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Research Article

Examining the Impact of EdTech Integration on Academic Performance Using Random Forest Regression

Nikolaos Tzenios

Ph.D., Prof. Public Health and Medical Research,
Charisma University, Grace Bay, Turks and Caicos Islands

Abstract

EdTech has the ability to revolutionize the learning process by enhancing student involvement, tailoring lessons to the unique needs of each student, facilitating distance and online education, enhancing evaluation and feedback, streamlining communication among classmates, and opening up a wealth of new resources for teachers. The goal of this study is to see whether deploying EdTech in schools enhances students' academic performance. The Random Forest Regression has been carried out with primary datasets of 479 high school students. In order to avoid any possible omitted variable biases, this study incorporated other aspects such as student involvement, family income, teacher-student ratio, and students' healthy lifestyle. According to the results of the Random Forest Regression, the integration of EdTech in schools seems to be essential to boost academic performance levels. Student involvement, teacher-student ratio, and a healthy lifestyle are determined to be important variables in enhancing academic achievement levels. It was also discovered that the factor of family income was the least important. The findings of this study imply that academic achievement is dependent on numerous variables, and hence concentrating on a few aspects may not substantially help students with low academic performance. While technology may provide numerous advantages to education, it is crucial to recognize that it must be utilized in combination with a well-designed curriculum and competent pedagogy in order to be genuinely successful.

Keywords: *Academic performance, Edtech, IoT, Schools, Students*

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Introduction

EdTech, or educational technology, has the potential to transform the way education is delivered and experienced by students. EdTech, or educational technology, refers to the use of technology to enhance and support teaching and learning [1], [2]. This can include a wide range of tools, such as online educational resources, virtual reality simulations, and adaptive learning software. The goal of EdTech is to make education more engaging, interactive, and accessible for students of all ages and abilities. One of the key benefits of EdTech is that it allows for personalized learning. For example, with the use of adaptive learning software, students can progress through material at their own pace, receiving more support and guidance on the areas where they need it most [3], [4]. Additionally, the use of virtual reality simulations can allow students to experience real-world scenarios in a safe and controlled environment, which can help to deepen their understanding of complex concepts.

The integration of technology in education can enhance the learning experience and provide students with the skills they need to succeed in the modern world. The benefits of EdTech are numerous and can be seen across various aspects of education. Another important aspect of EdTech is the ability to connect and collaborate with other students and teachers. Platforms such as learning management systems and virtual classrooms enable educators and students to communicate, share resources, and collaborate on projects in real-time [4], [5]. Additionally, the use of social media and other online tools allows students to connect with their peers and form learning communities, which can help to support and inspire each other.

One of the most significant benefits of EdTech is the increased engagement and motivation it can provide to students. With the use of technology, lessons can be made more dynamic, and students can be actively involved in their own learning. Interactive games, videos, and simulations can make the learning experience more engaging and fun for students, leading to better retention of the material [6], [7]. This is especially important for students who may have difficulty staying focused during traditional classroom lessons.

Another key benefit of EdTech is the ability to create personalized learning experiences for each student. Adaptive learning software can assess a student's understanding of a topic and adjust the curriculum accordingly. This ensures that each student is learning at their own pace, which can be especially beneficial for students who may have difficulty keeping up with the traditional classroom pace [8], [9]. Personalized learning can help to improve student's self-esteem and self-efficacy, which can lead to a more positive attitude towards learning.

The ability to access education remotely and online is another major advantage of EdTech. With the help of technology, students can attend classes and receive a quality education from anywhere. Online education platforms and virtual classrooms allow for live and recorded lectures, virtual office hours, and remote access to educational resources. This can be particularly beneficial for students who live in rural or remote areas, who may not have access to a traditional brick-and-mortar school. It also allows for a flexibility of schedule for working students, single parents, and other people who may have limited time to attend traditional classes [2], [5].

EdTech also allows for improved assessment and feedback. Automated assessment tools and e-portfolios can provide real-time data on student performance, and can be used to identify areas where students need more support. Additionally, with the use of audio and video tools, teachers can provide detailed and targeted feedback, which can help students to improve their skills. This can be especially useful for students who may have difficulty understanding written feedback or for students who are learning a new language [2], [10].

Collaboration and communication are another important benefit of EdTech. Platforms such as learning management systems and virtual classrooms enable educators and students to communicate, share resources, and collaborate on projects in real-time. Additionally, social media and other online tools allow students to connect with their peers and form learning communities, which can help to support and inspire each other [11]–[13]. This can help to promote a sense of community among students and can provide opportunities for social and emotional learning.

The access to resources is another key benefit of EdTech. With the use of the internet, students have access to a wide variety of educational videos, simulations, games, and other resources that can supplement the curriculum. Additionally, students can access educational resources from around the world and make connections with other students and teachers, which can broaden their perspective. This can help to expose students to diverse perspectives and cultures and can help to prepare them for a globalized world.

Academic performance and EdTech

Academic performance is a key aspect of a student's educational journey. It is a measure of a student's ability to learn, understand, and apply the material that is being taught in the classroom. It is also an indicator of a student's readiness for the future, as academic performance is often used as a predictor of a student's future success in college or in the workforce [14]–[16]. Good academic performance is important for a variety of reasons. Firstly, it can open up a wide range of opportunities for students in the future. Students who perform well academically are more likely to be accepted into prestigious universities and to receive scholarships, grants, and other forms of financial aid. Additionally, students who perform well academically are more likely to be successful in their future careers, as they have the knowledge and skills necessary to excel in their chosen field [17]–[19].

Academic performance is also important because it provides students with a sense of accomplishment and self-worth. When students see that they are able to understand and apply the material being taught in the classroom, it can boost their confidence and self-esteem. This can lead to a positive attitude towards learning, which can help students to perform better in the future. Additionally, when students see that their hard work is paying off, it can be a motivator for them to continue to work hard and strive for excellence [20], [21].

Academic performance is also closely tied to a student's mental and emotional well-being. Students who struggle academically may experience feelings of anxiety, depression, and low self-esteem. This can lead to a host of negative consequences, such as poor social skills, an inability to focus, and an overall lack of motivation [22], [23]. On the other hand, students who perform well academically tend to have a more positive outlook on life and are better able to cope with stress and setbacks.

Academic performance is not only important for the individual student but also for the society. An educated society is a more productive and prosperous society. Students who perform well academically are more likely to contribute positively to their communities and to the broader society. They are more likely to be involved in civic activities, to have greater economic mobility, and to have a more positive impact on the world around them [24]–[28].

To have a good academic performance, it's important to have good study habits. Having a structured study routine, breaking up study sessions into manageable chunks of time, and setting specific and achievable goals are some examples of effective study habits. It's also important to have good time management skills and to prioritize tasks effectively. In addition, surrounding yourself with a supportive environment, such as studying with peers, seeking help from teachers, or seeking academic support services can also be beneficial for academic performance [29]–[32].

It is also important to recognize that academic performance is not only about the grades and test scores. Non-cognitive factors such as motivation, persistence, and self-regulation play a critical role in academic performance. Encouraging students to set personal and academic goals, to work towards them with determination, and to reflect on their progress can help students to develop these skills, which are essential for academic success.

Furthermore, a well-rounded education that includes extracurricular activities and experiences outside the classroom, can also have a positive impact on academic performance. Engaging in activities that interest the student, such as sports, music, or community service, can lead to improved focus and attention, higher self-esteem, and greater motivation to learn.

EdTech, or educational technology, has the potential to play a significant role in enhancing academic performance for students of all ages and abilities [3]. With the rapid advancement of technology, educational tools and resources are becoming increasingly sophisticated and accessible. By integrating technology into the classroom, educators can create engaging and interactive learning experiences, personalize instruction, and provide real-time feedback to students [33], [34].

One of the most significant ways that EdTech can impact academic performance is by increasing student engagement and motivation. With the use of interactive games, simulations, and virtual reality, students can be actively involved in their own learning. This can make the learning experience more engaging and fun, leading to better retention of the material. Additionally, EdTech can provide opportunities for students to explore and experiment, which can foster a love of learning and promote critical thinking skills.

EdTech also has the potential to personalize instruction, which can be particularly beneficial for students who may have difficulty keeping up with the traditional classroom pace. Adaptive learning software can assess a student's understanding of a topic, and adjust the curriculum accordingly. This can ensure that each student is learning at their own pace, which can help to improve student's self-esteem and self-efficacy, which can lead to a more positive attitude towards learning [35], [36]. Furthermore, with the use of interactive and gamified learning platforms, learners can be motivated by seeing their progress and being rewarded for their achievements.

Another important benefit of EdTech is the ability to provide real-time feedback to students. Automated assessment tools can provide real-time data on student performance, which can help educators to identify areas where students need more support [37]–[39]. Additionally, with the use of audio and video tools, teachers can provide detailed and targeted feedback, which can help students to improve their skills. This can be especially useful for students who may have difficulty understanding written feedback or for students who are learning a new language.

EdTech also allows for remote and online learning. With the help of technology, students can attend classes and receive a quality education from anywhere. Online education platforms and virtual classrooms allow for live and recorded lectures, virtual office hours, and remote access to educational resources [40], [41]. This can be particularly beneficial for students who live in rural or remote areas, who may not have access to a traditional school. Additionally, it also allows for a flexibility of schedule for working students, single parents, and other people who may have limited time to attend traditional classes.

EdTech also offers opportunities for collaboration and communication among students and teachers. Platforms such as learning management systems and virtual classrooms enable educators and students to communicate, share resources, and collaborate on projects in real-time [42]. Additionally, social media and other online tools allow students to connect with their peers and form learning communities, which can help to support and inspire each other. This can promote a sense of community among students and can provide opportunities for social and emotional learning.

The access to educational resources is another key benefit of EdTech. With the use of the internet, students have access to a wide variety of educational videos, simulations, games, and other resources that can supplement the curriculum. Additionally, students can access educational resources from around the world and make connections with other students and teachers, which can broaden their perspective. This can help to expose students to diverse perspectives and cultures and can help to prepare them for a globalized world.

It's important to acknowledge that the integration of technology in the classroom is not a panacea for all the educational challenges. As with any change in pedagogy, proper implementation and teacher training is crucial.

Methods

This research applied Random Forest Regression. It is a machine learning algorithm composed of many decision trees. Machine learning is a subset of artificial intelligence (AI) that has the ability to automatically learn and improve from experience without being explicitly programmed. This technology has been utilized in various fields, such as finance, healthcare, and transportation, and it also has the potential to play a significant role in predicting academic performance.

Academic performance is a measure of a student's ability to learn, understand, and apply the material that is being taught in the classroom. It is an important indicator of a student's readiness for the future, as academic performance is often used as a predictor of a student's future success in college or in the workforce. However, the prediction of academic performance is a complex and challenging task that is influenced by various factors, such as cognitive abilities, socio-economic background, and student's motivation. Machine learning algorithms have the ability to analyze large amounts of data and identify patterns that can be used to predict future outcomes. In the context of academic performance, ML algorithms can be used to analyze various data sources, such as grades, test scores, demographic information, and attendance records, to predict a student's likelihood of success. This can be particularly useful for educators, as it can help them to identify students who may be at risk of falling behind and provide them with additional support and resources.

Random Forest Regression is a machine learning algorithm that is used for regression tasks. It is an ensemble method that uses multiple decision trees to make predictions [43], [44]. In Random Forest, a random subset of the features is selected for each tree and the best split feature from that subset is used to split each node in the tree. This creates a diverse set of trees that are not highly correlated with each other, which in turn improves the overall performance of the model [45]–[48].

One of the major advantages of Random Forest Regression is that it can handle high-dimensional data and large number of features without overfitting the model. It also provides a feature importance measure which can be used to understand the relative importance of each feature in the dataset. Additionally, it can be used for both classification and regression tasks, and handle both categorical and numerical data.

However, one of the main disadvantages of Random Forest Regression is that it is computationally expensive and requires a lot of memory. It is not always the most accurate algorithm, but it is generally considered to be a reliable algorithm that can be used as a benchmark for other algorithms. Also it might not be able to perform well in cases where there is a lot of noise in the data or where the relationship between the features and the target variable is very non-linear.

Despite the potential benefits of using ML algorithms to predict academic performance, there are also some limitations to consider. One limitation is that the accuracy of predictions can be affected by the quality and relevance of the data that is used. Additionally, the predictions made by ML algorithms can be affected by biases in the data, which can lead to unfair or inaccurate results. It is important to ensure that the data used is relevant and unbiased to achieve a high level of accuracy in predictions. Furthermore, it's important to recognize that academic performance is not only about

the grades and test scores. Non-cognitive factors such as motivation, persistence, and self-regulation play a critical role in academic performance. ML algorithms might not be able to capture these factors, which makes it important to combine them with other methods to have a comprehensive approach.

Table 1. List of variables

Variables	**Role**	**Measurement**
Academic performance	Label	Index calculated from Grades
Family income	Feature	Parent's income
Teacher-Student Ratio	Feature	Number of teachers divided by students
Healthy Lifestyle	Feature	Life style index of students
Student engagement	Feature	Engagement scores of each student
EdTech	Feature (Focus of this study)	Proportion of academic activities dependent on modern technology

Results

This research starts by exhibiting the pairplots among the factors. The pairplots are displayed in figure 2 with hue= academic performance levels. Looking at the various pair, we can observe that blue dots are located at the origin of plots. This suggest that the academic performance levels is low if healthy life style level, student engagement levels are lower. Most notably, the academic performance level is lower if the level of EdTech is lower.

The results of this research showed a satisfactory level of accuracy, scoring 93.87 percent overall as seen in table 2. Table 2 and figure 3 also show that the student engagement is the factor that matters the most for academic performance levels, as determined by the results of the random forest. The level of EdTech integration is the element that comes in second place. The results also shows that the third and fourth most significant aspects are the teacher-student ratio and healthy lifestyles of students. According to the findings, the family income is the least significant.

Figure 1. Pairplots among the features and lablel.

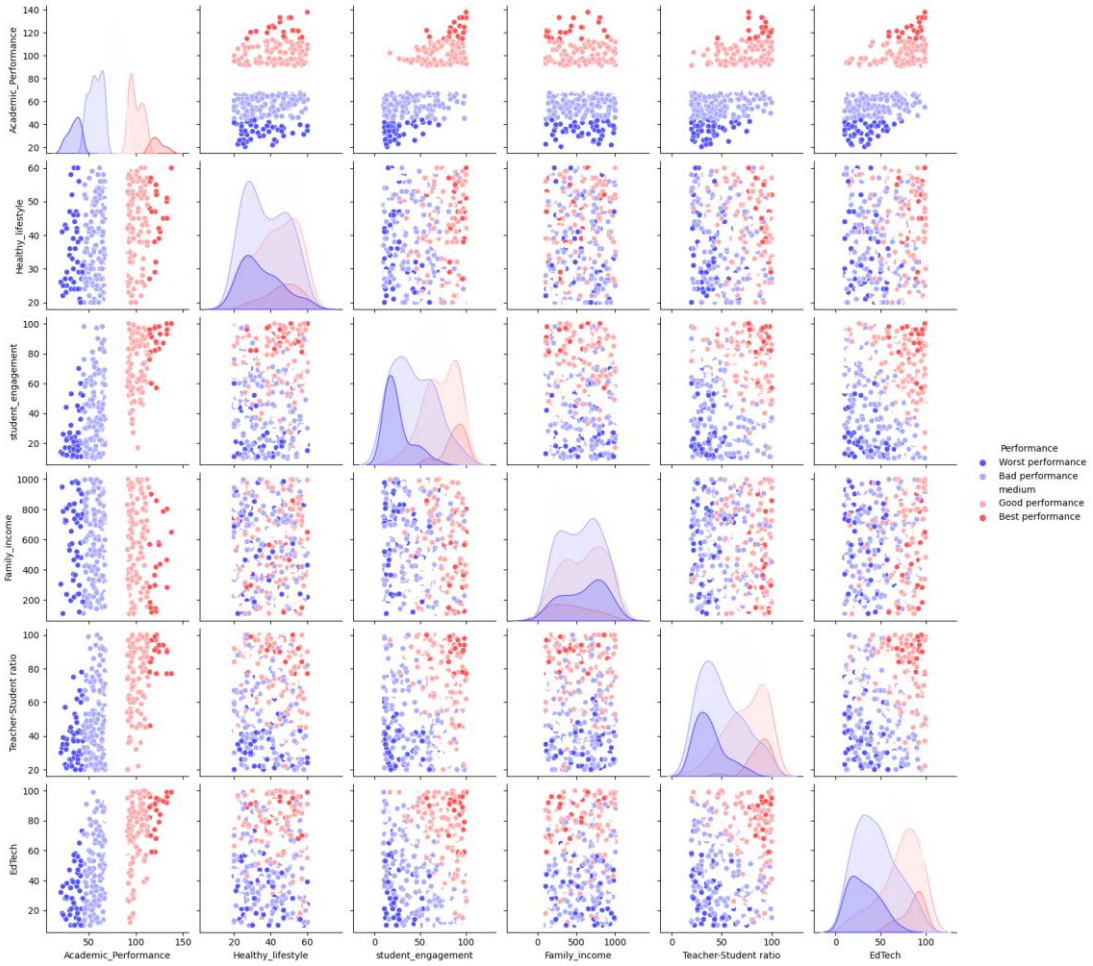

Academic_Performance
Healthy_lifestyle
student_engagement
Family_income
Teacher-Student ratio
EdTech
Performance
Worst performance
Bad performance
medium
Good performance
Best performance

Figure 2. Scatterplot between EdTech and academic performance levels

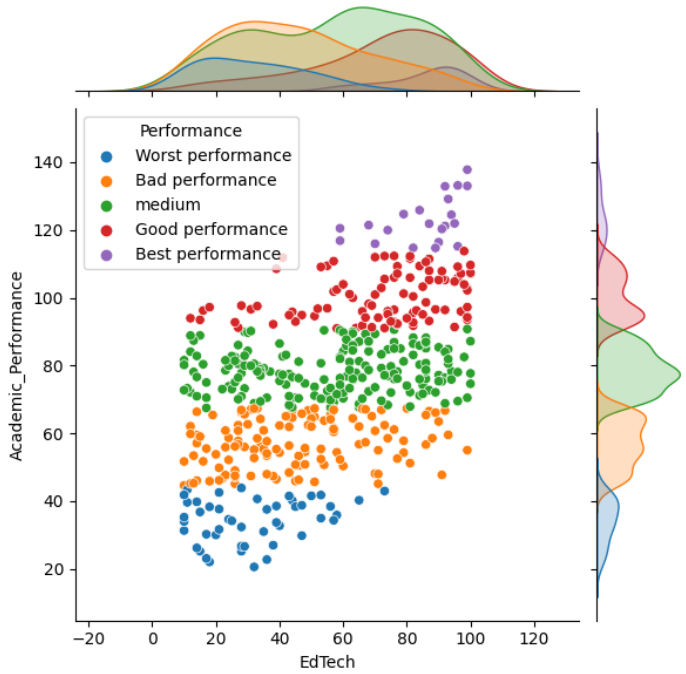
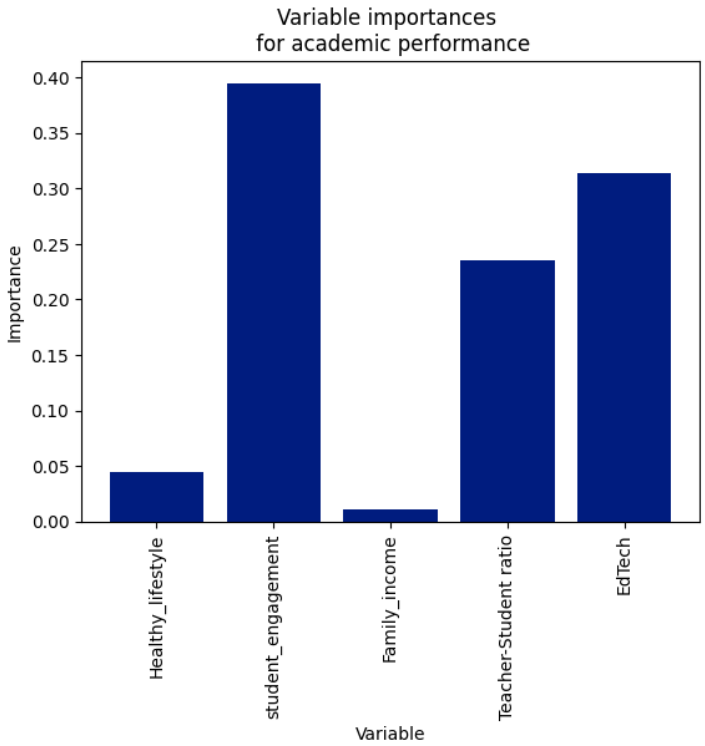


Table 2. accuracy score and feature importance in Random Forest Regression
Mean Absolute Error: 4.02 degrees. Accuracy: 93.87 %.
Variable: student_engagement Importance: 0.4 Variable: EdTech Importance: 0.31 Variable: Teacher-Student ratio Importance: 0.24 Variable: Healthy_lifestyle Importance: 0.04 Variable: Family_income Importance: 0.01

Figure 3. Importance of the features in Random forest regression.



Conclusion

Academic performance is an important aspect of a student's educational journey. It can open up a wide range of opportunities for students in the future, provide a sense of accomplishment, and contribute to a student's mental and emotional well-being. EdTech, short for "educational technology," offers the ability to boost students' grades by individualizing lessons and giving instantaneous feedback on their progress. Active learning using means such as games, simulations, and VR has been shown to improve students' interest in and persistence with course material. Students who have trouble keeping up with the speed of a regular classroom setting may benefit from EdTech's ability to tailor training via the use of adaptive learning software. Furthermore, with the use of interactive and gamified learning systems, students may be inspired by observing their progress and be rewarded for their successes. Students in outlying locations or with busy schedules may still get the education they need with the help of EdTech's online and remote learning options. Access to educational resources from all over the world, as well as the ability to collaborate and communicate with other students and teachers, are additional benefits. It is important for

individuals, for the society, and for the EdTech encompasses a wide range of technologies and tools, which can be used in a variety of ways to support and enhance teaching and learning. It can help to personalize education and make it more interactive and engaging, as well as providing opportunities for collaboration and connection. Machine learning (ML) has the potential to play a significant role in predicting academic performance. ML algorithms, such as regression analysis, decision tree, and neural networks, can be used to analyze various data sources, such as grades, test scores, demographic information, and attendance records, to predict a student's likelihood of success. However, it is important to ensure that the data used is relevant and unbiased, to achieve a high level of accuracy in predictions, and to combine the predictions with other methods.

Despite the many benefits of educational technology, there are also limitations to consider. One major limitation is that not all students have equal access to technology. For example, students from low-income families may not have access to the necessary devices or internet connectivity to fully participate in online or blended learning environments. Additionally, there may be disparities in the quality of technology infrastructure within schools, which can impact students' access to and use of educational technology.

Another limitation of EdTech is that it can be difficult to effectively integrate technology into instruction. This can be especially true for educators who may not have received adequate training on how to use educational technology effectively. Additionally, not all teachers are comfortable using technology in the classroom and may be hesitant to adopt it. Furthermore, technology can be a distraction for students and it may not be used in an appropriate way that aligns with student's learning needs. Lastly, not all content may be available online or in digital format. This can limit the accessibility and availability of certain educational materials for students.

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