

# The Pandemic Shift to Remote Learning under Resource Constraints

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The COVID-19 pandemic has forced the transition of workflows across sectors to digital platforms. In education settings, stakeholders previously reluctant to integrate computing technology in the classroom now find themselves with little choice but to embrace it. This move to the digital brings additional challenges in underserved contexts with limited, intermittent, and shared access to mobile or computing devices and the internet. In this rapidly evolving digital landscape, we investigate how educational institutions (schools and non-profit organizations) working with underserved populations in India are managing the transition to online or remote learning. We conducted twenty remote interviews with students, teachers, and administrators from underserved contexts across India. We found that online learning efforts in this setting relied on a resilient human infrastructure comprised of students, teachers, parents, administrators, and non-profit organizations to help navigate and overcome the limitations of available technical infrastructure. Our research aims to articulate lessons for educational technology design in the post-COVID period, outlining areas for improvement in the design of online learning platforms in resource-constrained settings, and identifying elements of online learning that could be retained to strengthen the education system overall.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**.

Additional Key Words and Phrases: education; Ed-Tech; COVID-19; India; resource-constrained; qualitative; interviews; HCI4D

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## 1 INTRODUCTION

The field of Human-Computer Interaction for Development (HCI4D) has long been interested in the design of educational technology in underserved settings (e.g., [17, 37, 38, 82]). This work is motivated by efforts to improve access to quality education, such as by delivering learning content that is designed to be locally relevant [37], providing after-school education [99], and enabling more hands-on and technical education [23]. Despite progress in this area, schools have been slow to take up technology within and beyond the classroom due to the high initial capital and time investment [20]. However, the COVID-19 pandemic has brought traditional learning to a standstill, and forced the adoption of technology and associated investments involved [26]. This

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unprecedented change gives us an opportunity to examine the efforts taken by teachers, students, and non-governmental organizations (NGOs) to navigate the resource constraints that accompany adoption of information and communication technologies (ICTs) in marginalized contexts. The uncertainties due to the pandemic also serve as a catalyst for iterative and situational workarounds to make sense of the newly incorporated digital infrastructure [81].

In an effort to control the COVID-19 pandemic and practice physical distancing, governments across the world closed down schools and other educational institutions [63]. As the pandemic continued, schools began to move to online modes of learning to continue delivering education [26]. Though the move to online learning was aimed at preventing loss in learning, it has also had severe consequences for those in resource-constrained contexts. Even as this transition has expanded learning opportunities for many, it has worsened inequalities across class, gender, and location (and associated intersections such as race or caste), across the globe [26, 93].

We studied the transition to online learning by educational institutions working with underserved communities in India, where these tensions have become highly visible. On 25th March, 2020, India announced a nationwide 21-day lockdown to stem the spread of the pandemic. This lockdown was extended till May, and then again till June, with conditional opening in regions that had contained the spread. Schools remained closed when we finished collecting data. We conducted twenty remote interviews with students, teachers, school administrators, and educational non-profit organizations working in underserved settings primarily across the state of Maharashtra, India. We investigated how these different stakeholders within the education system migrated to online learning platforms, the challenges they grappled with in doing so, and the creative solutions they came up with to navigate through resource constraints and reach communities on the margins.

Our paper is structured as follows. We begin by summarizing related literature on educational technology in resource-constrained environments, the use of technology in crisis response, and the role of human infrastructures in the field of Information and Communication Technologies and Development (ICTD). We then describe the context of our study, data collection methods, and our positionality. Next, we detail our findings on the transition to online learning, the response of students, teachers, and parents to the transition, challenges encountered in the process, and workarounds or solutions that stakeholders arrived at. Finally, we discuss three key takeaways for future efforts. First, we highlight the massive digital transformation that the pandemic has brought about across the Indian education system and a shift in attitudes towards educational technology. Second, we emphasize the critical role of human infrastructures in navigating the resource constraints that accompany the above transition. Third, we offer design considerations for educational technology in resource-constrained settings, the long-term sustainability of these efforts, and spaces for technology to strengthen the existing education ecosystem.

## 2 RELATED WORK

Our research draws on literature in three areas. First, we build on a rich body of HCI research on the design of technology for education in resource-constrained settings. Second, we link to prior efforts to use ICTs to respond to and make meaning during a crisis. Finally, we build on prior research that outlines the human infrastructures that help navigate challenges around digital access and literacy in resource-constrained environments like the one we studied.

### 2.1 Educational Technology Integration in Resource-Constrained Settings

Learning environments in the Global South have long witnessed inequalities in access to quality education, and there has been a significant effort to use digital technology to address this issue [24]. Projects like One Laptop Per Child (OLPC) were aimed at addressing the technology access gap by delivering low-cost laptops to millions of children [43]. Though this effort was deemed largely

unsuccessful and short-sighted [6], it also garnered worldwide attention towards the massive scale of this problem. Many researchers have designed ICT interventions that target use by children with and without support from teachers in classroom settings (e.g., [5, 8, 37, 92]). Researchers have also deployed interventions that target parents as facilitators, such as through the use of IVR systems [54]. These programs have traditionally focused on supporting basic English, local language, or numerical literacy, though computing education is increasingly an area of interest [8].

The increased affordability of smartphones and the internet has further enabled the delivery of online education. Varanasi and colleagues have studied the use of smartphones by teachers in classrooms in India [94, 95]. Recognizing varying access to the internet, Poon et al. designed an intervention that helped students in Cameroon prepare for exams using Short Message Service (SMS) and WhatsApp [66]. In the United States, Wong-Villacres et al. have studied the use of multiple smartphone-based technologies by Latino immigrant families, such as for communication with schools and completion of assignments, and the role of the human infrastructure of bilingual parent-education liaisons in supporting their navigation of these tools [101, 102].

There are also significant challenges to these efforts. Barriers to the adoption of technology in education include lack of access to technology, missing supporting technical and human infrastructure, and limited technological proficiency of teachers and parents [15, 17, 91]. In the case of OLPC deployments in Mexico, Cervantes et al. documented how organizations' abilities to build infrastructures was dependent on the enthusiasm, commitment, and training of teachers, staff, parents, and students, along with the support of other external organizations [17]. Toyama has argued that technological interventions that aim to undertake social change, including in education, can only amplify existing institutional intent [91]. Technology must be accompanied by a strong social support system and a deep understanding of a community's cultural beliefs and attitudes, with sensitivity to the social, political, and cultural challenges that the community experiences [31]. Vishwanath et al. have also examined teachers' use of online teaching systems, and cultural challenges they encountered that impacted their willingness to use technology in the classroom [98, 99]. Karusala and Vishwanath et al. have emphasized the importance of considering "non-material" resources in resource-constrained settings, such as care [38]. Organizations that acknowledge and address these areas while developing technological interventions thus have a better chance of accommodating the ever-changing contexts and needs of stakeholders [25]. Our research underscores how COVID-19 has accelerated educational technology integration that many of the above projects aimed at achieving in the near or long term.

## 2.2 Technology for Crisis Response

The adoption of educational technology during the COVID-19 pandemic emerged as a response to widespread school closures. Prior work on crisis situations has explained how technology can help communicate and coordinate for crisis response and recovery, or to make sense of uncertainty during a crisis. These questions have been explored extensively in the field of crisis informatics, a multidisciplinary field that draws on computing and social science knowledge of disasters to determine how ICTs can enable, constrain, and mediate individuals' creative responses to disasters and their efforts to cope with uncertainty [7, 64, 81]. Since its emergence in 2007, the field has contributed significantly to scholarly understanding of information systems during mass emergencies as a result of natural hazards such as earthquakes [103], floods [84], fires [96], and hurricanes [40]. Researchers have also studied response during criminal or political hazards such as the 2007 Kenyan election [59], the second Gulf War [77], and "urban warfare" in Mexico [60].

Taking a critical approach to literature in crisis informatics, Soden and Palen describe *informating*, or the process through which activities, events, social exchange, and objects are transformed into information, as a potential target of design open to experimentation and redeployment [81]. Our

findings align with their focus on iterative and situational adaptation of the different types and uses of ICTs to suit the immediate needs of the community. A large body of work in crisis informatics has examined how social media is adapted and used by citizens before, during, and after various crises (e.g., [69, 100, 103]). Research has shown how social media can support citizen participation in various individual and collective practices, such as disseminating information [41], coping with the crisis [69], and planning relief efforts [83, 90]. These studies bring out the potentialities and constraints of social media [103] and other digital platforms. Research on on-the-ground relief work during crises has uncovered citizen-led initiatives [104] around distribution of resources, formulation of contingency plans [76], and other practices [103]. Social media also plays a key role in helping citizens make sense of a crisis [57, 85].

We draw on this body of literature to not only evaluate the effectiveness of digital platforms (including chat applications like WhatsApp) being used to manage education during a crisis, but also observe the initiatives and workarounds that different stakeholders in the education system undertake to navigate these platforms. We see such resilience and adaptation in conflict-ridden settings like civil wars [21]. For example, Semaan and Mark have previously pointed to the reliance of technical infrastructures on robust human infrastructure, particularly in navigating technical breakdowns [78]. Similar networks can be found in the work of humanitarian organizations and volunteers delivering aid [19, 80, 83]. We next dive more deeply into prior research on the role of our human infrastructures.

### 2.3 The Human Infrastructures of ICTD

Prior research in the the fields of HCI4D and ICTD has brought attention to the human infrastructures that enable access and use of digital technology in resource-constrained settings. Sambasivan and Smyth have described the shared social norms and practices, flows of information and materials, and creative processes that underlie existing ICT access [75]. For instance, sharing of devices is a common scenario in many households in countries of the Global South as a means to navigate limited digital access [4]. Such “workarounds” have been well documented, and frequently involve the active re-configuring and shaping of technical infrastructure, as well as the meanings that they carry in these settings [73]. A rich body of work has also uncovered the role of intermediaries in mediating access and enabling individuals with limited digital literacies to come online. These are actors who may have more developed digital literacies or digital access as a result of power differentials, helping others come online—family members, neighbors community members [74]. Smyth et al. have described the piracy practices of media content in India, shared through multimedia phones and mediated by mobile phone shops, content distributors, and end users [79]. These practices were widespread well before the recent uptake of mobile data in the Global South. More recently, Dye et al. have studied how human infrastructures have been instrumental in helping develop a rich local “offline internet” in Cuba, where access to the internet is otherwise limited, expensive, and regulated [29].

Beyond enabling digital access, human infrastructures have also been critical in enabling access to domain-specific services using technology, such as in health and agriculture where frontline health workers [48] and agricultural extension workers [30] play key roles respectively. Pendse et al. have described how mental health helplines in India are reliant on a network of volunteers who are frequently invisible [65]. Along these lines, we also see that non-material resources that rely on human actors can play a significant role in light of material constraints, such as the role of care in crisis response [103] and education [38]. We find a similar reliance on the human infrastructure and the emergence of creative practices with the adoption of technology for education in the context we study, particularly for communities on the margins. This includes the networks of educational institutions, teachers, NGOs, students, and parents who are collectively attempting to

enable learning outcomes for students. We also see this human infrastructure itself being reshaped as a result of forced engagement with technology.

### 3 METHODS

The goal of our research was to understand the transition into remote learning by schools, colleges, and after-school learning centers in India, particularly across underserved communities. Below we describe the study context, and our approach for collecting and analyzing data.

#### 3.1 The Study Context

The education system in India is highly diverse. Schools can choose to follow state- or national-level boards of education and offer instruction in a number of languages, with English and Hindi being the most widely adopted [18]. Most schools are affiliated with the state-run Central Board of Secondary Education (CBSE) [18]. By law, government or public schools are required to provide free education till eighth grade (or age 14), and several states provide free education at the secondary level as well [18]. Approximately 65% of all school-going children attend government schools, though enrollment in private schools has been steadily increasing due to government schools being perceived as being of poorer quality [62]. Despite making small gains in learning outcomes in recent years, the overall state of education in India is in need of improvement [12]. The Annual Status of Education Report (ASER) 2018 of rural India stated that only 50.3% of fifth-grade students could read a second-grade text [67]. The rate was higher among students going to private schools (65.1%) than to government schools (44.2%) [67]. These poor learning outcomes have been attributed to a high curriculum load, and an overt focus on rote learning and passing examinations than providing education at the level that students are at [11]. Higher education in India similarly reflects a focus on lecture-based learning, and admissions are largely based on competitive examinations [18]. However, unlike at the school level, government colleges are perceived to provide higher-quality education and are significantly more affordable than private colleges, though the latter may have better facilities [18].

The COVID-19 pandemic has posed a significant challenge to the education system in India. An ASER 2020 survey with over 50,000 families on the impact of the pandemic on schooling in rural India found a significant reliance on mobile technology [68]. Children received learning materials through WhatsApp, phone calls, and personal visits. Regardless of school type, WhatsApp was found to be the most common medium (74% of all families surveyed). Smartphone ownership also increased from 36.5% (ASER 2018) to 61.8% (ASER 2020) [67, 68]. About one in every ten households bought a new phone to support their children's education after schools closed in March 2020, typically a smartphone [68]. Even among children who did not have a smartphone at home, about one in ten was able to access a smartphone elsewhere, for example from a neighbor. However, a higher proportion of students enrolled in private schools received materials through WhatsApp (87.2%) than their counterparts in government schools (67.3%). Among government schools, 31.8% still accessed learning materials in-person due to lack of access to smartphones [68].

#### 3.2 Data Collection

Between the months of May and August 2020, Prerna conducted 20 semi-structured interviews with students, teachers, and administrators who were affiliated with a diverse set of schools and colleges government and private, as well as non-profit organizations with different goals and target groups primarily based in Maharashtra, India. Our study was primarily based in the densely populated, urban cosmopolitan areas of Maharashtra where smartphone penetration is likely higher than most parts of the country. This region also has a rich network of non-governmental organizations (NGOs) that support government and less-resourced private schools [13]. Schools, colleges, and NGOs

Table 1. Participant Demographics

	Age	Gender	Participant Type		Age	Gender	Participant Type
S1	20	F	Student	A6	34	F	NGO Admin
ST1	21	M	Student and Teacher	A7	42	F	NGO Founder
S2	22	F	Student	A8	47	M	Principal
A1	24	F	NGO Admin and Teacher	A9	36	M	NGO Founder
A2	32	F	NGO Admin	S3	28	M	Student
A3	55	M	School Trustee	S4	24	M	Student
T1	24	F	Teacher	S5	19	F	Student
ST2	22	M	Student and Teacher	S6	21	M	Student
A4	37	F	NGO Volunteer	S7	21	F	Student
A5	36	M	NGO Founder	A10	57	F	NGO Founder

Key: S-Student, A-Administrator, T-Teacher, ST-Student and Teacher

in this region teach primarily in Hindi, Marathi, and English. We created an interview protocol with potential questions that could be asked during the interview. We also constructed a survey covering demographic information (age, gender, school/college) and details regarding their access to technology, for participants to fill out before the interview. The survey responses informed the interview questions. Our study was approved by the Institutional Review Board (IRB) at Georgia Institute of Technology, Atlanta, United States. All authors undertook IRB training to ensure that we aligned with the pertinent protocols and ethics code for conducting human and social/behavioral research. We obtained oral consent from all interview participants, detailing the purpose of our study. We also requested our survey participants for written consent.

During the interviews, we asked participants questions pertaining to their learning environments before COVID-19, during the onset of lockdown, and a few months into the transition. We started off with broader questions on materials they used for lectures, homework, exams, and other assignments before COVID-19, use of technology for teaching or learning, access to electronic devices and a stable internet connection, etc. We then transitioned into specifics around the time lockdown started, what actions schools, NGOs, and governments took, and how students and teachers responded to these changes. We did not ask participants to limit their responses to just education, but also included basic needs like food, water, and healthcare essentials. We also asked them more focused questions around the problems they were facing with the new learning systems, the digital infrastructure, their emotional mindset, etc. All interviews were audio-recorded with consent from the participants for the purposes of transcription and were conducted remotely via Zoom or Skype. They were conducted by Prerna and ranged from 30 to 60 minutes each. The interviews were conducted in English, if the participants were comfortable speaking in the language, and in Hindi otherwise.

### 3.3 Recruitment

Participants were initially recruited via MakerGhat, an educational non-profit organization based in Mumbai, India, which Azra and Neha had been working with for the past two years. After an initial introduction and addition to WhatsApp groups with community members, we were



able to recruit additional participants through snowball sampling [32]. Since we did not have direct linkages with the target population, snowball sampling was a fitting method for us to connect with additional students, NGOs, and teachers. It also helped ensure that all participants came from reasonably similar backgrounds. We attempted to address sampling bias by contacting multiple, diverse NGOs targeting different sectors of the Indian education system, schools and colleges, private and public institutions, volunteers, and full-time school teachers. Table 1 provides a breakdown of the participants who were enrolled in our study. All participants were above the age of 18. The students we interviewed were undergraduate and graduate students. We aimed for a balanced and diverse sample, in terms of gender, age, and education backgrounds, which had implications for access to devices, internet, and digital literacy. Two students we interviewed were also teachers/tutors for high-school students. We spoke to founders of various NGOs focused on providing education to underserved communities. In order to incorporate the perspectives of teachers during the pandemic, we asked the NGO administrators to connect us with teachers within their NGOs as well as administrators of schools whom they had collaborated with. A few NGOs we spoke to also had branches in other Indian states. Our understanding of the transitions that took place at the school level is primarily based on the perspectives of teachers and administrators, and at the college level, is based on the experiences of students. Though we attempted to also gain access to parents, those we reached out to were hesitant to participate due to time constraints and more pressing priorities with the pandemic situation.

### 3.4 Data Analysis

We followed an iterative data analysis process, with regular check-ins after every 5-6 interviews to discuss findings, themes, and modify interview protocols if needed. We transcribed all 20 interviews in English in order to initiate the coding process. Thereafter, we conducted several rounds of inductive coding on the transcribed data [87]. The first level of coding closely followed the text, while subsequent rounds of coding resulted in codes that were more high-level. This process was driven mainly by Prerna, with periodic discussions around the emerging themes and trends with the other authors. The first set of codes was closely linked to the data, such as *“wrote exams on paper, clicked photos, and submitted online”*, *“searches online or asks friends on WhatsApp”*, *“no communication from college at all”*. After multiple rounds of coding, some of the more general themes that emerged included *“digital access during COVID-19”*, *“resource constraint”*, *“parental concerns”*, and *“gender inequality in digital access.”*

### 3.5 Positionality

All authors identify as cis-women of Indian origin who completed their schooling either partly or fully in private schools that are a part of the Central Board of Secondary Education (CBSE), within and outside India. Neha has previously conducted research on educational technology in rural and underserved urban settings in India. Azra is also the co-founder of MakerGhat, an educational non-profit organization in India that aims to support the integration of project-based learning in STEM education. We recognize the class and (likely) caste differences between us and the populations whose experiences we aimed to understand in this study. We attempted to remain attuned to these power differentials throughout our data collection and analysis.

## 4 FINDINGS

We now outline the findings that emerged from our data. We first introduce the changes that online learning brought to the education system in India. Subsequent sections detail how diverse stakeholders adapted to these changes and the various challenges they faced both inside and outside the classroom.

## 4.1 Migrating to Online Platforms for Learning

Our interviews revealed that the operation of educational institutions stopped immediately after the lockdown was announced, across schools and higher education institutions. ST1 shared that, though private, “well-off” schools were able to transition to online classes, government schools did not have the resources to start online classes immediately. Several government and resource-constrained private schools and colleges ended classes early for the year (which typically ends in March or April), and exams were suspended. As the lockdown continued, our participants, both educators and learners, began to make sense of the overwhelming number of digital resources and technological platforms available to them, and navigate them to suit their educational needs. For all our participants, the primary medium of accessing these resources was a smartphone. Below we describe the transition of different components of classroom learning to the online medium.

*4.1.1 Shifting to Digital Platforms for Lectures.* The teachers and NGO volunteers we interviewed conducted lectures for schools and colleges on several video-calling platforms, the most common ones being Zoom, Jio Meet, Google Meet, and Hangouts. While some schools shared presentations and videos during these lectures, others chose to continue to teach on whiteboards using the rear-facing cameras on their phones. The teachers from schools, colleges, and NGOs supplemented these lectures with links to YouTube videos, websites, and PowerPoint presentations that were typically sent over WhatsApp or email. We found that NGO volunteers and administrators created special programs that catered to students who could no longer afford to go to school due to financial difficulties. To reach these students, volunteers taught them basic concepts periodically over phone calls. Participants also described that NGOs came up with creative community-based solutions for students who had limited access to devices. Sambasivan and Smyth have previously studied how human infrastructure enables digital access in resource-limited settings [75], and we observed a similar trend here:

“We have started in-person lane-wise classes outside slums... So for example, in one lane if there are three students, our teachers call them outside, make them sit there and from a distance she teaches them... only providing worksheets and materials is not enough..the students need some kind of clarification and explanation.”

—A10, 37, F, NGO Founder

We see that technology was adopted organically by teachers. In addition to accessing resources provided by their institutes, college students we interviewed completed online courses from Coursera, Udemy, National Programme on Technology Enhanced Learning (NPTEL) [44], and Tata Consultancy Services (TCS) [71] related to their field of study. Their colleges provided links to recommended courses and even subscriptions to access them for free. Some of these participants also took online courses on additional topics pertinent to their own interests outside of the prescribed syllabus to enhance their skill set. Though colleges organized webinars and workshops centered around career development and recruiting, according to ST1, these webinars were held at a “national level” and were hence too generalized to help students in specific colleges and courses.

*4.1.2 Moving Assignments Online.* For schools and colleges that did not end early, all assignments were moved online by teachers and administrators. Some private colleges, like the one S1 attended, already had access to online learning platforms like Learning Management System (LMS) [2] that supported assignment and project submissions, grading, and exams. Such portals facilitated a much smoother transition into online learning during the pandemic for students. College-going students like S1, S5, S7 and ST2 mentioned that they completed their assignments on paper, clicked photographs of their answers on their phone, using applications like Cam Scanner [1] and Adobe



Scan, and uploaded the PDFs to the portal for submissions. Teachers could then grade these assignments online.

For most other government colleges and schools catering underserved students or with less access to resources, such portals did not exist. WhatsApp was the most popular communication channel in those cases. This corroborates recent research that WhatsApp is increasingly being used in educational settings in the Global South to reduce student and teacher absenteeism, and improve teachers' effectiveness and student performance [61, 66]. As A4 (an NGO volunteer) described the value of WhatsApp thus:

“For any intervention, WhatsApp is the most effective platform for widespread use... It is also used as a medium for stories, artwork, and homework... Teachers have even started using the business version of WhatsApp to store and archive large amounts of data.”—A4, 37, F, *NGO Volunteer*

Our NGO participants explained that only platforms that allowed students and teachers access using phone numbers were used because teachers were not familiar with using emails and passwords for logging in. Students from colleges also used WhatsApp to seek help from peers, clearing their doubts, and discussing course information with their teachers. Teachers and NGO volunteers sent textbooks, worksheets, and assignments as PDFs on WhatsApp groups, and students scanned and sent their answers back to teachers on personal chats. Teachers would then edit the PDFs and photographs with feedback on assignments and send them back to students.

The communication channel used for sharing assignments and course content was often personalized by teachers depending on the infrastructure available to the student. Once again, the human infrastructure made it possible to navigate limited digital resources [75]. For example, T1 shared that she and other teachers in the non-profit organization she worked in spent significant time establishing contact with parents of school-going students. They called parents to determine their level of access to digital technology, and divided students into four groups: students accessible on Zoom, those available on WhatsApp but not Zoom, those with no internet but available through calls and messages, and those who were completely cut off and did not have access to calls or messages. T1 started out the day with Zoom calls and daily activities. These links were sent on WhatsApp. Chapter summaries were sent to those available only on SMS. T1 was still trying to get in touch with the final group of students. Prior work on Massive Open Online Courses (MOOCs) has stressed the importance of accounting for infrastructural problems like internet availability within local communities [105]. T1's example offers one way to address this challenge.

*4.1.3 Drifting Away from Traditional Forms of Assessment.* Along with lectures and assignments, evaluation also changed drastically for both schools and colleges. Our student participants shared that as soon as the lockdown was announced the state government indefinitely postponed exams and assigned student grades as follows:

“The Maharashtra board has decided that they won't conduct exams for this semester... since lectures were not there and they did not complete the syllabus, they have decided to take an average of their internal marks or the average of their last semesters' marks and they are passing students based on that only.”—ST1, 21, M, *Student*

This rule affected every government school and college, as well as independent schools that were receiving partial funding from the state government. Following this initial transition, schools, colleges, and NGOs slowly started looking at different formats they could use to evaluate students' understanding on different topics. In prior work, Poon et al. investigated how platforms like WhatsApp and SMS could be leveraged to facilitate online assessments [66]. Our findings uncover

similar approaches. For example, an NGO volunteer started using platforms like Google forms to conduct online assessments:

“I try taking assessments on google forms for kids who are on WhatsApp... Basically it is a quiz where they can mark their answers... after they submit they get their scores and they also get my feedback on every question, if their answer is wrong.”

—T1, 24, F, NGO Teacher

For students who did not have access to the internet, T1 conducted exams orally on phone calls. Some other school teachers like ST2 started sending exam papers on WhatsApp and gave students specific time slots to attempt the questions, then scan and send their answers back for evaluation. Grading was either done through photo editing, as in the case of assignments, or using online portals available to students. Some organizations, like that of A7, scrapped exams and other kinds of assessments altogether as they did not find them helpful for evaluations. Instead, they asked students questions on a call to test their understanding. This diversity in the approaches that different stakeholders took to transition to online learning brought with it a wide range of challenges in the classroom, as we discuss next.

## 4.2 Adapting to the Digital and Communication Infrastructure

The unprecedented shift to online learning platforms was accompanied by challenges with navigating varied access to digital devices and internet. After having enabled some level of access to digital education for their students, our teacher participants had to solve logistical issues during lectures, address poor internet access and connectivity, bridge communication gaps, and account for device-sharing across school-going students at home. Such issues resulted in workarounds by participants. Below we describe these challenges and participants’ resilient efforts to address them.

*4.2.1 Problems with Digital Infrastructure and Logistics.* As teachers used technological platforms to deliver classroom content, they encountered several constraints. The level of digital access (e.g., mobile phones with data access only) available to students shaped what teachers were able to do in terms of the kinds of content, medium of delivery, learning objectives, and assessments. Online learning did not always lend itself well to existing rote learning-based pedagogy. This was particularly the case for subjects like Mathematics traditionally taught by working problems out on whiteboards in the classroom. ST1 described his experience teaching remotely:

“So I switch on my phone’s back camera for students to see the board... If they have internet connection problems, I take a screenshot of the solution and send it on the group, so that they can go through the photo...If they do not understand the photo, the student can turn their back camera on and then I guide them on how to solve the question...But still, I wish I was there physically—it is easier to guide them.”

—ST1, 21, M, Teacher

The above quote from ST1, one of the teachers conducting after-school coaching classes, highlights that the digital infrastructure was often used to match the format with traditional in-person classes. He used his small phone screen to moderate on video calls, while using the rear-facing camera to teach on a whiteboard. He used his phone’s rear-facing camera since it provided better resolution as opposed to the front-facing camera. However, he mentioned that the video quality was bad due to intermittent connectivity, making it hard for students to follow. Posting online video links alone did not suffice either since he had to demonstrate how to approach and solve every math problem for students to fully grasp concepts. In an attempt to solve such problems around understanding, ST1 tried to engage students by asking more questions during the Zoom classes to assess their understanding. He also shared additional resources that students could access

in their own time, such as websites that allowed them to visualize mathematical concepts such as geometry. A3, a school admin, also told us that they found the general recording of lectures on Zoom challenging since the infrastructure needed to ensure the highest quality was often an “*expensive affair*” that schools in remote locations like his did not have access to and could not afford. His school also had to look into assigning moderators during online lectures who could clear doubts and answer questions as the teacher taught simultaneously. Even though these steps were a “*good investment in the long run*” according to him, the governments did not support such expenses, thus increasing the financial burden on schools and colleges.

Our participants also spoke about many other problems with the digital infrastructure. A4, an NGO Volunteer, said: “*English language learning is a major hurdle.*” Language posed a problem since many online platforms only supported the use of English and many students took classes in a different medium. This contrasts the Karusala et al. study that uncovered users’ enthusiasm to communicate in English proactively, despite their lack of English fluency [39]. Prior work in ICTD has found that mobile-based technologies are increasingly becoming accessible and affordable in the Global South [24]. A vast majority of the student participants in our study solely relied on their “*small screen phones*” for attending lectures, completing assignments and assessments, watching videos, reading e-books etc. Students like S5 thought that this was too cumbersome and in some cases not even feasible since online learning environments were designed to operate well on laptops with bigger screens and better features. The time allotted for lectures, especially amongst younger age groups was not adequate since teachers spent a huge chunk of it in resolving logistical issues. Crowded environments at home frequently disrupted the experiences of online lectures for our student participants. For example, S7, a student, describes:

“No one can hear properly during online lectures... Teachers have to keep repeating the same thing again and again.”—S7, 21, F, Student

Such problems arose not just because of students’ intermittent internet connections, but because they had to take classes from their homes that were very noisy with too many family members under one roof. In some cases, the messaging groups and calls became chaotic since they were not bifurcated by subject. The teachers we interviewed worked around this by switching over to other platforms like Google classroom which allowed for the use of different IDs for different subjects and sessions. It also took care of setting assignments deadlines, calendar integration, and accepting submissions. These teachers often came up with workarounds on the fly, but the added strain of having to deal with such unexpected issues in the process became cumbersome.

**4.2.2 Challenges around the Use of the Internet.** Beyond access to technologies needed to sustain learning during COVID-19, students, teachers, and NGOs we spoke to ran into various issues with the way the digital infrastructure was built. With the use of Zoom, Google Hangouts, and other video-calling services came the extensive use of the internet, which in most cases was provided through data recharge packages, since those were more affordable than setting up elaborate unlimited WiFi networks at home for our student participants. However, there were constraints associated with the type of applications used extensively on these packages. For instance, ST2, a teacher, shared:

“Some students don’t have enough data... here most students are using the 400 or 500 rupees data packages and it lasts for 3 months... everyday they get 1.5 GB... but this data gets exhausted... so the students started complaining.”—ST2, 22, M, Teacher

The daily 3G/4G data balance provided by network carriers was thus insufficient for students to attend multiple lectures on video calls with. Switching over to packages with better daily limits was too expensive and very often, even existing packages were too slow and reduced the quality of

online lectures, due to persistent glitches with screen sharing for videos and presentations. These issues were aggravated for students in remote villages with lower network bandwidths. Thus, the overall essence of discussions over calls was lost in this process. A4 mentioned that parents stopped recharging data packages on phones, since they did not find the recharges worth the amount of money they were paying in the midst of a pandemic. In some cases, the balance drain-outs were so bad that parents did not have money to make regular phone calls after.

*4.2.3 Workarounds for Internet.* Owing to the challenges described above, organizations began identifying solutions that did not involve the use technology. By administering their pre-existing community networks, non-profit organizations we interviewed started distributing books to homes and brought in small groups of students to their organization's center where technology was available. Prior work has demonstrated how communities often leverage available human infrastructure by bringing people together to solve technological issues that they encounter [75]. The organizations we spoke to in our study implemented this idea in a more formal setting. For example, A4, an NGO volunteer, mentioned:

“There are principals who go to the school... this principal I know goes there for 2 hours everyday... she takes 5 to 10 kids, makes them sit far apart and teaches them.”  
—A4, 37, F, NGO Volunteer

Larger and better funded non-profit organizations also began to distribute mobile phones and mobile data recharges to students without access to technology in their homes. T1's NGO organized weekly internet recharges for students. They also came up with creative solutions that would eliminate the use of the internet altogether. Past HCI4D work has focused on video dissemination through multimedia phones [48, 79]. Similar to that, A5's NGO introduced SD cards with preloaded lecture content that school students could purchase at a store with downloadable content available offline. For students unable to join online lectures, teachers like T1 made phone calls to the students at the same time as the Zoom meetings so that they could follow along, at least with audio explanations. Some college students like S4 downloaded various courses when he had access to the internet, so that he could view them offline later as per his convenience. S5, another college student mentioned that her teachers started sending handwritten notes with detailed explanations instead of solely relying on online resources, that students may not always have access to with the poor network infrastructure. Networks were thus necessary to undertake such activities during a crisis and this work was driven largely by WhatsApp groups where resources and information were shared across non-profit organizations, between the non-profit organizations and the community they served, and across communities.

*4.2.4 Issues Rising from Communication Gaps.* Problems within the digital infrastructure did not stop with the internet. Our student participants shared that communication from schools declined significantly during the initial phase of the pandemic. In some cases, the delay in starting communication channels extended to as long as three whole months after the lockdown began, as described by ST1. The absence of a proper digital infrastructure in place to start communication networks, coupled with the slow response from educational authorities as well as students aggravated this communication gap. With schools and colleges that stopped lectures completely, the only communication that students even received from teachers was regarding job placements and recruiting. Students received no instructions regarding plans around lecture formats and delivery for upcoming semesters. For students in their final year of college like S6, this communication gap regarding exams impacted their graduation timelines, thus delaying their ability to pursue a full-time skilled job.

In the absence of a robust communication system with parents, teachers from our study struggled to get in touch. Many migrant workers living in cities also traveled back to their native villages in Maharashtra or North India to take up agricultural labor and get away from the spread of the pandemic. This posed a challenge to schools and teachers who struggled to get in touch with students living in rural areas with poor network connectivity. As a teacher described:

“I would say network is a really big problem because many kids have gone back to very remote villages. They join the call and leave again and again. Some of them join, but they are not able to hear properly.”—T1, 24, F, Teacher

The above example demonstrates how the lockdown worsened the digital divide between rural and urban areas. According to A5, an NGO founder: “40-45% of the students come from rural areas with no access to phones or the internet.” More often than not, such children were also first generation learners. Their parents thus could not help them with using phones and other devices. The children had to learn to use not just the device, but the various applications on it themselves. Setting up this communication network and training students to use digital technologies thus posed much bigger challenges in rural, remote areas compared to the cities.

*4.2.5 Sharing of Devices at Home.* A vast body of ICTD literature has studied device-sharing in the Global South (e.g., [4, 14, 74]) These studies have brought out some of the challenges that device-sharing accompanies, around digital privacy [3] for example. Our findings also revealed problems within households when it came to the availability of shared digital devices to different family members. In many cases, there was only one device available per household. For example, ST1, one of the teachers we spoke to, mentioned that his students did not have access to the phone for a major part of the day since their parents had to take them out with them to work daily. This was particularly the case for kids who were too young to have their own phones. Sometimes they were able to use the phone only in the evenings after their parents got back from work. Adding to this, A8 stated that the device usage was very often split between multiple children within the household, belonging to different age groups and taking classes in different language mediums. Children belonging to higher age groups (9th-12th grade) were prioritized since there was less incentive for educating the younger kids in the family.

Our participants from NGOs revealed how gender roles often impacted levels of digital access and time available for learning. Prior research work in Bangladesh has indicated how gender plays a substantial role in prevalent sharing models at home due to economic, cultural, and educational factors [3, 34]. Our study revealed similar trends. A7, for example, shared that their organizations found significant differences in how parents treated girls and boys:

“If it is a girl child, the mindset of parents is completely different... If within a family there are multiple classes at the same time and only one device is there, the boy child will get the mobile phone while the girl child will have to skip class. If it is time for her to wash utensils, she has to pay attention to that first. We have to work out different times for classes for boys and girls—girls more towards the night time when they are free, for boys anytime since they are privileged. Problem is girls are very attentive—they listen to you and they want to study—but their parents do not give much importance.”  
—A7, 42, M, NGO Founder

A7’s comment reflects how gender inequities were further amplified during the pandemic. Sons were given priority when it came to using the device at home for online classes and assignments, regardless of how much attention and effort they put in. As stated by A7 above, girls had other responsibilities like household chores during the day, and got access to the phone at night.

### 4.3 Students' (Lack of) Adaptation to Online Learning

The transition to online learning in the classroom brought with it an array of challenges around students' understanding of different concepts, and problems with evaluating this understanding. The following section outlines these challenges not only from the students we interviewed directly, but also from the perspectives of teachers and NGO volunteers.

**4.3.1 Students' Struggle with Conceptual Understanding.** The teachers we interviewed revealed that the online lectures and videos alone did not suffice when it came to explaining concepts to students. This was particularly relevant to subjects like Mathematics as described by ST1 (teacher):

“For classes like Mathematics, it is difficult to do it on Zoom. If you want to give them some sums (problems) to solve, they still take two full hours to do just four questions—they are struggling.”—ST1, 21, M, Teacher

ST1's example depicts how school-going students grappled with basic concepts when they were taught online. Missing one lecture because of unstable network connectivity led to students not being able to follow along during future lectures as well. He also brought up how sending online tutorials and YouTube video links did not suffice either, unless he played them in class and explained them simultaneously. According to another teacher (A1), online lectures also lacked the much needed aspect of “*individual attention*” which teachers could previously easily provide students with in an in-person setting. Some NGO administrators, like A6, also felt that students spent too much time staring at the screen during online lectures, instead of focusing and absorbing the content being taught. Peer learning was also missing since students could no longer meet and talk to each other. According to some college-going students like S3, there was no way for his teacher to identify whether all students, particularly the “*shy and quiet ones*” were following along in classes since they often did not speak up when they had doubts.

**4.3.2 Challenges with Evaluation.** Assessments used to evaluate students' understanding of concepts in a classroom setting also underwent drastic format changes. With the shift to online exams, our participants stated that assessments were challenging because of rampant cheating among school-going students:

“For 10th grade, students can Google answers or do them on the calculator... They can also share photos of the answers during the test. So I made different question papers for different students or ask them to alternate between even/odd question numbers. But even then, I found students sending questions to one another... I had all students turn on their front cameras while taking the exam. Students can still have applications running in the background though.”—ST1, 21, M, Teacher

From the above example, it is evident that there was no good system to monitor/proctor students during exams. Students found ways to bypass the exam proctoring methods and resorted to sending each other answers during the exam, looking up answers on the internet, and seeking help from other family members. The goal of an online exam which was to assess the student's understanding on concepts being taught in class got diminished. Past research has shown that the extent of student participation in the online classroom is based on intrinsic motivations (such as a desire to learn) [45], and that students rarely blatantly cheat [58]. We thus recognize that cheating has always been rampant and creating better monitoring systems alone may not be the solution to this challenge. A8, a school principal we interviewed stated that teachers could no longer provide the much-needed initial individual guidance to younger kids in their formative learning years. As A6 and A8 stated, this was the case for homework assignments too. Several teachers discovered that the student's parents or siblings completed the homework assignments instead as a result of which there was no clear way of evaluating the child's understanding. As A8 stated:



“We don’t know how much these younger children are understanding... each child has different level of understanding... we just want them to play and learn... If we give them something that will trouble them, they will start avoiding classes then.”

—A8, 47, M, *Principal*

This reveals how the goal of online learning during COVID-19 shifted from evaluating the students’ understanding to simply keeping them engaged at home. Thus, several factors influenced the motivation levels of their students and the effectiveness of online evaluation systems.

**4.3.3 Lack of Motivation among Students.** Problems with conceptual understanding and the absence of good evaluation methods also influenced and were impacted by the motivation levels that students exhibited to study at home during the pandemic. According to some college students like S1, overall productivity levels decreased at home, even though she now had more time to study. ST1, one of the teachers we spoke to stated that school students spent hours surfing entertaining videos on YouTube and scrolling through social media feeds on their devices. However, they did not display the same level of enthusiasm for using online courses and tutorials to study topics of interest outside the classroom, despite having access to a device with the internet. According to administrators like A3, schools and colleges shutting down led to students viewing the lockdown as “*vacation time*”. They also mentioned that the absence of social interaction in the learning process contributed to the indifference amongst several students. Teachers willing to teach repeatedly reached out to several students for conducting online lectures but they received no response from them, even if they were available to contact through WhatsApp and other messaging platforms. T1, a teacher we interviewed, stated, “Consistency amongst students is another major concern.” T1 described how students missed classes regularly and would instead find excuses to skip them, especially since none of the lectures could be made mandatory. Younger kids especially had no motivation since the system allowed them to be promoted to the next class despite failing a previous grade. T1 also did not receive responses from students for homework’s and other assignments even after they attended lectures, since they put off studying at home. According to teachers like ST2: “*Participation of students dropped to as little as 25 percent*”. Students were frequently disruptive during lectures and ST2 shared that some students would engage in pranks during the class.

Some NGO founders like A4 also expressed the concern that due to challenging situations at home, many students’ creativity was impacted and the online medium was not conducive to creative activities. Organizations also shared existing online content with students such as videos on different topics on Khan Academy or YouTube as supplemental resources. Our findings align with prior research on online content for Virtual Reality on cardboard headsets which indicated that the content available to teachers was not always aligned with the school curriculum [98]. This observation we make can thus be applied to the broader domain of online learning, beyond Virtual Reality alone. Our NGO participants also noted that the applications used for online learning were typically in English which not all students were comfortable with. Thus, this absence of personalization and space for creativity also impacted student motivation.

#### 4.4 Teacher Response to Poor Learning Outcomes

The introduction of online learning in the classroom environments influenced the perspectives and response from teachers and parents. Teachers had to come up with new strategies to encourage participation and gauge interest amongst students, and accommodate their different schedules and needs. The teachers and NGO administrators from our study also mentioned that the concerns and priorities of parents shifted during the course of the pandemic. A major limitation of our study was that we could not get a different perspective on these problems from parents themselves due to challenges with recruitment.

**4.4.1 Strategies to Encourage Participation.** The nature of the activities conducted by our teacher participants as part of online learning played a critical role in determining the levels of participation amongst school students. There were two extremes to the approach teachers adopted during the pandemic. On one hand, A7 described how “*some teachers took no extra efforts during the pandemic since government schools had closed down.*” In contrast to this, some other teachers working with T1 came up with “*online podcasts on General Knowledge topics*” to gauge extra interest. They went above and beyond to keep students engaged so as to reduce dropout rates extending into periods after COVID-19.

To gauge further interest, many of the organizations that our participants were affiliated with adopted a more activity-based learning approach. Such efforts to engage in play-based learning have been undertaken in the past [86]. For instance, Kam et al. designed educational games based on traditional village games that were culturally meaningful to students [37]. Similar to this approach, our teacher participants like T1 supplemented the assignments sent on WhatsApp with several fun activities. Instead of focusing on the core curriculum expected by the state and national board, they conducted exercises with school students like arts and crafts, storytelling sessions, and games. Kahoots were often used for conducting quizzes since they brought in a social aspect to learning to keep students engaged. T1, along with her other NGO volunteers, sent out daily polls on WhatsApp asking how students were doing, to address any social and emotional problems they might potentially be facing during the pandemic.

Several NGOs and schools from our study also began training teachers on the nuances of conducting lectures online, right from learning to use applications to moderating lectures for questions, and tackling network issues that could potentially disrupt the flow of the lecture. These organizations took special training initiatives around troubleshooting common digital infrastructural issues. Prior studies suggest that training programs in the Global South do not adequately prepare teachers for classroom settings [56, 70, 97], and a few technological solutions have arisen to address this issue [88]. The organizations we spoke to paid special attention to this aspect. NGOs like that of A10 created a “*central platform for all teachers*” to access training videos, materials, and answers to commonly asked questions from kids of different age groups. A10 notes that this proved to be more beneficial in comparison to “*learning applications on the internet that required the user to clear complex levels to access content.*” These training platforms were instrumental in ensuring that teachers were able to gain an adequate level of proficiency in the use of online platforms so that they could exploit them to the fullest, not just for delivering lecture content, but for increasing engagement amongst students. Hence, overall participation was a culmination of several factors including but not limited to digital access and infrastructure, methods used to deliver content, and teachers’ training and initiatives towards steering creativity to increase engagement.

**4.4.2 Increased Workload on Teachers.** Owing to these many challenges described above, our teacher participants now had to develop learning experiences within the classroom that catered to diverse student needs. This was a significant burden:

“The load on teachers has increased. Previously the teacher would teach only 9-11 am. Now she teaches 9-11am, 2-4pm, and 5-7pm. She needs to accommodate every student’s schedule depending on when they have class, what assignments they are given, etc. She also needs to account for students in different grades and form groups accordingly. She has also assigned Saturdays and Sundays for doubt clearing. It becomes a nuisance for her since every child calls individually and may or may not call at a fixed time. So, she has started holding such sessions in groups of 3-4 students on WhatsApp to save on time.” —A6, 34, F, NGO Founder

A6's experience is just one among the many instances where teachers had to take out a lot more time, beyond the limited time allocated to lectures to accommodate different schedules for children and provide them with 1-on-1 help separately or in smaller groups outside of lectures. A6, an NGO administrator, noted that teachers had to be patient through all these calls and come up with efficient solutions to help students. In addition to these, several teachers also stated that they had to take out extra time to grade assignments online. For example, ST1 said that he had to evaluate assignments on WhatsApp, edit each photograph, and send it back to the student with feedback. This took up a lot of time even for a small number of students, thus affecting overall efficiency. In some cases with NGOs like that of ST2, only 1-2 teachers were even available to conduct lectures, so handling lectures, doubt clearing, and post lecture calls all at once took a heavy toll on their efficiency. Thus teaching online brought a lot of challenges around time management for instructors. This aligns with prior findings by Cannanure et al., who followed an assets-based approach to focus on teachers' intrinsic desire to grow and create solutions through solidarity for the problems they face. Their study makes design recommendations that balance teachers' career and personal aspirations [16].

*4.4.3 Addressing Parental Concerns.* The teachers and NGO volunteers we interviewed also pointed out the significant role that parents played in determining the effectiveness of the new learning environments. Previous studies have demonstrated the crucial role that parents in resource-constrained contexts play in supporting the development of children's literacy [53, 102]. Our findings identify several concerns from these parents that influence their roles and involvement during a crisis. Several teachers and administrators from NGOs including A1 and A2 stated that several parents no longer wanted to pay for their child's school fees during the pandemic. Since online classes did not entail individual attention from the teachers and did not have a robust structure for exams and other forms of evaluation in place, our participants mentioned that many parents they interacted with viewed those classes as futile and *"not worth the investment, especially in times of economic crisis"*. According to A2: *"Some parents have filed petitions against the high tuition charges by schools."* Parents also thought that the fees for online classes was too high and the quality did not match up to the massive amounts they were paying. They refused to recharge internet packages on their phones for online lectures since those were too expensive.

In families where the fees was not a major issue due to considerations from the schools and NGOs, there were significant differences in attitudes towards education during the pandemic. As T1, a teacher, brings out parents' perception of their child's education often belonged to two extremes. One end of the spectrum were parents who were so enthusiastic that they would often call up teachers asking them to assign their kids more homework and assignments for practice. On the other hand, there were parents who were okay with their children not studying at all during the lockdown, since the education system allowed for students till the 8th grade to be promoted regardless of their performance. A5, an NGO founder, mentioned that many parents' focus shifted further away from education in the midst of other pressing problems like food insecurity, unemployment, and the struggles to make two ends meet. A10, another NGO founder, shared:

*"In one area, our teachers tried to go and distribute worksheets to parents for their kids to solve... but the parents started abusing the teachers."*—A10, 57, F, NGO Founder

Thus involving the parents and convincing them was a huge problem that many of our participants had to tackle during the pandemic. Our teacher and NGO participants also stated that several parents saw the use of cellphones and other electronic devices as a *"source of distraction"* rather than a source of learning for their kids, especially those belonging to younger age groups. They were also irritated by the contradicting instructions they were receiving from teachers. The same teachers who previously told parents to limit laptops and phone usage at home, to retain the

student's focus were now encouraging their extensive use. In addition to overcoming this stigma, several teachers told us that they had to arrange for phone calls with parents, especially those of younger kids in order to explain the functionality for various video calling applications used for lectures, since a vast majority of them had no experience with the use of electronic devices. Schools and non-profit organizations also spent extensive resources contacting parents to convince them to keep the child in school and provide them with access to devices.

#### 4.5 Supporting Student Wellbeing Outside the Classroom

The pandemic's lockdown brought with it several challenges outside education as well. One factor that contributed to these problems was the shutting down of schools. Government schools were previously responsible for providing midday meals to fulfil the daily nutritional needs of their students. Some schools and NGOs we spoke to also provided access to mental health resources through counsellors, ensuring menstrual hygiene for girls, and preventing domestic violence. These initiatives were driven by organizations' care for the students' overall well-being. The lockdown put a halt to these activities thereby stripping students of this additional support and affecting their ability to focus on school. However, other forms of providing care emerged in the online format.

*4.5.1 Prioritizing Health of Students and their Families.* From the beginning of the lockdown, many low income-earning families that students belonged to struggled with food insecurity. A8, a principal of a school in Mumbai, talked about some of the hardships that families in the slum area faced when the lockdown first started:

“In my area, there was a time when for three days we were not supposed to step out the house. And I heard that more than 35 people died in those three days because of no food. This is the condition where we are living.”—A8, 47, F, *Principal*

This is just one example of the levels of food insecurity in the slums that went unaddressed during the initial phase of the lockdown. To combat this, our participants from schools and non-profit organizations shifted their focus from education to working with underserved communities to support their immediate needs for the first one month. T1, a teacher, shared some of the initiatives her NGO took:

“After March 30th when the lockdown extended, we came together as an organization and started a fundraiser to help parents with essentials. We contacted and partnered with supermarkets in the lockdown areas and we arranged for ration that would go to the parents. During that time, we did not do much for education and even participation reduced.”—T1, 24, F, *Teacher*

Similar to T1's organization, several other NGOs also looked into distribution of healthcare essentials, providing places to stay for those unable to afford rent, improving awareness of health information and government schemes, and enabling access to healthcare. Some NGOs from our study came together to distribute sanitary napkins to women, and masks and sanitizers to families. A10, one of the NGO founders, we interviewed also spoke about the water supply issues in slums that were looked into, to provide families with access to running water, required hand-washing and good hygiene practices during the pandemic. They made videos to train people on making masks with readily available clothing. A4's NGO also used its education funds to provide children in slums with day shelters for food, water, and clothing. There were also foundations that allowed people to simply call them up to ask for ration kits, when in need. A10's NGO conducted mental health programs online to help students and their families cope with any emotional problems that they had had to face during the pandemic. This was particularly relevant in cases where abuse and domestic violence surged in the face of the lockdown, as a result of frustration and unemployment:

“So when we hear stories of what was going on in the first three months, we heard that the child abuse rate has increased by 300%... In schools we had previously appointed psychiatrists where these kids used to go to with such problems... But these things not happening now.”—A7, 42, F, NGO Founder

A7’s example shows us how the much-needed mental health services that women and children had access to before the pandemic was no longer available. The links to the community that non-profit educational organizations had developed over the years served critical here in identifying families that needed support. These organizations also collaborated with each other to extend their network and provide resources beyond their region.

**4.5.2 Working to Keep Students in School.** With the advent of the lockdown, schools and colleges saw a severe decline in the levels of participation and response from students. Similar to the findings from Kumar et al.’s study, educators from our study (teachers, principals and NGO volunteers) struggled to keep students in school [49]. According to T1, one of the teachers we spoke to, participation in her class reduced to 50% of what it was before COVID-19. This number went as low as 25% for some other teachers like ST2. Several teachers working with T1 took extra initiatives to keep students engaged so as to reduce dropout rates extending into periods after COVID-19. A5, one of the NGO founders, shared details around teachers’ increased motivation to take on extra efforts during the pandemic:

“Some teachers were really worried. The kind of background that kids in the government school ecosystems come from creates gaps in the education system that forces them to work at a young age. Girl children have the fear of getting married as well. There is also a lot of fear that these children might get themselves involved in some unsocial, inappropriate activities and it will be very difficult to bring them back from it. A lot of these government school teachers had this fear and hence they wanted to stay connected to the students no matter what happened.”—A5, 36, M, NGO Founder

A5 above notes how teachers were worried about several social issues aggravating in the light of the pandemic. They were worried that dropouts would cause students to take up odd illegal jobs to earn some money. Similar to observations from previous research studies [49], child marriage amongst girls was another big concern for the teachers we interviewed. The teachers and NGO administrators from our study identified a variety of factors contributing to the drastic dropout rates. The financial strain on families during the pandemic took a toll on enrollment in those schools where parents were still expected to pay the fees for their child’s education. With the deteriorating economy and rising unemployment levels, these parents could no longer afford to pay for their child’s education. They were also unable to pay for books and other materials being used in the classroom. Some schools catering to the needs of children in slums, like the one that A8 worked at, did not force parents to pay the fees during the pandemic thus allowing students to continue classes online. Many others, however, were stringent about fee payments. During the months of June and July, when summer vacation in schools started, several migrant families living in the city went back to their villages. With the absence of reliable internet networks and device access in these remote villages, the dropout rates from schools and colleges increased even further. It was hard to reach such students even on phones since many of them deactivated their SIM cards after getting there. Some NGO administrators like A6 decided to stop classes altogether for kids of very young age groups since they were worried that the “*chances of distraction*” from the use of phones and other electronic devices was too high and hard to control. They also did not want to use traditional classroom methods of content delivery for these kids since it was too difficult for them to follow along and it would lead to them being tagged as “*slow learners*” during their critical learning years.

Our participants from NGOs noted that in families with more members and limited resources, students had also begun engaging in odd jobs to contribute to their family's income. This meant that they now had less time to attend online lectures. The lockdown also saw an increase in child abuse incidents at home, malnutrition, and issues around menstrual health and hygiene. Not only did these lead to more dropouts, these also impacted students' abilities to focus in classes that they did attend.

## 5 DISCUSSION

Our research highlights several gaps in current education infrastructures in India, online and offline, as surfaced by the COVID-19 pandemic. These challenges are not unique to the Global South; similar challenges in reaching students with limited digital access or facing financial hardships during the pandemic are increasingly being brought to attention in contexts in the Global North as well [52]. Even in the face of significant challenges, however, we witness the resilience and adaptability of educators, learners, and entrepreneurs who are part of the ecosystem. Learning from current, ongoing efforts to adapt to online means, we offer insights for researchers, educators, activists, and entrepreneurs committed to bringing learning within greater reach.

### 5.1 Digital Transformation Effected by the Pandemic

Our findings demonstrated how forced technology diffusion during the COVID-19 pandemic has radically transformed the online learning landscape in India, though several gaps and challenges remain. The field of ICTD has long struggled with the sustained adoption of interventions in education, as in other fields [10], consistently indicating that entertainment and the desire for social connection are primary drivers of technology adoption [9, 35, 47, 79]. However, the pandemic has recast the role of mobile phones as primary connectors to infrastructures like schools, hospitals, and financial institutions. The capital-intensive efforts to distribute smartphones and data packages by cash-strapped NGOs to get students online further points to the changing perception of the internet as an essential resource. Our findings also indicate that digital literacies were now being forced on teachers, students, and other administrators, which has long-term implications. Thus, not only has the assimilation of technology into the education system (and other domains) been accelerated significantly, but perceptions around the role of technology have shifted. This could indicate new opportunities for the long-term integration of ICTD interventions, such as for learning.

These changes in the digital ecosystem mean that we need to revise several assumptions around the use of technology for education in contexts in the Global South. Most past interventions in this space assume that only a single (or no) technology is being used. However, we found educators using an array of technologies to enable different kinds of interactions and activities with students with varying digital access. The suspension of exams and typical formats that educators were expected to follow offered more freedom to experiment in the classroom. These practices indicate opportunities for future design that centers the agency of educators, enabling them to configure technology to meet their unique needs. Researchers also need to consider how multiple technologies can collectively offer a richer experience overall for learners and educators.

The challenges around digital access in education highlighted in this paper are not unique to the Global South. Forced digitization during the pandemic has revealed inequities in access to devices and stable internet in parts of the Global North as well [28, 52, 93]. There is an opportunity to learn from research being pursued in the Global South for years, particularly from the ICTD context, where these issues have long been a focus of attention (e.g., [17, 37]). The design implications we propose in the following sections could potentially apply at a wider global scope, even as they are centered around the local challenges that we observed in our context of study.



## 5.2 Leveraging Cyber-Human Infrastructures in Education

The digital transformation taking place in the education system resulted in creative workarounds to make online learning work for most students. ICTD researchers have previously described this practice of *jugaad*, or creating workarounds in the face of perennial resource constraints to execute everyday tasks during a crisis [47, 72, 73]. We find a similar practice in the setting we studied. The human infrastructures—of individuals and institutions—worked together to navigate and overcome the limitations of available technical infrastructure during the pandemic. Sambasivan and Smyth have described how such human infrastructures have the ability to overcome several constraints, including device and internet availability, precarious electricity, and various forms of literacy [75].

Our findings demonstrated how networks of schools, NGOs, teachers, and parents worked together to coordinate crisis relief and share resources for online learning. Research from the field of crisis informatics has shown how social media platforms can be leveraged to support individual as well as collective relief efforts [83, 90] and circulation of valuable information [41] during emergency situations. We observed how communication across different groups was facilitated largely using online chat platforms like WhatsApp. This network infrastructure was thus crucial to undertake and sustain such activities during the crisis [81, 103]. These relationships also enabled NGOs to organize and deliver resources like food and healthcare essentials to families. School administrators also connected with NGOs to facilitate the distribution of books and worksheets to children living in slums. Little research has looked at how such networks can be supported and strengthened in education, but similar efforts undertaken by humanitarian organizations during crisis situations have been extensively studied and could be adapted [19, 80, 83]. We also found educators regularly go beyond expected roles and work hours to reach students. Prior research has indicated how such *care* can play an important role in materially constrained environments [38]. Teachers from government schools paired up with NGOs to get in touch with students regularly and keep them engaged, and provide them with access to mental health resources to address issues around increased domestic violence, child labor and dropout rates as a result of the pandemic. Technology can further augment such efforts. For example, our findings showed how NGOs leveraged the use of online platforms and communication channels such as WhatsApp to start mental health programs that tackled the emotional problems families were facing during the pandemic. This could be further supported with Technology Mediated Mental Health Support (TMMHS) systems and Interactive Voice Response (IVR) systems that route callers based on the type of issues needing to be addressed [65]. The digital platforms in place for online learning can be extended to support the distribution of such resources.

Our findings also show evidence of the stakeholders' resourcefulness in navigating a changing digital landscape. Educators leveraged applications that students were already comfortable with, such as WhatsApp and YouTube. Chat-based interactions were most pervasive, reminiscent of previously proposed mobile ICTD interventions. For instance, SMS and WhatsApp were used for sending quizzes, sharing content with teachers on groups, connecting with parents, and facilitating peer learning [61, 66, 101]. Teachers and NGOs also juggled multiple platforms to navigate diverse student needs and levels of digital access. They moved between the use of online platforms (e.g., WhatsApp, Zoom, Google Hangouts) and offline channels (SMS, phone calls, and even in-person meetings) to connect with students, frequently using these in tandem. Educators also had to prepare for shared device settings as children rarely had access to personal devices. They expended significant effort in working out timings for different students based on the household situation. Our participants also took an active role in addressing the limitations of available technical infrastructure. For example, NGOs introduced tablets in schools that were pre-loaded with lecture content and fully charged before being distributed to students, to eliminate the need for internet and stable electricity.

Other organizations started radio channels for learning, thus leveraging a resource available in most households. In areas with limited device and internet access, teachers conducted in-person classes outside the slums to keep students engaged during the pandemic. NGOs brought children to their physical centers with social distancing measures so that they could leverage resources like projectors to share videos with them on big screen.

Finally, these online and offline engagements reshaped the roles and relationships of actors that were part of the human infrastructure. NGOs that had previously focused on supplementing classroom learning through informal after-school activities, now began to teach content that was part of the school curriculum as several schools were closed. The key role of such intermediaries in filling service gaps has been observed extensively in other domains like healthcare in the past [30, 48]. However, the critical role that the human infrastructure plays in the field of education is less studied, perhaps due to a focus on more formal learning environments. Wong-Villacres et al. point to the role of intermediaries in education in their study of school liaisons working with immigrant parents in the United States [101]. With the pervasive penetration of technology during the pandemic, the roles assumed by different sections of the community has also shifted. Future research could look into how these new human networks could be leveraged and reshaped to suit local learning and other needs. It could also examine how the increasing availability of technology itself can be utilized to prepare people better, thereby strengthening the efficacy of these communities. This opens up possibilities for exploring the interdependence between the human and digital frameworks in underserved communities.

### 5.3 Towards a More Inclusive and Sustainable Future for Online Learning

The burden of managing regular technology breakdowns and operating in highly variable online environments, and the loss of social interaction, resulted in our participants being largely anxious to return to traditional classroom learning. However, the online medium also offered certain strengths. We outline where technology might add most value in this context, and strengthen the education system in the long term, even in a post-COVID world.

ICTD researchers have long sought to enable access to quality education in countries in the Global South using technology. For example, Varanasi et al. have studied the use of smartphones by teachers in classrooms in India, uncovering the workload that they add for teachers [94, 95]. Poon et al. recognized the challenges around intermittent internet access, and employed interventions involving SMS and WhatsApp to prepare students prepare for exams [66]. Nedungadi et al. also deployed an intervention on WhatsApp to address teacher absenteeism and increase their accountability in government schools in rural parts of India [61]. Such interventions also meet the typical daily allowance of data packages, which our findings showed were otherwise not adequate to sustain multiple online lectures. Prior work has also attended to the gender inequalities impacting education and digital access [5, 49]. Though access to smartphones and the internet has enabled technology integration in education during the pandemic, we find that many of the above challenges remain. We also note the differences in the impact of these problems between older and younger students, girls and boys, public and private schools, etc. The technologies and designs proposed in the literature outlined above could help address existing challenges if integrated on a wider scale, and could be a focus of emerging entrepreneurial efforts.

The plethora of digital resources that *were* readily available to educators rarely addressed such challenges. Most available content and technologies were designed primarily for settings in the Global North, and did not always meet the needs of educators nor were designed for the digital and classroom contexts of our participants. We found that students struggled to understand concepts online, since the new learning environments leveraged teaching styles that were very different from the traditional rote learning approach they were used to. In some cases, teachers resorted to using

the conventional classroom styles online (e.g., teaching on a board using their phone camera on video lecture calls) though online platforms were not designed to be employed in that way. There are thus important considerations needed around the potential target audience while developing new educational technology platforms. Addressing challenges within the education system requires guidelines for better navigation through available resources as well as identification of the correct combination of those resources to best accommodate specific local needs.

The increasing prevalence of technology in the classrooms also indicates a shift in the role of an instructor from an expert knowledge provider to an expert facilitator. For some participants, the amount of content available was so overwhelming that students and teachers had trouble deciding where to look, and identifying which digital tools would best suit their individual needs. Sustainable solutions therefore need to take a more flexible approach, offering components of the online programs that educators can pick and choose—such as providing supplemental online resources, and enabling better communication with parents and students. WhatsApp was the platform of choice for both of these activities and more work is needed to understand how it could be effectively leveraged in education in the Global South, beyond just WhatsApp groups. For example, Konagai has shown how creative techniques such as the use of emoji reactions can increase teacher engagement and instill a sense of appreciation for teacher well-being [42]. Madge et al. investigated the use of WhatsApp by African international distance education (IDE) students to not only fulfill ‘formal’ pedagogic goals like contacting academic instructors but for self-motivated purposes like peer-organized learning, career networking, and seeking future educational opportunities [55]. Thus, WhatsApp has the potential to transfer, translate, and transform the educational experience of students [55]. There is also a pressing need for more robust teacher training programs that include guidance on troubleshooting common digital infrastructural issues. The training initiatives from A10’s NGO that created a central platform for all teachers to access training videos, materials, and answers to commonly asked questions and errors is a good model for improving teachers’ proficiency levels for content delivery and online engagement with students. A mobile-first approach is critical to this online learning ecosystem. There is a need to rethink the design of digital learning platforms to adapt better to small-screen devices like mobile phones.

Finally, the gaps in adapting traditional classroom education to the online learning that we observed offer an opportunity to reimagine the structure of the Indian education system. The online setting amplified the limitations of the current modes of teaching [91], but also brought a wide array of strengths that could be leveraged. We found that educators were forced to reassess traditional lecture-based and rote learning models which were not conducive to student learning in the online environment. They instead introduced more activities that support peer engagement to increase student motivation to learn, both inside and outside the classroom, such as through collaborative games [27]. Thus the pandemic not only transformed the educational technology landscape, but also brought about changes in pedagogical strategies. Such work has taken place to a limited extent in the Global South, mostly using cellphones, such as for English and local language literacies [36, 46, 50, 89] and mathematics [33, 51], but has seen little adoption. Collaborative games could also help address student social and emotional wellbeing, frequently overlooked in the Indian education system [22]. Another approach could be to incorporate polls that check in with students on a daily basis. Finally, online learning also offers an opportunity to re-evaluate the dominant mode of assessing learning. Though the main concern of educators was that online tests made it easy for students to cheat, this indicates a deeper issue with assessments that evaluate student ability to retain information rather than their understanding. The structure of assessments could be revised to instead get students to respond to creative and deeper questions, more comprehensively evaluating conceptual understanding. Such efforts would not only help leverage the strengths

of online learning, but would go a long way in strengthening the education system overall by addressing current limitations.

## 6 CONCLUSION

As the COVID-19 pandemic accelerates the adoption of educational technologies in the classroom and the home, the limitations of these technologies and current approaches to online learning have also been revealed. These are amplified in resource-constrained settings, such as the one we studied. Our interviews with students, teachers, and non-profit organizations in India uncovered that digital access was constrained, students struggled to learn in the online format, and content was frequently not aligned with local needs, among other issues. However, teachers, students, and educational institutions were actively working to tackle these challenges. Drawing inspiration from their resilient efforts, we offer recommendations for the design of educational technology in resource-constrained settings that take into account varying digital access and digital literacies.

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