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Exploring teacher characteristics and participation in TPACK-related online teacher professional development in Assam, India

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ABSTRACT

Recent years have seen a significant increase in professional development opportunities to support teachers in enhancing their digital skills in India. However, to date, there is little evidence that teachers are confidently harnessing digital technologies within their classrooms. We suggest that this may be explained by insufficient attention on how teachers' participation in TPACK-focused teacher professional development (TPD) programmes is mediated by their values, prior experiences and positioning within society. To explore this, we examined government upper primary and secondary school teachers' experiences of participating in a course entitled 'Constructivist teaching and learning with technology within the TPACK framework' (CTLT), which was offered to over 500 teachers in 23 districts in the Indian state of Assam. Based on the survey responses of 209 (pre-course) and 109 (post-course) teachers, the findings of the study indicated that, contrary to expectations and much current scholarship, the female teachers significantly outperformed the male teachers in terms of course completion. However, the teachers who undertook the survey in English performed better than those who did so in Assamese. This paper explores possible reasons for these outcomes while recommending the need to take teacher characteristics into account when designing and implementing inclusive large-scale TPD programmes for TPACK.

1. Introduction

In 2020 the Government of India introduced a new National Education Policy 2020 [1]outlining a comprehensive framework of reforms at each level of the state education system. A core theme of these reforms was the extensive integration of technology with equity, to enhance the quality of education and 'preparing youth to meet the diverse national and global challenges of the present and the future' [1]. To achieve these aims, NEP 2020 acknowledged the need to support school teachers to meaningfully integrate digital technologies into the core school curricula and associated pedagogy. Multiple sources indicate that many teachers in India were not digitally competent before the COVID-19 lockdown period (CLP) [2,3]. This low digital capability across the teaching body became more visible during the pandemic, with the transfer to teaching online being highly problematic for most educators [4–6].

There is thus a tremendous need for Teacher Professional Development (TPD) that is focused on building teachers' competence in utilising the affordances of digital technologies within their classroom practice. Recent scholarship suggests that this TPD should develop teachers' understanding of the complex relationships between subject content and pedagogical and technological knowledge in the context in which they are working [7]. Building on Shulman's categories of forms of knowledge needed for effective teaching [8], the technological pedagogical content knowledge (TPACK) framework [9] offers a conceptual analysis of the types of knowledge arising from these relationships. The TPACK framework has prompted much research and discussion on effective teaching with technology and is frequently used as the basis of assessment rubrics, specifying what teachers need to know to integrate technology successfully in their classrooms, hence informing the design of related TPD programmes [10].

However, the use of the TPACK framework is not unproblematic. There are different interpretations of how the interplay of the knowledge components should be described theoretically, as well as fundamental challenges in defining the core knowledge bases [11]. The development of TPACK knowledge is acknowledged to be contextually bound but interpretations of the meaning of 'context' differ widely in current scholarship. Mishra [[12], 76–78] conceptualises this as an additional

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knowledge component, while other scholars emphasise how teachers' classroom technology integration is influenced by broader, systemic context and discourses [13] and emphasise the importance of teacher knowledge of pupil characteristics [14]. A further group has explored the relationships between teachers' TPACK development and their socio-demographic characteristics, such as pedagogical beliefs, attitudes towards technology, expectations of success and self-efficacy [15].

Yet, despite the prevalence of TPACK related initiatives and research for nearly 20 years and much scholarship on the features of effective TPD, there is as yet no paradigm shift in how digital technologies are used in school classrooms, with the situation in India reflecting the wider picture across the Global South. Together with well-documented resource challenges [16], we suggest that one possible explanation for this situation could be the design of TPACK focused TPD and whether sufficient attention is being paid to how individual teachers' participation in such programmes is mediated by their own characteristics, values, prior experiences and positioning within society. Efforts have been made to categorise TPACK focused TPD [17], but there has been little scholarship on how to ensure that such TPD is truly equitable [18], enabling the engagement and professional growth of all teachers, including those working in under-resourced contexts, those working in minority languages, those with little prior experience of ICT, and those for whom expectations of ICT embedded practice are low.

Our research contributes to addressing this gap through an exploration of the relationship between teachers' subjective realities (influenced by their characteristics, prior experiences, and the particular social space of their practice), and their learning. In this paper, we draw on field research from a recent online TPD programme composed of micro-courses that was offered to upper primary and secondary school teachers in the Indian state of Assam during the restrictions of the COVID Lockdown Period (CLP.) The TPD programme aimed to develop teachers' TPACK by exploring the pedagogies of project and inquiry-based learning, utilising the digital technologies available to participants during the pandemic. The programme's design and prior implementation research [19] give us confidence that those teachers who achieve a pass grade on the courses are expanding their use of ICT in their pedagogical practice. Our study explores how different groups of teachers engaged with this TPACK based TPD, namely, their ease of participation (for example, when and in what ways they requested assistance) and their achievements (completion and performance).

Currently, we are seeing a tremendous expansion in the use of online platforms for TPD, such as the DIKSHA [20] and NISHTHA platforms in India. It was reported in 2022 that around 4.7 m teachers had directly engaged with the courses offered on the DIKSHA and NISHTHA platforms [21]. Since the beginning of the CLP in March 2020, many millions of teachers have visited these platforms, although it is less clear how this engagement has resulted in changes to teaching practice. Many teachers, particularly in contexts such as rural India, nevertheless lack the digital confidence required to engage with these platforms and are sceptical of the relevance to their contexts of much centrally designed online TPD [5]. We suggest that our findings are valuable to efforts to realise the potential of these platforms to enhance all teachers' pedagogical use of ICT to improve pupil learning, while offering TPD course designers and educators' pointers to improve equity in participation and outcomes of TPACK-oriented TPD.

2. Overview of the literature

2.1. The core TPACK framework

The TPACK framework proposed by Mishra & Koehler [9] offers a prescription for what teachers need to know to be able to integrate technology into their teaching of the core curriculum. Advocates of the framework argue that teachers need explicit technological knowledge (TK) in addition to content knowledge (CK) and pedagogical knowledge (PK) to teach effectively with technology. TK is defined as encompassing not merely knowledge of technologies (analogue and digital) but also how to apply this knowledge productively to teaching and continually adapt to changes in technology [22]. The interweaving of these three core knowledge bases (C, P and T) generates three first-level hybrid knowledge forms - pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK) and technological content knowledge (TCK). Their subsequent integration generates an emergent second-level hybrid form of knowledge: technological pedagogical content knowledge (TPCK) [22]. Proponents of the TPACK framework suggest that these different knowledge components are drawn on by teachers when they utilise any form of technology in their practice. However, although the TPACK framework is often depicted diagrammatically showing seven distinct knowledge components [22], analytically these are difficult to separate and exist in dynamic equilibrium, such that change in any one component will lead to change in other components. While the TPACK framework has been highly influential, scholars have recently challenged aspects of its theoretical conception and questioned how TPACK relates to teacher beliefs and impacts on lesson planning [11].

2.2. Context in TPACK

Early versions of TPACK made brief reference to the way the three core knowledge bases and their interactions would be complicated and mediated by the specific teaching and learning context in which they are instantiated by situating the PCK knowledge bases TPACK framework within a dotted frame (Fig. 1) to denote context [22].

Context was conceptually somewhat vague in these early TPACK iterations, such that subsequently the meaning ascribed to this term - and hence the way it interrelates with the seven knowledge components - varies across researchers. Mishra [12] proposes closing the dotted frame to represent an eighth knowledge domain, contextual knowledge (XK), consistent with the TPACK view of knowledge as a psychological construct. XK signifies teachers' knowledge of their context: the available technologies, relevant policies, the functioning of their organisation and 'how levers of power and influence can effect sustainable change' (p.77). Teachers' low competence in developing contextual knowledge and using this knowledge to 'effectively contextualise their TPACK' ([23]: 734) in their setting is argued to limit their integration of

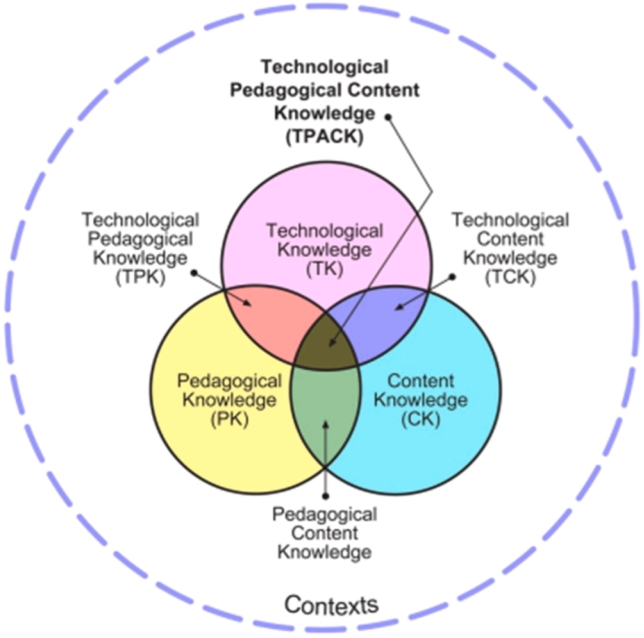

Fig. 1. TPACK Framework
Note. Koehler & Mishra [22].

technology within their practice.

Other researchers have interpreted context differently, as being external to TPACK knowledge but in a mutual relationship with it. Kelly [24] and Cox and Graham [25] view context as the physical characteristics of the site of teachers' practice. Angeli and Valanides [26] suggest that context refers to both the surrounding conditions, which they propose should include pupil characteristics and the mediating impact of teachers' beliefs and philosophical views. Porras-Hernandez and Salinas-Amescua [15] situate teachers' TPACK development within concentric nested systems – micro (classroom), *meso* (school and community) and macro (state or national), arguing that the extent to which teachers' classroom practice involves technology will also be influenced by broader systemic and cultural contexts and discourses, such as levels of resourcing, assessment regimes, performance evaluation metrics and policies for technology use [27]. Lim [28] points to the need to look at whether teachers are working collectively to integrate technology or undertaking this as individuals.

However, evidence on the impact of these different contextual factors on teachers' TPACK development is mixed [14,29–32] and scholars argue that context has been insufficiently researched in the TPACK framework [33].

2.3. Effective TPD for TPACK

The development of teachers' TPACK will be influenced, and hopefully enhanced, by the amount and type of relevant TPD they receive [34,35]. Frameworks, such as the International Standards of Technology Education (ISTE) [36] for teachers, argue for TPD to be a continuous practice offering teachers the opportunity to participate in specific, goal-directed activities, such as designing and carrying out authentic project-based activities with their pupils, mediated by cultural artifacts and social relations (UNICEF, 2017, [37,38]). Peer dialogue (involving practitioners with different levels of expertise) is also critical. It is through these interactions that teachers make meaning in the context of their settings [39]. Teacher professional learning is thus a situated, social and collective process: TPACK development needs to be embedded in teachers' professional lives and working conditions.

Recent scholarship reviewing TPACK focused TPD interventions identifies different approaches utilised to develop teachers' TPACK: method based (for example, through problem-based teaching); using specific tools such as WebQuest; and centred on a technical intervention (AI or an interactive whiteboard, for example) [40]. Unsurprisingly, the impact is more marked in the case of the longer interventions. Other literature on TPACK based TPD highlights the usefulness of including TPACK based lesson plans, micro-teaching, peer feedback and TPACK based lessons [41].

2.4. Equity in TPD for TPACK

As outlined above, teacher learning is a complex process, involving not only the construction of knowledge, as described in the TPACK framework, but also the development of identity. Teachers do not merely learn facts. They learn to act in their classrooms and schools in socially recognised ways, what Bruner [42] describes as 'learning to be'. Teacher development is an ongoing dialogical learning process which involves constructing identities that reflect both how a teacher sees the world and how the world sees the teacher [43]. For a teacher to be successful in TPACK focused TPD, other people, including their peers, need to recognise the teacher as a technology competent practitioner, and accept them as such. This has implications for the design of equitable TPACK focused TPD. Factors such as a teacher's gender, their prior teaching experiences and use of technology, their own perception of their digital competency and their pedagogical beliefs – how people come to know and to learn - will impact on their engagement in TPACK focused TPD and the ease with which they are able to exercise agency to develop a professional identity as a technology competent practitioner [16]. Furthermore, the learning culture of the context of the teacher's practice - encompassing location, language, history and so on - will influence what is deemed important to learn and the roles appropriate for different teachers to take [44].

Gender is one possible factor that is highly likely to influence teachers' productive participation in TPACK focused TPD. Recent meta analysis shows that gender differences in attitudes towards technology remain, but when attitude is broken down into different dimensions, gender differences in affect and self-efficacy have diminished whilst differences in belief (how much value the user places in technology use) have remained [45]. The findings with teachers are similar; gender differences in teachers' technology access and use have tapered, gender differences remain with respect to attitudes, confidence and participation in technology focused TPD. Male teachers show more favourable attitudes towards technology integration, participate more in training that relates to technology use in education, and display more confidence and ability to choose and deploy appropriate technology in their practice [29,46,47]. Comparable literature from the Global South is sparse; most studies are concerned with students, not teachers[48]. However, Islahi and Nasrin [49] found that, after controlling for factors such as the amount of training, school location, medium of instruction and marital status, there was no significant gender difference in teachers' attitudes towards technology in terms of its value for teaching and adoption in the classroom. This suggests that, if female teachers can be supported to complete the TPACK TPD, they are just as likely to use technology in their classrooms as male teachers. However, few programmes designed to improve TPACK include a gender lens in their design.

Geographical place, where the school and teachers' own household are located - rural, peri-urban, suburban or urban, has also been shown to influence teachers' use of technology [50]. However, there are no common global patterns; factors such as social structures, socioeconomic levels and household characteristics play out differently in different places [51].

Currently, a plethora of online platforms (Virtual Learning Environments - VLEs or Learning Management Systems - LMS) are being utilised for TPD. These appear to offer economies of scale, facilitate quality assurance, and enable greater participation through flexible provision accessible to anyone with an internet connection [52]. However, there are problems associated with the use of large digital platforms to offer TPD at scale. One important consideration is equity in participation in the TPD. Usually, the TPD offered is not personalised or differentiated for specific groups of teachers and issues such as differential access to ICT, geographical location, gender, and socioeconomic-political issues will necessarily lead to variability in the uptake and application (that is to say, impact) of learning from these programmes [53].

Overall, implementing TPD for TPACK involves considering both the policies and structures of the education system [54] and the specific needs and context of individual teachers [55]. In India, the structure for delivering TPD is complex and decentralised. It requires teachers to complete a certain number of hours for professional development each year [1]. In future, this may be linked to career progression.

The study described in this paper explores the possible influence of teachers' individual demographics and experiences (their ways of being as teachers), on their engagement and completion of a TPD programme that aimed to develop their TPACK during the CLP. To date there has been little scholarship on how these factors might relate to teachers' completion of TPD on the constructivist use of technology in teaching. Deepening our understanding of these factors could be critical to designing equitable TPACK TPD.

3. Background to the study

This paper is based on the TPD programme conducted by the teacher education institute located within a central university in India. The programme involved around 500 upper primary and secondary teachers

(teaching grades 6 to 10) in the state of Assam. Located in the north east of the country, Assam has a population of almost 35.4 m, of which 86 % live in rural areas, which is higher than the all-India average of 69 % [56]. Assamese is the state's indigenous and official language, with Bengali being the next most commonly spoken. Assam is one of the states with lower economic development [57]. A history of ethnic conflicts and natural calamities have affected socio-economic growth across the state, with the education sector being particularly affected [58]. Pupil dropout rates are high, at 20.3 %, as compared to the national average of 12.6 % at secondary level, 8.8 % (compared to the national average of 3 %) at upper primary level and 6 % (compared to the national average of 1.5 %) at lower primary level [59]. The State of Education Report [60] highlighted the need to improve the availability and deployment of qualified teachers and basic amenities in the 'aspirational districts' of the north eastern states of India. The availability of functioning computers in only 2651 of 60,859 schools in Assam is an indication of the lack of proper infrastructure in such institutions [59].

Entitled 'Constructivist teaching and learning with technology within the TPACK framework' (CTLT), the TPD course under study evolved over a decade from an in-person workshop to a blended certificate course to a fully online digitally badged course [19,34]. The content of the course was influenced by a large field initiative on project-based learning with technology within the core curriculum [61], which was designed to build teachers' TPACK. This original course was split into two micro-credit courses, with a third micro-credit course on the curation and classroom use of Open Educational Resources (OER) to create meaningful learning experiences for their pupils [62] being a further addition. These three online micro-courses were offered online by a university in India for three to four weeks each over a period of six months [16,63] during the CLP. In collaboration with a UK-based university and the Assam Education Department, the university in India awarded digital badges to teachers who completed each of the micro courses.

The courses aimed to develop a constructivist pupil-centered approach to the use of technology within the TPACK framework. The courses did not intend to highlight the separate knowledge dimensions (TK, PK, PCK, etc.) of the TPACK framework, but rather to develop these in a holistic manner. However, for the purpose of this paper, Table 1 below maps some of the readings, resources, activities and assessments of the courses on the various individual knowledge dimensions of the TPACK framework. The definitions of the TPACK dimensions are taken from Chai et al. [64], with context (X) being added as a new category.

Overall, all the courses used active and collaborative pedagogies, offering ample opportunities for teachers to develop TPACK and practice this with their peers and pupils during the course.

Besides the course facilitators at the university, teachers (about 10) who had taken this course earlier in the blended mode stepped in as Master Trainers (MTs) to provide learning support via Instant Messaging applications, phone calls and discussion forums on the Learning Management System in the local language.

The curriculum, pedagogy and assessment of the courses described in Fig. 2 resonate with the characteristics of TPACK in the literature. For example, building teachers' knowledge on the selection and use of technologies in constructive ways supports subject teaching or simultaneously using content, pedagogy and technology [22]. However, unlike many TPD programs dominated by a procedural approach in which the associated learning goals are reduced to lists of tasks to complete, these courses outline and explore the core principles which teachers appropriate and interpret to create new meanings for themselves, develop new learning activities which are suited to their pupils, their own social values and the relationships in their practice site and reflect on these activities to deepen their understanding of these principles.

In this approach, context is viewed holistically as comprising multiple dimensions such as the teachers' experiences and socialisation, the resources available to them (both physical and conceptual), the power relations within the site of their practice and the characteristics of their pupils. These dimensions interact in complex ways and are conceptually difficult to separate.

Table 1
Mapping of courses with TPACK dimensions.

TRACK Dimensions	Definition from Chai, et al. [64] with the inclusion of Context (X)	Example of the dimensions in the two Digital Badge Courses
TK	Knowledge about how to use ICT hardware and software and associated peripherals	Videos on what online learning is and strategies for effective learning in online mode.
PK	Knowledge about the pupils' learning, instructional methods, different educational theories, and learning. assessment of teaching a subject matter without references towards content.	Video and readings on how learning takes place, learning theories, and what is project and problem-based learning with examples and quizzes. Readings and discussion on TPACK and authentic learning. (However, some examples from content were included.)
CK	Knowledge of the subject matter without consideration	No subject content was covered in isolation
XK	Knowledge of pupils' context and that of the teaching environment about teaching the subject matter	Discuss the challenges faced during the COVID-19 lockdown period in teaching children of different ages and their access to digital technologies.
PCK	Knowledge of representing content knowledge and adopting pedagogical strategies to make the specific content/ topic more understandable for the pupils	An example of teaching air quality index, situating the concept in the learner's authentic context, and forming an authentic problem statement.
TPK	Knowledge of the existence and specifications of various technologies to enable teaching approaches without reference towards the subject matter	Introducing WebQuest for inquiry-based learning.
TCK	Knowledge about how to use technology to represent/ research and create the content in different ways without consideration for teaching.	Introduction and links to Phet Simulations, GeoGebra, etc., as examples of technologies in different content/subject areas.
TPACK within the context.	Knowledge of using various technologies to teach and/ represent and/ facilitate knowledge creation of specific subject content within the knowledge of context within which teaching and learning is to take place.	Develop a lesson plan on a core subject topic in the K-12 curriculum, integrating project and/or inquiry-based learning with technology applications to be used by pupils in the CLP. Practice the lesson plan or WebQuest after receiving peer feedback. and submit a reflection of practice including knowledge, experience, challenges, and mitigations planned or unplanned to implement the lesson during the Lockdown Period.

Given the focus on TPACK in the curriculum, pedagogy and assessment of the TPD courses in this study, success in these courses is considered an indication of the development of TPACK within the context of teaching and learning during the CLP.

We are interested in equity [18] within constructivist TPACK focused TPD [16], specifically, how TPD might be made available in ways that enable all teachers to participate and develop their understanding of the mutuality of technology affordances and subject construction within the context of their pedagogic practice.

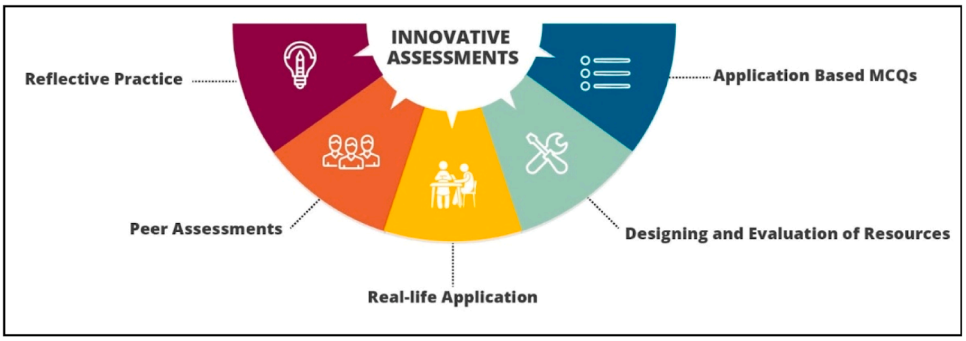

Fig. 2. Types of assessments in the digital badge courses.

4. Research questions

The research questions were concerned with better understanding the ways in which the teachers' success in the TPACK based course varied according to their demographic and professional characteristics, school location and other preferences in the course:

1. How did success on the course vary in line with the teachers' gender?
2. How did teachers' gender vary with other teacher characteristics?
   a. Teachers' prior use of technology in teaching
   b. Teachers' digital competence
   c. Teachers' preference for learning support during the course
3. How did the teachers' teaching experience relate to their success on the course?
4. How did the teachers' school locality (rural or urban) relate to their successful completion of the course?
5. How did the teachers' language preference (Assamese versus English) in completing the pre- and post-course surveys relate to their successful course completion?

5. Method

The aim of this exploratory study was to better understand the interrelationship between various demographic and contextual variables related to the teachers' completion of digitally badged course 1 (DB01). Overall course enrolment and completion data shows that 586 teachers enrolled in DB01. Of these, 143 were female teachers (24.4 %) and 443 male teachers (75.6 %). All those teachers completing DB01 had the choice of enrolling in the next course, DB02. Of the 586 teachers who enrolled in DB01, 238 chose to enrol in DB02.

The key research tool consisted of two surveys: a pre-course survey sent out just before DB01 started and a post-course survey that was sent after the DB01 concluded.

The pre-course survey tool focused on self-reports of teachers' demographics, their prior use of technology devices and technology enabled activities in classrooms, their attitudes towards technology use in the classroom, their motives for enrolling on the course, and their perception of their competence in the use of technology. The items on digital competence and prior use of technology were taken from the tool used with initiatives in the Indian rural context with government school teachers (CLIx and ITE, 2017–18). This tool was adapted from the teachers' survey developed as part of a large-scale field action programme on education technology, implemented in government-run schools across four states in India [61,65]. The survey was previously administered with >500 government school teachers across Indian states, in multiple languages. The items on digital competence resonate with the items on the Digi Comp framework developed by the European Union (2022) under the information and data literacy, and communication and collaboration sections of the framework [66].

The post-course survey included a range of items relating to the teachers' experience, perceptions, and existing practice. However, as outlined later, this paper only makes use of responses to questions about the school location and the use of support relating to teachers' help-seeking and communication.

The surveys were administered in English and in Assamese, giving teachers the opportunity to respond in their preferred language. The survey was first compiled in English by the research team based in India and the UK and was then professionally translated, reviewed and further validated by experts.

The pre-course survey was administered to participants using the free Google Forms application in the month of January 2021 at the beginning of DB01 (Table 2). It was embedded within the course on the LMS platform and was kept open for around two weeks for participants to fill in once the course started. The pre-course survey had 209 valid responses (an additional 24 responses were judged incomplete), representing a 35.7 % response rate based on the number enrolled. The post-course survey had 109 valid responses (an additional 26 were judged as incomplete), representing a 18.6 % response rate based on the number enrolled.

The pre-course survey included questions regarding the demographic details of the participants, such as the number of years of experience they had as a teacher, their age and gender. When asked about their gender, participants could select from four options: Male; Female; Prefer not to say and Any other. In this paper gender refers to 'the socially constructed roles, behaviours and identities of female, male and gender-diverse people' [67]. The age profile of respondents to the pre-course and post-course survey was similar, with the male teachers comprising 78.0 % of the pre-course survey responses and 67.9 % of the post-course responses (Table 3). Table 3 shows that the male and female groups are similar with respect to age profile.

Digital competence was measured using thirteen items taken from previous research instruments (see above). These items asked teachers how well they felt they could perform technology related activities ranging from searching the internet and using email to using a smartphone and making PowerPoint slides. The respondents rated their skills on one of four levels: 'Cannot to do it' (coded 1), 'Need help' (2), 'Can do it' (3) and 'Can do it extremely well' (4). Factor analysis using principal axis factoring was used to confirm how satisfactorily the items loaded on to a single factor. Inspection of the scree plot indicated that a single-factor solution was appropriate, and subsequent analysis showed a single factor accounted for 62.59 % of the variation. The thirteen question items, mean, standard deviation and factor loadings are shown in Table 4. The item with the highest mean (indicating the greatest

Table 2
Details of learners and survey for the DB courses.

Learners enrolled in DB01	Responses to Pre-course survey for DB01 (Administered in January 2021)	Responses to Post-course survey for DB01 (Administered in April 2021)	Learners enrolled in DB02	Learners enrolled in DB02 and DB01
586	209	109	322	238

Table 3
Gender and age of survey respondents.

Category	Pre-course survey (*n*)	Post-course survey (*n*)
Gender		
Male	163 (78.0 %)	74 (67.9 %)
Female	46 (22.0 %)	35 (32.1 %)
Age		
25–34 years old	66 (31.6 %)	35 (32.1 %)
35–44 years old	90 (43.1 %)	44 (40.4 %)
45–54 years old	47 (22.5 %)	28 (25.7 %)
55 years old and over	6 (2.9 %)	2 (1.8 %)

Table 4
Digital skill competencies of the teachers.

Statements	*M*	*SD*	Loading factor 1
Starting a computer	3.43	.690	.805
Typing on a computer	3.29	.646	.848
Handling a computer mouse	3.47	.580	.860
Searching the internet	3.46	.628	.852
Using email	3.40	.620	.814
Saving files or documents to a computer	3.29	.788	.885
Playing games on a smartphone for pleasure	3.06	.812	.569
Using a smartphone to access the internet	3.54	.537	.816
Downloading and uploading files	3.39	.656	.851
Making a spreadsheet (e.g. in Excel)	2.73	.970	.738
Making slides (e.g. in PowerPoint)	2.72	.823	.764
Studying a course on an online learning platform	2.92	.823	.660
Using WhatsApp or other online chat services	3.45	.587	.721

proficiency) was 'using a smartphone to access the internet', and the items with the lowest means were the productive tasks 'making slides' and 'making a spreadsheet.'

Composite reliability was calculated as 0.955. This is very good and significantly exceeds the recommended threshold of 0.7 [68]. The average variance extracted co-efficient was calculated as 0.621. This is also very good and exceeded the minimum recommendation of 0.5 [69]. Following satisfactory reliability testing, a single scale measuring the teachers' Digital Skills Competency (DSC) was created by averaging the thirteen question items in the survey.

Technology use for teaching was also based on a previous evaluation instrument [61,65]. The question contained eight items relating to a range of varied uses. These were not intended to be used to generate scales so no factor analysis was conducted. These data are reported in the Results section.

The post-course survey also asked the participants about their school's location, with options including 'rural', 'semi-rural', 'town' and 'city'. It also asked teachers about their use of the course website and social media to support their study, help-seeking and communication with their peers. The survey respondents selected one of five options: 'very often', 'often' 'occasionally' 'once' and 'never.' The Results section presents these data.

The Assamese survey responses were translated into English, after which the two datasets (English and Assamese) were merged. SPSS software was used to run the tests on the data for analysis purposes. Non-parametric chi-square and Mann-Whitney-U tests were predominantly used in the analysis to compare data for male and female teachers. A *t*-test was used for the analysis of the digital skills measure.

Grade and completion data was taken from the course LMS. The percentage score that teachers received reflected their performance in the assessed activities during the course. For the purposes of this analysis, a 'successful teacher' was considered to be one who achieved a grade score of 60 % or above to pass the course.

6. Results

Of the teacher characteristics that related to course completion, gender was found to be a significant variable. The results of the study present interrelated combinations of gender with other teacher characteristics variables.

6.1. Completion rates and grades as per gender of the teachers

6.1.1. Completion rates and grades as per gender of the teachers enrolled for the courses on the learning management system

Overall course enrolment and completion data show that 586 teachers enrolled in DB01. Of these, 143 were female teachers (24.4 %) and 443 male teachers (75.6 %). Approximately three times as many male teachers enrolled than female teachers. 322 teachers enrolled in DB02, i.e. 112 female teachers and 210 male teachers. Of the 322 teachers who enrolled in DB02, 238 (73 %) had also enrolled in DB01, 74 female teachers (51 % from DB01) and 160 male teachers (36 % from DB01). Of the 238 teachers who enrolled in DB01 and DB02, 201 (84.5 %) had completed DB01. 91.8 % ($n = 68$) of the female teachers who completed DB01 also enrolled in DB02, compared to 81.0 % of the male teachers ($n = 130$).

DB01 completion rates were significantly higher for the female teachers than the male teachers. 47 % of the female teachers completed compared to 32 % of the male teachers. Chi-square statistics indicated a significant association between gender and completion ($\chi 2(1) = 10.658$, $p < .001$) in DB01. For DB02 there was not much difference in completion rates between male and female teachers (51 % and 57 %, respectively), about 73 % of the teachers in DB02 were also enrolled in DB01. Overall, while fewer female teachers enrolled on the course, their completion percentage on DB01 was significantly higher than the male teachers, and a significantly higher proportion of female than male teachers who enrolled on and completed DB01 subsequently enrolled on DB02 (Table 5).

The above analysis was based on overall enrolment and completion rates of teachers on the LMS. The following sections of results are based on the survey responses of the teachers, and therefore the number of respondents will vary from the total number of teachers on the course LMS.

6.1.2. Completion rates and grades as per gender of the teachers who took the pre-course survey

Analysis of the responses to the pre-course survey ($n = 209$) shows that more than three-quarters of the survey respondents ($n = 163$) were male, and a little less than a quarter ($n = 46$) were female. This is broadly consistent with the pattern of enrolment in the course. There was a significant difference in completion rates between the male and female teachers responding to the survey (Table 3) ($\chi 2(1) = 4.533$, $p = .033$) (all participants responded to either the male or female option in the surveys in relation to the question on gender). More female teachers responding to the survey passed the course (76.1 %) compared to the

Table 5
Enrolment in LMS and completion.

Category	Female (*n*)	Male (*n*)
Teachers enrolled in DB01 ($N = 586$)	143 (24.4 %)	443 (75.6 %)
Teachers completed DB01 ($N = 208$)	67 (47 %)	141 (32 %)
Teachers enrolled in DB02 ($N = 322$)	112 (34.8 %)	210 (65.2 %)
Teachers completed DB02 ($N = 175$)	64 (57 %)	108 (51 %)
Teachers who enrolled in both DB01 and DB02 ($N = 238$)	74 (51 %)	160 (36 %)
Teachers who completed DB01 and enrolled in DB02 ($N = 201$) (gender for 3 learners could not be retrieved)	68(91.8 %)	130 (81 %)

male teachers (58.9 %) (Table 6), although in percentage points both are higher than the overall cohort who enrolled. A comparison of the number of female and male teachers who (after enrolling on DB01) subsequently enrolled on DB02 with the number who did not, shows that a significantly higher portion of female teachers (n = 39, 84.8 %) continued to DB02 then male teachers (n = 104, 63.8 %) ($\chi 2(1) = 7.308$, $p = .007$).

Furthermore, the mean grade achieved by the female teachers who started DB01 was 58.76 %. This is significantly higher than the male teachers, who achieved a mean score of 46.93 % (t(207) = 2.427, $p = .016$). These data show that the performance and commitment to the course was higher for female teachers than male teachers.

6.2. Teaching experience

Most teachers participating in the course surveys had between 5 and 14 years of prior teaching experience (Table 7). There were proportionally older male teachers than female teachers but this is not a significant difference ($\chi 2(2) = 2.347$, $p = .309$). There was no significant difference in completion rates between participants with less or more experience of teaching ($\chi 2(2) = 0.943$, $p = .624$).

6.3. Digital skills competency

Teachers' competency in a range of basic digital skills was measured by thirteen items comprising the DSC scale. These items are listed in Table 4 and the scale was found to have a strong reliability coefficient. The mean level of digital skills (Table 8) of the female teachers (M = 2.17, SD = 0.501) and male teachers (M = 2.26, SD = 0.589) who started DB01 were similar (t(207) = −0.981, $p = .328$). There was no significant difference in the mean Digital Skills Competency of those teachers who completed and passed DB01 (M = 2.25, SD=0.509) and those who did not (M = 2.23, SD=0.666) (t(207) = 0.177 $p = .860$).

One item in the scale - the self-reported skill level of 'studying a course on an online learning platform' – was deemed particularly interesting to this study, given that the learning was delivered using an online learning platform (Table 9). There was no difference found between the female and male teachers on this item ($\chi 2(3) = 3.350$, $p = .341$). Analysis of this response item found a significant difference ($\chi 2(3) = 10.290$, $p = .016$) between teachers who completed DB01 (M = 2.95, SD=0.732) and those who did not (M = 2.87, SD = 0.958). Of those who completed DB01, 77.1 % said they could study an online course or study an online course extremely well compared with 65.4 % of those who did not complete it.

6.4. Technology use for teaching and learning

Teachers starting the course were asked about their use of different technologies for three aspects of teaching and learning: professional development, lesson preparation and classroom teaching (Table 10). Most teachers regularly or sometimes used social media to interact with either their peers (82.3 %) or their pupils (86.6 %). <5 % of teachers participating in the course survey did not use social media for teaching and learning interaction. Less than half of teachers regularly or sometimes took videos of their classroom activity (38.7 %) while over half (57.9 %) had regularly or sometimes looked at online courses (although it is not clear if respondents were including the present course in this).

Table 7
Gender wise number of years of experience as a teacher.

Gender N = 209	Under 5 years	5–14 years	15–24 years
Female	4	34	8
Male	15	102	46
Total (n)	19	136	54

Table 8
Digital skills competency (DSC) scores.

Variable	M	SD	Total (n)
Digital Skills Competence at Pre Test			
Female	2.17	.501	46
Male	2.26	.589	163
Digital Skills Competency at Pre Test			
Completed DB01	2.25	.509	131
Did not complete DB01	2.23	.666	78

Table 9
Digital skill competencies relating to studying a course on an online learning platform.

Variable	M	SD	Total (n)
Competency in studying a course on an online platform			
Female	2.96	.698	46
Male	2.91	.856	163
Competency in studying a course on an online platform			
Passed DB01	2.95	.732	131
Did not pass DB01	2.87	.958	78

Since the study was conducted during the CLP, the high use of social media platforms in teaching was not surprising.

The data in Table 10 shows a range of responses with respect to the frequency of use of technology for classroom teaching. This, in part, may reflect the different levels of access teachers have to technologies and the way that teaching is organised at their school. Video-based classes still feature as part of their classroom activity for many teachers (52.6 % do this regularly or sometimes) whilst only a minority of teachers use PowerPoint and projectors regularly or sometimes.

There is a significant difference between male and female teachers in their use of the internet to collect teaching materials ($\chi 2(2) = 6.045$, $p = .049$), taking video clips on their smartphone to show their pupils in class ($\chi 2(3) = 9.229$, $p = .026$), and taking videos of their classroom activities ($\chi 2(3) = 8.282$, $p = .041$). The female teachers participating in the study were more likely to have undertaken these activities over the previous two months than the male teachers. The other five variables did not show statistically significant differences.

Mann-Whitney-U tests were performed on participants' responses to eight questions on use of technology for classroom teaching and course completion. There was no significant difference found for any of the technology usage and the completion of the course (table in Annexure C).

6.5. The language used to answer the survey

Two identical versions of the pre-course survey – one in English and one in Assamese – were offered to the participating teachers. 107 (51.2

Table 6
Gender wise enrolment and completion data for DB01 and DB02 courses.

Gender (Categories)	Enrolled in DB01 (n)	Completed DB01 (n)	DB01 total score		Enrolled in DB02 (n)	Completed DB02 (n)
N = 209			M	SD		
Female	46	35	58.76	25.48	39	33
Male	163	96	46.93	30.16	104	74

Table 10
Frequency of technology usage.

$N = 209$		Frequency			
Teaching activity	Gender	Regularly	Sometimes	Occasionally	Not at all
Professional development					
Taken video of classroom activity	Female	7(15.2 %)	13(28.3 %)	10(21.7 %)	16 (34.8)
	Male	6(3.7 %)	55(33.7 %)	42(25.8 %)	60 (36.8 %)
Looked at online courses for teachers	Female	11(23.9 %)	21 45.7 %)	6 (13 %)	8 (17.4 %)
	Male	28(17.2 %)	61(37.4 %)	46(28.2 %)	28 (17.2 %)
Lesson preparation					
Browsed or searched the internet to collect teaching material to prepare lessons or other teaching material	Female	26(56.5 %)	12(26.1 %)	8(17.4)	0(0 %)
	Male	60(36.8 %)	69(42.3 %)	28(17.2 %)	6(3.7 %)
Taken a video clip on your smartphone to show to pupils in class	Female	16(34.8 %)	17(37 %)	8(17.4 %)	5 (10.9 %)
	Male	25(15.3 %)	70(42.9 %)	48(29.4 %)	20 (12.3 %)
Classroom teaching					
Used PowerPoint slides to present in the classroom	Female	1(2.2 %)	14(30.4 %)	11(23.9 %)	20 (43.5 %)
	Male	8(4.9 %)	44(27 %)	39(23.9 %)	72 (44.2 %)
Used WhatsApp groups to interact with pupils	Female	34(73.9 %)	6(13 %)	5(10.9 %)	1(2.2 %)
	Male	100(61.3 %)	41(25.2 %)	18(11 %)	4(2.5 %)
Use of social media in teaching					
Conducted classes using video software	Female	13(28.3 %)	9(19.6 %)	8(17.4 %)	16 (34.8 %)
	Male	29(17.8 %)	59(36.2 %)	28(17.2 %)	47 (28.8 %)
Interacted online with teachers on WhatsApp or other digital groups	Female	25(54.3 %)	15(32.6 %)	5(10.9 %)	1(2.2 %)
	Male	79(48.5 %)	53(32.5 %)	23(14.1 %)	8(4.9 %)

%) answered the Assamese version and 102 (48.8 %) answered the English version. 56.5 % of the female teachers used the English version compared to 46.6 % of the male teachers. This difference is not significant ($\chi 22(1) = 1.406$, $p = .236$). There was no difference in the level of digital skills between teachers answering in Assamese ($M = 2.21$; SD=0.582) and teachers answering in English ($M = 2.28$; SD=0.560) ($t(207) = 0.827$, $p = .409$).

A greater proportion of those answering the English version of the survey went on to complete the first course (70.6 %) compared to those answering in Assamese (55.1 %) (Table 11). This difference is significant ($\chi 2(1)=5.327$, $p = .021$).

6.6. Locality

Teachers were not asked about the location of their school in the pre-course survey, but they were asked to describe it in the post-course survey. Most teachers who responded to the post-course survey had successfully completed the course (89 %), and of these successful teachers ($N = 84$) most classified their school as 'rural' (66.7 %), while 19.1 % rated it as in a 'town' or 'city' and 14.3 % selected the 'semi-rural' option (Table 12).

Table 11
Language of the survey and gender.

Language of the survey $N = 209$	Gender	
	Female (n)	Male (n)
English	26	76
Assamese	20	87
Language of the survey	Digital Skills Competencies score	
	M	SD
English	2.28	.560
Assamese	2.21	.582
Language of the survey	Completed the course (n)	Did not Complete the course (n)
English	72 (70.6 %)	30 (29.4 %)
Assamese	59 (55.1 %)	48 (44.9 %)

Table 12
Self-reported school location of teachers (includes only teachers who achieved a pass grade for DB01).

Location $N = 109$	Gender		Survey language	
	Female	Male	Assamese	English
Rural	16	40	27	29
Semi-rural	6	6	4	8
Town or city	6	10	4	16
Total(n)	28	56	35	49

There was no significant difference in school location between the female and male teachers who completed the course ($\chi 2(2) = 2.196$, $p = .334$). 21.4 % of the female teachers said they were based in town or city schools compared to 17.9 % of the male teachers. A greater proportion of successful teachers answering the post-course survey in Assamese were from areas they described as 'rural' (77.1 %) than teachers answering in English (59.2 %). This difference is not significant, yet the contrast in percentages does indicate the potential association between locality and language chosen to answer the survey may benefit from further investigation. There were insufficient responses from teachers who had not completed the course ($N = 10$) for comparison.

6.7. Preference for different forms of learning support and completion

Post-course survey data shows some differences in how successful female and male teachers accessed the course materials and social media, but no difference in help seeking behavior. Mann-Whitney-U tests were performed on participants' responses to six questions about engagement with the course materials, other teachers and the course support (Table 13). Survey respondents selected one of five options: 'very often', 'often' 'occasionally' 'once' and 'never.'

When compared to the male teachers, a statistically greater proportion of female teachers logged on to the course using their Smartphone often or very often, read messages on social media and read messages on the course VLE website forums. However, the majority of both male and female teachers often or very often used smartphones to access content and a small minority of both used computers or laptops at their school to do so.

While the frequency of accessing the course was higher, no differences in proactive help- seeking behavior was reported. Male and female teachers report a similar pattern of help seeking behavior using the social media groups associated with the course to ask for help from others, and in contacting the Master Trainer (a teacher with prior experience of the course acting as mentors and supporting the grading of assessment)

Table 13
Types of support availed by participant teachers during the course.

Questions	Female teachers % Often or very often ($n = 35$)	Male teachers % Often or very often ($n = 74$)	MWU test statistic	p value
Logged in to the course using a handheld devices such as a smartphone	32 (91.4 %)	57(77 %)	597.0	.037*
Logged in to the course using a computer at my school	4(11.4 %)	10 (13.5 %)	567.5	.029*
Read messages in the course Telegram or WhatsApp group	32 (91.4 %)	61 (82.5 %)	605.0	.047*
Read messages in course (LMS) discussion forums on the VLE website	32 (91.4 %)	60 (81 %)	619.5	.089
Asked for help or advice via the Telegram or WhatsApp group	17 (48.5 %)	32(43.2 %)	637.5	.145
Contacted a Master Trainer directly for help and advice	13 (37.1 %)	24(32.5 %)	684.0	.323

Sig. at $p<.05$.

directly for help and advice. Further analysis showed that at least 90 % of the female and male teachers asked for help at least once during the course.

6.8. Regression analysis

To study the predictive role of gender and other teacher characteristics on course completion status, binary logistic regression (dichotomous dependent variable for completion) was conducted. Binary 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 [70]. The Hosmer–Lemeshow test is a commonly used statistical test for goodness of fit for the logistic regression model.

Block-wise, the Enter method was used to run the binary logistic regression. In the first block, gender was added; in the second block, the age of the teachers; the third block had the language in which the survey was taken. After these demographic-related teacher characteristics, the last block entered average scores for digital skills at the pre-survey.

Another variable related to teacher characteristics, like a location, where responses were available only at post-survey, was not included in the regression model. The tables can be found in the Annexure B.

After entering the gender of the teachers in the first block, it significantly ($p<.036$) predicted but explained only about 3 % of the variance (Nagelkerke R2= 0.031) in completing the course. The unstandardised Beta weight for the Constant; $B = (-1.955)$, SE = 0.709, Wald = 7.596, $p < .006$. The unstandardised Beta weight for the predictor variable Gender: $B = (0.798)$, SE = 0.381, Wald = 4.395, $p < .36$. The estimated odds ratio favoured 2.2 times increase or decrease [Exp (B) = 2.221, 95 % CI (1.053, 4.682)] in completion status (pass or fail) for every unit change in gender.

After entering age in the second block, there was not much change in the variance (NagelkerkeR2= 0.033) in predicting completion status. While gender continued to significantly predict completion in the second block, age did not significantly predict completion ($p<.551$). The Hosmer–Lemeshow (H–L) test yielded a $\chi2(3)$ of 0.521 and was not statistically significant ($p = .914$), suggesting that the model was a good fit for the data.

The unstandardised Beta weight for the Constant; $B = (-1.669)$, SE = 0.854, Wald = 3.813, $p < .051$. The unstandardised Beta weight for the predictor variable Gender: $B = (,815)$, SE = 0.382, Wald = 4.553, $p < .033$. The estimated odds ratio favoured a 2.3 times increase [Exp (B) = 2.260, 95 % CI (1.069, 4.780)] for completion with every unit change in gender. On the other hand, the unstandardised beta weight for the predictor variable age did not significantly contribute to explaining the change in completion status after controlling for gender.

After entering the language in which the survey was taken in the third block, the variance improved from 3 to 6 percent in (NagelkerkeR2= 0.063) in predicting the completion status. In addition, after entering the language of the survey taken in the third block, the Hosmer–Lemeshow (H–L) test yielded a $\chi2(7)$ of 11.993 and was not statistically significant ($p = .101$), suggesting that the model was a good fit for the data.

The unstandardised Beta weight for the Constant; $B = (-2.551)$, SE = 0.960, Wald = 7.067, $p < .008$. The unstandardised Beta weight for the predictor variable Gender: $B = (,772)$, SE = 0.387, Wald = 3.984, $p < .046$. The estimated odds ratio favoured a 2.2 times increase or decrease (pass or fail) [Exp (B) = 2.163, 95 % CI (1.014, 4.614)] for completion status with every one unit change in gender. On the other hand, the unstandardised beta weight for the predictor variable age was not significant and did not significantly contribute to explaining the change in completion status after controlling for gender. The unstandardised Beta weight for the predictor variable language in which the survey was taken: $B = (0.636)$, SE = 0.295, Wald = 4.656, $p < .031$. The estimated odds ratio favoured a 1.9 times increase or decrease ([Exp (B) = 1.889, 95 % CI (1.060, 3.367)] for completion status with every unit change in language in which the survey was taken, after controlling for gender and age.

After entering the average of teachers' digital skills at pre-survey in the fourth block, there was not much change in the variance (NagelkerkeR2= 0.064) in predicting completion status. The Hosmer–Lemeshow (H–L) test yielded a $\chi2(8)$ of 22.961 and was statistically significant ($p < .003$), suggesting that the model was not a good fit for the data.

The regression analysis suggested a statistically significant contribution of teacher characteristics, gender and language used to respond to the survey in explaining the completion status. However, as per R-square statistics, this contribution was weak. The prior digital skills of the teachers did not significantly predict the completion status. This aspect, along with the locality of the school, would benefit from a closer look in future study.

7. Discussion

The findings indicated a strong relationship between gender and completion of the course. Assam is largely a rural state, and a majority of its government teachers (80 % or above) are from rural areas [60], with 62 % of their secondary government school teachers across all subjects noted as male [59]. However, 76 % of the teachers enrolled in the DB01 course were male, a much higher percentage than the average percentage of male teachers in Assam. It is not known which teachers in the DB01 course self-selected themselves and which were nominated by their headmaster/school principal.

This lower representation of women could be due to the emphasis on technology in the DB01 course at the time of enrolment. A more masculine image of technology use and a lack of female role models in technology in general [71] can negatively affect female teachers' confidence about using technology in classrooms [72] or their principals' perceptions of who it might be most appropriate to nominate for the course. However, this study did not find any significant difference between male and female teachers in the pre-course survey on digital skills, years of experience and other demographic variables.

Contrary to the popular trends in the literature that would predict supported higher levels of participation and use of technology on the

part of men, the results of this study indicated a significantly higher proportion of female teachers completing the course with a higher mean pass percentage than their male counterparts. This difference in performance and completion on the course across genders of the teachers would warrant further investigation.

On the other hand, the study found some significant differences between male and female teachers in their engagement with the course. For example, the female teachers' reported use of smartphones and course-dedicated Instant Messaging Applications was significantly higher than that of the male teachers. The course facilitators provided active support in these groups and the course's learning management system was made smartphone accessible. Interestingly, the course also has a good social media presence, and the data reported female teachers using significantly more social media than their male counterparts.

Other factors not found in the data but in the making and delivery of the courses could have been favourable for female teachers' success. A high proportion (95 %) of course facilitators and the main faculty teaching the courses were women including some of the authors of this paper. Their insights indicate that female role models as course leaders and facilitators could have had a positive impact on the female teachers in the course. This finding has some support in the literature, which indicates that repeated association of male models with technology could lower female confidence in technology [72,73]. Overall, society views technology as highly technical and part of a male domain, and the use of IT tools is perceived as a masculine activity [74]. In the Indian context, very few women are working in STEM subjects, and very few women are speakers at STEM conferences [75]. This lack of female role models in STEM, which was in contrast with the female gender of the facilitators in these courses, could have deterred those male teachers who were uncomfortable with women's leadership and facilitation of their learning and, more probably, positively influenced female teachers' engagement and commitment to their development.

Another important factor could be careful consideration of gender neutrality in the resources used in the course to ensure all teachers were able to recognise themselves in the materials. Offering flexible study opportunities for teachers to complete the course could have been also favorable for female teachers who often juggle with home-related chores. The digital badge courses were chunked into smaller content and duration option, with flexible entry and exit options for teachers [19,63], which could have appealed to female teachers.

Besides gender, the language in which the pre-course survey was taken by the teachers, namely Assamese versus English, was found to be significantly related to the course completion rates. More teachers who took the survey in English completed the course. This relationship had no significant intersection with digital skills, and analysis of the post-course survey responses did not find any association between language and school location (i.e. urban, semi-rural, rural). Familiarity with English and living in urban areas could have supported their access to a better infrastructure, and more opportunities for training and exposure in the state and district capital areas.

All the teachers who took the survey were teachers in government schools, which largely teach in Assamese medium. It may be possible, therefore, that teachers who took the survey in English could be assumed to be more familiar with both English and Assamese than their counterparts who took the survey in Assamese. One reason the teachers familiar with English and Assamese could be more likely to complete the course may be that the course content was originally written in English and translated into Assamese for the teachers who preferred to take it in that language. However, this was the very first attempt at translating a course into Assamese and it is possible that the translation was compromised and could have affected teachers' performance on the course. The main university facilitators did not speak Assamese but took the help of local mentor teachers to facilitate the WhatsApp and Telegram discussions in Assamese. These mentor teachers also facilitated discussion groups on the course LMS for the course in Assamese, while the discussion forums in the English version of the course were facilitated by the university facilitators. The mentor teachers were associated with this course in its original form, which was a blended certificate course in the year 2017–18 [34] and continued their engagement with the university faculty of this course and activities in the area of constructivist technology over three to four years.

The last two decades have seen increasing recognition of the role that language plays in learning and the benefits - both cognitive and social justice related - of drawing on learners' dominant languages as much as possible in this process (e.g. [76,77]). Representing a challenge to long-held assumptions as to the effectiveness of 'immersive' pedagogic experiences in unfamiliar language contexts has been growing evidence of the value of extended mother tongue teaching in basic education in improving levels of pupil engagement, retention, progression and long-term educational achievement across all subject areas [78]. Similar positive effects have been found as a result of the creation of pedagogic 'translanguaging spaces' in which learners are encouraged to use elements of all their known languages to communicate and make meaning [79]. Yet, despite their notable impact, the availability of language-focused educational initiatives of this kind remains somewhat limited.

Adding to the challenges of supporting learners whose home language differs from language of learning has been the rapid demand for English Medium Instruction (EMI), starting at ever earlier stages of schooling and extending into university provision worldwide.

To date, initiatives and research in language in education policy and practice have focused primarily on school pupils or university students, with very little attention having been paid to the role of language in the training and continued professional development of adult learners, including teachers. In view of its high levels of linguistic diversity, on the one hand, and the legacy of English as a colonial, high-status language, India represents a particularly interesting context in exploring this hitherto neglected area. The absence of gender-related information as to the teachers' knowledge of different languages and their preferred language of study on DB01 means it is not possible to consider any correlation between the female participants' better performance - as compared to that of their male counterparts - on the one hand, and aspects of language use on the other.

Rather than simply enquire what their preference is for completing a survey or undertaking a course of a limited number of options available, of value in future studies would be to pay greater attention to the adult participants' linguistic backgrounds - by establishing both their dominant language and the main language they use in their work or study.

More generally, we suggest that future research uses mixed methods and larger samples and predictive or path analysis to study these complex interrelationships between the gender of the teacher, the language of the TPD, mentorship, the locality and other contextual variables with teachers' performance in TPD related to technology integration within the framework of TPACK.

8. Implications

Developing TPACK knowledge is a complex process; the content and pedagogy in the courses studied in this paper used a continuous, practice-based, collaborative and flexible approach [19] to develop TPACK in government teachers in highly rural and economically poor a North Eastern state of India.

This paper argues that the design and delivery of TPD apart from the content and design of TPD used in these courses to develop TPACK, needs to pay attention to teachers' subjective realities as an integral aspect of context. Identities formed from unique experiences, particularly gender identities, will influence how they navigate the ICT landscape in their practice. In particular, regarding teachers' gender identity, concrete efforts are required to raise awareness among teachers to reflect on their social identity and issues of inclusivity. The implications of the results of this study will be useful to inform policymakers, designers and implementers of TPD for TPACK to be sensitive to

inclusivity especially related to gender and language of instruction in the course design and implementation. The study contributes to the evolving literature on context in TPACK, by highlighting the importance of considering, as an aspect of context, diverse teacher characteristics and their influence on its contribution to successful and inclusive TPD for TPACK.

One of the cautionary notes to the findings in this paper is that the DB01 course was implemented during the COVID-19 lockdown period and teachers were working from home. Normally in the Indian context, this would have leveraged more time for female teachers to balance their household chores with school work. At the same time, more or less time at home for male teachers in CLP and its implication on their participation in this TPD is not known. Overall, policymakers and designers can consider keeping the delivery of such rigorous TPD for TPACK flexible and allowing teachers to use some dedicated time from their regular working hours.

9. Limitations of the study

The section above indicated that the results of this study may have been impacted by the fact that it took place during CLP. Another limitation of the study was that the post-test data drew primarily on those who completed the courses, rather than those who withdrew over its duration. The proportion of demographic data, such as gender, was thus disproportionate in the survey responses. However, it reflected the proportion at the point of enrolment, which was the focus of analysis in this paper.

CRediT authorship contribution statement

Amina Charania: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization. **Simon Cross:** Writing – review & editing, Writing – original draft, Validation, Project administration, Funding acquisition, Formal analysis, Data curation. **Freda Wolfenden:** Writing – review & editing, Visualization, Resources, Investigation. **Sohini Sen:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Data curation. **Lina Adinolfi:** Writing – review & editing, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Annexure A

Table A1
Descriptive statistics for survey items.

	Pre-course survey $N = 209$			Post-course survey $N = 109$		
Questions	*M*	Median	*SD*	*M*	Median	*SD*
How long have you been a teacher?	2.25	2.00	0.739			
What is your age? (Response options included under 25; 25–34; 35–44; 45–54; and 55 or over)	2.97	3.00	0.811	2.97	3.00	0.810
Frequency of technology usage by teachers (Frequency response options included regularly, sometimes, occasionally & not at all):						
Browsed or searched the internet to collect teaching material to prepare lessons or other teaching materials	1.82	2.00	0.818	1.50	1.00	0.765
Used Powerpoint/slide to present in the classroom	3.08	3.00	0.943	2.35	2.00	0.985
Looked for online courses for teachers	2.41	2.00	0.982	2.15	2.00	0.951
Interacted online with teachers on WhatsApp or other digital groups	1.72	2.00	0.855	1.78	2.00	0.900
Taken a video of your classroom activities	2.91	3.00	0.967	2.49	2.00	1.015
Taken a video clip on your smartphone to show to pupils in class	2.31	2.00	0.922	1.89	2.00	0.832
Used Whatsapp groups to interact with pupils	1.52	1.00	0.785	1.44	1.00	0.673
Conducted classes using video software (e.g. Zoom, Google meet, etc.)	2.57	2.00	1.120	2.28	2.00	0.963
Digital skills competency (Frequency response options included cannot do it; need help; can do it; and can do it extremely well):						
Starting a computer	3.43	4.00	0.690	3.47	4.00	0.675
Typing on a computer	3.29	3.00	0.646	3.40	3.00	0.682
Searching the internet	3.46	4.00	0.628	3.55	4.00	0.601
Using email	3.40	3.00	0.620	3.55	4.00	0.601
Saving files or documents to a computer	3.29	3.00	0.788	3.37	4.00	0.778
Playing games for pleasure on a smartphone	3.06	3.00	0.812	3.12	3.00	0.900
Using a smartphone to access the internet	3.54	4.00	0.537	3.62	4.00	0.574
Downloading and uploading files	3.39	3.00	0.656	3.32	3.00	0.804
Making a spreadsheet (e.g. in Excel)	2.73	3.00	0.964	3.02	3.00	0.952
Making a slides (e.g., in Powerpoint)	2.72	3.00	0.970	3.05	3.00	0.927
Studying a course on an online learning platform	2.92	3.00	0.823	3.41	3.00	0.627
Using Whatsapp or other online chat service	3.45	3.00	0.587	3.64	4.00	0.570
Types of support availed by participant teachers during the course (Frequency response options included never; once; occasionally; often; and very often):						
Logged in to the course using a computer at my school				2.13	2.00	1.210
Logged in to the course using a handheld device such as my smartphone				4.37	5.00	0.889
Read messages in the course Telegram or WhatsApp groups				4.42	5.00	0.808
Read messages in course (LMS) discussion forums on the VLE website				4.21	4.00	0.851
Asked for help or advice via the Telegram/WhatsApp groups				3.35	3.00	1.031
Contacted a Master Trainer directly for help or advice				2.92	3.00	1.313

Annexure B

Table B1
Regression analysis: block 1.

Variables in the equation									
								95 % C.I.for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1a	Q. What is your gender?	.798	.381	4.395	1	.036	2.221	1.053	4.682
	Constant	−1.955	.709	7.596	1	.006	.142		

a. Variable(s) entered on step 1: Q1c. What is your gender?.

Table B2
Regression analysis: block 2.

Variables in the equation									
								95 % C.I.for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1a	What is your gender?	.815	.382	4.553	1	.033	2.260	1.069	4.780
	What is your age?	−0.108	.180	.355	1	.551	.898	.630	1.279
	Constant	−1.669	.854	3.813	1	.051	.189		

a. Variable(s) entered on step 1: Q1b. What is your age?.

Table B3
Regression analysis: Block 3.

Variables in the equation									
								95 % C.I.for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1a	What is your gender?	.772	.387	3.984	1	.046	2.163	1.014	4.614
	What is your age?	−0.112	.182	.380	1	.538	.894	.625	1.278
	Language used to complete the survey	.636	.295	4.656	1	.031	1.889	1.060	3.367
	Constant	−2.551	.960	7.067	1	.008	.078		

a. Variable(s) entered on step 1: Language used to complete the survey.

Table B4
Regression analysis: Block 4.

Variables in the equation									
								95 % C.I.for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1a	What is your gender?	.785	.388	4.094	1	.043	2.192	1.025	4.688
	What is your age?	−0.138	.194	.508	1	.476	.871	.596	1.273
	Language used to complete the survey	.628	.296	4.518	1	.034	1.874	1.050	3.345
	Average of Digital Skill Competencies	−0.108	.271	.159	1	.690	.897	.527	1.527
	Constant	−2.136	1.414	2.282	1	.131	.118		

a. Variable(s) entered on step 1: Average of Digital Skill Competencies.

Annexure C

Table C1

Table C1
Technology usage for classroom teaching.

Questions	MWU test statistics	p value
Taken video of classroom activity	4721.5	.335
Looked at online courses for teachers	4807.5	.455
Browsed or searched the internet to collect teaching material to prepare lessons or other teaching material	4848.5	.508
Taken a video clip on your smartphone to show to pupils in class	4816.5	.466
Used PowerPoint slides to present in the classroom	4459.5	.101
Used WhatsApp groups to interact with pupils	4704.0	.260

(*continued on next page*)

Table C1 (*continued*)

Questions	MWU test statistics	p value
Conducted classes using video software	4715.0	.333
Interacted online with teachers on WhatsApp or other digital groups	5019.5	.817

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