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Professional paper

THE IMPACT OF USING EDUCATIONAL TECHNOLOGY ON STUDENTS' ACHIEVEMENT BY APPLYING CORRELATION AND LINEAR REGRESSION USING R

Rushadije RAMANI-HALILI[1], Selma XHELADINI, Mirlinda SHAQIRI, Lazim KAMBERI

Faculty of Natural Sciences and Mathematics, University of Tetova, Tetovo, Republic of North Macedonia
Corresponding email: rushadije.ramani@unite.edu.mk

Abstract

The rapid development of technology in recent decades has significantly influenced the field of education, bringing new tools and methods for teaching and learning. This study aims to examine the impact of using educational technology on the academic success of primary and secondary school students. Through a structured questionnaire, data were collected regarding the frequency of technology use, attitudes towards it, and students' academic performance. The collected data were processed and analyzed using the R language, employing statistical methods such as Pearson, Spearman, and Kendall correlations, as well as linear regression analysis. This enabled a deeper understanding of the relationships between the variables involved in the study. Preliminary results indicate a positive correlation between the use of technology and academic performance, particularly when technology is used in a structured and intentional manner during instruction. Furthermore, it was observed that the use of interactive platforms, educational applications, and digital resources contributes to improved student motivation and engagement. Students who use technology to follow lessons, complete homework, or review subjects generally show higher academic outcomes. This study contributes to the ongoing discussion about the role of technology in education and provides practical data that can assist teachers, schools, and educational institutions in determining the most effective ways to integrate technology into the learning process.

Keywords: Digital resources, Interactive platforms, Educational applications, Correlation, Linear Regression

Introduction

The accelerated evolution of technology in recent decades has markedly transformed various domains of life, particularly the field of education. In this context, traditional methods of teaching are gradually evolving, being replaced by new forms of learning that rely on the use of technology. However, the integration of technology into the educational process is not always uniform, and its effectiveness may vary depending on how it is utilized and the specific school context. This usually entails educational endeavors spanning various educational stages from early childhood to advanced studies and occurs in both curricular and extracurricular programs. [4]
The digital transformation of educational systems requires an evaluation of the effects of the integration of technologies in teaching-learning processes. From a pedagogical approach, Information and Communication Technologies (ICT) are defined, on the one hand, as the set of technologies that contain, store, and disseminate information (e.g., e-books, videos, or databases) and, on the other hand, those technologies designed for short-term communication (e.g., social networks and smartphones). Academic achievement is one of the most widely used variables to try to understand how information and communication technologies affect student learning outcomes. [2]
The use of digital educational technology is not a new phenomenon in higher education and gained traction in the early ‘70s in the form of telecourses and the ‘80s in the form of computer-

assisted learning and online learning (Garrison, 1985). In recent years, technology has received significant attention as a means to support distance education during the COVID-19 pandemic (Abu Talib et al., 2021) and as a disruptor of traditional teaching, learning, and assessment forms with the advent of generative artificial intelligence (GenAI) tools such as ChatGPT, Google Gemini, and Dall-E (Farrelly & Baker, 2023; Godsk & Elving, 2024). [2]
With education being faced with new challenges and calls for adjustment to virtual changes, there is a need to understand how the use of technology affects the academic performance of students. The matter is of special significance to primary and secondary levels of education, as students begin to use technology more independently as part of their learning process on a daily basis. While technology presents a lot of possibilities for improving the teaching and learning process, the absence of tangible data and empirical investigations makes it difficult to determine its actual influence.
Thus, concrete data must be studied that show whether, and to what degree, technological application is connected with students' academic achievement

Purpose of the Study and Research Questions

This study aims to analyze the impact of technology use on academic performance (Academic achievement is a measure of performance. The degree to which a student, instructor, or school has realized their set educational objectives within a set period is known as academic achievement or academic performance [1] of secondary and primary school students. By employing statistical tools through the R programming language, the objective is to determine whether there is a statistically significant relationship between the use of technology in the learning process and students' academic outcomes. Furthermore, the study examines students' attitudes toward technology use and how these attitudes influence their academic progress.
The research aims to explore the following questions:

1. Is there a statistical connection between how much students use technology and their grades?
2. Does using technology more often help students improve their academic performance?
3. In what ways do students typically use technology for learning, and what do they think about these methods?
4. Are there clear differences in academic results between students who use technology regularly and those who use it rarely or not at all?
5. How is students' attitude toward technology related to their academic success?

Methodology

This study is based on a quantitative, descriptive, and correlational approach, designed to examine the relationship between the use of educational technology and academic performance among primary and secondary school students. Data were collected and analyzed using appropriate statistical methods.
As a correlation study, the research aims to identify patterns and associations between technology usage and academic outcomes, without altering the natural learning environment of the students.
The sample consists of students from primary schools (grades VI–IX) and secondary schools (grades I–IV), selected randomly from various public and private educational institutions. A total of N = 100 students participated, representing a range of age groups, with balanced gender representation and from diverse geographical areas. All participants were informed about the purpose of the study and took part voluntarily, with full assurance of anonymity and data confidentiality.

Data were collected through a structured questionnaire specifically designed for this study and administered within the participating schools. The questionnaire was distributed electronically via Google Forms and consisted of three main sections:

- **Demographic data**: age, gender, grade level, school
- **Technology use in learning**: used tools
- **Academic performance and attitudes toward technology**: self-assessed average grades in core subjects and attitudes toward technology use, measured using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree)

Data analysis and results

The data analysis was carried out using the R programming language, applying statistical methods to explore the relationship between the amount of time students spent using technology for learning and the type of device they used. Three correlation coefficients were utilized: Pearson's coefficient to measure linear relationships between numerical variables, and Spearman's and Kendall's coefficients to assess monotonic relationships, particularly useful when the data do not meet the assumption of normality.

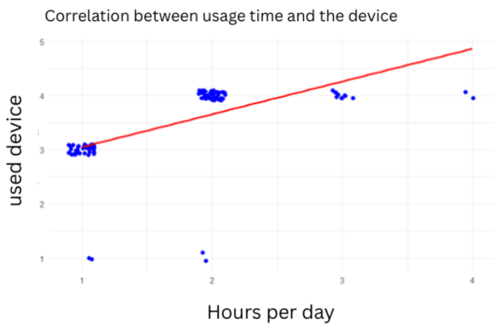
To further explore the patterns in the data, linear regression analysis was conducted to model the dependency between these variables. This method provided deeper insights into how students engage with technology in the learning process, allowing for a more comprehensive understanding of their behavior and academic context.

Pearson Correlation Coefficient

The Pearson correlation coefficient (r) was used to measure the strength and direction of the linear relationship between the time spent using technology for learning and the type of device used by students. This coefficient ranges from -1 to +1, where values close to +1 indicate a strong positive correlation, while values close to -1 indicate a strong negative correlation. In the analysis conducted in R, this coefficient was calculated based on numerically coded data and visualized using a scatter plot with a regression line. Pearson's correlation is sensitive to outliers and is appropriate when data are approximately normally distributed and when the relationship between variables is linear. [5].

Based on the findings of our study, Pearson's correlation coefficient indicated a positive linear relationship between the number of hours students spent using technology for learning and the type of device used. This suggests that increased usage time is associated with a greater likelihood of using more advanced technological devices.

This outcome is consistent with theoretical expectations about the interdependence between usage patterns and device choice, highlighting a statistically significant relationship between these variables.

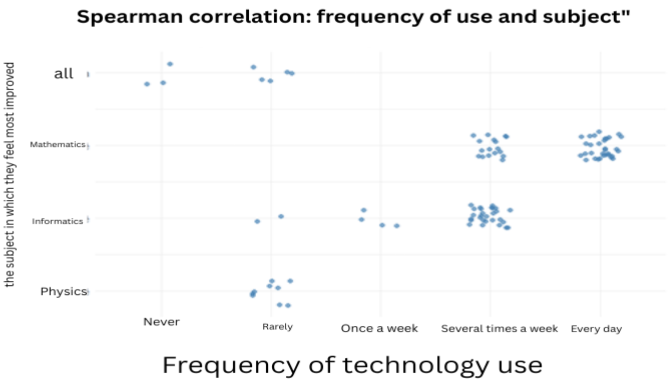


	laptop	tablet	cellphone	other
1-2 hour	13	1	31	3
2-3 hour	4	0	4	2
less than 1 hour	9	1	28	2
more than 3 hour	0	0	2	0

Spearman Rank Correlation

The Spearman rank correlation is a non-parametric counterpart to the Pearson correlation coefficient. To perform this procedure, the x-values are first sorted from smallest to largest and ranked from 1 to n for each value, with R_i denoting the rank of value x_i. Similarly, the y-values are ranked, with S_i denoting the rank of value y_i.
In cases of tied observations, average ranks are assigned by averaging the ranks that would have been assigned to the tied values.
The next step is to substitute x_i and y_i with their corresponding ranks R_i and S_i, n the formula for Pearson's correlation coefficient. The resulting measure is Spearman's rho (ρ), which is a widely used rank-based correlation coefficient that assesses monotonic relationships between variables. [5]

$$\rho = \frac{\sum_{i=1}^{n}(R_i - \bar{R})(S_i - \bar{S})}{\sqrt{\left[\sum_{i=1}^{n}(R_i - \bar{R})^2\right]\left[\sum_{i=1}^{n}(S_i - \bar{S})^2\right]}} = 1 - \frac{6\sum_{i=1}^{n}(R_i - S_i)^2}{n(n^2 - 1)}$$



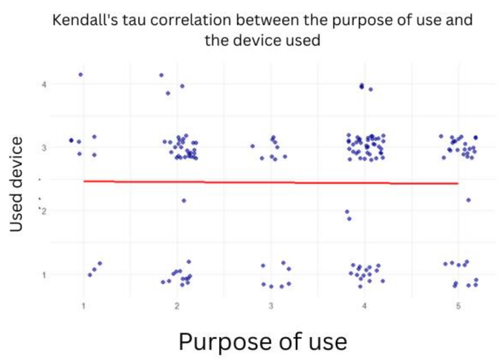
The graph illustrates a clear association between the frequency of technology use and the subjects in which students perceive the greatest improvement. The findings indicate that students who use technology more frequently report feeling most improved in subjects such as Mathematics and Computer Science.
Those who engage with technology daily commonly associate their academic progress with these two subjects, as well as with overall improvement across multiple areas. In contrast, students who use technology rarely or not at all tend to report greater perceived improvement in subjects like Physics.
These results suggest that frequent use of technology may have a positive influence on students' academic development, particularly in subjects that often integrate digital tools and interactive learning methods.

Kendall's Rank Correlation Coefficient (Tau)

Unlike Spearman's rho, Kendall's rank correlation coefficient (τ, tau) is defined and calculated in a fundamentally different way, although both measures often yield similar numerical results. This method is illustrated as following steps:

1. The x and y values are presented in two rows, with the x-values in the first row sorted in ascending order.
2. For each corresponding y-value in the second row, we count:
    (a) The number of larger y-values to its right (recorded in the third row). The sum of these values is denoted as **C** (concordant pairs).
    (b) The number of smaller y-values to its right (recorded in the fourth row). The sum of these values is denoted as **D** (discordant pairs).
    C and D represent the number of concordant and discordant pairs, respectively.
3. Kendall's rank correlation coefficient is then calculated using the formula:
$$\tau = \frac{C - D}{\frac{1}{2}n(n-1)}$$

where n is the number of observations.



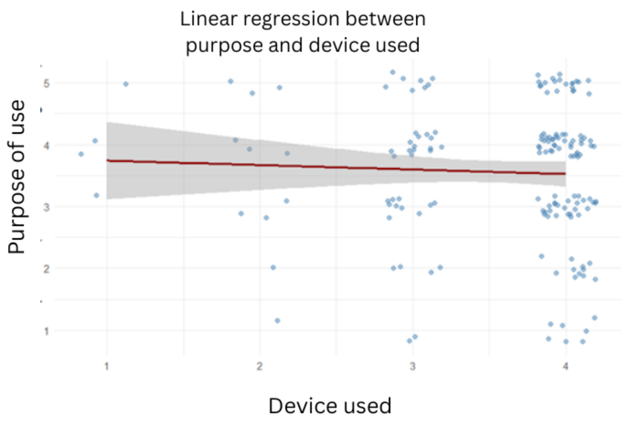
This coefficient assesses the strength and direction of the association between two ranked variables and is particularly useful when the data contain outliers or do not meet the assumptions of parametric tests. [5]

The graph explores the relationship between students' purpose for using technology and the type of device they use most often, using ordinal coding and a scatterplot for visualization. The data are widely dispersed, with no visible pattern, and the red regression line is almost flat, which indicates a lack of any clear trend.

Kendall's correlation coefficient further supports this observation, showing a weak association between the two variables. This suggests that the choice of device is not strongly influenced by the specific purpose for which students use technology.

Linear Regression

To better understand the nature of the relationship between the time spent using technology and the type of devices used, this study also applied linear regression analysis. This method describes the overall trend of the data by fitting a straight line that minimizes the deviations from the actual values. In R, the analysis was performed using standard modeling functions and was visualized with a trend line on a scatter plot. Linear regression helps identify a predictable relationship between variables and provides a simplified interpretation of the dependency between them, particularly when a linear association is likely to exist.



Results

The findings of this study indicate a positive relationship between the use of educational technology and the academic performance of students in primary and secondary education. It was observed that the higher the frequency and quality of technology use in the learning process, such as digital platforms, educational applications, or the use of multimedia materials, the higher the students' achievement in core subjects.
This aligns with the initial objective of the study, which was to examine the potential impact of technology on academic outcomes. In particular, regular use of technology contributes to faster knowledge acquisition, increased student motivation and engagement during the learning process, and more personalized learning tailored to individual needs. These results are further supported by the applied statistical models, which demonstrate that more intensive use of technology is a significant predictor of an increase in students' average grades.

Conclusion

As emphasized by Drijvers et al. (2010), technology should be utilized not merely to facilitate the mechanical application of rules, but to foster a deep conceptual understanding by creating flexible learning environments in which students can actively explore mathematical ideas and develop multiple representations of concepts. This integrated approach supports the construction of a solid knowledge base, which in turn promotes critical thinking and the ability to apply knowledge in diverse contexts. [3]

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