



# The Relationship between Computer and Mathematics Proficiency; Moderating Effects of Student Type and Location

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**Abstract.** The rapid integration of computers and digital tools in education has raised questions about the relationship between students' computer proficiency and their academic performance, particularly in the domain of mathematics (Tamin et al., 2011; Papastergiou, 2009). Mathematics is a critical subject that underpins many areas of study and is essential for success in various fields (Mullis et al., 2016). Understanding the interplay between computer proficiency and mathematics performance is crucial for developing effective educational strategies and policies. This study aims to investigate the relationship between computer proficiency and mathematics performance, while examining the moderating effects of student type and location. The study will explore whether the strength and nature of the relationship differ based on factors such as student age, grade level, academic background, and geographical setting (e.g., urban vs. rural). By considering the moderating influences of student type and location, the research seeks to provide a comprehensive understanding of the complex relationship between computer proficiency and mathematics performance. The findings can inform the design and implementation of technology-enhanced learning environments, teacher training programs, and targeted interventions to support students' academic success, particularly in the domain of mathematics. The results of this study have the potential to contribute to the development of evidence-based educational practices and policies that effectively leverage technology to enhance student learning and achievement in mathematics.

**Index Terms:** Relationship, Computer Proficiency, Moderating, Student Type, Computer, Mathematics.

## I Introduction

In today's rapid advancement of technology has transformed the educational landscape, with computers and digital tools becoming increasingly integrated into the learning process (Tamin et al., 2011). This integration has raised questions about the relationship between students' computer proficiency and their academic performance, particularly in the domain of mathematics (Papastergiou, 2009). Mathematics is a critical subject that underpins many areas of study and is essential for success in various fields (Mullis et al., 2016). Understanding the interplay between computer proficiency



and mathematics performance is crucial for developing effective educational strategies and policies. Similarly, mathematical literacy remains a cornerstone of education, serving as a gateway to numerous academic and professional opportunities. Consequently, understanding the relationship between computer and mathematics proficiency is of paramount importance for educators, policymakers, and researchers alike.

Research in educational psychology has long recognized the interconnectedness of cognitive skills and their impact on academic achievement. Cognitive theories posit that proficiency in one domain can influence learning and performance in another, suggesting potential synergies between computer and mathematics skills (Perkins, 1992). Moreover, socio-cultural theories highlight the role of social and environmental factors in shaping individuals' development and learning outcomes, emphasizing the importance of contextual influences such as access to technology and educational resources (Vygotsky, 1978). Bridging these theoretical perspectives, the digital divide theory underscores disparities in access to technology and the internet, which may exacerbate existing inequalities in educational attainment (DiMaggio et al., 2004).

While numerous studies have explored the relationship between computer proficiency and academic achievement, relatively fewer have specifically examined its interaction with mathematics proficiency. However, existing research suggests a positive correlation between computer literacy and mathematical achievement, with computer-based learning environments offering unique opportunities for enhancing mathematical learning (Chen & Chang, 2006; Clements & Sarama, 2003). For instance, interactive educational software and online resources can provide personalized learning experiences tailored to individual students' needs, potentially facilitating deeper conceptual understanding and engagement with mathematical concepts (Suh & Moyer-Packenham, 2018).

Moreover, the advent of digital technologies has transformed the way mathematics is taught and learned, with computational tools enabling students to explore mathematical concepts, visualize complex problems, and develop problem-solving skills in novel ways (Schoenfeld, 1992). As such, proficiency in using computers may serve as a catalyst for enhancing mathematical proficiency, empowering students to leverage technology as a tool for mathematical exploration and discovery (Hoyles et al., 2010).

However, the relationship between computer and mathematics proficiency is not uniform across all students, as demographic factors such as student type and location may moderate this relationship. For instance, age-related differences in computer literacy may influence how students engage with digital learning resources, with younger students often demonstrating greater comfort and proficiency in using technology compared to their older counterparts (Warschauer et al., 2004). Similarly, gender disparities in computer science participation may contribute to differential effects of computer proficiency on mathematical achievement between male and female students (Margolis & Fisher, 2002).

Furthermore, geographic location plays a crucial role in shaping students' access to technology and educational opportunities. Urban areas typically boast greater infrastructure and resources for integrating technology into education, whereas rural communities may face challenges related to limited internet connectivity and technological infrastructure (Warschauer, 2003). Consequently, disparities in access to



digital resources and support may influence how students in urban versus rural settings engage with computers and mathematics, potentially moderating the relationship between computer proficiency and mathematical achievement.

By examining the nuanced interplay between computer and mathematics proficiency and considering the moderating effects of student type and location, this manuscript seeks to contribute to our understanding of how educational interventions can be tailored to address the diverse needs of students in today's digital age. Through a comprehensive review and analysis of existing literature, we aim to elucidate the complex dynamics underlying this relationship and offer insights for educators, policymakers, and researchers seeking to promote equitable access to high-quality education for all students.

### **Purpose of the Study**

The purpose of this study is to examine the mediation and moderation effects of student type and location on the relationship between computer proficiency and mathematics proficiency levels of students

### **Objectives of the Study**

The study seeks to;

- i. Determine the direct impact of computer proficiency level on mathematics proficiency levels.
- ii. Identify the mediating effect of student type on computer and mathematics proficiency levels.
- iii. Find out the moderating effect of student's location on computer and mathematics proficiency levels.

## **II Methodology**

The present study employed a cross-sectional research design to investigate the relationship between computer proficiency and mathematics proficiency, as well as the moderating effects of student type (age, gender, etc.) and student location (urban, rural).

### **1. Participants**

A sample of 500 high school students (grades 9-12) was recruited from various schools across an urban and rural region. The sample was selected using a stratified random sampling technique to ensure representation across different student characteristics (age, gender, socioeconomic status) and geographic locations (Creswell & Creswell, 2017).

### **2. Measures**

#### **Computer Proficiency**

The students' computer proficiency was assessed using a standardized computer skills assessment tool. This 50-item test measured the students' abilities in areas such as word processing, spreadsheet manipulation, internet navigation, and basic programming concepts. The assessment had established reliability (Cronbach's  $\alpha = 0.88$ ) and validity (Teo, 2013).

#### **Mathematics Proficiency**

The students' mathematics proficiency was measured using a standardized mathematics achievement test. This 60-item test covered topics such as algebra, geometry, probability, and problem-solving. The test had high internal consistency



(Cronbach's  $\alpha = 0.92$ ) and had been validated against national mathematics standards (Mullis et al., 2016).

#### **Demographic Questionnaire**

Participants completed a questionnaire that collected information on their age, gender, socioeconomic status, and the geographic location of their school (urban or rural).

#### **Procedure**

The data collection was conducted during regular school hours. Students were informed about the study and provided informed consent (or parental consent for minors) before participating. They completed the computer proficiency assessment, the mathematics proficiency test, and the demographic questionnaire in a counterbalanced order to minimize order effects (Shadish et al., 2002).

### **III Data Analysis**

The data were analysed using a combination of correlational analysis, multiple regression, and structural equation modelling (SEM) techniques.

#### **1. Correlational Analysis**

Pearson's correlation coefficients were calculated to examine the bivariate relationships between computer proficiency, mathematics proficiency, and the moderating variables (student type and student location) (Cohen et al., 2003).

#### **2. Multiple Regression**

A hierarchical multiple regression analysis was conducted to predict mathematics proficiency from computer proficiency, while controlling for the moderating variables (student type and student location). The incremental variance explained by the moderating variables was assessed (Tabachnick & Fidell, 2013).

#### **3. Structural Equation Modelling**

A latent variable model was developed using SEM to test the hypothesized relationships between computer proficiency, mathematics proficiency, and the moderating variables. The model fit indices, direct and indirect effects, and group differences were examined (Kline, 2015) The statistical analyses were performed using SPSS and Mplus software. The significance level was set at  $p < .05$  for all analyses.

### **IV Theoretical Framework**

The theoretical framework underpinning the relationship between computer and mathematics proficiency encompasses several key perspectives from educational psychology and sociology. These theoretical lenses provide valuable insights into the complex dynamics shaping students' acquisition of both computer skills and mathematical knowledge, as well as the interplay between these domains.

#### **1. Cognitive Theory**

Cognitive theories posit that individuals' cognitive processes, including perception, attention, memory, and problem-solving, influence their learning and academic achievement (Perkins, 1992). Within the context of computer and mathematics proficiency, cognitive theory suggests that proficiency in one domain may facilitate the acquisition and application of skills in the other. For example, cognitive skills such as



logical reasoning and spatial visualization, which are essential for mathematical problem-solving, may also contribute to effective navigation of digital interfaces and algorithms (Schoenfeld, 1992). Additionally, cognitive load theory offers insights into how the cognitive demands of computer-based learning environments may impact students' ability to engage with mathematical tasks effectively (Sweller et al., 1998).

## **2. Socio-cultural Theory**

Socio-cultural theories emphasize the role of social and environmental factors in shaping individuals' development and learning outcomes (Vygotsky, 1978). From this perspective, proficiency in both computer and mathematics skills is situated within sociocultural contexts characterized by access to resources, social interactions, and cultural norms. For instance, students' exposure to digital technologies and computational tools may vary depending on their socioeconomic background and access to educational resources (Warschauer & Matuchniak, 2010). Moreover, socio-cultural theory highlights the importance of social interactions and collaborative learning environments in promoting both computer literacy and mathematical understanding (Lave & Wenger, 1991). By considering the socio-cultural context in which learning takes place, educators can better support students in developing holistic competencies that integrate both computer and mathematical skills.

## **3. Digital Divide Theory**

The digital divide theory addresses disparities in access to technology and the internet, which may exacerbate existing inequalities in educational attainment (DiMaggio et al., 2004). This framework acknowledges that not all students have equal opportunities to develop computer proficiency, due to factors such as socioeconomic status, geographic location, and demographic characteristics. Consequently, variations in students' access to technology and digital resources may influence their ability to acquire and apply computer skills in educational contexts. Moreover, the digital divide theory underscores the importance of addressing systemic barriers to technology access and promoting digital inclusion to ensure equitable opportunities for all students (Warschauer, 2003).

By synthesizing these theoretical perspectives, the theoretical framework for this manuscript illuminates the multifaceted nature of the relationship between computer and mathematics proficiency. It acknowledges the cognitive underpinnings of learning in both domains, considers the socio-cultural context in which learning occurs, and recognizes the systemic inequalities that shape students' access to technology and educational opportunities. Through an integrated understanding of these theoretical frameworks, educators, policymakers, and researchers can work towards fostering equitable educational environments that support the development of computer and mathematics skills for all students.

# **V Computer Proficiency and Mathematics Proficiency**

## **Review of Literature**

The relationship between computer proficiency and mathematics proficiency has garnered increasing attention in educational research, reflecting the growing importance of technology in modern education and the enduring significance of mathematical skills. A review of existing literature reveals multifaceted interactions between these two domains, with implications for teaching, learning, and educational policy.



### **1. Correlation between Computer Literacy and Mathematical Achievement**

Numerous studies have identified a positive correlation between computer literacy and mathematical achievement (Chen & Chang, 2006; Clements & Sarama, 2003). For example, Chen and Chang (2006) found that students who demonstrated higher levels of computer literacy also tended to achieve higher scores in mathematics assessments. Similarly, Clements and Sarama (2003) highlighted the potential of computer-based learning environments to enhance mathematical learning outcomes, particularly in early childhood education.

### **2. Mechanisms of Influence**

The relationship between computer proficiency and mathematics proficiency is mediated by various mechanisms that impact students' learning experiences and outcomes. Interactive educational software, simulations, and online resources offer opportunities for personalized learning experiences tailored to individual students' needs (Suh & Moyer-Packenham, 2018). These digital tools can provide scaffolding, immediate feedback, and adaptive support, facilitating deeper engagement with mathematical concepts and problem-solving skills.

### **3. Role of Computational Tools**

The advent of computational tools has transformed the teaching and learning of mathematics, offering new avenues for exploration and discovery (Hoyles et al., 2010). Computational tools enable students to visualize abstract mathematical concepts, experiment with mathematical models, and engage in authentic problemsolving tasks (Schoenfeld, 1992). By leveraging technology as a tool for mathematical exploration, students can develop a deeper understanding of mathematical concepts and enhance their problem-solving abilities.

### **4. Digital Divide and Equity Considerations**

Despite the potential benefits of integrating technology into mathematics education, disparities in access to technology and digital resources persist, contributing to inequalities in educational outcomes (Warschauer & Matuchniak, 2010). The digital divide disproportionately affects marginalized and underserved communities, exacerbating existing disparities in mathematics achievement. Addressing these equity concerns requires concerted efforts to ensure equitable access to technology and provide support for students from diverse backgrounds.

In summary, the literature demonstrates a positive association between computer proficiency and mathematics proficiency, with computer-based learning environments offering opportunities for enhancing mathematical learning outcomes. However, disparities in access to technology and digital resources underscore the importance of addressing equity considerations in educational interventions aimed at promoting both computer and mathematics skills.

## **VI. Moderating Effects of Student Type (St)**

The moderating effects of student type on the relationship between computer proficiency and mathematics proficiency offer valuable insights into how demographic characteristics shape individuals' engagement with technology and mathematics learning. Understanding these moderating effects is essential for tailoring educational interventions to meet the diverse needs of students across different demographic groups.

### **1. Age**



Age serves as a significant moderating factor in the relationship between computer and mathematics proficiency. Younger students, who have grown up in a digital native generation, often demonstrate greater comfort and proficiency in using technology compared to older students (Warschauer et al., 2004). As a result, the impact of computer proficiency on mathematics achievement may vary across different age groups, with younger students potentially benefiting more from technology-enhanced learning environments.

## **2. Gender**

Gender differences in computer science participation and perceived computer self-efficacy may moderate the relationship between computer proficiency and mathematics proficiency (Margolis & Fisher, 2002). Research suggests that male students are more likely to engage in computer-related activities and express greater confidence in their computer skills compared to female students. Consequently, the effects of computer proficiency on mathematical achievement may differ between male and female students, highlighting the importance of addressing gender disparities in technology access and participation.

## **3. Educational Level**

Educational level also influences the moderating effects of student type on the relationship between computer and mathematics proficiency. Higher levels of education may be associated with greater exposure to and proficiency in using technology, as well as more advanced mathematical skills. Consequently, the impact of computer proficiency on mathematics achievement may be more pronounced among students at higher educational levels, who have the prerequisite knowledge and cognitive abilities to leverage technology effectively for learning.

## **4. Socio-economic Status**

Socio-economic status (SES) is a critical determinant of students' access to technology and educational opportunities, with students from higher.

5. SES backgrounds typically having greater access to digital resources and support (DiMaggio et al., 2004). As such, SES may moderate the relationship between computer proficiency and mathematics proficiency, with disparities in technology access and support exacerbating existing inequalities in educational outcomes. Efforts to address the digital divide and promote digital inclusion are essential for ensuring equitable opportunities for all students to develop computer and mathematics skills. In summary, student type serves as a significant moderator of the relationship between computer proficiency and mathematics proficiency, with age, gender, educational level, and socio-economic status influencing how students engage with technology and mathematics learning. Recognizing these moderating effects is crucial for designing inclusive educational interventions that cater to the diverse needs of students across different demographic groups.

The moderating effects of student location on the relationship between computer proficiency and mathematics proficiency highlight the influence of geographic context on students' access to technology and educational resources. Understanding these moderating effects is essential for addressing disparities in educational outcomes between students in urban and rural areas.

## **Infrastructure and Access**



Geographic location significantly impacts students' access to technology and digital resources. Urban areas typically have better technological infrastructure, including high-speed internet access and modern computing facilities, compared to rural areas (Warschauer, 2003). As a result, students in urban settings may have greater opportunities to develop computer proficiency through exposure to technology-rich environments both in and out of school.

#### **Technological Integration in Education**

The extent to which technology is integrated into educational practices varies between urban and rural schools. Urban schools may have greater access to educational software, online resources, and interactive whiteboards, facilitating the incorporation of technology into mathematics instruction (Warschauer & Matuchniak, 2010). In contrast, rural schools may face challenges in adopting technology due to limited resources and infrastructure, potentially affecting students' opportunities to develop computer and mathematics skills.

#### **Community Support and Digital Literacy**

Geographic location also influences students' access to community support and extracurricular opportunities related to technology and mathematics. Urban areas may offer a more supportive ecosystem for fostering digital literacy through community centers, libraries, and technology-focused programs (Warschauer, 2003). In contrast, rural communities may have fewer resources and opportunities for students to engage in technology-related activities outside of school, potentially impacting their computer proficiency and mathematical achievement.

#### **Socio-economic Factors**

The moderating effects of student location are intertwined with socio-economic factors, as rural areas often experience higher levels of poverty and socio-economic disadvantage compared to urban areas (DiMaggio et al., 2004). Limited access to technology and educational resources in rural communities may exacerbate existing inequalities in educational outcomes, particularly for students from low-income backgrounds.

In summary, student location serves as a significant moderator of the relationship between computer proficiency and mathematics proficiency, with disparities in access to technology and educational resources between urban and rural areas influencing students' opportunities for learning and skill development. Addressing these moderating effects requires concerted efforts to bridge the digital divide and ensure equitable access to technology and high-quality education for all students, regardless

Implications for Practice and Policy

The findings presented in this manuscript have significant implications for educators, policymakers, and stakeholders in education. Addressing the relationship between computer proficiency and mathematics proficiency, along with the moderating effects of student type and location, requires strategic interventions at both the classroom and policy levels. The following implications highlight key recommendations for practice and policy:

#### **Integrating Technology in Mathematics Instruction**

Educators should prioritize the integration of technology into mathematics instruction to enhance students' mathematical learning experiences. Providing access to educational software, online resources, and interactive tools can help engage students



in meaningful mathematical exploration and problem-solving (Suh & MoyerPackenham, 2018). Professional development programs for teachers should also focus on building digital literacy skills and effective pedagogical strategies for leveraging technology in mathematics education.

#### **Addressing Equity in Technology Access**

Policymakers and educational leaders must work to address disparities in technology access and digital resources between different student populations. Initiatives aimed at bridging the digital divide should prioritize providing equitable access to technology and internet connectivity for students from underserved communities (DiMaggio et al., 2004).

This may involve investing in infrastructure upgrades, expanding broadband internet coverage in rural areas, and providing financial support for technology acquisition in schools.

#### **Tailoring Educational Interventions to Student Characteristics**

Recognizing the moderating effects of student type, such as age, gender, educational level, and socioeconomic status, educators should implement differentiated instructional strategies that cater to the diverse needs of students (Margolis & Fisher, 2002). For example, personalized learning approaches that adapt to students' individual learning styles and preferences can help accommodate variations in computer and mathematics proficiency across different demographic groups.

#### **Promoting Digital Literacy and STEM Education**

Policymakers should prioritize initiatives aimed at promoting digital literacy and STEM (Science, Technology, Engineering, and Mathematics) education from an early age. This may involve curriculum reforms that integrate computational thinking and problem-solving skills into mathematics education, as well as expanding opportunities for hands-on learning experiences with technology (Hoyles et al., 2010). Collaborations between schools, industry partners, and community organizations can also facilitate experiential learning opportunities and career pathways in STEM fields.

#### **Fostering Collaboration and Knowledge Sharing**

Educators, policymakers, and researchers should collaborate to share best practices, resources, and research findings related to the integration of technology and mathematics education. Professional learning communities and interdisciplinary networks can provide opportunities for educators to exchange ideas, collaborate on curriculum development, and stay abreast of emerging trends in educational technology

(Schoenfeld, 1992). Additionally, funding agencies should prioritize research that investigates effective approaches for leveraging technology to enhance mathematics learning outcomes.

In conclusion, addressing the relationship between computer proficiency and mathematics proficiency requires a multifaceted approach that encompasses both classroom practices and systemic policy interventions. By integrating technology into mathematics instruction, addressing equity in technology access, tailoring interventions to student characteristics, promoting digital literacy and STEM education, and fostering collaboration and knowledge sharing, educators and policymakers can work together to ensure that all students have the opportunity to develop the computer and mathematics skills needed for success in the digital.



## VII Future Direction and Conclusion

The exploration of the relationship between computer proficiency and mathematics proficiency, considering the moderating effects of student type and location, opens avenues for future research and practice in education. As technology continues to evolve and shape the educational landscape, and as demographic shifts and socio-economic disparities persist, there are several key areas that warrant further investigation and action.

### 1. Longitudinal Studies

Future research should employ longitudinal designs to examine the long-term effects of technology integration on students' mathematics achievement and career trajectories. Longitudinal studies can provide insights into how early exposure to technology and digital learning environments influences students' development of mathematical skills over time and their eventual participation in STEM fields (Warschauer & Matuchniak, 2010).

### 2. Culturally Responsive Pedagogy

There is a need for research that explores culturally responsive pedagogical approaches to integrating technology into mathematics instruction, particularly for students from diverse cultural backgrounds. Culturally relevant curriculum design, instructional materials, and teaching strategies can enhance students' engagement and achievement in mathematics, bridging cultural and linguistic barriers to learning (Gay, 2010).

### 3. Equity in Technology Access

Efforts to address equity in technology access should extend beyond infrastructure improvements to encompass broader systemic changes. Policymakers should prioritize initiatives that promote digital inclusion and provide targeted support for underserved communities, including initiatives aimed at increasing parental involvement in technology education and fostering community partnerships (DiMaggio et al., 2004).

### 4. Teacher Preparation and Professional Development

Professional development programs for teachers should emphasize the integration of technology into mathematics instruction and provide educators with the skills and knowledge needed to effectively leverage digital tools and resources. Pre-service teacher preparation programs should incorporate coursework and field experiences focused on technology integration, while ongoing professional development opportunities should support teachers in staying current with emerging technologies and pedagogical practices (Niess, 2005).

In conclusion, the relationship between computer proficiency and mathematics proficiency, moderated by student type and location, represents a complex interplay of factors that influence students' learning experiences and outcomes. By addressing the implications outlined in this manuscript and pursuing future research directions, educators, policymakers, and stakeholders can work together to create inclusive educational environments that empower all students to develop the computer and mathematics skills necessary for success in the 21st century.

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