The Impact of Technology Integration in Teaching on Student Performance in China

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ABSTRACT

This study investigates the impact of technology integration on student performance at Nanjing University of Information Science and Technology, focusing on key dimensions such as technology type, purpose, and frequency. Using a survey method, data were collected from 259 respondents, and regression analysis was employed to examine the relationships between technology use and academic performance, measured by GPA. The findings reveal that all three dimensions of technology use positively affect GPA, with technology type exerting the most significant influence. The combined model, which includes control variables such as age and grade, explains 61.4% of the variance in GPA, demonstrating the comprehensive impact of both technological and demographic factors on student performance. Robustness checks confirm the stability of these results, emphasizing that older students and those in higher grade levels tend to perform better academically. These findings highlight the importance of integrating meaningful and strategic uses of technology in teaching to enhance educational outcomes. The study also underscores the need for equitable access to technology in education, addressing regional disparities in China, and promoting policies that support the effective use of diverse digital tools in learning environments.

INTRODUCTION

The integration of technology into teaching and learning has been a significant shift in the educational landscape over the past decade. This transformation has been driven by the rapid growth of technology in society, prompting educators to innovate and adapt their teaching methods for greater effectiveness and efficiency. The advent of technology has opened new doors, making the learning process more conducive, interactive, and fruitful for both teachers and students.

Technology integration in teaching plays a crucial role in enhancing the productivity and performance of students in the classroom. Findings have shown that students become competent members of the class through their engagement with innovative pedagogical routines, which incorporate technology into the teaching and learning experience. Frye, Elizabeth M. et.al. (2010)

The traditional learning environment in educational settings has been gradually replaced by the integration of digital technology. Numerous technological tools and applications are now available for teachers to use in their classrooms. The integration of digital technology in teaching and learning has been associated with enhancing the effectiveness of knowledge construction and distribution, as well as improving academic performance. However, the impact may not be as expected if digital technology is not properly and systematically integrated into teaching and learning.

In today's world, the use of technology has become a necessity rather than a privilege. Technology is embedded in every aspect of our lives, from mobile phones and cars to apps, computers, and smart homes. The education system is open to all kinds of changes in society, as its task is to prepare individuals for society and real life (Ozan, 2013). Technology contributes to the education system in many direct and indirect ways, including online learning, simulation environments, virtual laboratories, access to scientific information, instant access to technological developments, online learning applications, and many others (Brito, Dias & Oliveira, 2018).

Technological developments have also changed the expectations of educators. In addition to being academically successful, students are now expected to acquire many alternative skills (Trilling & Fadel, 2009). The teacher-centered traditional education has been replaced by student-centered education. Students are now as close to technology as a smartphone, able to instantly access the information they want. Software, coding, and digital applications have become indispensable components of our daily life and the education process (Area & Ribeiro, 2012; Yilmaz, Gulgun, Cetinkaya & Doganay, 2018).

This paper aims to delve deeper into these aspects, providing a comprehensive understanding of the impact of technology integration in teaching on student performance. The findings of this study could contribute to the ongoing discourse on the effective use of technology in education and its implications for student achievement.

LITERATURE REVIEW

Technology Integration in Teaching

One of the most important things that educators can do to help students learn and be able to engage with a digitalized society is to integrate technology into the classroom (OECD, 2015; US Department of Education, 2020). When used in a teaching context, technology integration typically refers to the use of educational technologies by teachers in the classroom. Examples of this include the use of specialized hardware, such as tablets or mobile technology (Beauchamp, Burden, & Abbinett, 2015), or software applications, such as tools (Krauskopf, Zahn, & Hesse, 2012), to realize particular teaching processes (Danniels, Pyle, & DeLuca, 2020; Dukuzumuremyi & Siklander, 2018; Paratore, O'Brien, Jimenez, Salinas, & Ly, 2016). There are two ways to conceptualize technology integration: quantitatively and qualitatively. Technology integration on a quantitative level is commonly defined as the mere frequency of technology integration. This can be ascertained, for example, by counting the number of times a specific technology was used during classroom instruction (e.g., Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014). These quantitative indicators provide a broad picture of the amount of technology used in schools; however, they do not address qualitative aspects of technology integration that are likely essential to its success (e.g., improve teaching quality; OECD, 2015).

The quality of technology integration can be operationalized along two distinct dimensions, per Backfisch et al. (2020): First, the ability of educators to use the unique potential of educational technologies to support students' learning is referred to as the level of technology exploitation (Endberg, 2019; Hamilton, Rosenberg, & Akcaoglu, 2016). The SAMR-model (short for substitution, augmentation, modification, redefinition; Backfisch, I., Lachner, A., Stürmer, K., & Scheiter, K. 2021) and the RAT-model (short for replacement, amplification, transformation; Backfisch, I., Lachner, A., Stürmer, K., & Scheiter, K. 2021) are the most well-known models that describe various hierarchical levels of technology exploitation. In both models, there are different levels of technology integration. At the lowest level, new technologies are

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employed in place of or in addition to more established ones (reading a digital PDF document rather than a printed book, for example). Technology integration aids in the realization of more effective teaching strategies and supplements conventional teaching strategies at the intermediate level (e.g., using a live synchronized collaborative digital whiteboard). At the highest level, technology integration may enable educators to redefine or transform current teaching strategies that would not be feasible without it. Examples of such strategies include offering adaptive support (e.g., Lachner, Burkhart, & Nückles, 2017; Ma, Adesope, Nesbit, & Liu, 2014; Zhu & Urhahne, 2018) or multi-media information (Renkl & Scheiter, 2017).

Technology integration in basic education in China

China has a huge population and is a developing nation with a high standard of education. Up until 2020, there were more than 13 million full-time teachers working in primary and secondary schools, with a student population of 198 million. The number of elementary and secondary schools exceeds 240 thousand. With scores of 555 in reading, 591 in math, and 590 in science on the PISA 2018 exam, China topped the list of 79 nations and regions. However, there are significant differences in the quality of education between districts, particularly between rural and urban areas, as a result of unequal social and economic development as well as the localized basic education financing system. According to studies, students from wealthy areas are more likely to be admitted to prestigious universities than students from underdeveloped areas (Li & Yang, 2013; Liu, 2015).

The incorporation of ICT into elementary education aligns with China's national technological development progress. Macro planning and direction are made for the advancement of basic education by national policy. Simultaneously, the advancement of global technology continuously fosters innovation and iteration in educational ICT (Hu, 2019). China first proposed building a national information superhighway during the 1990s, when it began integrating ICT into education (Jiao et al., 2014). A decade later, the Ministry of Education introduced the Chinese New Basic Education Curriculum Reform, a significant educational reform. Since then, Chinese basic education has placed an emphasis on all-around education rather than exam-oriented education. Scholars and the general public have long criticized the exam-focused basic education system for its excessive emphasis on memorization, disconnect from everyday life, heavy homework loads for students, teacher-dominated classrooms, and boring instructional methods (Guo et al., 2019).

Technology's effect on student performance

Student performance is an important aspect of assessing school performance because it reflects the school's effectiveness in achieving its core mission. One of the fundamental measures of student performance, as stated in the Framework for Quality Assurance of School Performance in Kosovo (Kosovo Pedagogical Institute, 2016), is how well students use technology, their surroundings, and other resources to enhance their instruction. Technology enhances student performance (Spears, 2012) and academic achievement (Harris, Al Bataineh & Al-Bataineh, 2016), according to research. According to Cavanaugh, Dawson, and Ritzhaupt (2011, p. 360), "the belief that the new learning environment will support engaged students and increases in academic achievement is the primary motivation for laptop classroom technology and accompanying teacher professional development."

All classrooms should incorporate technology into essential elements of the daily curriculum and use it to improve student performance on real applications (Monserate, 2018). The traditional methods of teaching and learning are being altered by a variety of learning tools, such as computer and internet resources. When students achieve better results by memorizing fewer procedures, they show greater interest. Based on cognitive skills that enable learners to perform at the analysis, synthesis, and evaluation levels of Bloom's Taxonomy, research indicates that the use of technology has a significant impact on high-level thinking (Lee & Choi, 2017). Scholars have investigated how a technology-enhanced classroom affects elementary students' learning effectiveness (Chauhan, 2017) as well as the development of higher-order thinking skills in students (Yang & Wu, 2012). As a result, technology puts the learners at the center, enabling them to express their inner potential and enhance learning. According to research findings, educational technology enhances critical thinking and exposes students to new learning strategies (Bakir, 2016).

METHODOLOGY

Data

To examine the impact of technology integration in teaching on student performance in China, we employed a survey method to collect relevant data. The survey was meticulously designed to capture comprehensive information about both the respondents' personal profiles and their experiences with technology in the classroom. It was divided into two main parts: the first part collected demographic information, including age, gender, and grade, while the second part focused on key variables such as technology type, technology purpose, technology frequency, and GPA. Nanjing University of Information Science and Technology was chosen as the sampling frame, and we used a non-probability convenient sampling technique to distribute the questionnaires. Out of the distributed questionnaires, 259 were correctly responded to, providing a robust dataset for analysis. The respondents' ages ranged from 18 to 34 years, capturing a broad spectrum of university students, with data on various grade levels ensuring diversity in academic experience and exposure to technology. This dataset enables a thorough investigation of how different aspects of technology integration (type, purpose, frequency) influence student performance, as measured by GPA, offering nuanced insights into the factors that enhance or hinder academic success in technology-enhanced learning environments.

Model

Dependent Variable:

Student Performance (GPA): The Grade Point Average (GPA) is used as the measure of student performance. GPA is a standard indicator of academic success, reflecting a student's overall academic achievement in their courses. GPA provides a quantifiable measure of how well students are performing academically, making it an effective dependent variable for analyzing the impact of various factors, such as technology integration in teaching.

Independent Variables:

Technology Type: This variable refers to the different kinds of technologies used in teaching. Examples include computers, tablets, interactive whiteboards, and educational software. Different technologies may have varying impacts on student learning and engagement. For instance, computers and tablets can provide access to a wide range of educational resources, while interactive whiteboards can facilitate interactive learning sessions. Educational software can offer personalized learning experiences, adapting to individual student needs.

Technology Purpose: This variable addresses the specific purposes for which technology is used in the classroom. Examples include instructional delivery, student collaboration, assessment, and providing additional resources. The purpose of technology use can influence how effectively it enhances learning. For instance, using technology for instructional delivery can make lessons more engaging and accessible, while using it for student collaboration can enhance group work and communication skills. Technology used for assessment can provide immediate feedback, helping students to improve continuously.

Technology Frequency: This variable measures how often technology is used in the teaching process. It

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can range from occasional use to regular, daily integration in classroom activities. The frequency of technology use can determine the extent to which technology integration influences learning outcomes. Regular use of technology can lead to better familiarity and more effective use, potentially enhancing learning outcomes. Conversely, infrequent use might not provide sufficient exposure for students to fully benefit from the technological tools available.

These variables were chosen to comprehensively understand how different aspects of technology integration affect student performance. By analyzing technology type, purpose, and frequency, we can identify specific factors that contribute to or hinder academic success.

The model to quantify the relationship between the independent variables (technology type, technology purpose, technology frequency) and the dependent variable (student performance measured by GPA) is as follow:

$$GPA=\beta 0+\beta 1(\text{Technology Type})+\beta 2(\text{Technology Purpose})+\beta 3(\text{Technology Frequency})+\beta 4(\text{Age})+\beta 5(\text{Grade})+\epsilon$$

Where:

- **GPA** is the dependent variable representing student performance.
- **Technology Type** is an independent variable representing the kind of technology used.
- **Technology Purpose** is an independent variable representing the purpose of technology use.
- **Technology Frequency** is an independent variable representing how often technology is used.
- **Age** is a control variable representing the age of the students.
- **Grade** is a control variable representing the educational level of the students.
- $\beta 0$ is the intercept.
- $\beta 1, \beta 2, \beta 3, \beta 4, \beta 5$ are the coefficients for the respective variables.
- ϵ is the error term.

These variables were chosen to comprehensively understand how different aspects of technology integration affect student performance. By analyzing technology type, purpose, and frequency, we can identify specific factors that contribute to or hinder academic success. For instance, understanding whether certain types of technology are more effective or if the purpose and frequency of use significantly influence outcomes can help educators and policymakers make informed decisions about technology integration in the classroom.

DISCUSSION

Descriptive Analysis

Table 1. Descriptive Statistics

VARIABLES	Obs	Mean	Std. Dev	Min	Max
Gender	246	0.455	0.499	0	1
Age	246	24.36	4.439	18	34
Grade	246	1.935	0.685	1	3
Technology Frequency	246	3.752	1.057	1	5
Technology Purpose	246	3.768	1.128	1	5
Technology Type	246	4.008	1.080	2	5
GPA	246	83.50	12.78	51	97

Table 1 provides an overview of the data collected in the study on the impact of technology integration in

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teaching on student performance in China, specifically at Nanjing University of Information Science and Technology. The sample comprises 246 respondents, with a nearly equal gender distribution (mean of 0.455, where 0 represents males and 1 represents females), indicating that approximately 45.5% of the participants are female. The average age of the respondents is 24.36 years, with a range from 18 to 34 years, suggesting a diverse age group. The grade variable, which represents represent the educational level of the students, has a mean of 1.935, indicating that most students are bachelor or master degree students.

The variables related to technology usage reveal high levels of integration in teaching. The frequency of technology use has a mean of 3.752 on a 1 to 5 scale, while the purpose of technology use has a mean of 3.768, indicating that technology is frequently and meaningfully incorporated into the teaching process. The type of technology used also shows a high diversity, with a mean of 4.008. The dependent variable, GPA, has an average of 83.50, with a standard deviation of 12.78, demonstrating a generally high level of academic performance among the respondents. The range of GPAs, from 51 to 97, highlights variability in student performance, which can be explored further in relation to the independent variables. Overall, these statistics set a solid foundation for analyzing the impact of different aspects of technology integration on student academic outcomes.

Regression Results

Table 2. Regression results

VARIABLES	**Technology Type**	**Technology Purpose**	**Technology Frequency**	**Combine**
Technology Type	8.368***			7.049***
	(17.77)			(13.59)
Technology Purpose		5.623***		2.960***
		(8.88)		(4.92)
Technology Frequency			4.090***	1.148**
			(5.07)	(2.40)
Grade				2.394***
				(2.99)
Constant	49.957***	62.306***	68.149***	35.145***
	(21.94)	(24.59)	(20.22)	(16.72)
Observations	246	246	246	246
R-squared	0.500	0.246	0.115	0.614

Table 2 indicates that various aspects of technology integration significantly impact student performance, measured by GPA, at Nanjing University of Information Science and Technology. Individually, technology type has the most substantial effect, with a coefficient of 8.368 and an R-squared value of 0.500, indicating that it explains 50% of the variance in GPA. This suggests that the kind of technology used in teaching is a crucial determinant of student performance. Technology purpose and frequency also show positive and significant effects, with coefficients of 5.623 and 4.090, and R-squared values of 0.246 and 0.115, respectively. This implies that the specific purposes for which technology is used and how often it is utilized also play significant roles in enhancing student performance, though to a lesser extent than technology type.

In the combined model, which considers all three technology-related variables simultaneously, all remain significant. Technology type continues to have the largest impact, with a coefficient of 7.049, followed by technology purpose (2.960) and technology frequency (1.148). Additionally, the grade level of students also positively influences GPA, with a coefficient of 2.394, indicating that higher grade levels are associated with better academic performance.

The combined model's R-squared value of 0.614 indicates that these factors together explain 61.4% of the variance in student performance. This high explanatory power demonstrates that a comprehensive consideration of technology type, purpose, and frequency provides a more thorough understanding of their effects on academic success.

Overall, the results highlight the significant positive impact of various dimensions of technology integration on student performance, with technology type being the most influential factor. The combined model underscores that considering multiple aspects of technology use offers a more comprehensive understanding of their effects on academic success, suggesting that strategic integration of diverse technologies, tailored to specific educational purposes and used frequently, can significantly enhance student outcomes.

Robustness Check

Table 3. Robustness Check

VARIABLES	Technology Type	Technology Purpose	Technology Frequency	Combine
Technology Type	8.368***			7.064***
	(17.77)			(14.72)
Technology Purpose		5.623***		3.315***
		(8.88)		(5.34)
Technology Frequency			4.090***	1.183**
			(5.07)	(2.48)
Age				0.376***
				(-2.92)
Constant	49.957***	62.306***	68.149***	47.403***
	(21.94)	(24.59)	(20.22)	(13.74)
Observations	246	246	246	246
R-squared	0.500	0.246	0.115	0.614

Table 3 examines the stability and reliability of the regression results by incorporating the variable 'Age' as an additional control. The results show that the inclusion of 'Age' does not substantially alter the significance or direction of the coefficients for the technology variables. In individual models, technology type remains highly significant with a coefficient of 8.368 and an R-squared of 0.500, indicating that it explains 50% of the variance in GPA when considered alone. Technology purpose has a significant positive effect with a coefficient of 5.623 and an R-squared of 0.246, and technology frequency also remains significant with a coefficient of 4.090 and an R-squared of 0.115. In the combined model, all three technology variables continue to show significant positive impacts on GPA: technology type (7.064), technology purpose (3.315), and technology frequency (1.183). The 'Age' variable is also significant in the combined model, with a positive coefficient of 0.376, indicating that older students tend to have higher GPAs. The R-squared value of the combined model remains high at 0.614, suggesting that these variables collectively explain 61.4% of the variance in student performance. These findings confirm the robustness of the initial results, reinforcing that different aspects of technology integration in teaching significantly enhance student performance. This consistency across models highlights the reliability of the identified relationships between technology integration and academic success, even when accounting for additional

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demographic factors like age.

CONCLUSION

In conclusion, the integration of technology in educational settings, as demonstrated at Nanjing University of Information Science and Technology, significantly enhances student performance. This study reveals that while frequency and purpose of technology use positively impact GPA, the type of technology employed holds the most substantial influence. This underscores the importance of thoughtfully selecting and applying technologies that align with specific educational goals to maximize their benefits.

Furthermore, the analysis shows that a comprehensive approach, considering both technological factors and student characteristics such as age and grade, provides deeper insights into academic success. The combined model explaining 61.4% of GPA variance highlights the pivotal role of strategic technology integration in fostering learning outcomes. Robustness checks affirm these findings, showcasing the reliability of the positive relationship between technology integration and student achievement.

These results emphasize the need for educators to move beyond superficial application of digital tools, aiming instead to transform and redefine teaching practices. Educational policies must prioritize diverse, meaningful, and frequent use of technology to bridge the gap between traditional and modern pedagogies. Additionally, addressing regional disparities and ensuring equitable access to quality educational technologies in China remain critical steps toward fostering a digitally inclusive learning environment. By doing so, education systems can better prepare students to excel in a technology-driven world while encouraging critical thinking and personalized learning experiences.

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