Impact of the COVID-19 Pandemic on Teaching Delivery and Student Learning Outcomes: A Quantitative and Computational Analysis

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***Abstract*—This study investigated the impact of the COVID-19 pandemic on teaching delivery and student learning outcomes across pre-, during-, and post-pandemic phases using a quantitative, computational framework supported by Python-based analysis. Data from 600 students, combining survey responses and institutional records, revealed significant declines in academic performance, attendance, and engagement during the pandemic, with only partial recovery afterward. Comparative analysis highlighted widening disparities between urban and rural learners and between public and private schools, driven largely by digital access and institutional readiness. Correlation and regression results identified pre-pandemic performance and student engagement as the strongest predictors of pandemic-era achievement, while teacher support contributed indirectly by enhancing engagement. The study concludes that the pandemic exposed systemic inequities but also accelerated digital transformation in education. It recommends strengthening digital infrastructure, teacher training, student support, and flexible, blended learning models to build a resilient and equitable education system.**

***Index Terms*—COVID-19 Education, Learning Outcomes, Digital Divide, Student Engagement**

I. INTRODUCTION

Teaching is a purposeful, systematic, and dynamic process through which educators design, organize, and facilitate learning experiences that help students acquire knowledge, develop skills, and cultivate attitudes essential for lifelong success. A teaching method represents *how* instruction is delivered—shaped by the teacher's philosophy, pedagogical beliefs, subject demands, learner characteristics, and classroom context. Contemporary education acknowledges that no single method can meet all learners' needs; rather, effective teaching requires a flexible blend of approaches, strategies, and techniques tailored to diverse learning styles and environments. Traditional teacher-centred methods, such as lectures and demonstrations, remain important for delivering foundational knowledge and structuring complex concepts. However, modern pedagogy increasingly emphasizes student-centred approaches like discussion, inquiry-based learning, project-based learning, and collaborative learning. These methods encourage students to question, explore, create, and apply knowledge in meaningful contexts. They also promote 21st-century competencies such as critical thinking, creativity, communication, and problem-solving. The integration of assessment—both formative and summative—within instruction further helps teachers monitor learning progress, identify gaps, and provide timely feedback.

Students learn not only through direct instruction but also through experiential activities, interaction, questioning, using multiple senses, making connections with prior knowledge, and repeated practice. Understanding diverse learning styles—visual, auditory, kinaesthetic, reading/writing, reflective, solitary, social, sequential, and global—helps teachers design inclusive learning experiences that respect individual differences and ensure educational equity. The COVID-19 pandemic profoundly affected global education systems, highlighting both the possibilities and limitations of contemporary teaching methodologies. The abrupt shift to online learning exposed deep digital divides, created learning losses, and heightened mental health concerns, while also pushing educators to innovate

through digital tools, hybrid models, and flexible teaching approaches. It prompted reflection on curriculum priorities, assessment reforms, inclusive education, and the need for resilient, technology-enabled systems. The crisis accelerated the shift from content memorization to skill-focused, competency-based learning, and underscored the value of global collaboration and policy reforms. Thus, understanding teaching methods in the post-pandemic era requires a holistic view of pedagogy—one that integrates technology, promotes equity, and prepares learners for an increasingly complex and interconnected world.

II. RELATED REVIEWS

Dickinson and Griffiths (2025) examined how university lecturers navigated issues of time, continuity, and pedagogical change amid increasing expectations for flexibility and digital innovation in post-1992 UK institutions. Using an abductive, socio-material lens influenced by spatial theory, they analysed lecturers' responses to evolving delivery modes during and after the COVID-19 pandemic. Their findings centred on three themes—reshaping practice, negotiating teaching spaces, and maintaining control—which together highlighted how digital tools acted as new pedagogical artefacts. The study contributed insight into lecturers' sense-making processes, technological affordances, and strategic adaptations required for future blended and hybrid higher-education models.

Rampersad et al. (2024) addressed a research gap by investigating optometry educators' teaching-style preferences and their experiences with online teaching during the pandemic. Using a case-study design, they collected survey and interview data guided by the Grasha-Riechmann Teaching Style Inventory, categorising educators as Experts, Formal Authorities, Demonstrators, Facilitators, or Delegators. Descriptive statistics and thematic analysis revealed shifts in instructional approaches, varied comfort with online platforms, and mixed attitudes toward remote teaching. Their study underscored how pandemic-driven disruptions reshaped pedagogical choices and highlighted the need for professional support to strengthen digital teaching competence within optometry education.

Aizenberg and Zilka (2023) analysed distance-teaching practices among first-year early-childhood preservice teachers during the COVID-19 lockdown in Israel. Using qualitative methods with 32 female participants, they identified three teaching clusters: synchronous instruction, asynchronous messaging, and task-initiated distance teaching. Themes included communication, interaction, personal traits, attitudes, and technological readiness. Their findings showed that differences in creativity, perseverance, autonomy, and e-readiness shaped teaching effectiveness and resilience. Experience and competence in digital environments emerged as key factors influencing preservice teachers' confidence and instructional adaptability, highlighting the importance of targeted preparation for remote early-childhood teaching.

Vidergor (2023) explored how teachers' self-innovativeness influenced their distance-learning practices following the abrupt shift to online instruction during COVID-19. Surveying 200 Israeli elementary and secondary teachers, the study examined relationships among innovativeness, self-efficacy, accountability, and teaching quality. Results indicated that teachers who perceived themselves as more innovative reported higher confidence and stronger distance-learning practices. Work experience significantly shaped self-innovativeness, with older teachers rating themselves more innovative than younger colleagues. The study recommended professional development that strengthens teachers' innovative capacities and supports implementation of hybrid models tailored to evolving post-pandemic educational needs.

Nikolopoulou (2022) investigated Greek early-primary teachers' experiences with online teaching for children aged 4–8 during COVID-19. Interviews with 14 teachers revealed initial negative attitudes that gradually shifted toward more positive perceptions as familiarity increased. Reported challenges included technological limitations, insufficient resources, minimal parental support, and lack of online-teaching training. Despite this, teachers acknowledged children's surprisingly quick adaptation and the role of technology in maintaining learning continuity. The study recommended strengthening digital literacy, ensuring adequate resources, and enhancing parental involvement to improve early-years online instruction in future crises.

Drijvers et al. (2021) explored how mathematics teachers in Flanders, Germany, and the Netherlands adapted their instruction during COVID-19 school

closures. Using extensive online questionnaires (N = 1,719), they examined shifts in beliefs, didactics, and assessment practices. Findings showed heavy reliance on general video-conferencing tools, with reduced use of subject-specific digital resources compared to pre-pandemic teaching. Teacher confidence with technology was generally high, while national policy differences influenced implementation. The study emphasized the need to examine long-term impacts on teacher attitudes and student learning, as well as sustained digital-tool integration in mathematics education.

Kim (2020) described early-childhood online learning as a necessary adaptation during the COVID-19 pandemic, despite ongoing debates around young children's screen exposure. The article detailed the redesign of a preservice teacher education module in the United States to prepare student teachers for remote ECE instruction. It outlined three phases—Preparation, Implementation, and Reflection—through which preservice teachers practised digital pedagogy, interacted with children online, and reflected on communication strategies suitable for early learners. The study concluded that structured online practicum experiences supported preservice teachers' competence and adaptability in technology-mediated early-childhood teaching.

Nel and Marais (2018) examined the "wicked feedback problem" in preservice teacher practicum, where students needed timely, actionable, and cognitively engaging feedback. Using action research with 15 preservice teachers and two educators in South Africa, they evaluated technology-enhanced feedback using digital screen recordings. Findings showed that personalised, visual feedback boosted student motivation, improved engagement with assessment, and strengthened educator-student connections. Participants reported enhanced clarity and greater confidence in their teaching performance. The study suggested that technology-mediated feedback has strong potential for improving practicum quality and should be sustained as teaching increasingly incorporates digital elements.

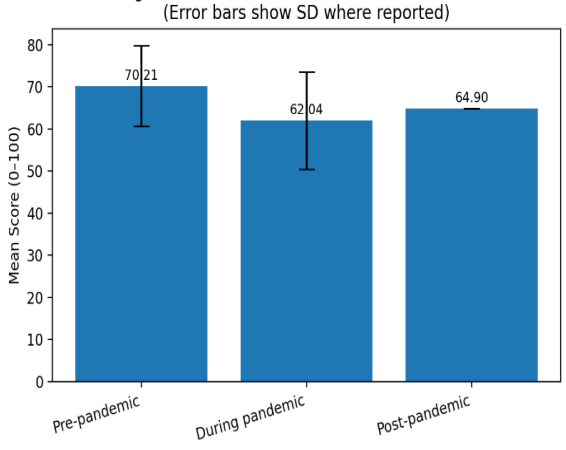
III. RESEARCH METHODOLOGY

This chapter outlines the quantitative methodology used to assess the impact of COVID-19 on teaching delivery and student learning outcomes. A positivist, data-driven design was adopted, combining survey-based primary data with secondary academic records from 600 stratifiedly sampled urban and rural students across public and private schools. Python served as the core analytical environment for data cleaning, descriptive analysis, comparative assessment, hypothesis testing, correlation mapping, and regression modelling. Descriptive statistics highlighted overall declines in scores, attendance, and engagement during the pandemic, while comparative analysis revealed disparities across regions and school types. A paired-sample t-test confirmed significant performance drops, and correlation and regression analyses identified pre-pandemic scores, engagement, teacher support, and institutional context as major predictors of during-pandemic performance. Visualisations generated through Matplotlib and Seaborn enhanced interpretation and clarity. This computationally integrated, statistically rigorous methodology ensures accuracy, reproducibility, and meaningful insights into how the pandemic reshaped student learning.

IV. RESULTS AND DATA ANALYSIS

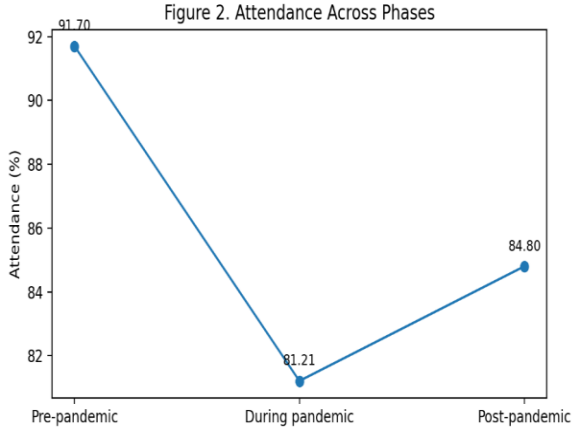
This section presents the results of a quantitative analysis of 600 secondary students, using Python (Pandas, NumPy, SciPy, Scikit-learn, Matplotlib, Seaborn) to evaluate the impact of COVID-19 on teaching delivery and learning outcomes. Cleaned and encoded data (urban/rural, public/private, gender, grade 9–12) combined primary survey responses (engagement, teacher support: 1–5 scale) with secondary records (scores, attendance: 0–100) across three phases.

Figure 1. Mean Academic Scores Across Phases
(Error bars show SD where reported)



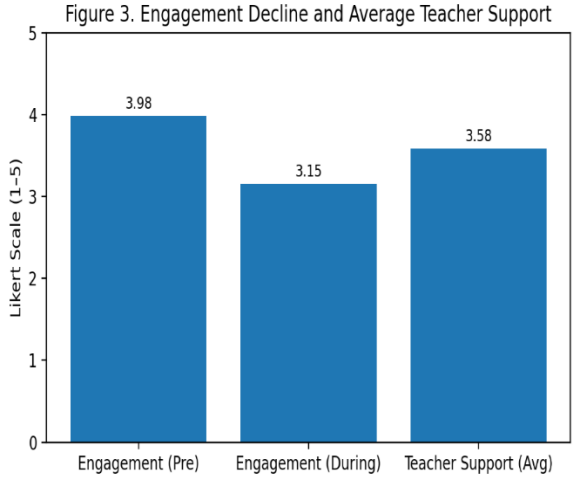
This figure illustrates the variation in students' mean academic scores across pre-pandemic, during-pandemic, and post-pandemic phases. A substantial decline in performance is observed during the pandemic, followed by partial recovery afterward. The trend highlights significant learning loss due to prolonged disruption and incomplete academic recovery post-COVID-19.

Figure 2. Attendance Across Phases



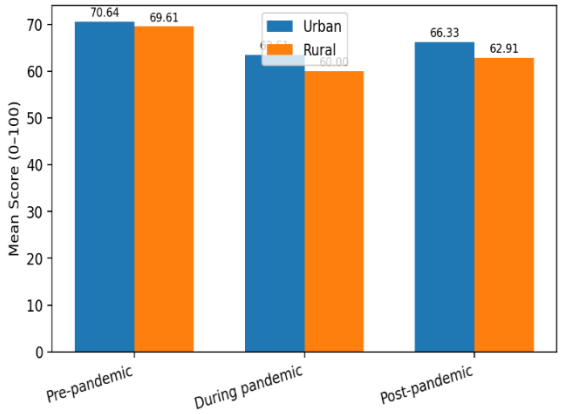
The figure depicts changes in student attendance rates before, during, and after the COVID-19 pandemic. Attendance declined sharply during the pandemic, reflecting disengagement and access barriers, and improved modestly in the post-pandemic phase. However, attendance levels did not fully return to pre-pandemic norms, indicating lingering participation challenges.

Figure 3. Engagement Decline and Average Teacher Support



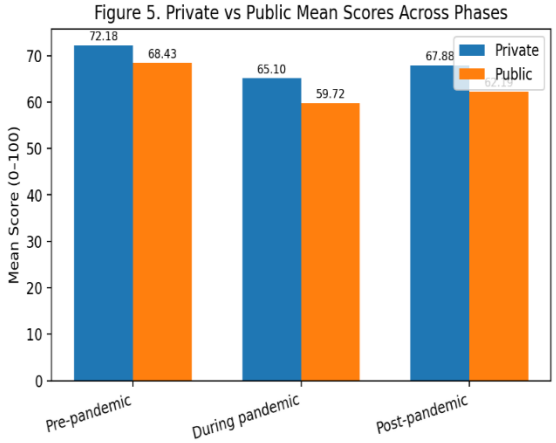
This figure compares student engagement levels before and during the pandemic alongside average perceived teacher support. Engagement declined notably during the pandemic, whereas teacher support remained moderate. The pattern suggests that while teachers provided support, structural and digital constraints limited student engagement in remote learning environments.

Figure 4. Urban vs Rural Mean Scores Across Phases

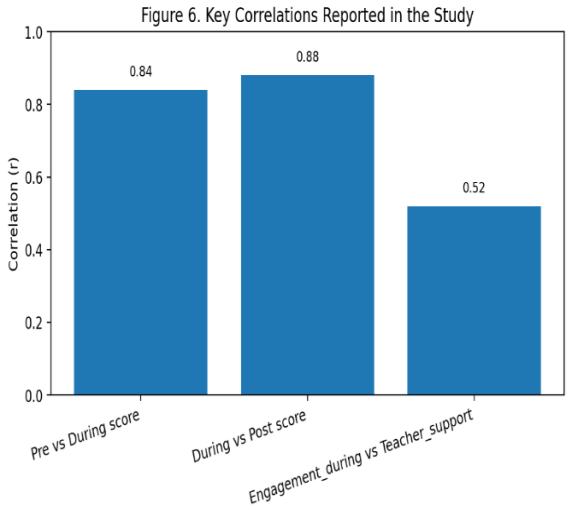


This figure presents a comparative analysis of mean academic scores of urban and rural students across three phases. Urban students consistently outperformed rural counterparts, with the gap widening during the pandemic. The findings underscore the role of digital access, infrastructure, and learning resources in shaping educational inequality.

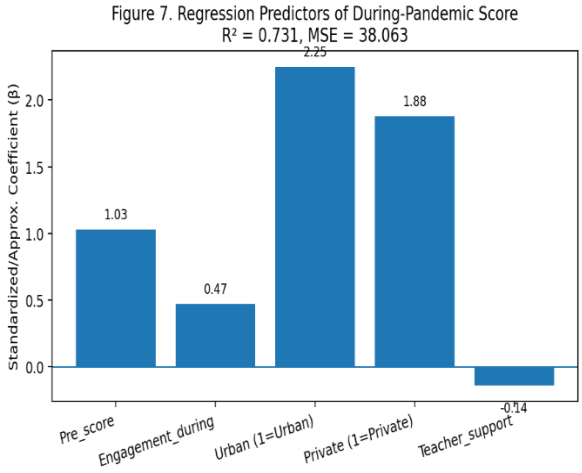
Figure 5. Private vs Public Mean Scores Across Phases



The figure compares academic performance between private and public-school students before, during, and after the pandemic. Private school students maintained higher scores across all phases, particularly during COVID-19. This highlights disparities in institutional readiness, digital infrastructure, and pedagogical support between school sectors.



This figure summarizes key correlations among academic scores and engagement variables. Strong positive relationships are observed between pre- and during-pandemic scores, and between during- and post-pandemic scores. A moderate correlation between engagement and teacher support emphasizes engagement as a critical mediator of academic performance during crisis periods.



This figure displays regression coefficients identifying predictors of academic performance during the pandemic. Pre-pandemic achievement and student engagement emerged as the strongest positive predictors, while urban location and private schooling also contributed significantly. Teacher support showed a compensatory effect, reflecting targeted assistance to lower-performing students.

V. FINDINGS FROM STUDY

Descriptive statistics showed a clear decline in performance: mean pre-pandemic score was 70.21 (SD 9.62), dropping to 62.04 (SD 11.57) during the pandemic, with partial recovery to 64.90 post-pandemic. Attendance fell from 91.70% (pre) to 81.21% (during) and rose to 84.80% (post). Engagement decreased from 3.98 to 3.15, while perceived teacher support averaged 3.58. Comparative analysis revealed consistent gaps: urban students (pre 70.64; during 63.51; post 66.33) outperformed rural students (pre-69.61; during 60.00; post 62.91); private school students (pre 72.18; during 65.10; post 67.88) outscored public school students (pre 68.43; during 59.72; post 62.19). A paired t-test confirmed a significant pre–during performance drop (mean difference −8.17; $t = 33.276$; $p < 0.001$). Correlation analysis showed strong links between pre- and during-pandemic scores ($r = 0.84$), during- and post-scores ($r = 0.88$), and a notable association between engagement_during and teacher_support ($r = 0.52$). Multiple regression explaining during-pandemic scores ($R^2 = 0.731$; MSE = 38.063) identified pre_score ($\beta \approx 1.03$), engagement_during ($\beta \approx 0.47$), urban area ($\beta \approx 2.25$) and private school ($\beta \approx 1.88$) as major positive predictors, while teacher_support ($\beta \approx -0.14$) reflected compensatory support for weaker students. Overall, results confirm significant learning loss, widened urban–rural and public–private gaps, and the central role of engagement, prior achievement, and digital inequality in shaping outcomes.

VI. CONCLUSION

This study examined how the COVID-19 pandemic transformed teaching delivery and student learning outcomes using a quantitative, Python-based analytical approach. Findings showed a significant decline in academic performance, attendance, and engagement during the pandemic, with only partial post-pandemic recovery. Urban and private school students consistently outperformed rural and public-school students, highlighting a persistent digital divide. Engagement emerged as a stronger predictor of performance than attendance, while pre-pandemic scores were the strongest determinant of during-pandemic achievement. Teacher support aided engagement but could not fully offset infrastructural

barriers. The pandemic exposed systemic inequities but also accelerated digital innovation. Conclusions emphasize the need to strengthen digital infrastructure, improve teacher training, enhance student support, and adopt flexible, blended learning models. Future research should explore long-term learning recovery, the effectiveness of hybrid models, socio-emotional impacts, digital divide mechanisms, and AI-based learning tools to build a more resilient and equitable education system.

REFERENCES

[1] Dickinson, J., & Griffiths, T. L. (2025). The new artefacts: teaching development during the Covid-19 pandemic and implications for future practice. Higher Education Research & Development, 44(1), 133-146.

[2] Rampersad, N., Gcabashe, N., Chetty, D., Dubazane, F. S., Lafitte, C., Ndwandwe, Z., ... & Tembe, A. (2024). Teaching style preferences and online teaching practices of optometry teachers during COVID-19: A preliminary study. Advances in Medical Education and Practice, 15-24.

[3] Aizenberg, M., & Zilka, G. C. (2023). Preservice kindergarten teachers' distance teaching practices during the COVID-19 lockdown period. Journal of Early Childhood Teacher Education, 44(3), 408-424.

[4] Vidergor, H. E. (2023). The effect of teachers' self-innovativeness on accountability, distance learning self-efficacy, and teaching practices. Computers & Education, 199, 104777.

[5] Nikolopoulou, K. (2022). Online education in early primary years: Teachers' practices and experiences during the COVID-19 pandemic. Education Sciences, 12(2), 76.

[6] Drijvers, P., Thurm, D., Vandervieren, E., Klinger, M., Moons, F., van der Ree, H., ... & Doorman, M. (2021). Distance mathematics teaching in Flanders, Germany, and the Netherlands during.

[7] Kim, J. (2020). Learning and teaching online during Covid-19: Experiences of student teachers in an early childhood education practicum. International journal of early childhood, 52(2), 145-158.

[8] Nel, C., & Marias, E. (2018). Technology-enhanced assessment feedback on preservice teachers' core teaching practices. Higher Education, 43(8), 1315-1325.