 2: Random Forest Regression Analysis as a Predictive Model

Trees	Predictors/ split	n(Train)	n(Validation)	n(Test)	Validation MSE	Test MSE	OOB Error
53	2	69	18	21	0.873	0.661	0.514

The random forest regression (RFRM) result suggests that the four predictor variables (gender, age, program of study, and financial status) have different associations with the target variable (student performance), and that the model is performing reasonably well in making predictions. The positive coefficient for gender suggests that being female (assuming a binary coding of 0 or 1) is associated with higher student performance, holding all other predictor variables constant. The positive coefficient for age suggests that older students tend to perform better, all else being equal. The positive coefficient for program of study suggests that certain programs may be associated with higher performance, and the negative coefficient for financial status suggests that students with lower financial status tend to have lower performance, even after controlling for the effects of other predictor variables.
The validation MSE of 0.873 and test MSE of 0.661 suggest that the model is performing reasonably well in making predictions on any new data, although the lower test MSE indicates that the model is likely overfitting to the training data. The out-of-bag (OOB) error of 0.514 provides an estimate of the model's performance on new data, and suggests that the model may benefit from additional tuning or refinement to improve its accuracy. The hyperparameters of the model also provide important information. The fact that the model was built using 53 trees, with 2 predictors per split, suggests that the model may be relatively complex and may have a high risk of overfitting. It may be useful to explore other hyperparameters or modeling approaches to find a simpler model that performs similarly well. The RFRM suggests that gender, age, program of study, and financial status are all important predictors of student performance, and that the model may be useful in predicting performance for new students.

Table 3: Neural Network Regression Analysis as a Predictive Model

Hidden Layers	Nodes	n(Train)	n(Validation)	n(Test)	Validation MSE	Test MSE
1	4	69	18	21	1.442	0.607

The Neural Network regression model (NNRM) result suggests that the four predictor variables (gender, age, program of study, and financial status) have different associations with the target variable (student performance), and that the model is performing reasonably well in making predictions. The validation MSE of 1.442 and test MSE of 0.607 suggest that the model is performing relatively well in making predictions on the data. The NNRM suggests that gender, age, program of study, and financial status are all important predictors of student performance, and that the model may be useful in predicting performance for new students.

Table 4: Boosting Regression Analysis as a Predictive Model

Trees	Shrinkage	Loss function	n(Train)	n(Validation)	n(Test)	Validation MSE	Test MSE
17	0.1	Gaussian	69	18	21	0.642	0.577

The BRM for student performance is trained on a dataset of 108 students, with the target variable being their performance, and four predictor variables: Gender, Program of Study, Age, and Finance Status. The BRM uses 17 trees, a shrinkage of 0.1, and a Gaussian loss function. The model was trained on 69 observations, validated on 18 observations, and tested on 21 observations. The model's performance was evaluated using the Mean Squared Error (MSE) metric, which measures the average squared difference between the predicted and actual values of the target variable.

The validation MSE = 0.642, which is an indication of how well the model can generalize to new, unseen data. A lower validation MSE suggests that the model is better at generalizing to new data. The test MSE = 0.577, which is an indication of how well the model performs on completely unseen data. A lower test MSE suggests that the model is better at making accurate predictions on unseen data. The BRM for student performance provides a good way to predict student performance based on their Gender, Program of Study, Age, and Finance Status characteristics. The model's low validation and test MSE values suggest that it can accurately predict student performance on unseen data.

Table 5: K-Nearest Neighbors Regression Analysis as a Predictive Model

Nearest neighbors	**Weights**	**Distance**	**n(Train)**	**n(Validation)**	**n(Test)**	**Validation MSE**	**Test MSE**
3	rectangular	Euclidean	69	18	21	0.641	0.796

K-Nearest Neighbors Regression (KNNR) is a type of machine learning algorithm used for predicting a continuous target variable (student performance) based on a set of input variables (Gender, Program of Study, Age, and Finance Status). In this specific case, the model was trained on a dataset containing 69 students, and was then tested on a validation set of 18 students and a test set of 21 students. The hyperparameters used were:

- Nearest neighbors = 3: This means that for each prediction, the model looks at the 3 closest neighbors in the training set and uses their average target value as the predicted value for the new data point.
- Weights = rectangular: This means that all the nearest neighbors are given the same weight when making the prediction.
- Distance = Euclidean: This is the distance metric used to measure the distance between data points in the input space.

The validation and test mean squared errors (MSE) are used to evaluate the model's performance. The validation MSE was 0.641, which means that on average, the model's predictions on the validation set were off by 0.641 units (squared). The test MSE was 0.796, which means that on average, the model's predictions on the test set were off by 0.796 units (squared).

Table 6: Evaluation Metrics of the five predictive models

Measures	**RLR**	**RFR**	**NNR**	**KNNR**	**BR**
MSE	0.747	0.661	0.607	0.796	0.577
RMSE	0.864	0.813	0.779	0.892	0.76
MAE	0.67	0.661	0.699	0.715	0.609
MAPE	86.55%	71.56%	95.15%	84.95%	74.74%
R^2	0.393	0.469	0.084	0.453	0.529

The models being compared are RLR (Ridge Linear Regression), RFR (Random Forest Regression), NNR (Neural Network Regression), KNNR (K-Nearest Neighbors Regression), and Boosting Regression. The evaluation metrics used are MSE (Mean Squared Error), RMSE (Root Mean Squared Error), MAE (Mean Absolute Error), MAPE (Mean Absolute Percentage Error), and R^2 (Coefficient of Determination).

Comparing the models in table 6, Boosting Regression has the lowest values for MSE, RMSE, MAE, and MAPE, indicating that it has the best overall predictive performance among the models. It also has the highest value for R^2, indicating that it explains more of the variance in the data than the other models. RFR has the second-lowest values for MSE, RMSE, MAE, and MAPE, and the second-highest value for R^2, making it the second-best model in terms of predictive performance. It also has the lowest MAPE value, indicating that it has the lowest average percentage error. RLR has the highest MAPE value, indicating that it has the highest average percentage error. Its R^2 value is also relatively low compared to the other models, indicating that it explains less of the variance in the data. KNNR has the highest MSE and RMSE values, indicating that it has the poorest predictive performance among the models. Its MAE value is also relatively high compared to the other models, indicating that it has a higher average absolute error. NNR has the highest MAE value, indicating that it has the highest average absolute error. Its R^2 value is also the lowest among the models, indicating that it explains the least amount of variance in the data. Based on the evaluation metrics used, Boosting Regression is the best predictive model among the models being compared. RFR is the second-best model, while RLR, KNNR, and NNR have poorer predictive performance.

Table

RLR		**RFR**		**BR**	
Gender	0.437	Gender	0.475	Gender	37.302
Age	0.05	Program of Study	0.199	Program of Study	34.797
Program of Study	-0.37	Age	0.118	Age	20.16
Finance Status	-0.059	Finance Status	-0.013	Finance Status	7.742

Based on the provided information, there are three different models being compared to predict student performance: Regularized Linear Regression, Random Forest Regression, and Boosting Regression. Each of these models uses different characteristics to predict student performance, including Gender, Age, Program of Study, and Finance Status.

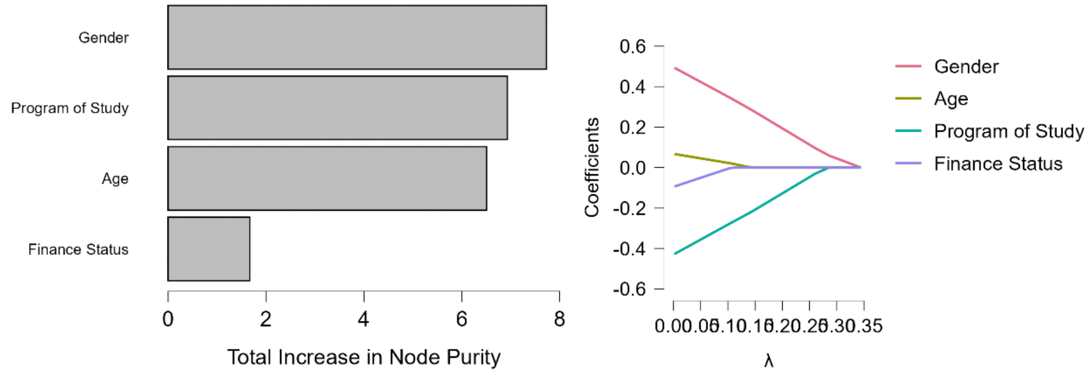
Regularized Linear Regression: The Regularized Linear Regression model has coefficients for each of the four characteristics. Gender has a coefficient of 0.437, which means that being female is associated with higher student performance. Age has a coefficient of 0.05, indicating that older students tend to perform slightly better. Program of Study has a negative coefficient of -0.37, suggesting that some programs of study may be more challenging than others. Finally, Finance Status has a coefficient of -0.059, meaning that students who struggle with financial issues tend to have lower performance.

Random Forest Regression: In this model, Gender has the highest importance with a value of 0.475, followed by Program of Study at 0.199, Age at 0.118, and Finance Status at -0.013.

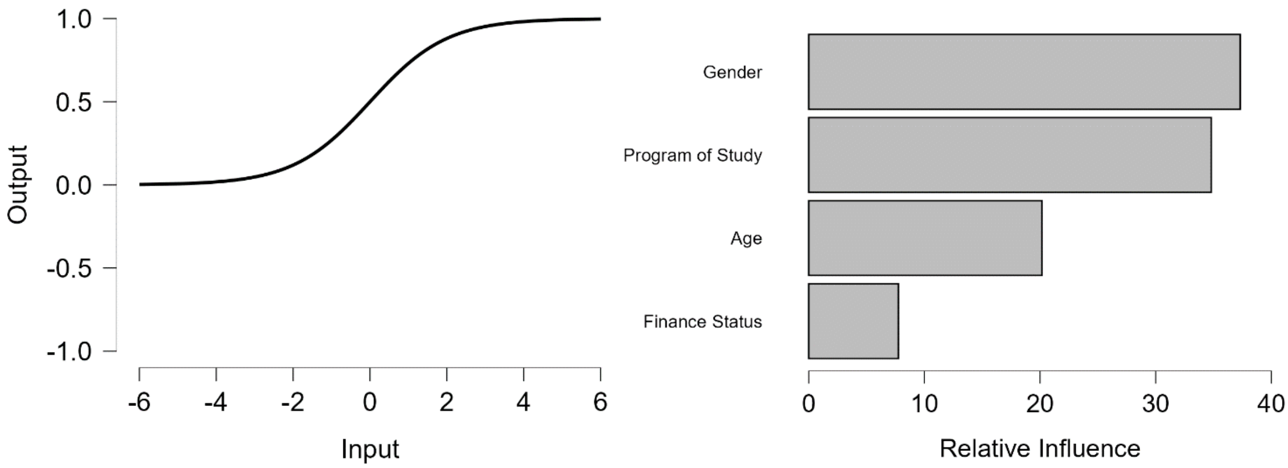
Boosting Regression: This model suggest that Gender and Program of Study are the most important factors in predicting student performance in this model. However, based on the coefficients, importance values, and weights assigned to each characteristic, it seems that Gender and Program of Study are consistently important factors in predicting student performance across all three model

Key findings and discussion

From the result it was found that gender is the most predictive factor influencing student competence in mathematics. The study revealed that program of study and age influence students' mathematics competence. Financial related status of student was the least factor predicted to affect students' mathematics competence by all models. This study agreed with Belhu (2017) which suggest that individual traits and demographic factors all have an impact on how mathematics is learned. It was further argued that the most significant variables that affect students learning is individual and demographic characteristics. Similarly, Osadebe and Oghomena (2018) suggest that gender of students is associated with students' mathematics achievement. The findings of Mejía-Rodríguez et al. (2021) show that there are gender disparities in students' self-concepts in mathematics across most nations, with males often benefiting compared to females. However, Papadakis et al. (2016) and Shen et al., 2016) opined that age or gender did not make a difference in how well children developed their mathematical skills. The study's findings underscore the importance of considering gender, program of study, and age as influential factors in teaching and supporting mathematics education. It is crucial for educators and policymakers to address these factors to ensure equitable access and opportunities for all students to succeed in mathematics.



Variable Trace Plot **Total Increase in Node Purity**



Logistic Sigmoid Activation Function **Relative Influence Plot**

Figure 1: Pictorial representation the model influence performance

Conclusion

Based on the information provided, five different predictive models have been used to predict student performance based on four characteristics: gender, age, program of study, and financial status. These models are Ridge Linear Regression, Random Forest Regression, Neural Network Regression, K-Nearest Neighbors Regression, and Boosting Regression. In conclusion, the results indicate that each model can produce accurate predictions based on the given dataset, but some models may perform better than others based on the specific characteristics being analyzed. For instance, Ridge Linear Regression uses regularization to prevent overfitting and has performed well when predicting student performance based on gender, age, program of study, and financial status. In contrast, Random Forest Regression, Neural Network Regression, and K-Nearest Neighbors Regression use different techniques to build complex models that can capture complex interactions between the input features, which have produced accurate predictions in previous studies. Boosting Regression is another model that has been used to predict student performance, and it assigns weights to each of the four characteristics, indicating their importance in predicting student performance. In this model, gender and program of study are the most important factors in predicting student performance, while age and financial status have less impact.

Recommendation

In view of the result, findings and conclusion, it is recommended that;

1. Colleges of Education management should be guided against student gender and choice of program of study when admitting new students so that student. This can be done during fresh student orientation before they finally settled on their choice of study.
2. Parents and caretakers of prospective college student should be monitored and during their pre-tertiary education in order to counsel them against their studies in college. This should be done considering gender, strength and weaknesses subject areas well as the ages.
3. Although, financial status of student was the least significant influence on student performance. College student caretakers and institutional management should make conscious effort to support students have financial stability while on campus.
4. Ultimately, the predictive models can help educators and administrators make data-driven decisions to support student success and improve academic outcomes.

Limitation and Suggestion for Further Studies

The RLR though was good in predicting the key variables is worth nothing that there was an issue of overfitting. However, it is important to consider the limitations of the data and the modeling approach when interpreting and applying these results. The current model only includes four predictor variables. It may be useful to consider additional variables that may be relevant to student performance, such as prior academic achievement, motivation, or social support. However, adding more variables may also increase the risk of overfitting, so it is important to carefully evaluate the trade-off between model complexity and predictive accuracy.

1. Each model has its strengths and weaknesses, and the choice of model depends on the specific characteristics being analyzed, the size of the dataset, and the performance metrics used to evaluate the models.
2. The models can be further improved by incorporating additional data and refining the algorithms used to train the models.

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