Post-COVID E-Learning in Primary Education: A Critical Review of Global

and Qatari Responses with a Focus on Mathematics Instruction

Module Title: Research Methods and Professional Practice

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Contents

Word Count: (2050 excluding references)

1. Introduction

The COVID-19 pandemic triggered an unprecedented shift in global education systems, displacing over 1.6 billion learners and accelerating the adoption of digital platforms (UNESCO, 2020). This sudden transformation brought e-learning to the forefront, revealing both its potential and its limitations particularly in primary education, where the cognitive, social, and developmental needs of younger learners pose distinct pedagogical challenges.

This literature review critically evaluates how e-learning was implemented in primary education following the pandemic, focusing on global responses and a national case study of Qatar. By examining the intersection of policy, pedagogy, and technology, the review aims to explore how various education systems adapted to digital delivery and with what consequences. Particular attention is given to the teaching of mathematics, a subject that relies heavily on scaffolding, interactivity, and developmental alignment (European Journal of Mathematics and Science Education, 2020).

Two key theoretical frameworks underpin this review: Constructivist Learning Theory and Vygotsky's Socio-cultural Theory. These frameworks provide insight into how learners construct meaning through interaction and guidance, which are often disrupted in remote settings (Piaget, 1952; Vygotsky, 1978). Through these lenses, the review explores the extent to which digital education strategies aligned with the learning needs of primary students.

Focusing on Qatar allows for a deeper understanding of how a well-resourced, policy-driven education system leveraged national digital infrastructure in response to the crisis.

Qatar's experience is compared with international trends to highlight best practices, gaps, and lessons for the future of primary education in a digital age.

2. Research Methodology and Theoretical Framework

This review adopts a secondary research methodology, synthesising peer-reviewed academic literature, policy reports, and grey literature published between 2015 and 2025. Databases such as Google Scholar, ERIC (Education Resources Information Center), and ResearchGate were used to retrieve literature relevant to e-learning in primary education, particularly in the post-COVID context. Search terms included "e-learning," "COVID-19," "primary education," "mathematics instruction," and "Qatar education policy," with inclusion criteria limited to English-language sources offering empirical or conceptual insights.

While this method enables the aggregation of diverse findings across contexts, it inherently limits the scope to already-published perspectives potentially excluding the voices of learners, particularly primary-aged children, whose experiences are underrepresented in academic discourse. Moreover, reliance on digital databases may inadvertently bias the review toward more technologically advanced or well-funded regions.

A thematic synthesis approach guided the data analysis. This qualitative method facilitates the organisation of complex findings into meaningful categories such as equity of access, digital pedagogy, and learner outcomes. However, its interpretive nature also introduces subjectivity, as themes are shaped by the researcher's lens. Thematic synthesis offers breadth across contexts but may lack the depth associated with grounded

theory or ethnographic approaches more suited to capturing learner agency and in-situ adaptation.

Two theoretical frameworks underpin the analysis. Constructivist Learning Theory, rooted in the work of Piaget (1952), views learning as an active process through which learners construct knowledge via exploration and interaction. This model aligns well with face-to-face pedagogies but poses challenges in digital settings, where experiential learning can be limited by screen-based formats. Vygotsky's Socio-cultural Theory (1978), which emphasises scaffolding, peer interaction, and teacher mediation, provides a complementary yet distinct perspective, highlighting the social dimensions of learning often constrained in isolated e-learning environments.

Although both frameworks support child-centred learning, they operate from different assumptions: Piaget prioritises individual exploration, while Vygotsky foregrounds guided participation within cultural contexts. Their intersection offers a nuanced lens through which to interrogate the effectiveness of digital education particularly in mathematics, where structured guidance, peer collaboration, and contextual learning are essential. However, these frameworks are not inherently designed for online modalities, raising important questions about their applicability and the need for theoretical adaptation in the digital age.

The chosen methodology and theoretical frameworks offer a robust foundation for evaluating post-COVID e-learning responses. Yet, they also reveal epistemological and methodological constraints that should inform future research design and policy formulation.

3. Post-COVID E-Learning Responses: Global and Qatari Perspectives

The global pivot to e-learning during the COVID-19 pandemic was driven by necessity rather than strategy, resulting in highly uneven educational outcomes. Over 1.6 billion learners across 190 countries experienced unprecedented disruption, triggering rapid adoption of digital delivery modes such as Microsoft Teams, Zoom, and Google Classroom (UNESCO, 2020; World Economic Forum, 2020). However, the implementation of these technologies was often reactive, lacking the pedagogical foresight needed to support equitable, age-appropriate instruction. Structural inequalities especially the digital divide were immediately magnified, as UNESCO (2023) estimated that nearly half the world's students lacked access to reliable internet or appropriate devices. These disparities were not merely technical, but socio-economic and political, disproportionately affecting rural communities, low-income households, and marginalised groups.

Compounding these access issues were critical gaps in teacher preparedness and instructional design. Many educators, particularly at the primary level, lacked the training to translate in-person pedagogy into meaningful online experiences. This gap is particularly problematic when viewed through Vygotsky's Socio-cultural Theory, which highlights the role of guided instruction in cognitive development. Without appropriate scaffolding, as Vygotsky suggests, learners may struggle to bridge the gap between potential and actual performance (Vygotsky, 1978). The assumption that conventional teaching materials could be seamlessly transferred to digital platforms proved flawed, especially for younger learners who require high levels of scaffolding, interaction, and developmental alignment (ERIC, 2023; European Journal of Mathematics and Science

Education, 2020). From a constructivist lens, this oversight is critical: meaningful mathematical learning requires active manipulation of concepts, which Piaget (1952) argues is best achieved through tangible, exploratory tasks that digital interfaces often fail to replicate. Moreover, global initiatives often adopted a 'one-size-fits-all' approach to online learning, favouring platform scalability over adaptability to cultural and age-specific needs. While hybrid models have gained traction as a long-term solution, their success remains context-dependent and raises questions about the sustainability of such models in under-resourced environments.

Qatar's response to the crisis was comparatively swift and technologically ambitious, underpinned by the strategic vision of Qatar National Vision 2030. The Ministry of Education and Higher Education (MOEHE) launched five national e-learning platforms, distributed digital devices, and rapidly integrated Microsoft Teams and Maktabati across public schools, reaching over 400,000 students and educators within three days (MOEHE, n.d.; State of Qatar, 2024; Microsoft, 2022). This rollout demonstrates a capacity for large-scale policy coordination rarely matched globally. Yet, this success in technological implementation did not necessarily equate to pedagogical effectiveness. Although teachers reported improved digital literacy, they continued to struggle with sustaining learner engagement and implementing interactive, student-centred approaches (Allouh et al., 2021).

Furthermore, Qatar's model exhibited certain blind spots common to centralised policy responses. The emphasis on infrastructure, while commendable, tended to overlook the complexity of home learning environments and the socio-emotional needs of learners. Alshaboul et al. (2024), drawing on responses from over 3,000 K-12 parents in Qatar,

observed that parental capacity to support home learning varied significantly across linguistic and socio-economic lines, introducing new inequities in learner experience. Additionally, despite generous provisioning, some schools in less affluent areas reported bandwidth instability and underutilisation of provided devices raising concerns about the effectiveness of resource distribution and digital inclusion strategies.

In both global and Qatari contexts, the assumption that technological access inherently facilitates learning was problematised. Success in digital education depends not just on connectivity or devices but on how these tools are embedded within a responsive, inclusive, and developmentally appropriate pedagogical framework. This suggests that the future of e-learning must move beyond infrastructure-focused interventions towards a more holistic, evidence-informed approach that considers culture, curriculum, and child development as equally essential design parameters.

4. Subject-Specific Insights and Research Gaps in Primary E-Learning

Primary mathematics presents one of the most complex challenges in e-learning due to its reliance on abstract reasoning, conceptual scaffolding, and tactile engagement. Unlike literacy, which can often be reinforced through reading and repetition, mathematical understanding depends on manipulatives, real-time feedback, and iterative guidance elements that are difficult to replicate in virtual settings (ERIC, 2023). This mismatch is particularly acute for young learners, whose cognitive and metacognitive abilities are still in development (European Journal of Mathematics and Science Education, 2020). Consequently, remote mathematics instruction often results in superficial understanding and procedural learning, rather than deep conceptual mastery.

In response, educational systems globally deployed tools like GeoGebra, Prodigy, and Kahoot to visualise and gamify learning. However, their effectiveness hinges not on the technology itself, but on how well they are pedagogically integrated. Research indicates that in the absence of structured training and curriculum alignment, such tools risk becoming mere engagement gimmicks that do little to support meaningful mathematical reasoning (International Journal of Online Pedagogy and Course Design, 2023). Furthermore, the digital medium introduces its own constraints: screen fatigue, limited peer interaction, and the absence of physical manipulatives often undermine the quality of learning, particularly in topics like number sense, place value, and spatial reasoning (Claremont Colleges, 2021).

Qatar's case exemplifies these dynamics. While platforms such as Microsoft Teams and ClassDojo were rapidly adopted, mathematics instruction outcomes were mixed. In digitally disadvantaged households, parental limitations in technological fluency further impeded student engagement (Alshaboul et al., 2024). Even in better-resourced schools, teachers identified a pressing need for discipline-specific training that would enable them to reframe abstract content in ways suitable for online delivery (Allouh et al., 2021; Alshaboul et al., 2024). This underscores a critical insight: high investment in infrastructure does not guarantee pedagogical effectiveness. The assumption that access equals quality fails to account for the nuanced, subject-specific needs of early mathematics instruction.

At a broader level, the literature suffers from three notable shortcomings. First, there is a lack of longitudinal evidence on the cognitive and academic effects of sustained e-learning in primary contexts. Existing studies prioritise short-term metrics such as

engagement rates or user satisfaction over deeper indicators of learning transfer and retention (ERIC, 2023; IJLTER, 2023). Second, learner perspectives are systematically underrepresented. By excluding primary students' voices, current research neglects critical insights into how digital learning is experienced by its intended beneficiaries. This weakens the capacity to design developmentally appropriate interventions. Third, the predominance of standardised, top-down e-learning models often imported or repurposed from secondary or higher education ignores cultural specificity and curricular relevance. Particularly in foundational disciplines like mathematics, this can lead to poor pedagogical fit and exacerbated inequities (UNESCO, 2023).

These gaps collectively point to an urgent need for more context-aware and learner-sensitive approaches. Effective primary e-learning especially in mathematics demands more than technological provision; it requires culturally responsive design, curriculum alignment, and mechanisms that centre student agency. Without these dimensions, digital education risks not only replicating but also deepening the inequalities it aims to solve.

5. Conclusion

This literature review has critically explored the post-COVID implementation of e-learning in primary education, with a particular focus on global trends, Qatar's national strategy, and the complexities of teaching mathematics in digital environments. While digital platforms were instrumental in maintaining educational continuity, they often reproduced or magnified pre-existing disparities in infrastructure, pedagogical capacity, and learner support. This aligns with socio-cultural learning principles, which stress that learning

environments must be co-constructed and culturally situated to be effective (Vygotsky, 1978).

Qatar's policy-led response, framed by Vision 2030, demonstrated commendable speed and resource mobilisation. However, its effectiveness was uneven, revealing persistent challenges in teacher training, learner engagement, and the contextualisation of content issues mirrored globally. Many e-learning models, both in Qatar and abroad, relied heavily on standardised solutions developed for older learners, neglecting the developmental and disciplinary demands of early education.

Critically, the evidence base remains underdeveloped. Most research focuses on short-term access and satisfaction, offering limited insight into long-term learning outcomes or the nuanced experiences of primary students themselves. This limits the capacity of policymakers and educators to refine digital strategies based on evidence that reflects learners' cognitive, emotional, and cultural needs.

To move beyond technological determinism, future efforts must prioritise pedagogy over platform. Effective e-learning in primary education particularly in subjects like mathematics requires curriculum-aligned tools, sustained professional development, and mechanisms for student voice. Without these, digital education risks becoming an exclusionary substitute rather than a meaningful alternative. A more equitable and effective digital future depends on addressing these gaps through interdisciplinary, learner-centred, and culturally responsive approaches. Ultimately, until e-learning is reimagined not as a digital translation of traditional classrooms but as a dynamic

ecosystem tailored to children's cognitive, emotional, and cultural development, it will fall short of fulfilling its promise—particularly for the youngest and most vulnerable learners.

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