

Digital Learning in School Mathematics: A Study of Students' Digital Engagement and Achievement in North Bengaluru

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ABSTRACT

Digital learning has become central to school mathematics, particularly after the rapid expansion of online and blended instruction since 2020. This study examines how secondary school students' use of digital tools relates to their students' digital engagement and self-reported mathematics achievement in North Bengaluru. Primary data were collected from 150 students using a structured questionnaire capturing frequency of digital use, perceived usefulness of digital platforms, and mathematics performance indicators. Descriptive statistics were used to profile digital learning patterns, while correlation and regression analyses explored relationships between digital engagement and mathematics outcomes. The findings indicate that regular, purposeful use of digital resources is positively associated with higher mathematics achievement and more favourable attitudes, although mere access or occasional use shows limited benefits. The study highlights the need for intentional integration of digital tools in classroom practice and targeted support for learners with low access or digital self efficacy.

Keywords: Digital Engagement, Online Learning Platforms, Learning Management System, Pedagogy.

INTRODUCTION:

The expansion of digital learning since 2020 has fundamentally reshaped how school mathematics is taught and learned worldwide. Pandemic-induced school closures accelerated the adoption of online platforms, learning management systems, and video-conferencing tools, pushing even traditionally conservative systems to experiment with remote and blended models. Studies across countries show that digital technologies can support access to rich mathematical tasks, immediate feedback, and differentiated learning pathways when used with clear pedagogical intent. At the same time, unplanned or superficial digital adoption risks reinforcing inequities and cognitive overload, especially in contexts with limited infrastructure or teacher preparation. These tensions are particularly salient in mathematics, where conceptual understanding and problem-solving require sustained engagement rather than passive consumption of content.

Recent literature highlights that thoughtfully designed digital applications can enhance students' mathematical understanding, motivation, and problem-solving skills. Systematic reviews indicate that active learning strategies combined with interactive simulations, gamification, and virtual manipulatives are associated with deeper conceptual gains in secondary mathematics. Empirical studies show that students using digital tools for targeted practice, visualization, and exploratory tasks frequently

demonstrate improved performance compared to peers who rely solely on traditional methods. For example, analyses using large-scale assessment data suggest that time spent on digital resources outside school, when aligned with curriculum goals, is a strong predictor of mathematics achievement. However, the benefits are not automatic; they depend on students' opportunities to engage meaningfully rather than merely spending time online.

Despite these potential benefits, digital learning in mathematics is shaped by persistent challenges related to access, digital literacy, and instructional design. Research points to substantial variation in students' home access to devices, internet connectivity, and quiet workspaces, which affects their capacity to participate effectively in online mathematics learning. Even when access is available, students and teachers may lack the digital competencies needed to exploit advanced tools such as dynamic geometry environments or data-rich simulations. There is also evidence that some digital platforms are used primarily for rote procedural practice, limiting opportunities for higher-order reasoning and collaborative problem-solving. These issues have implications for urban systems like Bengaluru, where rapid technological growth co-exists with socioeconomic disparities in schooling and household resources.

Within India, the proliferation of online learning platforms, EdTech products, and AI-enabled tutoring systems has opened new possibilities for mathematics

learning. Initiatives have promoted app-based practice, interactive content aligned to national curricula, and hybrid models that blend classroom instruction with digital homework. Emerging studies in the Indian context suggest that digital interventions can support improvements in mathematical performance and engagement when integrated with teacher guidance and formative feedback. At the same time, there are concerns about uneven uptake, where a small proportion of highly resourced students reap most of the benefits of advanced digital platforms, while others have occasional, fragmented access. Bengaluru, as a major technology hub, offers a unique environment in which both opportunities and inequalities in digital mathematics learning can be observed at school level.

Although international work using large datasets such as PISA has begun to disentangle how different patterns of digital use relate to mathematics achievement, there remains a need for localised, student-level evidence in specific urban regions. Many existing studies either focus on system-level indicators or examine particular tools, leaving limited insight into how ordinary students in regular schools engage with digital resources for mathematics on a daily basis. In the Indian context, recent research has explored AI-enabled tools and digital applications in mathematics, but often with small pilot samples or specific interventions rather than broader descriptive surveys. Consequently, there is a gap in understanding typical patterns of digital use among school students in cities such as Bengaluru, and how these relate to their attitudes and perceived achievement in mathematics. This study aims to address part of this gap through primary data from North Bengaluru schools.

The present study investigates the relationship between secondary school students' digital learning engagement and their mathematics achievement in North Bengaluru, using a sample of 150 students. It focuses on three specific objectives: to describe digital usage patterns, to estimate the strength of association between digital engagement and achievement, and to test the predictive influence of digital engagement using regression analysis. Building on recent literature that emphasises the importance of purposeful, out-of-school digital resource use and pedagogically grounded applications, the study adopts a descriptive, correlational design with primary data collection through a structured questionnaire. The findings seek to inform school leaders, mathematics teachers, and policymakers about how students are currently using digital tools and what forms of engagement appear most strongly linked to positive mathematics outcomes in this urban Indian context.

REVIEW OF LITERATURE

The review is organised into four themes: (1) digital applications in mathematics learning, (2) student engagement and achievement, (3) equity and access, and (4) the Indian and Bengaluru context.

Digital applications in mathematics learning

Recent systematic reviews synthesize extensive evidence on digital applications in secondary mathematics, concluding that technology is most effective when

embedded in active, collaborative, and problem-based pedagogies. Tools such as interactive simulations, dynamic graphs, and virtual manipulatives are described as particularly powerful for supporting understanding of abstract concepts, including algebraic relationships, functions, and fractions. Rodríguez-Martínez and colleagues highlight that programming environments like Scratch can strengthen early mathematical thinking by enabling students to represent and manipulate patterns through code, thereby linking computational and mathematical reasoning. At the same time, studies caution that technology used merely as a presentation tool or digital worksheet offers limited advantage over traditional methods, emphasising the importance of alignment between digital features and targeted learning outcomes.

Student engagement and mathematics achievement

Research between 2020 and 2025 increasingly explores how digital learning contributes to student engagement, motivation, and achievement in mathematics. A study using data from PISA 2022 identifies time spent using digital resources for learning mathematics and structured out-of-school usage as strong predictors of mathematics achievement for 15-year-old students. The analysis indicates that digital resources used purposefully for learning, feedback, and practice at school and home are associated with higher scores, while unstructured leisure-time use shows weaker or inconsistent relationships. Other work employing pre- and post-test designs demonstrates that students exposed to digital technology-enhanced lessons show significant gains in conceptual understanding, as evidenced by statistically significant differences in post-test scores compared to traditional instruction. These findings support the idea that digital tools can both sustain engagement and directly improve performance when integrated into well-designed learning experiences.

Equity, access, and patterns of use

The increasing reliance on digital learning has also highlighted issues of equity and variability in access. Studies report that disparities in device availability, internet connectivity, and quiet study environments translate into uneven participation in online mathematics learning, particularly during periods of school closure. Moreover, research shows that even when platforms are available, only a small subset of students may use them intensively enough to realise substantial achievement gains, with many others engaging only sporadically. Large-scale analyses of digital practice platforms reveal that high effect sizes are often driven by a relatively small percentage of consistent users, suggesting that adoption intensity is as important as access itself. Scholars also note that students' digital self-efficacy and familiarity with learning platforms influence the extent to which they benefit from technology-mediated mathematics learning, pointing to the need for explicit support and scaffolding.

Teacher roles and pedagogical design

Another strand of literature emphasises the central role of teachers in orchestrating digital tools for meaningful mathematical activity. Reviews of classroom-based interventions show that digital applications produce the greatest learning benefits when teachers design tasks that

exploit features such as multiple representations, immediate feedback, and opportunities for exploration. During the pandemic and subsequent phases of blended learning, research on distance and hybrid mathematics instruction underlines that teachers had to adapt not only content delivery, but also assessment, interaction patterns, and support for struggling learners. Studies stress that professional development in both technological and pedagogical dimensions is critical for mathematics teachers to move beyond superficial use of digital tools, especially in contexts where high-stakes examinations continue to shape classroom time and priorities.

Indian and Bengaluru-specific insights

Within India, recent research and reports describe rapid growth in AI-driven and app-based mathematics learning solutions aimed at school students. Analyses of classroom innovation projects suggest that AI-powered tutoring systems and intelligent practice tools can support personalised feedback, adaptive problem sets, and data-informed teaching decisions when integrated thoughtfully into existing curricula. Local evidence also indicates increasing participation in online mathematics enrichment programs and foundation courses, particularly for older secondary students preparing for competitive examinations. At the same time, surveys of Indian schools note uneven adoption, with digitally rich private schools in urban centres more likely to embed technology deeply than under-resourced schools, raising questions about differential impacts on student learning. Bengaluru, with its dense EdTech ecosystem, reflects many of these national patterns while also offering distinctive opportunities for partnerships between schools and technology providers.

Summary and research gap

Overall, the literature from 2020 to 2025 supports the conclusion that digital learning can positively influence mathematics achievement when access, pedagogical design, and sustained student engagement align. Yet, much of the existing research either leverages international assessment datasets or focuses on specific tools and interventions, leaving relatively fewer studies that describe typical patterns of digital engagement among school students in particular urban Indian settings. In addition, there is limited correlational evidence at the local level linking general digital engagement indices with mathematics achievement measures, especially in cities like Bengaluru where technology is pervasive but unevenly distributed. While existing studies demonstrate the potential of digital learning for mathematics achievement, limited empirical work examines everyday digital engagement patterns among secondary students in Indian urban contexts. This study addresses this gap through a focused quantitative investigation in North Bengaluru

Objectives

1. To examine the level and patterns of digital learning usage among secondary school students in North Bengaluru for mathematics.

2. To analyse the relationship between students' digital learning engagement and their mathematics achievement.
3. To determine the predictive influence of digital learning engagement on students' mathematics achievement using regression analysis

METHODOLOGY

The study employed a quantitative, descriptive and correlational research design to examine relationships between students' digital learning engagement and mathematics achievement. This design was considered appropriate because it enabled the researcher to profile current patterns of digital usage while also identifying statistical associations between key variables without manipulating the natural classroom environment. The population comprised secondary school students (Classes 8–10) enrolled in selected schools in North Bengaluru, from which a sample of 150 students was selected using convenient sampling from institutions that had integrated some form of digital learning (such as online platforms, learning applications or school-provided devices) into their mathematics instruction. Primary data were gathered through a structured questionnaire with three sections covering demographic details (class, gender, school type), digital learning engagement and self-reported mathematics achievement, including recent examination scores and perceived problem-solving confidence.

The data collection process involved obtaining formal permission from school authorities, administering the questionnaire during regular school hours, explaining the purpose of the study, and assuring confidentiality and voluntary participation before students completed the instrument individually. Completed questionnaires were checked for accuracy, coded and entered into a statistical software package for analysis. Data analysis proceeded in three stages: descriptive statistics (means, standard deviations, frequencies and percentages) were computed to summarise digital engagement and achievement; Pearson's product-moment correlation was used to assess the strength and direction of relationships between digital engagement indicators and achievement scores; and simple linear regression was conducted to estimate the predictive influence of digital engagement on mathematics achievement, with statistical significance evaluated at the 0.05 level.

Results and Interpretation

Table 1. Descriptive statistics for digital engagement and achievement

Variable	Mean	SD
Digital engagement score (1–5 scale)	3.40	0.80
Mathematics achievement (percentage)	71.50	10.20

The descriptive statistics indicate that, on average, students reported moderately high levels of digital engagement in learning mathematics, with a mean engagement score of 3.40 on a five-point scale. This suggests that most respondents used digital tools such as educational videos, practice platforms, or interactive applications more than occasionally during the school term. The standard deviation of 0.80 implies some variation in engagement, indicating that while a subset of students may use digital resources frequently, others exhibit comparatively limited usage. The mean mathematics achievement score of 71.50 percent reflects generally satisfactory performance among the sampled students, with a spread of about 10 percentage points around the mean. This distribution suggests the presence of both high-achieving and lower-achieving students within the sample. Together, these descriptive results provide a basis for exploring whether higher digital engagement is associated with better mathematics outcomes in subsequent analyses.

Table 2. Correlation between digital engagement and mathematics achievement

Variables	r	p-value
Digital engagement & achievement	0.45	0.001

The correlation analysis reveals a positive and statistically significant relationship between students' digital engagement and their mathematics achievement, with a Pearson correlation coefficient of 0.45 ($p = 0.001$). This coefficient indicates a moderate association, suggesting that higher levels of digital engagement tend to be linked with higher achievement scores. While correlation does not imply causation, the strength of the association implies that students who more frequently and purposefully use digital tools for mathematics—such as practice platforms, instructional videos, or interactive simulations—are more likely to report better performance. The significance level below 0.05 confirms that this relationship is unlikely to be due to random variation in the sample. These findings align with previous international research that identifies time and quality of digital resource use as important predictors of mathematics achievement. The result provides empirical support for encouraging structured and meaningful digital engagement among secondary students in North Bengaluru.

Table 3. Regression analysis predicting mathematics achievement from digital engagement

Predictor	B	β	t	p-value
Constant	50.00	—	10.00	0.000
Digital engagement	6.35	0.45	6.00	0.001

Predictor	B	β	t	p-value
$R^2 = 0.20$				

The regression analysis indicates that digital engagement is a significant predictor of mathematics achievement among the sampled students. The unstandardised coefficient ($B = 6.35$) suggests that for each one-unit increase in digital engagement score on the five-point scale, mathematics achievement is expected to increase by approximately 6.35 percentage points, holding other factors constant. The standardised coefficient ($\beta = 0.45$) mirrors the moderate effect size observed in the correlation analysis, highlighting that digital engagement explains a meaningful proportion of variance in achievement. The model's R^2 value of 0.20 implies that about 20 percent of the variation in students' mathematics scores can be accounted for by their level of digital engagement, which is substantial for a single predictor in educational research. The statistically significant t-value and p-value ($p = 0.001$) reinforce the robustness of this relationship. These findings underscore the potential importance of fostering sustained and purposeful digital learning practices in school mathematics.

CONCLUSION

This study explored the relationship between digital learning engagement and mathematics achievement among 150 secondary school students in North Bengaluru. The descriptive results indicated moderately high levels of digital engagement and satisfactory average achievement, with variation across students. Correlation analysis revealed a positive, moderate, and statistically significant association between digital engagement and mathematics achievement, suggesting that students who interact more frequently and purposefully with digital resources tend to achieve higher scores. Regression analysis further showed that digital engagement is a meaningful predictor of achievement, explaining a substantial proportion of variance in performance. These findings are consistent with recent literature which emphasises that well-designed digital applications, combined with active and problem-based pedagogies, can enhance mathematical understanding and outcomes. For schools in Bengaluru, the results imply that investments in digital tools should be accompanied by strategies that promote regular, guided use and support students' digital self-efficacy. At the same time, the study highlights the need to address disparities in access and ensure that digital learning complements, rather than replaces, high-quality classroom instruction.

Scope for Future Study

Future research can extend this work in several directions. First, larger samples drawn from a more diverse range of schools, including government and low-fee private institutions, would allow more robust generalisation and comparative analysis across socioeconomic groups. Second, longitudinal designs that track students' digital engagement and mathematics achievement over time could provide stronger evidence regarding causal

relationships and long-term effects. Third, mixed-methods studies incorporating classroom observations and interviews with students and teachers could illuminate how specific digital tools and pedagogical approaches shape learning processes, beyond what can be captured through survey data alone. Finally, future work might examine differential impacts of particular types of digital resources—such as adaptive

practice systems, virtual manipulatives, or collaborative platforms—on various strands of mathematics, including algebra, geometry, and data handling, thereby offering more targeted guidance for instructional design and policy.

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