Constructivist teaching and learning with technologies in the COVID-19 lockdown in Eastern India

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Abstract
This paper reports a study on teaching and learning strategies during the COVID-19 lockdown period (CLP) that were used by the secondary government school teachers and students in Eastern India. These teaching and learning strategies were analysed in relation to their engagement with an initiative called Integrated approach to Technology in Education (ITE). ITE engagement in the pre-CLP involved using project-based learning (PBL) with technology and continuous, practise-based professional development for teachers focusing on integrating constructivist use of technology in their curriculum and pedagogy. A survey and interviews of teachers revealed that teachers with higher ITE engagement in the pre-CLP were more likely to use PBL with technology during the CLP. Students' interviews indicated that this PBL involved deep research and technical skills that were also practised during the CLP using distance technologies. Thus, the study demonstrated adaptation of ITE innovation into a distance mode; the introduction of WebQuests during the CLP improved the likelihood of teachers engaging in project-based teaching and PBL during the CLP. Policymakers, practitioners and researchers are recommended to
Practitioner notes

What is already known about this topic

• Project-based learning (PBL) with technology is related to constructivist use of technology which leads to higher order thinking skills and the learner's ability to adapt learning and knowledge in new contexts.

• Effective teacher professional development (TPD) is continuous, uses community of practise (CoP) groups and offers opportunities to practise new knowledge and skills in the classroom context. TPD for technology integration allows the demonstration and practise of constructivist pedagogies.

• Access to devices, connectivity and digital resources in the local language are major issues faced by students to connect with teaching and learning in the COVID-lockdown period (CLP), especially students in underprivileged settings.

What this paper adds

• Prior exposure to PBL with technology and effective TPD when combined with demonstrations of this learning in a new context (COVID-19 lockdown period, CLP required distance mode) will increase the likelihood of implementing PBL with technology in this new context.

• Besides increased use of technology, the CLP created a scope for adoption of teaching and learning pedagogies in the post-CLP, such as the use of Instant Messaging Application (IMA) for a flipped classroom experience across home/social and school settings.

Implications for practice and/or policy

• Standardised digital resources may not be the only solution for teaching and learning when schools have to be closed.

• Constructivist use of technology by students with project-based learning (PBL), artefact creation on authentic tasks and inquiry-based learning has the potential to transform students from passive consumers into active adapters in newer contexts like COVID-19 lockdown period (CLP).

• Investment in practise-based continuous professional development of teachers can develop a sense of agency and competence so that teachers can adapt technologies for constructive teaching pedagogies and mitigate access related challenges for students in different contexts.

• Integrate new teaching and learning strategies that emerged during the CLP in the curriculum and pedagogy of both in-service and pre-service teacher professional development.
INTRODUCTION

In March 2020, when the lockdown was initiated by the Government of India due to the COVID-19 pandemic, all educational institutions were instructed to temporarily close to contain the spread of the virus. With all face-to-face (F2F) classes for government, government-aided (private schools receiving government aid) and private schools suspended till the beginning of January 2021, the education system was compelled to shift to teaching and learning in a distance mode using technology, to allow students to continue their education. The Government of India and other non-governmental organisations developed a number of initiatives in an attempt to support the continuity of the teaching and learning processes across the country. In addition to the efforts of the government, other private organisations have also rapidly scaled their operations during the COVID-19 lockdown period (CLP), providing paid digital resources directly to students and private schools. The National Education Policy 2020 (MHRD, 2020c) which was announced on 31 July 2020 also stressed technology integration in subjects and teacher professional development (TPD) processes. The government has focused its efforts on curating and making available e-content for teachers and students in the form of e-textbooks, worksheets and videos amongst others. (MHRD, 2020a) These resources were made available through government initiatives like the Diksha platform (https://diksha.gov.in) which hosts a large number of learning resources relevant to the prescribed curriculum for teachers, parents and students, in addition to other state-led platforms. The Diksha platform has reportedly been accessed nearly 215 million times, and there was a significant increase in its access during the CLP (MHRD, 2020d). In addition, to reach the more marginalised sections of society where learners might not have access to devices and Internet connectivity, educational programmes were broadcast via 32 television and radio channels (MHRD, 2020a).

However, despite extensive efforts of the Central and State Governments in India to provide access to digital resources, a large number of teachers found them inadequate and inappropriate for their learners, syllabus and local contexts; teachers were also concerned about attendance during the online classes. Singh and colleagues (2020) also found that the available centralised digital resources were not contextualised for the local needs of teachers and students, and fewer than 50% of the students had access to devices and/or connectivity, with rural students more disadvantaged than urban students.

Other studies conducted in the Indian context during the CLP by Vyas (2020) and Pratham (2020) indicated that in both government and private schools WhatsApp, an instant messaging application (IMA), was the most common medium used by teachers for sharing resources and communicating with learners. Across the globe, other strategies employed to facilitate smooth remote teaching and learning included creating networks of support for teachers (Williams et al., 2020) and providing continuous teacher professional development (CTPD) to support teachers in the use of online pedagogies (Hulon et al., 2020; Williams et al., 2020). The concept of flipped classrooms has also been adapted in the CLP to enable teachers to use active pedagogies in the distance mode (Cunningham & Bergstrom, 2020). In the pre-CLP, the term flipped classroom referred to teaching techniques involving an interactive classroom session and computer-based individual instruction outside the classroom. The adapted modality of flipping in the CLP for many teachers (Cunningham & Bergstrom, 2020) was between two online modes: asynchronous self-paced instruction and synchronous classrooms. This technique of flipped classroom allows for the classes to become places engaging in collaborative learning and problem solving with basic instruction of the lesson taking place beforehand through videos and interactive lessons at home. (Bishop & Verleger, 2013).
THE ITE INNOVATION AND ADAPTATION DUE TO COVID-19

The context of this paper is situated within a large-scale programme called the Integrated approach to Technology in Education (ITE), an initiative of Tata Trusts, which started in 2012. Project-based learning (PBL) using ICT is the central component of ITE (Charania, 2011). This study investigates the relevance and use of the ITE approach from the pre-CLP to the CLP. The following section describes the ITE approach and the theoretical support for its constructivist pedagogy.

Constructivist pedagogy and digital agency (Passey et al., 2018) are central to the ITE programme and its approach and best resonate with Papert and Harel (1991) and Jonassen's (1999) claims that learners should be actively engaged in constructing artefacts using technology for constructing knowledge. For many decades, researchers have emphasised that constructive use of technology involving PBL and providing authentic learning environments lead to the development of higher-order thinking skills (Bagley & Hunter, 1992; Jonassen, 1999; Papert & Harel, 1991) and the ability to transfer these skills to newer contexts (Neo & Neo, 2010). PBL is a student-centred pedagogic approach that promotes student autonomy, constructive investigation, goal setting, collaboration, communication and reflection (Kokotsaki et al., 2016). PBL is considered to be a type of inquiry-based learning wherein the context is provided through authentic questions within real-world practises (Al-Balushi & Al-Amri, 2014). PBL using technology makes learners responsible and active in the learning process (Grant, 2002); it allows learners to develop an understanding of new concepts in real-life contexts (Wirkala & Kuhn, 2011).

‘Teacher designs and student creates’ is the PBL pedagogy employed in the ITE intervention (Charania, 2011). The use of Information and Communication Technology (ICT) to design and create projects is embedded within the regular transaction of the school curriculum, as opposed to being an additional layer. Since its inception, this approach has been adopted within the ITE community, which comprises approximately 3500 teachers, over 400,000 students (many of whom are underserved), and around 900 government schools (Tata Trusts, 2020). This approach allows students to engage deeply with various concepts using their creativity and local context. The ITE philosophy is rooted in the conviction that learners are not mere consumers of ICT resources but are creative producers of ICT artefacts, and this shapes their learning and cultural expression (Charania, 2020).

In implementing the ITE approach in the classrooms, teachers play a significant role. TPD is central to ITE and is provided through a blended (online and F2F) practiise-based certificate course on constructing teaching and learning with technology called ‘ICT and Education’. A resource team at the Tata Institute of Social Sciences (TISS) has developed and run this course for ITE implementing teachers in collaboration with the state governments. The overall objective of the course is to develop teachers’ critical perspectives and skills for using technology in a constructive and student-centred approach and, in the process, to practise and disseminate the ITE approach. The teachers who have earned the certificate ‘ICT and Education’ through a course lasting 4 months have earned the title Master Trainers (MTs). In addition, as part of the course, these MTs have trained other teachers (who became known as Outreach Teachers) in their neighbourhood schools on the ITE approach. They also continue their leadership through ITE activities and Community of Practise (CoP) groups on WhatsApp.

Drawing on literature relating to best practise, this format of TPD is continuous; starting with a long certificate course, teachers continue to engage in online CoPs (Kozma, 2011), ITE-related trainings and events are offered frequently and teachers have many opportunities to practise this pedagogy in their classrooms (Trucano, 2005; UNICEF, 2017). Williams et al. (2020) have highlighted that effective CoP’s and CTPD are key elements required to ensure smooth teaching and learning during the CLP as teachers required support on
selecting and curating digital resources, online pedagogies, and assessment plans, amongst others.

The blended ICT and Education certificate course was offered in 2017 and 2018. It resonated with most of the principles of CTPD laid down by Darling-Hammond et al. (2017) and other literature that emphasises providing authentic technology experience and role models for technology integration (eg, Baran et al., 2019) at teacher education institutes. The teachers engaged in creating ICT integrated instruction in their core subjects and implemented them in their classrooms. They reflected on their practise of PBL with ICT by the students. The course also offered teachers an opportunity to conduct short training and to establish their CoP, sharing their learning and practise in the course with other teachers in their own and neighbourhood schools (Paltiwale et al., 2020). The course facilitators stayed connected with the teachers round the clock to respond to their questions and queries and kept them updated with course activities. After the course, many district level ITE activities kept teachers abreast with practising knowledge and skills acquired in the certificate course.

Just before the CLP in March 2020, the ITE was implemented in the F2F mode in around 250 government schools and madrasahs (institutions imparting Islamic education along with school education), often in socio-economically disadvantaged sections of the states of Assam, West Bengal and Uttar Pradesh. In response to the lockdown, students who had prior knowledge of the ITE projects across the participating states were approached with the help of their teachers to engage in the online WebQuests. These WebQuests are inquiry-oriented activities conducted on an online platform that supports students' collaboration and active participation, critical thinking and deep understanding of concepts (Alias et al., 2013) using technology. During CLP between March and May 2020, the resource team at TISS conducted two WebQuests: one on communicable diseases and the other on the air quality index. The first CLP WebQuest, which had been conducted in the month of March 2020, was on the topic 'Communicable Diseases' and took place over three days (six hours online synchronous study). The students had selected a communicable disease of their choice and researched it with the help of their teachers. Students, using their own devices from the safety of their home, worked online individually or in groups, conducted online research, created projects for presentation and discussion and completed synchronous quizzes. During this WebQuest, these students also had the opportunity to virtually interact with a practising emergency physician, to clarify points that they could not solve using Internet search about their selected communicable disease. After these first two WebQuests with students studying from their own homes, the teachers and MTs were able to organise their own WebQuests with facilitation from the resource team at TISS (Charania et al., 2020).

PURPOSE OF THIS STUDY

The main objectives of this study were to explore the following:

1. How does prior engagement with ITE for both teachers and students help them to use the ITE projects (project-based teaching and learning with ICT) in the CLP?
2. What strategies are used by the teachers to teach with ICT during the CLP?

METHOD

A mixed methodology was used to collect self-reported data through semistructured interviews and survey responses which also aimed at triangulating data from both students and teachers. Forty MTs were interviewed, and 61 teachers with varying levels of engagement
with ITE were surveyed. Twelve students with active engagement in ITE WebQuests were interviewed. The details of the selection of participants are presented in the following sections. The focus of both teachers' and students' data collection was to understand the role of ITE engagement in using PBL with ICT and other strategies for teaching and learning in the CLP. The interviews were collected from MTs to understand in detail the relationship between ITE in the pre-CLP and their teaching strategies during the CLP. The survey included MTs, Outreach Teachers as well as those who had not been associated with ITE before CLP, which gave some variation in the level of ITE engagement. The interviews with students aimed to understand the role of pre-CLP ITE activities in supporting students' participation in the CLP WebQuests.

**MT interviews**

Based on the ITE activity reports, a list was collated of MTs from Assam, Madrasahs of West Bengal and government schools of Kolkata who had implemented ITE during the previous year (pre-CLP) in their schools. These criteria of selection yielded 64 MTs who were then contacted via telephone. Forty of the 64 MTs reported that they had been teaching in the distance mode during the CLP in the month of May 2020. The schools in their states had shut down either at the end of March or the beginning of April. Of these 40 MTs, 16 were from Government schools in Assam, 14 from madrasahs in West Bengal and 10 from government schools in Kolkata. All the participants in this study were from government-run and aided schools in which ITE and the certificate-course are being implemented. All interviews were conducted via telephone because of the CLP-induced restrictions. The consent form was read to the respondents over the phone call before starting the interview, and their consent was audio-recorded. After the interview, a copy of the consent form was sent to the respondent MTs who had shared their e-mail addresses. The interviews were conducted in the language that the MTs were comfortable with and then translated into English during the transcription process. The interview questions were developed based on a small study with seven MTs to better understand their teaching strategies in the CLP. The final interview schedule had the following topics: strategies used for teaching in the CLP, support and challenges whilst teaching in the CLP, if and in what ways ITE experience prior to the CLP and the ITE WebQuest in the CLP was useful to support their teaching during the CLP. The data collected from the interviews were analysed using the MAX Qualitative Data Analysis (MAXQDA) software (Kuckartz & Rädiker, 2019); all transcriptions were divided into multiple themes and subthemes that emerged from the data. The frequency of responses in each subtheme was recorded.

**Teacher survey**

A survey for teachers was developed drawing on the analysis of interviews conducted with the seven MTs and a few items adapted from the teacher survey by Singh et al. (2020). This survey aimed to reach both ITE and non-ITE implementing teachers from government-run or aided schools in the same districts. The survey was administered in Assamese-English and Bengali-English mixed versions in the respective states.

Following basic demographic questions, teachers were asked about the types of online activities they were conducting, the devices the teachers and their students were using and the challenges of teaching and learning in the distance mode during CLP. The last section covered the engagement of the respondents with the ITE pre-CLP and its relation to the activities they conducted in the CLP. The survey was administered using a digital platform and was shared
through ITE (CoP) groups on WhatsApp whose members consisted of MTs. The MTs were also requested to share the survey link with other teachers (including those who they trained during the certificate course) in their school and acquaintances from similar schools and districts. A consent form was integrated at the beginning of the survey, and the survey questions were made accessible only after the teachers consented to participate in the survey.

**Student interviews**

The students' interviews aimed to explore the experiences of students whilst participating in the ITE WebQuests during the CLP and its relation with their prior ITE engagement. Therefore, the criteria used for students' selection were those whose teachers had implemented ITE pre-CLP, and the students who attended all the sessions and activities for the two ITE WebQuests organised by the resource team at TISS in the months of March and May 2020. Twelve students whose teachers had implemented ITE prior to the CLP (11 students had prior experience of ITE project making) and who attended all the sessions and activities for the two ITE WebQuests were interviewed to understand their interest, motivation, challenges and impact of prior experiences of ITE. A consent form was sent to the parents of the students with the help of their teachers before conducting the interview. The consent forms were sent in Assamese, Bengali and Hindi language based on the language preferred by the parents as indicated by the respective teacher. The teachers confirmed that the parents received and understood the consent form. Each interview was administered for about 30–45 min in the relevant language.

**FINDINGS**

The findings section is divided into three parts: Strategies used by teachers during the CLP as indicated through MTs' interview data, impact of teachers' prior-CLP engagement with ITE analysed through teachers' survey data and impact of students' prior-CLP engagement with ITE as indicated through students' interview data.

**Strategies used by teachers during the CLP**

Categories with commonly reported responses for each of the themes were used to summarise the findings on strategies used by the teachers to teach in the CLP. For details on all the responses please refer to table in Annexure.

**Type of technologies and activities used to teach in the CLP**

a. The interview data showed that most of the teachers (37 out of 40) used IMA like WhatsApp and a combination of IMA and Video Conferencing (VC) to teach in the CLP.

b. Across categories, many responses (29 out of 39) indicated that teachers used IMA or WhatsApp groups to track and stay in touch with their students, schedule classes (13 out of 17), share resources and undertake small tasks related to teaching (51 out of 59 responses).

c. Amongst different activities used by the teachers in the CLP, several responses indicated teachers facilitated students to work on assignments (24 out of 59) from the textbooks. A
few responses (11 out of 59) also indicated that the teachers created and assigned tasks for students like project making and undertaking research. Other responses included conducting lectures using VC tools (8 out of 59).

d. Half of the responses (25 out of 50) indicated teachers made their own resources like audio-video, lesson plans or instructions to share with students. The other half of the responses indicated using online digital resources on the Web including resources from government portals. Following are some of the quotes from the MT interviews that support the findings in the above section.

Once or twice, I used YouTube and other applications but I do not find them much useful as they are one-way communication...

I have a plan for an ITE project on ‘Selva forest’, for that I created a group ‘(School name) hangout group’ with the students of grades 8 and 7 (12–13 year-olds)... I asked the students for research and download relevant pictures and videos on the topic.

Some of the students told me that they get the Internet network from 11 pm to 6 am. Therefore, I do not fix the time for classes. I told them I will give the study materials and you people will use it and complete the activities. I give them the recorded video, new information, photos and all.

I have given them an activity where students have to research (on) tribal people through videos via YouTube, national geography, etc, ... Then I divided students into four groups namely Group A, B, C & D and then gave each group a particular tribe.

We have completed the chapter called organic farming. There I asked students, have you burned sugar and salt, what will you see? Then students went to the kitchen and burned salt and sugar in their kitchen. They have observed that sugar turns into black and salt does not because sugar has carbon compounds in it. These data they have observed doing the activities. So, while teaching them online class we give them these kinds of activities. We always plan the activities before the online class and share with the students then during the classes I ask them to explain the activity and how they have completed it.

Benefits of teaching in the distance mode

Some of the responses indicated that teachers found the classes in the CLP useful to cover the syllabus (15 out of 41), that these classes increased participation (12 out of 41) in their students and were useful for staying in touch (9 out of 41) with the students.

Continuation of IMA Post-CLP

Most of the responses (34 out of 36) also indicated that the teachers would like to continue the distance mode engagement with students even after the F2F classes resume. This was primarily to share resources and stay in touch during holidays through WhatsApp (18 out of 34).
We can keep the students engaged via these online classes. Usually, they do not study when at home. But now they are studying and the parents can also keep a tab on the students. The syllabus is also moving forward and the students are learning something new.

Support from authorities

Many of the responses (36 out of 57) indicated that teachers were supported and motivated by the school heads to conduct the classes in the CLP. Some of the responses (21 out of 57) indicated support of the state and central government bodies through disseminating digital resources for teaching and learning on the platforms like Diksha and Bangla Shiksha.

Contribution of ITE activities in supporting teaching in the CLP

Some of the responses (22 out of 54) on motivation to teach in the CLP were around the category of engagement with ITE, such as engagement with CoP group and certificate course. When specifically asked for ITE contribution to support teaching in the CLP, several of the responses indicated ITE engagement before and during the CLP helped them acquire technical skills (16 out of 38) and developed their understanding of using ICT in a constructive way like project-based teaching (13 out of 38), which were useful in teaching during the CLP.

Challenges faced during the CLP teaching

Some of the responses indicated that poor Internet connection (26 out of 86) and lack of devices (19 out of 86) with the students were challenges faced whilst conducting classes in the CLP. Other responses indicated the inability to teach in person (8 out of 86) and technical difficulties faced by the teachers (6 out of 86) themselves.

Impact of teachers' prior-CLP engagement with ITE

Demographics of teachers who took the survey

Out of the 61 teachers who responded, 44% (27) were from urban districts and 56% (34) were from rural districts of West Bengal and Assam. About 39% (24) teachers taught languages in their schools, whilst 28% (17) taught mathematics, 34% (21) taught science and 20% (12) taught social sciences. About 62% (38) of the teachers taught school grades six to eight (age 11 to 13 years), 75% (46) of the teachers taught grades nine and ten (age 14 years to 15 years) and 38% (23) taught grades 11 and 12 (age 16 to 17 years).

Out of the total of 61 teachers, 48% (29) teachers held a Bachelor of Education (B.Ed.) degree and 21% (13) had passed the Teacher Eligibility Test (TET) along with the B.Ed. Ten teachers had a diploma in computer applications.

ITE engagement score

An ITE engagement score was created (ranging between 0 to 4) reflecting the teachers' involvement with ITE-activities pre-CLP: completion of ‘ICT and Education’ certificate course
by TISS, attending ITE trainings, implementation of ITE lesson plans in their respective schools and the existence of ITE MT (a teacher who completed ITE course) in their school. The engagement in these four activities was rated as yes or no. A “Yes” response for each of the four activities would give them a total score of 4. Twelve teachers scored 0, 17 teachers scored 1, 7 teachers scored 2, 15 teachers scored 3 and 10 teachers scored 4. Besides the ITE engagement activities in the pre-CLP, the teachers were also asked if they attended ITE Webinars or WebQuests during the CLP. Out of the 61 teachers, 22 attended the ITE Webinars/WebQuests.

**Predicting use of ITE during CLP**

Use of ITE during CLP was the dependent variable, which was a dichotomous variable (Yes or No), and teachers were asked in the survey if they had conducted any activity-based teaching and learning using ITE projects. To study if the ITE engagement scores in the pre-CLP predicted use of ITE during CLP, binomial logistic regression analysis was used. Binomial logistic regression predicts the probability of the outcome of a dichotomous-dependent variable based on one or more independent variables that can either be continuous or categorical (Garson, 2014). The Hosmer–Lemeshow test is a commonly used statistical test for goodness of fit for the logistic regression model.

Hosmer–Lemeshow (H–L) test yielded a $\chi^2(3)$ of 1.69 and was not statistically significant ($p = 0.639$) suggesting that the model was a good fit for the data. The ITE engagement scores significantly ($p < 0.001$) predicted or explained about 40% of the variance (Nagelkerke $R^2 = 0.42$) in use of ITE during CLP (the response was Yes or No).

The unstandardised Beta weight for the Constant; $B = (-3.05), SE = 0.77, Wald = 15.68, p < 0.001$. The unstandardised Beta weight for the predictor variable Engagement Score: $B = (1.09), SE = 0.28, Wald = 14.84, p < 0.001$. The estimated odds ratio favoured 2.9 times increase [%$Exp(B) = 2.99$, 95% CI (1.71, 5.22)] for use of ITE during CLP with every one unit increase of ITE Engagement Score in the pre-CLP.

Further, participation in ITE WebQuests was added (Step 1: ITE Engagement Score in pre CLP and Step 2: participation in ITE WebQuests in CLP) and the model was re-run with both the variables in the binary logistic regression to predict variance change in use of ITE during CLP. This addition improved the variance explained (Nagelkerke $R^2 = 0.53$). Hosmer–Lemeshow (H–L) test yielded a $\chi^2(6)$ of 4.76 and was not statistically significant ($p = 0.575$) suggesting that the model was a good fit for the data.

The unstandardised Beta weight for the Constant; $B = (-3.057), SE = 0.806, Wald = 13.96, p < 0.001$. The unstandardised Beta weight for the predictor variable Engagement Score: $B = (0.77), SE = 0.31, Wald = 5.89, p < 0.05$. The estimated odds ratio favoured 2.1 times increase [%$Exp(B) = 2.16$, 95% CI (1.16, 4.02)] for use of ITE during CLP with every one unit increase of Engagement Score.

The unstandardised Beta weight for the predictor variable Number of WebQuests/Webinars attended: $B = (0.79), SE = 0.36, Wald = 4.76, p < 0.05$. The estimated odds ratio favoured 2.2 times increase [%$Exp(B) = 2.21$, 95% CI (1.08, 4.50)] for use of ITE during CLP every one unit increase of Number of WebQuests/Webinars attended.

The binomial logistic regression test indicated that engagement with ITE in the pre-CLP significantly predicted the use of ITE during CLP. The statistical model improved when the teachers’ attendance or participation in demonstrations of student WebQuests was added as a second variable in the model predicting the use of ITE during CLP. Thus, indicating the added value of concrete demonstration of project-cum-inquiry-based learning (WebQuests) in an online mode during the CLP.
Responses on other variables in the teachers' survey

About 33% (20) of the teachers could connect with 40%–60% of their students, 21% (13) teachers could connect with 60%–80% of their students, whilst 21% (13) of the teachers could only connect with 0%–20% of their students (11% could connect to 20%–40% and 8% could connect not with any of their students whilst about 6% of the teachers could connect to 80%–100% of their students). About 92% (56) of the teachers reported that the students who attended online classes used phones with Internet connections. About 77% (47) of the teachers reported that accessibility of good network connection for students was a limitation for conducting online classes whilst 87% (51) of the teachers reported accessibility of the devices for students was a limitation. Another 75% (46) of the teachers reported that lack of online resources in regional languages was not a limitation to teach in the CLP. About 74% (45) of the teachers reported not using the lecture method to teach, whilst 64% of the teachers reported making students create projects. About 62% (38) of the teachers reported that they would like to continue the classes in distance mode even after CLP.

Some of the common findings from the interview and survey responses were that ITE engagement in the pre-CLP and WebQuests demonstrations in the CLP supported teachers in using ITE PBL, IMA (WhatsApp) in creating and sharing activities and resources for active teaching and learning during the CLP. Data analysis from both the data sets highlighted that the top challenges for teaching during the CLP were students’ access to Internet connectivity and devices.

Impact of students' prior-CLP engagement with ITE

Students (12) identified six different activities that they enjoyed during ITEWebQuests: conducting online research on a given problem or tasks (7 responses), synchronous quizzes (3 responses), giving presentations of findings and projects (2 responses), comparing graphs (2 responses), creating artefacts (2 responses) and interaction with experts (2 responses).

All students who had participated in ITE projects in the pre-CLP (11 out of 12 respondents) indicated prior experience of ITE projects had helped them to perform ITE WebQuests activities in the CLP. Particular skills developed during pre-CLP ITE activities that supported them in WebQuests included the following: in-depth research on the given concept and task (7 out of 10 respondents), the experience of working and presenting many ITE projects on different online and offline platforms before the CLP (3 out of 11 respondents) and the experience of ITE interstate residential camp that included a F2F computational thinking project (1 out of 11 respondents). Following are a few quotes from the students supporting the results explained in this section: ‘Whenever I did an ITE project, (I) went in-depth because during the presentation viewers and assessors would ask questions’. ‘I learned how to prepare for the quiz in WebQuest, in Delhi ITE camp’.

Ten of the 12 students said that before the CLP, teachers helped them understand the concept of the ITE project because of which they were able to work with their groups to complete it. And during the CLP, all the students said that their teachers shared information about WebQuests on WhatsApp which encouraged them to participate. Some of the reasons given by the students on why their other peers could not attend WebQuests were as follows: poor Internet connectivity (7), lack of smartphone (2), lack of interest (2) and conflict with the timings of the coaching class (external classes after school) (1). A few challenges raised by the students during the ITE WebQuests were the low Internet bandwidth and connectivity issues (3), lack of personal Smartphone (3), difficulty in making project using mobile phones that is without a computer (1), audio disturbance from their surroundings during the online session (2) and experiencing a power cut for long durations (1). Five out of
12 students said that they preferred the ITE WebQuests to F2F ITE projects. A few reasons explaining their preference for WebQuests were enjoying the process of seeking solutions to the challenging problem (3), more opportunity to do work online (1) and the opportunity to work independently (1). One student said that he liked to make ITE projects in school rather than working on online WebQuests because he preferred working with his friends F2F. Two students also said that the ITE projects in school and the ITE WebQuests in distance mode were the same and they liked both.

Two of the students in the interview were also asked if they thought that completing the WebQuests tasks would have been difficult for a student who has no prior experience of ITE projects in school. One of the students said that if the students have never done an ITE project, then it would have been difficult to perform in the ITE WebQuests. Another student said that such students (without prior ITE experience) would not have been able to use the Internet for research and develop in-depth analysis as required in ITE WebQuests.

**DISCUSSION AND CONCLUSIONS**

The teacher survey data supported the research question that prior experience of ITE implementation and professional development helped teachers to use PBL with ICT (ITE) during the CLP. These results reiterated previous research that TPD which is continuous including CoPs (Kozma, 2011), with an opportunity to practise PBL with ICT or constructive use of technology (Trucano, 2005; UNICEF, 2017) in the classroom, can lead to continuation or transfer of the practise in newer contexts (Darling-Hammond et al., 2017). Moreover, ITE using constructive pedagogy and CTPD has over time shown some scale in its implementation (reaching about 5,000 teachers in 900 schools) (Tata Trusts, 2020). There is evidence in the literature that claims that when innovations are scaled and introduced in new contexts, they often change or evolve to fit with local needs and demands of the new contexts (Davis, 2018; Niederhauser et al., 2018; Rogers, 2003). Further analysis of transfer or sustainability of ITE pedagogy can be conducted to include school or organisation context supporting MTs leadership (Weiner & Lamb, 2020) within the larger ITE ecosystem (Charania & Davis, 2016) of multiple stakeholders including administrative leaders from state and local organisations.

Moreover, the analysis indicated that demonstrating project and inquiry-based learning during CLP directly through conducting ITE WebQuests with students improved the likelihood of teachers with the prior engagement of ITE to use ITE PBL during the CLP. The literature indicates that demonstrating direct, concrete and successful examples (Guskey, 2002) of including technology in specific contexts may be helpful (Ertmer & Ottenbreit-Leftwich, 2010) and will encourage teachers to use similar examples and practise with their students (Nanjappa & Grant, 2003). The teacher interviews also indicated that prior engagements with both ITE and the ITE WebQuests in the CLP supported teachers to conduct ITE projects during the CLP.

Besides teachers, the students' interview findings suggested that prior experience of ITE project making, especially the experience of performing in-depth research for the ITE projects, helped students to work on the ITE WebQuests from their homes during the CLP. Moreover, the students in the interviews indicated that going deeper into the concept is something they learned during ITE project making in the F2F classrooms and that helped them to participate in the ITE WebQuests during the CLP. Prior literature supports PBL as used by ITE (curriculum and real-life connect, students designing and managing project creation) and allows the transfer of knowledge and skills in newer situations (Thomas, 2000, cited in Barron & Darling-Hammond, 2008). Overall, the findings suggest that both teachers and students in this study adapted the ITE approach from F2F to distance mode during the
CLP. However, there is a need to be cautious about generalisation given the small number of participants selected based on convenience during the CLP and data based on self-reports.

The second research objective explored strategies used by teachers during the CLP. The interview data findings indicated that teachers mostly relied on IMA-WhatsApp to teach, communicate and share self-created, external as well as textbook resources and assignments. Teachers teaching in government and private schools across the country surveyed in Singh et al. study (2020) indicated that they did not find the accessible digital resources appropriate for their students' context. On the other hand, at least 50% of ITE implementing teachers indicated that they used self-created resources during the CLP. Additionally, this study also brings out the potential of resources created by students as part of inquiry-based tasks using ICT. Teachers' use of WhatsApp to disseminate resources was found to align with the findings of the large-scale COVID-19 education status study in India (Pratham, 2020; Vyas, 2020).

Teachers who could use VC software also relied on the IMA which provided a flipped classroom strategy (Bishop & Verleger, 2013; Fulton, 2012). Besides the challenges of connectivity and devices, this flipped approach could also be a solution to prolonged screen time due to synchronous online classroom; as per Government of India guidelines (MHRD, 2020b), it should not be more than two sessions of 45 min each for online classes per day for students in grades 1 to 8 (aged 6 to 14 years). The findings also indicated that several of the teachers would like to continue using the IMA for providing seamless contact and access to resources to the students even after the F2F regular classroom resumes. It will be also interesting to study further the strategies used by these teachers during the CLP and its continuation post-CLP with the lens of the literature that suggests the benefits of bridging formal and informal learning with technology for active and lifelong learning experiences (Lewin & Charania, 2019).

This study also highlights a potential, in both regular times and CLP, for interventions like ITE that allow constructive learning through PBL with ICT for the students from the disadvantaged regions. Such an approach of using technology can break the well-established socio-economic divide of the technology-enabled pedagogy between the schools for the rich and the poor. Teachers integrate technology into instructional tasks differently for the same purposes across the continuum of SES (Hohlfeld et al., 2008, 2017; Reinhart et al., 2011). For example, in a longitudinal study in Florida, it was found that teachers used technology-enabled teaching allowing students to create and research with technology in higher SES schools, whereas teachers in the lower SES schools used drill and practise and remedial-based technologies (Hohlfeld et al., 2017).

According to the findings of Singh et al. (2020), an overreliance on standardised digital resources in a diverse country like India may not be an efficient solution to teaching with distance technologies. The findings of this study indicated that a CTPD model which is continuous, blended, models practise and allows the practise of constructivist pedagogies with technology can build capacities and agency of teachers to seek constructive and adaptive pedagogy and technology solutions and resources better fitted to their different situations. Moreover, demonstrating and supporting students through the use of constructive pedagogies like PBL and inquiry-based learning through WebQuests, which allow students to research, create and share their own resources in situations like COVID, can be explored further.

This study also suggests that investment in practise-based continuous professional development of teachers can develop a sense of agency and competence so that teachers can adapt technologies for constructive teaching pedagogies that can mitigate access-related challenges for students in challenging contexts. There is also potential to build on the new teaching and learning strategies that emerged during the CLP by integrating these with ITE innovations in the curriculum and pedagogy of both in-service and preservice TPD.
Participating teachers were willing to carry on using IMA for continuous communication and resource sharing with the students. This practise can be capitalised for flipped classroom strategies that may require adaptation in curriculum, assessment and teacher professional development. However, infrastructure and connectivity remain a challenge for many students, even for asynchronous use of technologies, which will require creative solutions.

**Limitations**

The data in this study were limited and were based on self-reports of teachers and students accessible during the CLP. This led to the selection of teachers and students who were digitally connected and active in the teaching and learning process during the CLP. Future research is recommended with larger samples, representative sampling strategies and including objective methods like classroom observation of pedagogy and assessments of student projects for learning skills. A study of the continuation of PBL with ICT and IMA in the post-CLP can also be explored.

Despite these limitations, the findings of this study suggest interesting trends for teacher professional development with continuous and constructive pedagogies like PBL with technologies that are useful for both teachers and students to adapt and transfer their experience and learning with technologies in challenging contexts, such as a pandemic.

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**CONFLICT OF INTEREST**

The study and its authors have no known conflict of interest.

**DATA AVAILABILITY STATEMENT**

The data used in this study will be available for the reviewers and researchers upon reasonable request via e-mail correspondence with the first author.

**ETHICS STATEMENT**

The project data were collected under the project called Integrated approach Technology in Education (ITE) which has received the Internal Review Board (IRB), TISS approval for conducting ongoing research. Special permission to conduct research related to the COVID situation from IRB was not possible, and therefore, the guideline for the overall ITE project data collection was used to collect the data for this study. Consent from all the participants of the study was derived and is explicitly stated in the Methods section; consent from students’ parents was collected in accordance with the guidelines provided by the IRB.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

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