Understanding the Situated Practices of School Technology Leaders in the Early Stages of Educational Technology Adoption

Seray B Ibrahim
University College London
s.ibrahim@ucl.ac.uk

Asimina Vasalou
University College London
a.vasalou@ucl.ac.uk

Laura Benton
University College London
l.benton@ucl.ac.uk

ABSTRACT

School-driven technological innovation has the potential to positively impact on classroom practice, yet it can also be disrupted by incompatibilities between the existing school ecology and new educational technologies. To help mitigate this disruption a particular staff member often takes on a facilitative leadership role to champion new technology initiatives. However little is known about how this technology leader role impacts on the adoption of new technologies in the classroom. Taking a situated lens, we embarked on a multiple case study of four schools who were aiming to adopt a new literacy game in the classroom. Through interviews with technology leaders and fieldnotes from our site observations, we systematically analysed their actions and concerns over two academic terms. This highlighted an overwhelming concern with managing the material dimension of the technology, teacher agency and division of labour and mechanisms for communication and monitoring. Our findings raise important considerations for HCI researchers seeking to embed their technologies into practice alongside recommendations for supporting leaders tasked with coordinating this process.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **Empirical studies in HCI**;

KEYWORDS

Educational Technology, Adoption, Technology Leader, Situated Practice

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1 INTRODUCTION

Researchers in the field of HCI have been increasingly concerned with maximising the positive impacts that new educational technologies can have on classroom practice and children's learning. Educational technologies used in schools have the potential to contribute a number of benefits. These include improved access to digital resources for organising and monitoring learning, fostering student-centred learning, as well as offering flexible and personalised learning materials [8, 17, 25]. When scaling up educational technology use beyond a single classroom, previous research has frequently carried out pilots which were supported by the researchers (e.g. [27, 30]). This has ensured the digital technology is used following a pre-determined methodology, whilst teachers receive support when needed in class. This approach has evidenced the effectiveness of new technologies and has been oftentimes a persuasive force to inform the school leadership on their technology investment decisions. However, when schools have embarked to deploy new digital initiatives that are outside the purview and care of the researcher a new set of concerns emerge. The introduction of new technologies has been found to bring significant challenges and incompatibilities between the existing school ecology and new educational technologies [5], placing higher demands on teachers who are already struggling to work within the confines of limited resourcing [7, 9]. These tribulations can be particularly evident in the early stages of technology adoption during which new classroom practices are still forming and are thus fragile. When attempting to disentangle the challenges of introducing new technologies in school settings, prevalent discourses have focused on the social and psychological implications of technologies or separately, have considered the characteristics of the technologies independent of their practical uses [22]. However, educational technologies and their social practices are inseparable [22]. A 'situated lens' is therefore necessary to understand how teaching staff adopt new educational technology within their everyday practices, including the mundane practices that foster the sustained use of technology [42].

The present work takes this lens focusing on the role of the school technology *leader*. Technology leaders are champions of the technology who are responsible for motivating and supporting teaching staff in the process of adopting new educational technology in the classroom [33]. Previous research has shown the significance of leadership in whole-school technology initiatives and the roles taken that support this: e.g., organising staff development, or initiating technology policy in the school [26]. Even though this work has contributed broad leadership recommendations, it has not shown how leadership practices are shaped within specific school settings, their operational structures, and the social relationships developing between the technology leader and the school staff team. Given that each school has a diverse character, it is unclear how technology leaders prioritise and support others to adopt technology within the boundaries of their local setup. Also, since the technology leader has a facilitative role in new technology initiatives, a situated understanding of these practices could equip HCI researchers seeking to

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embed their technologies into the classroom longer term with new strategies that support leaders from a diversity of school settings. We address this gap with a multiple case study of four schools who signed up to use a new adaptive literacy game 'Navigo' designed for primary school students across multiple classes and year groups, under the direction of a technology leader tasked with coordinating the process. Combining field notes from school observations and interviews with technology leaders, we systematically analyse a period of two academic terms when the technology was first introduced and new classroom practices had begun to develop in order to compare and contrast the four cases. Our goal is to understand the concerns of school technology leaders and the practices they employ to support other staff when introducing new educational technologies within the classroom. Based on the four case studies, our paper makes three main contributions. First, we add to empirical research on educational technology adoption by illustrating four diverse cases of how technology leaders coordinated this process. Second, we present a systematic methodological approach for investigating school-based technology adoption by focusing on situated action. Third, we propose recommendations for HCI researchers interested in supporting technology leaders tasked with leading technology adoption in their school.

2 RELATED LITERATURE

2.1 Technology leaders and school leadership

The use of technology in education can be led by motivated teachers at a small scale, or conducted as a school-wide implementation involving multiple classes and teaching staff. Research by Forkhosh-Baruch et al [16] examined the differences between teacher-led and school-wide adoption of educational technology, showing that in both instances there were similar patterns in relation to how and when the technology was used to support the curriculum. However, in the case of the school-wide initiatives, a member of staff within the school was required to coordinate it. Taking a longitudinal multiple case study, Ottenbreit-Leftwich et al [32] interviewed newly qualified teachers over four years to understand the process of technology adoption. Teachers' practices with technology were overwhelmingly impacted by their school structures, policies, cultures and resources, as opposed to internal enabling factors held by individuals, such as their attitudes or technical skills, which had a weaker impact. These examples illustrate the important role of *technology leaders* in coordinating the process of technology adoption within the complex institutional context of the school. In line with previous work which has shown that school principals delegate the leadership of technology programmes to senior staff [41], in this research, technology leaders are individuals who occupy a senior role in the school and are also responsible for a school-wide technology adoption initiative.

Aiming to understand which leadership approaches best supported technology adoption, Yuen et al [46] analysed models of change in 18 schools who had sought to integrate educational technology into their teaching and learning practices. They attended to several characteristics, such as school values, the perceived impact of technology, the school culture and its history of pedagogical innovation. Based on these, they identified three clusters of leadership. Model A schools were led by a top-down management approach that ensured all staff reached a minimum level of technology competency. Model B schools were also managed top-down, although the leadership involved teachers actively in the process of adoption. Model C schools displayed multiple leadership strategies that did not necessarily involve the senior leadership team, e.g. the school principal, but instead supported teachers to implement new technology initiatives bottom-up.

Model A schools tended to develop teachers' digital skills, which did not alone yield successful technology adoption within the school. In contrast, by involving teachers in the process of curriculum innovation, Model B schools successfully engaged in a process of adoption. They also displayed technology-supported pedagogical practices that were found to be more student-centred as compared with those of Model A schools. Finally, Model C schools, characterised by teachers driving the change process, were also successful in adopting technology. Technology was used to initiate and implement new ideas by both teachers and students, thus it was an empowering tool . This third cluster of schools additionally displayed a strong sense of mission and a clearly identifiable vision of education that permeated practice across the school (see also [12]). The study by Yuen et al [46] suggests that *effective technology leaders involve teachers in the process of technology adoption* and leadership can be either hierarchical, or distributed, as evidenced through the success of both Model B and C schools. Harris clarifies that [18] (p.174) "distributed leadership does not imply that the formal leadership structures within organisations are removed or redundant. Instead, it assumes that there is a powerful relationship between vertical and lateral leadership processes". In related work, Ertmer and Ottenbreit-Leftwich [12] conducted a review of past research in the area of technology-enhanced learning providing further support for the importance of involving teachers to shape technology adoption initiatives. The same authors suggested that for teachers to leverage technology as a meaningful pedagogical tool, technology leaders must not only communicate a consistent and shared vision for the technology use, but also create opportunities for teachers to actively shape this vision by carving role identities within the school and including teachers in key decisions.

2.2 Collaborative cultures

Alongside the collaborative relationship between technology leader and teacher, Ertmer and Ottenbreit-Leftwich [12] discuss the importance of horizontal collaboration between teachers, for example through peer coaching [32]. Collaboration has generally been regarded as integral for teacher learning about technology since it can support teachers to reflect on and problem solve how to use technology within their teaching practices [10, 28, 32]. Meirink et al [28] investigated the specific characteristics of teacher collaborations across five schools undergoing pedagogical change that included technology adoption [28]. They identified that teacher groups who developed sharing practices about content and instruction evidenced increased learning about the new technology.

Other work by De Jong et al [23] found that the school culture and institutional values go on to inform the nature of collaboration between teachers. In some of the schools they observed there were symmetrical collaborations between teachers aiming to improve teaching in line with their existing school culture. However, the

school leadership in one of the schools held rigid beliefs about teaching resulting in a hierarchical approach to collaboration in which teachers sought regular feedback from the leadership in order to meet their expectations. Having little ownership over the process, these teachers expressed little desire to continue their collaboration. Therefore, collaboration approaches within teacher teams are situated, they can take varied forms depending on the culture of the school context and this may in turn have an impact on the relationship between teachers and the technology leader.

2.3 Enabling conditions orchestrated by technology leaders

Although past work has predominantly focused on the organisational dimension of schools, some research has also recognised the pragmatic, operational tasks that fall under the purview of the technology leader when planning and maintaining technology initiatives, such as *professional development*. Whilst many schools tend to recognise the importance of teacher development [46], this has been often planned in the form of one-off training on specific topics. To provide effective teacher development, Kearsley [24] argues that schools must create the space and time for teachers to practice what they learned [24] through a range of organised opportunities such as collaboration and coaching, on-site, individualized instruction, observation of ICT integration in practice, and self-directed learning [20, 21].

Another operational task, that has been given less attention in the literature is the *planning and maintenance of technology* [15]. Flanagan and Jacobsen [15] highlight the importance of the material and spatial arrangement of technology through its access. Placing tablets or computers within classes, as well as introducing mobile workstations, can remove physical barriers and establish technology as part of the classroom ecology of learning resources. Other work by Rosner and Ames [37] highlights the foresight technology leaders must have to maintain the technology when it breaks down. In a school-wide technology initiative in Paraguay, the authors reported a tension when tablets broke down and required repair. Since the school leadership had not taken the responsibility of resourcing this, over time the tablets became obsolete. Separately, Sheepmaker et al [38] suggest that planning and maintaining technology projects beyond the end of planned research fieldwork also encompasses attending to both the material tools and social practices within the setting. Following a three-year co-design project with neurodiverse children and teachers, the authors developed a toolkit consisting of material tools (methodological guidance) and social tools (guidance on supporting the social community). Interviews and surveys with teachers revealed that one of the challenges reported by teachers involved having the skills to explain the technologies to the children. As such, the authors suggest that for schools to continue using technologies beyond the end of a specified project, schools and their technology leaders must engage in creating a supporting community within which technologies can be used.

3 MOTIVATION AND RESEARCH QUESTIONS

To summarise, prior research on technology *adoption* in schools has shown that school-wide technology initiatives that involve multiple teachers/classes require coordination and collaboration at an institutional level in order to succeed [16]. To achieve this, the school leadership takes an important role in orchestrating the process, namely through a technology leader [41]. Previous research has shown that teachers should be actively involved in shaping the new initiative [12], which is possible in schools with both vertical and hierarchical leadership approaches [18, 46]. Technology leaders must orchestrate this involvement and collaboration [13, 35] and simultaneously support a range of operational tasks, for example developing teachers' technical competence through teacher development, allocating time for planning or managing the technology [11, 46].

Educational technology adoption occurs in the school's complex institutional and socio-cultural context [24, 38]. From a situated lens, each school setting can have its own way of enacting leadership processes that in turn mediate the process of adopting new technology. Prior research has often employed teacher interviews to identify patterns of leadership during the adoption process (e.g. [23, 28, 29, 32]) highlighting a gap in understanding *technology leaders'* concerns and their situated practices when leading a teaching team. Moreover, whereas research in this area has often applied an organisational lens, considering the nature of the technology leader's work as reported in Section 2, we propose that it is equally important to recognise that organisational factors, such as time or resourcing, can be intertwined with social and material considerations [14, 22, 40]. This matters, as technology adoption can only be supported when there are common understandings about how each school enacts technology leadership and how school team members take responsibility over enabling conditions and resourcing [37, 46]. Alongside equipping HCI researchers with a new understanding on how to better support school-research partnerships, research in this area can contribute a new situated understanding of technology leaders' practices in the permeating use of technology in schools. It can also provide new recommendations to guide technology leaders on how to plan and improve technology initiatives within their school context. To this end, our research question asked:

What are the *processes that technology leaders engage in and how do these support or hinder technology use?*

- What are the concerns of technology leaders when leading a teaching team in technology adoption?
- What are the practices they employ in leading their team and how effective are these practices in fostering technology adoption?

4 NAVIGO GAME AND APPROACH TO SCHOOL SUPPORT

The *Navigo* literacy game was designed to support Primary School children's acquisition of reading skills. The game covers the first four years of the primary literacy curriculum (age 5-8). Additionally, owing to their difficulties in acquiring early reading skills, the game was designed to support older children (age 8-11) with persistent reading difficulties. Navigo has an Egyptian inspired narrative and the child is tasked to find their missing grandma by exploring a pyramid with their avatar. Entering the pyramid activates a series of game activities through which they progress towards this goal.

Figure 1: Three example Navigo game mechanics (left: multiple choice, middle: sequencing, right: hit the target). ©Navigo, iRead project consortium

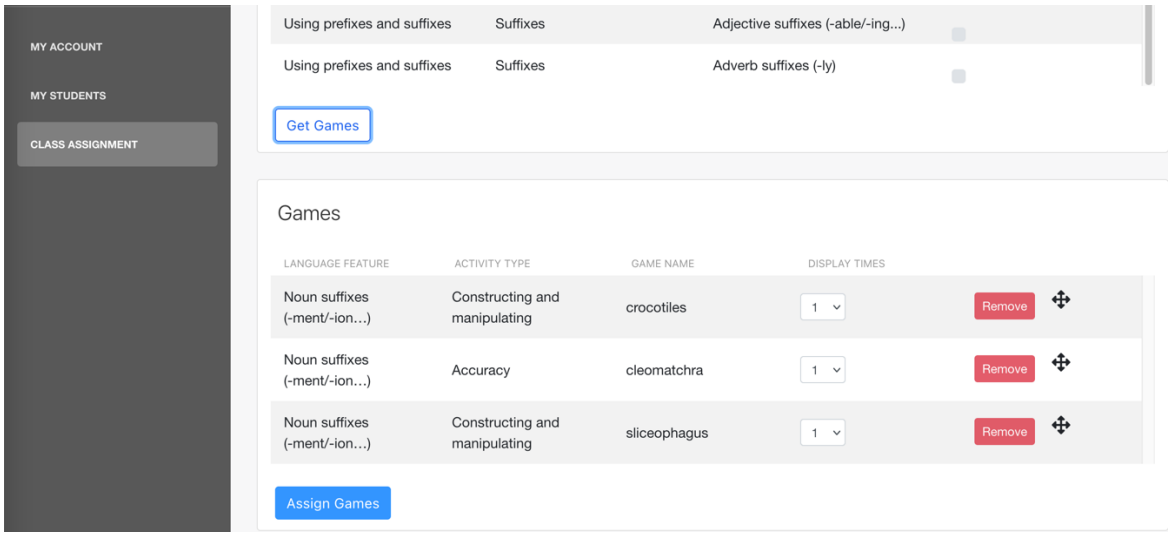

Figure 2: Teacher tool used to assign games for 'Using prefixes and suffixes'

Navigo contains over 900 game activities that cover a range of literacy skills, including phonics and phonemic awareness, exception words, reading for meaning, and reading fluency. To maintain children's interest in the game and foster transferability of learning, there are a total of 15 different themed game mechanics that enable children to practice the same learning objective through a variety of game activities. These mechanics include multiple-choice, matching, splitting, sequencing, hit-the-target and fill-in-the-gaps (see Figure 1 for examples).

Navigo was designed to be used in two different ways in the classroom. First, the game operates in an adaptive mode. To cater to the diverse language and cognitive profiles of different ages and groups, Navigo identifies what language features each child should work on, the content they should practice for a given feature, and the most suitable game mechanic to maintain an appropriate level of challenge based on their initial user profile and subsequent performance within the game [1]. Therefore, whilst a class of children are seemingly playing the same game, the content and mechanics is customised to each child's profile. Second, using Navigo's teacher tool, teachers can browse through the available literacy features and pre-assign games to the whole class, or individual students. Informed by early feedback from teachers, this functionality was vital to identify games that align with teachers' weekly learning aims (see Figure 2). Therefore, the teacher tool enables teachers to bypass the adaptive function through their own game choices. Once a child has played all the teacher-assigned games Navigo automatically reverts to adaptive mode.

Given its functionality, Navigo requires the setup of individual student accounts to maintain a live record of a student's performance, as well as classes associated with a teacher to allow for teacher tool game assignments.

Schools that signed up to use Navigo received a set of new Android tablets with the game installed. In addition to the software and hardware provided to the schools, the research team recognised the important role of teacher development in line with previous research [43]. Initially a two-hour Continuing Professional Development (CPD) training session was undertaken with participating teachers. The CPD sessions occurred directly within the schools, linking to the idea that CPD based in school settings of teachers involved leads to better student and teacher outcomes [6]. CPD was delivered face to face, as this was the key preference expressed in teacher interviews that took place at an earlier stage. CPD scaffolded the learning process to empower the teachers to develop confidence, skills and knowledge [34, 44] in the process of technology adoption. In many learning contexts the dominant form of professional development remains as a 'transfer' of knowledge or 'best practices' from an expert presenter to an audience. In practice, within the education sector, this often includes a process whereby a teacher participates in an external course and then returns to school to share knowledge with colleagues. However, despite continued dominance, this CPD model is known to be unlikely to lead to improvements in teaching and learning [31] unless further active participation by all is involved [19]. Therefore, alongside the CPD, the research team continued to monitor the school's technology use and supported the schools as required through a designated team member. In addition to emergent questions that the teachers had, the content of the CPD and continuous support from the research team were designed to address four topics: (1) the school technology leader's role in coordinating the teaching team (2) the weekly timetabling of Navigo (3) tablet maintenance and access, i.e., storage and charging (4) training and alignment of Navigo with teachers' intended use of this technology within their teaching.

5 METHODOLOGY

5.1 Context and Sampling

The research took place in a UK Primary School setting with students who were learning to read from Years 1-3 (aged 5-8 years) and those with reading difficulties from Years 4-6 (aged 8-11 years). All of the schools had prior experience using technology with their students as part of their teaching. Once ethical approval was obtained through the university ethics board, eleven schools in the South of England signed up to use Navigo. As part of the sign-up process, we agreed a target number of students that each school would aim to meet and schools were subsequently provided with a sufficient number of Android tablets to enable them to fulfil this target given their particular school circumstances (e.g. timetabling allowing for tablets to be shared between classes). For this study we chose to take a case study approach, focusing on four schools that met the following criterion: planned for multiple teachers to use Navigo across different classes and whose work was coordinated by a technology leader. Given our research question, the unit of analysis is the technology leader. The case study approach is well suited to studying the contextual complexities of real-world settings [45]. Rather than seeking to identify and abstract generalisable actions that describe how technology leaders coordinate the introduction of technology, case study research recognises that actions are inextricably linked to the context, i.e., the school. As such, we investigate how technology leaders' actions are dependent on social and material circumstances [42], as well as how their decisions and actions impact on the use of Navigo in the early stages of educational technology adoption.

5.2 Case studies

5.2.1 Blue School Overview. Blue is a mixed, inner city community school. The school size is considered small with one class per year group. There are approximately 30 pupils in each class, ranging from reception class through to year 6. Half of the pupils in the school are described as being from ethnic minority backgrounds although few are at the early stage of learning English as an additional language. Fewer pupils than the UK national average are described as having special educational needs and/or disabilities.

The target set for this school was 100 pupils. These were formed of 83 students in Years 1-3 and 17 students with reading difficulties in Years 4-6. Students were supported to take part by 8 teaching staff. There were no reported issues with the school Wi-Fi internet connectivity (which was required for accessing the game). The school was provided with 30 tablets, which were shared across classes and charged through a combination of individual and multiport USB chargers. The tablets were stored in the lockable photocopy room when not in use, in plastic storage boxes. The school had offsite tertiary IT technical support, which was used to set up the tablets with internet connectivity and security at the start of the project.

Blue technology leader: The school literacy lead acted as the technology leader. In addition to their literacy lead role, they were also the class teacher for Year 3. The involvement of the literacy lead was initiated by the school team following a university workshop that Blue staff had attended. Having established consent from the Headteacher, the staff member who attended this earlier workshop had signed up to be part of the project, indicating that the literacy lead would be their technology leader. As literacy lead, Blue was part of the school's middle leadership team. Another school contact, the school special educational needs coordinator (SENCO), acted as a second leader and intermediary with researchers for specific activities, like establishing child consent and addressing initial technical challenges.

5.2.2 Orange School Overview. Orange is a mixed community, inner city school. The school size is described as 'larger than most', with two classes per year group from reception through to Year 6, with approximately 30 pupils in each class. Over 80% of all pupils come from ethnic minority backgrounds with over half of all pupils learning English as an additional language. The proportion of children with special educational needs and/or disabilities is described as 'very much higher than the UK national average'.

The school target was 94 pupils, which included 59 pupils from Year 3 and 35 pupils, who were described as having reading difficulties, from Years 4-6. In total, 6 teaching staff supported the use of Navigo. The school was issued with 30 tablets, which were shared across classes and connected to the school Wi-Fi with no reported issues. The tablets were stored in a lockable drawer in the technology leader's office (the inclusion room) and charged overnight on multiport charging sockets. The school held an external contract with an offsite IT technical support team who set up and maintained a range of technologies within the school.

Orange technology leader: The school SENCO acted as the project technology leader. The SENCO and school became involved after being invited to take part by a member of the research team, owing to an existing relationship. In her existing role within the school, the SENCO occupied a senior leadership position.

5.2.3 Silver School Overview. Silver is a large inner city mixed, community school. The school is considered large with two classes per year group, and 30 pupils in each class. The proportion of pupils from minority ethnic groups and the number of pupils who speak English as an additional language is much higher than the national average. The proportion of students with special educational needs and/or disabilities is also above the UK national average.
The school target was 156 pupils, supported by 15 staff members. Of these pupils, 121 were from Years 1-3 and 35 pupils with reading difficulties had been identified from Years 4-6. The school was issued with 60 tablets which were stored in a dedicated tablet storage unit and charging station, located centrally within the school. There were no reported internet connectivity issues. In addition to teaching staff, there was an onsite IT technician who offered advice on internet connectivity and security related to the tablets.
Silver technology leader: The school's literacy lead acted as the technology leader. The school had volunteered to participate after learning about the project from an existing school-university partnership. In their role as literacy lead, this technology leader held a middle leadership role within the school. The technology leader also worked with a secondary leader who was a learning mentor for the older primary aged students with reading difficulties.

5.2.4 Yellow School Overview. Yellow is an inner city, mixed primary school. It is a new school that is sponsored by a national-level Academy Trust, meaning that the trust receives direct funding from the government for managing the school, independently of the local educational authority. The school started from reception through to Year 4 with two classes per year group, and 30 pupils were in each class. The proportion of pupils who have special educational needs and/or disabilities is above UK national average. Pupils are from a wide range of different ethnic backgrounds and almost half of the pupils speak English as an additional language although there are no pupils in the early stages of learning English.
The school target was 133 pupils, 117 were from Years 1–3 and 16 children with reading difficulties from Year 4. These pupils were supported by 5 teaching staff. The school were issued with 60 tablets stored within a lockable technology server room overnight with access to multi-port charging points. In this early stage of setting up the technologies, it was identified that the school existing internet bandwidth was insufficient for supporting their daily school needs, as well as the additional internet requirements posed by Navigo. This issue was resolved within two months and the bandwidth was reported to be drastically increased from 50mbps to in excess of 300mbps. There was no locally identified IT support within the school, although the technology leader worked with an offsite IT service to address internet connectivity and storage solutions.
Yellow technology leader: As literacy lead and Year 4 class teacher, the Yellow technology leader was identified by the Headteacher. The school were recruited to the project via an existing relationship between the school and a member of the research team. In contrast to the other schools, Yellow's technology leader did not hold a leadership role within the school's operational structure.
A summary of school technology leader profiles is presented in Table 1. In each case 'P1' indicates the school's primary technology leader. Figure 3 illustrates the target number of child users agreed with each school alongside the number of active child accounts within the research period (two school terms from the start of the academic year September 2019 until mid-March 2020).

5.3 Data collection and analysis

As part of the overall procedure for introducing the new technologies into the four schools, once headteacher consent was established, the research team liaised with the school technology leader to arrange a CPD session at the start of the school term. Following this, project tablets were issued to schools and schools obtained consent from teachers, parents and children to take part in the project, which also involved creating teacher and student user accounts. Once all these steps had been taken, the research team contacted each school to arrange an interview with the technology leader. Depending on the leader's availability, this was held after the first school term (i.e., 12 weeks) of using the technologies. Semi-structured interviews were held with technology leaders across the four schools to identify leadership practices and to understand the impact these practices had on how Navigo was used in the school context. Informed by usage analytics collected through the game during the 12-week period, the interview questions were adapted towards understanding the school's plans for and experiences of using the Navigo game, as well as understanding about the facilitators and challenges that impacted on this process. Each interview lasted between 30-45mins and was structured around the following topics: *1.* Technology leader expectations regarding the Navigo game; *2.* How the technology leader had begun coordinating the technology adoption process; and *3.* Challenges and opportunities encountered by their school team. The interviews were held initially physically in school and later via online video conferencing, owing to the pandemic. Following participants' informed consent, the interviews were recorded and transcribed.
To develop a credible account that would reflect the complex dynamics within each school, additional data in the form of fieldnotes and game play usage data was collected and triangulated with the interviews [39]. Field notes were captured immediately after each school visit that was carried out as part of CPD or researcher support, documenting specific events and conversations with the technology leader and other school staff involved. Also, to produce a visual representation of the adoption and use of the Navigo game, we continuously inspected how schools engaged with Navigo by extracting usage data collected throughout children's game play using the visualisation software Tableau ©[47].
An inductive qualitative analysis was performed to generate themes reflecting technology leader concerns and actions during their adoption of Navigo. Following Braun and Clarke (2006) [3], the analysis applied a constructivist view that credited the socially situated ways in which meaning was produced. Using the qualitative data analysis tool NVivo 2020 ©[48], our analysis was geared towards identifying the concerns expressed and steps taken by technology leaders when introducing the Navigo game within their schools.

Table 1: Technology leader profiles

School	Primary technology leader, role	Secondary technology leader, role (if applicable)
Blue	P1:Blue, Literacy Lead & Y3 teacher	P2:Blue, SENCO
Orange	P1:Orange, SENCO	
Silver	P1:Silver, Literacy Lead & Y2 teacher	P2:Silver, Learning Mentor
Yellow	P1:Yellow, Literacy Lead & Y4 teacher[a]	

[a] P1:Yellow did not hold SLT position, unlike the other primary technology leaders.

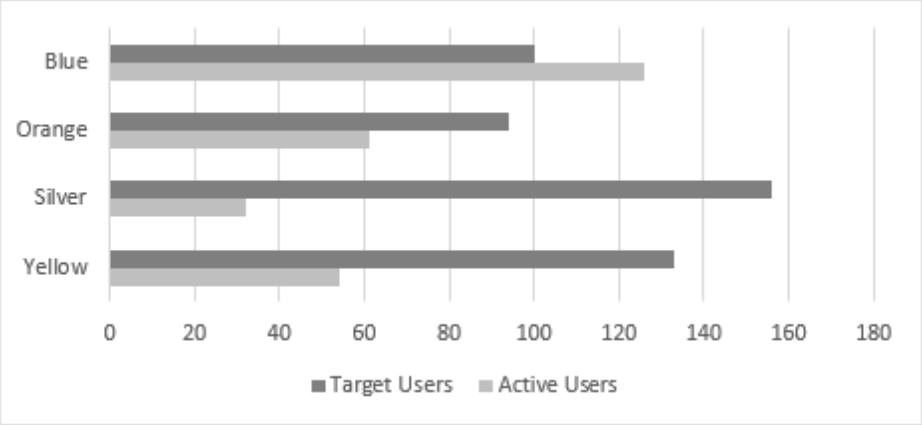

Figure 3: Total number of target and active users across the four schools

First, we transcribed the interviews and then began by descriptively coding salient features in the data about what technology leaders expressed of their concerns, priorities and actions relating to introducing the technology. We then collated these codes into potential themes to capture what was happening within the school context. Next, we reviewed these themes to check that they reflected what technology leaders were expressing across the whole data set. In order to apply a systematic and rigorous analysis, all authors read through the themes and codes multiple times so that we could exhaust the different possible interpretations of events. Group discussion involving all authors enabled us to test out alternatives and further develop and define the themes. Finally, the themes and codes were triangulated with the other data sources (i.e. field notes and game play usage data) to help explain the context of why certain things happened. For example, in the case of one technology leader, P1:Orange, who talked about issues with resource and time management, the researcher fieldnotes helped to explain why particular teachers were not using the game in class, namely because it competed with another key commitment in term 1. Similarly, game play usage data added additional contextual information about technology use as Orange teachers began using the game more frequently in term 2. In the findings section that follows, we discuss the concerns and actions of school technology leaders.

6 FINDINGS

Based on semi-structured interviews with technology leaders from four schools, fieldnotes and usage data, we found that technology adoption patterns and game play usage was dependent on three main themes that characterised technology leader concerns and actions. These were:

- Technology leaders' challenges with resource and time management
- Teacher agency and division of labour
- Communication and monitoring

We first provide an overview of technology adoption patterns in each school, then discuss the three main themes as they related to the four schools.

6.1 Summary of technology adoption patterns

In all four schools, technology leaders liaised with the research team to plan and deliver CPD. For Blue, Orange and Silver this happened at the start of term 1 and at Yellow, CPD took place half-way through the first school term.

Three schools took a simultaneous whole school approach to introduce the technologies within classes, i.e. introducing the Navigo game across all participating classes. These were Blue, Yellow and Silver. In Blue, the introduction as a whole school worked well. All participating teachers at Blue were actively involved in trialling the Navigo game and would explore different set-ups until they found a good fit. By the middle of the term 2, Blue teachers began

establishing a routine for using the game in their teaching and as game play became more established, Blue teachers also upscaled and involved more students than anticipated, as reflected in Figure 3. In Silver and Yellow, the whole school approach was not successful. In Silver, P1:Silver had nominated TAs from each of the classes to deliver the intervention. However, as there was minimal uptake from TAs, P1:Silver and P2:Silver decided to downscale their plans to involve only five students with reading difficulties, as an out-of-class targeted intervention. In Yellow, P1:Yellow wanted to establish parental consent for all participating students before training teachers, which delayed them in starting to use the technology. Also at Yellow, there was no established storage and charging solution so the tablets quickly became unpowered and inaccessible to classes when needed. This meant they were not used.

In contrast to the simultaneous whole school approach detailed above, in Orange, P1:Orange took a staggered approach by identifying teachers who would be motivated to take part prior to the CPD session, and opted to initially support one class in trialling the Navigo game. This was led by a TA requiring close support from a member of the research team. This was followed by introducing the game in a second class during the second term, as the second teacher had more time available. The TA in the first class then acted as an expert within the school for three other teachers.

6.2 Technology leaders' challenges with resource and time management

Schools were given tablets to ensure the smooth operation of the Navigo game. The tablets issued ranged between 30-60 per school. This technological resource, however, introduced a requirement to set up and maintain the charging and storage of tablets. This resulted in an initial phase of the adoption where technology leaders were predominantly preoccupied with setting up resource management procedures and resolving any issues that arose (e.g Figure 4, * depicts limited game usage for first 12 weeks of term across all schools). This concern spanned at least the first half of the school term. Across the schools there were a range of approaches taken during this phase by the technology leaders which had implications for the subsequent use of the Navigo game.

At the start of term 1, technology leaders across all four schools opted to set up their tablets in a lockable space away from the classrooms. However, this approach had its challenges which some schools tried to address. At Silver, despite P1:Silver establishing an effective joint charging and storage solution, teachers lacked immediate access to the tablets when they were needed in class. Moreover, without a way of managing the joint resource across the team, teachers were not aware whether tablets had been signed out. Recognising this barrier, the second technology leader, P2:Silver moved a smaller set of tablets to the inclusion room. This ensured that tablets were charged and accessible for children who were receiving support within a smaller intervention group. This decision also removed the need for resource management contributing to an increased use of the game within Silver (see Figure 4, ±).

In contrast to Silver, P1:Blue acknowledged the need for resource management from the onset and created an online shared document to manage the use of the tablets across multiple classes. Yet, despite this, tablets were often left uncharged highlighting the collective responsibility to care for the material.

For Yellow there were challenges related to keeping the tablets charged. This became an insurmountable obstacle that resulted in an abandonment of Navigo within that school (Figure 4, §). As P1:Yellow explained "*We had [multiport] chargers for 10 or 15 of them, and I remember when they started to die it was a bit of a challenge. . . And over time they did just die and then they never really got charged again, and that's the reason that people [teachers] weren't using them.*"Managing the adoption timeline was another critical challenge for all schools. Following the CPD offered at the start of the school year, Blue and Orange technology leaders were able to resolve the tablet resource management challenges swiftly and therefore used the first school term to habituate new practices (e.g. Figure 4, ¤). In beginning to use the technologies earlier on, teachers from these two schools had the opportunity to communicate emergent questions about the technology to the research team before continuing to use Navigo more independently in the second school term. In contrast, technology leaders in Silver and Yellow were more hesitant in committing dates for the introduction of Navigo, which eventually happened toward the end of the first school term. As a result, staff reported forgetting what was covered in the CPD session. Starting later also resulted in clashes with other regular school activities and events which were given greater importance. For example, at Silver, there was a clash with national attainment tests for some of its year groups.

Therefore, schools that evidenced the most use of Navigo, tended to have technology leaders who introduced the technology at an 'opportune' moment, i.e., swiftly early in the year following the CPD teacher training. Those who waited experienced a tension between teachers' growing workload during the school term and the time investment required on their part to learn a new technology. However, whilst some technology leaders appreciated the importance of using Navigo early in the first school term, an example from P1:Orange also shows the significance of being flexible and appreciative of the circumstances of particular staff. Whereas one class had begun using Navigo in the first term, P1:Orange suspended her expectations from one of the teachers who was busy organising the school nativity play until the second term, explaining a sudden increase in activity seen in term 2 within that school (Figure 4, *).

* All schools had minimal usage between Sep – Dec 2019 as preoccupied with tablet resource management

¤Blue usage increases as teachers begin habituating new practices

ˆ Orange usage increases at start of 2nd term, following end of nativity play rehearsals

± Silver usage increases when smaller set of tablets are stored in inclusion room

§Yellow unable to establish game play usage throughout the two terms

6.3 Teacher agency and division of labour

A hierarchical leadership model prevailed in three out of the four schools where the senior leadership team (SLT) was responsible for key decision-making which encompassed the adoption of new technology. In practice this meant that SLT staff members had control

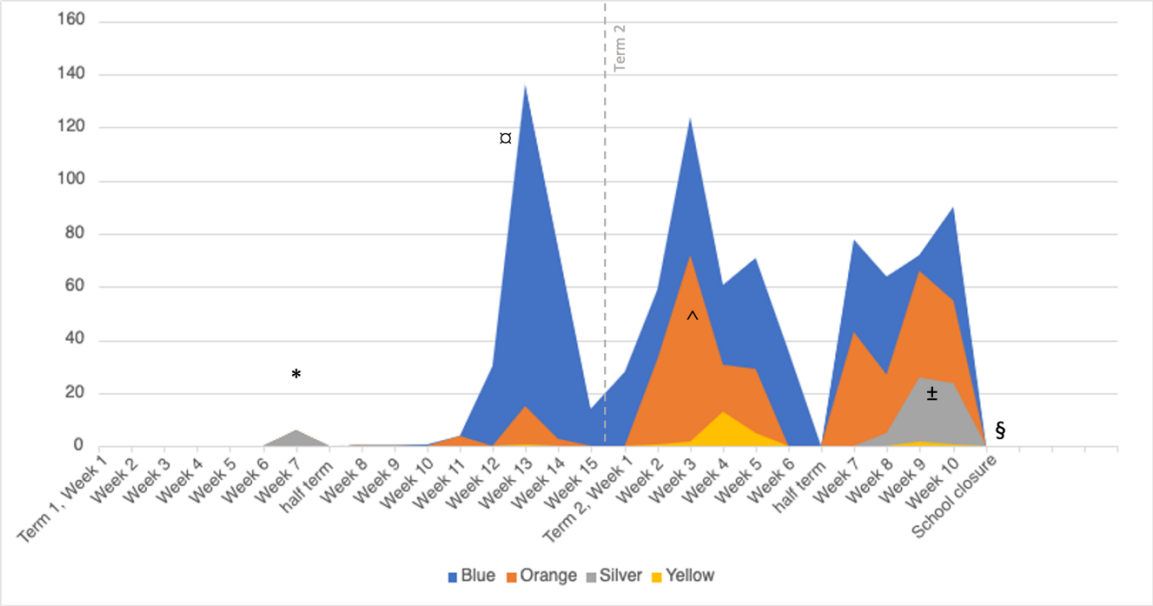

Figure 4: Visualisation of school usage for Navigo game across terms 1 and 2 of academic year

over decisions regarding which teachers to involve, how to allocate staff to support technology use, and tablet resource management. It depended on the school as to whether the technology leader was part of the SLT and this had implications for the adoption of Navigo. P1:Yellow, did not occupy a role in the SLT. They struggled to spark teachers' involvement crediting this to their lack of authority to coordinate this type of initiative: "*Had SLT had more of a role. . . they would have been able to support it and actually the teachers would have responded to them and listened to what they're saying and been like, "Oh, yes, I'm going to do it because I know they're going to look at it." Whereas I don't really have the same sway with people, people were just like, "Well, whatever, it's another teacher." So, there's no authority in some sort of, in the dynamic.*"P2:Silver stepped into a leader-supporter role, aiding the main technology leader, P1:Silver, with their busy workload. Acknowledging that they were not able to exercise the same authority as their leader colleague, P2:Silver explained: *"None of this can happen unless [P1: Silver] says yes. . . it needs [them] to make the decisions and to tell the classes and the class teacher and class TAs that we're doing this. And then to organise the timetable and . . . just to make sure it actually gets done.*"

When it came to identifying teachers to involve in the new technology initiative, P1:Silver and P1:Yellow both pre-designated the teachers and TAs who would use Navigo in class. In Silver, TAs who were tasked to run group sessions did not voice their opinions about the technology during site visits, with P2:Silver recognising that TAs did not have a forum to share their views within the school. In contrast, P1:Orange took a different approach to selecting the team. P1:Orange approached staff who would be most likely to engage, owing to their experiences and interest in using technology in the classroom and elicited their commitment to the initiative at the onset. This appreciation for teacher agency was expressed by both P2:Blue and P1:Orange in relation to teachers' intellectual leadership within their classroom practice. As P1:Orange explained: "*I have to leave that to them. I'm not going to pressure them. I think they need to decide what it is they are going to do . . .and then maybe they can think more flexibly around how they're going to use them [the technology].*" Similarly, the field notes from Blue indicated the subtle approach taken by P1:Blue which fostered teachers' exploration before they could identify the most appropriate practical and pedagogical fit of Navigo in their classroom.

However, with regards to sustaining the more practical aspects of technology, the same technology leaders in Blue and Orange promoted the teaching team's ownership of the adoption process through designated roles that also ensured there was a distribution of work. For example, in Blue, a teacher who already acted as the IT subject specialist supported with setting up the tablet charging and storage solution whilst the technology leader organised the logistics of teacher training. The technology leader's own role in contributing to this division of labour depended on whether they were using Navigo themselves. Those who used the game within their own teaching, such as P1:Blue, had a deeper understanding of its functionalities and played a critical role in advising on time management, student logins and selection of content. In contrast to Blue and Orange, within Silver and Yellow, technology leaders did not report on practices that promoted teacher agency and responsibility over the adoption process.

6.4 Communication and monitoring

Technology leaders recognised the importance of setting up effective ways to communicate with teaching staff since it allowed them to establish a shared understanding of the school's vision for using the technology. By regularly communicating with teaching staff, technology leaders could understand how their plans to introduce the technology fit in with the everyday routines across the school.

Communication was also the main means through which to monitor how teachers were using the Navigo game and the extent to which students were accessing the game. Given technology leaders' accountability toward the school, monitoring was also important for justifying the leader's decisions about allocating resources to the technology initiative, such as staffing and additional teacher training.

In Silver and Yellow, both technology leaders planned to introduce the Navigo game to staff from all Primary school classes. At the outset, P1:Silver and the research team agreed on using the Navigo game within each class's 'guided reading' hour. P1:Silver arranged for teachers' CPD, timetabling and made curriculum decisions. However, by the end of the first school term it became evident that P1:Silver was not monitoring how the technologies were being used as the school's existing communication practices which made it difficult to work collaboratively with teaching assistants (TAs), who were expected to run the programme. Describing the school's communication mechanisms, P2:Silver commented *"We communicate up and down corridors, and in the staffroom. TAs as a rule, don't generally send out a lot of emails. Most of the time, they don't have a laptop with them anyway"*. As the technology leaders had no established mechanism for communication and thus monitoring, they were delayed in identifying that the technology was not used by TAs throughout term 1.

Similar to Silver, Yellow found that introducing the technologies across multiple classes placed a demand on coordination and communication, yet this challenge was not resolved. At Yellow, there was an expectation that the SLT would not directly intervene in teachers' lesson planning and P1:Yellow expressed that teachers were not used to being closely observed. Consequently, as P1:Yellow aligned their practices with the school's norms, there was little awareness by this technology leader of the practical challenges that class teachers were facing in using the tablet and the game.

In contrast, at Blue and Orange, where the Navigo game was introduced at a smaller scale across 2-3 classes, the technology leaders were able to better manage communication and monitoring . Owing to the small size of Blue, there were established, informal communication opportunities among teachers that allowed for face-to-face communication throughout the school day. As detailed in Section 6.3, there was also a distributed approach for sharing the responsibility of related tasks, meaning that all teachers regularly shared their experiences with each other and raised queries with P1:Blue and the research team as needed. Therefore, P1:Blue reported a collective monitoring practice through the sharing of experiences. Through this mechanism the teaching team was then able to find solutions for the many interacting factors that impacted on them using the game, including tablet charging, student login processes and supporting younger students in understanding the game's mechanics. At Orange, although P1:Orange did not use the technology in their own teaching, they liaised closely with an identified TA who was using the Navigo game in their class and was able to provide indirect guidance. By first piloting Navigo in one class, P1:Orange was therefore more aware of the kinds of practical challenges and opportunities that other teachers might encounter since it was introduced in another class during the next term. In addition to their understanding of the operational tasks that required monitoring within the second school term, P1:Orange also established fluid communication with the TA who went on to support three other teachers in the school. Communication between staff was possible owing to starting small and having regular, informal opportunities to share their experiences; drawing on existing effective communication systems within the school to perform monitoring and using monitoring as a tool to problem solve.

7 DISCUSSION

The goal of this research was to understand technology leaders' practices when coordinating the introduction of educational technologies that are new to their school setting. We focused on the technology leader since prior research has identified that these leaders take on an important role in championing and supporting the introduction of new technologies [12, 32, 41]. Through interviews and researcher fieldnotes from four schools we identified that in the main, technology leaders focused their efforts on two concerns during the early phase of technology adoption: (i) managing the material dimension of new educational technologies and (ii) embedding the technology in school time. In line with Johri (2011) [22], we found that the introduction of new technology raised unexpected considerations relating to the materiality of the tablet, such as its storage, charging and accessibility. Therefore, while the technology initiative had been framed around the literacy game, the technology leaders' focal concern was the tablet. Our findings also revealed that technology leaders did not take a major role in providing the teaching team with advice on the pedagogical alignment of the game in this early stage of adoption. We discuss three considerations that impacted on how technology leaders coordinated the process of technology adoption. Table 2 summarises the challenges associated with each consideration, alongside recommendations for HCI researchers seeking to support technology leaders in school-wide technology initiatives involving their prototypes.

7.1 Recognising tasks and distributing the workload as a team

A major concern for technology leaders was the charging, storage and access to tablets within and across classes. In some classes, the aim was to use 30 tablets simultaneously within a whole class, creating an expectation that all tablets would be charged when needed in class (Orange, Blue, and initially, Silver). Moreover, in most of the schools, tablets were stored and charged in a central location away from the individual classrooms to ensure access to tablets across classes (Blue, Silver). This posed challenges, which we describe next alongside the approaches technology leaders took to resolve them.

An important characteristic of effective technology leaders was the *ability to reflect, problem solve and put in place practices to support their teams with the challenges arising from tablet management*. For example, the technology leader in one the schools (Silver) recognised that the tablets' central storage was a barrier to the whole-school technology initiative leading them to take practical steps to scale down their plans. Moving a smaller set of tablets to the school's inclusion room enabled a designated member of the teaching team to charge and access the tablets for intervention sessions with a smaller set of students. The decision to limit the

Table 2: Summary of key challenges and recommendations for HCI researchers supporting school technology adoption

Consideration	Challenge	Recommendation for HCI researchers
Recognising tasks & distributing workload as a team	Problem solving and establishing practices to support tablet management	Support leaders to reflect on practical steps for downscaling or adapting storage and charging solutions for specific classes
	Collective caring for material aspects of technology (e.g. charging, storage)	Create a collective workload by supporting schools with tablet management systems and designated roles
Identifying when and how to involve teachers	Identifying and capitalising on the 'opportune' moments for introducing a new technology within the school year	Encourage school to introduce new technology early in school year or when other 'extra-curricular' activities are not happening which could distract
		Minimise gap between training and use by ensuring practical barriers in setup are addressed before CPD happens
	Teacher autonomy over technology use and identifying teachers who are committed to piloting new technologies within their teaching	Consider staff characteristics that make them good candidates for early adoption and encourage early adopters to mentor further teachers within the school
Communication and monitoring strategies that are in line with scale of implementation.	Collective monitoring of the material and practical challenges through current school communication practices	Important to understand existing school communication channels in advance and encourage technology leaders to consider how sufficient these are to support scaling up the use of technology
	School culture may not foster collaboration between participating teachers	Enable the creation of new communication channels e.g., through regular school wide CPD sessions

initiative to a single location removed the need for shared management of the tablet resource. In contrast, within another school (Yellow), the technology leader did not employ problem solving when facing a new challenge with tablet charging, which led to the abandonment of the technology as the tablets very quickly ran out of battery charge.

Alongside their problem-solving role, effective technology leaders recognised the significant workload required to maintain the tablet, and took a coordinating role. *These technology leaders promoted the teaching team's ownership of the adoption process* [46] *through designated roles and a distribution of tasks.* In some cases, the technology leader identified staff whose existing roles in the school fit with the new tasks that were required to sustain the use of Navigo, enabling schools to build on their existing capacity (Blue, Orange). This approach is in line with Rogers' Diffusion of Innovation model [36], which proposes that *successful innovation involves setting up a social system for joint problem solving of a common goal.* In addition to the need to distribute the workload/tasks across different team members, schools sharing the same hardware across classes needed to take collective responsibility over the charging of the tablets. For example, one school created a live document to manage the use of the tablets across multiple classes (Blue). Even though this approach successfully facilitated tablet sharing between classes, tablets were sometimes left uncharged by teachers who had previously used them. Like in the case of Rosner and Ames [37], tablet maintenance became problematic without collaboration. Therefore, technology leaders were most effective when they encouraged the teaching teams to hold a collaborative appreciation of the tablet's worth [37] with *collective responsibility and effort* to maintain the technology.

7.2 Identifying when and how to involve teachers

Technology leaders who introduced the tablet and the game at an 'opportune' moment, e.g. either swiftly in the first school term or as soon as teachers had more capacity, had more success in fostering teachers' adoption patterns across the two school terms. This approach to adoption afforded technology leaders with more time to reflect on emergent practical issues and problem solve them early. It

also established the important link between the CPD session teachers attended and their immediate use of this training in practice [20, 21]. However, our research also shows that this approach was shaped by situational operational barriers such as Yellow's internet bandwidth issue which took time to resolve. *Our findings highlight the importance of introducing new technology early in the year when schools are the least busy and new ideas can take root. Moreover, it is important to overcome practical barriers to setting up and using technology before CPD sessions are held, in order to reduce the time between training and teachers' use of the technology.*Alongside the importance of introducing technology at the right time of the year, considerations over the teaching staff involved were equally important. Previous work has shown that technology initiatives in schools are successful only when technology leaders involve teachers in technology adoption decisions [13, 46]. In support of this, we found that leaders inviting staff who were positive about educational technology observed teachers' commitment to the technology adoption process. Indeed, in two of the schools (Orange, Blue), participating teachers embraced new opportunities that the technology could bring to supporting students with their reading, and could thus be described as early adopters [36]. A second way that leaders established teacher involvement was through providing the creative space for the teachers to use the game within their teaching practice (Orange, Blue). This stood in stark contrast with the remaining two schools where teachers had limited involvement in decision making, as was case at Silver where TAs from across all year groups were expected to take part. Our findings suggest several implications. *As early adopters develop expertise with technology, technology leaders could initiate peer coaching within their school to scale up the use of technology by involving more staff. Moreover, considering the complexities surrounding whom to involve, it is helpful for technology leaders to understand the characteristics of staff that make them good candidates for early adopters of technology within their setting.* Whilst there is a large body of prior work that has considered how teacher characteristics, attitudes and beliefs influence technology adoption (e.g. [2, 4, 12]), tools are needed that support technology leaders to make more informed decisions about whether to involve first as early adopters first, given the resources and expertise that is available locally to support technology adoption.

7.3 Communication and monitoring strategies that are in line with the scale of the implementation

Our findings show that when the Navigo game was introduced at a small scale in 2-3 classes within the school, technology leaders were able to communicate and consequently monitor the technology initiative easily through existing informal mechanisms e.g. impromptu conversations with peers. In one of the schools (Blue), we observed a shared practice of monitoring, with staff members regularly reporting their progress and adoption barriers toward finding joint solutions. Previous research has found that teacher collaboration can foster problem solving and learning during the adoption of educational technology [12, 46]. *In orchestrating collaboration, technology leaders could promote teachers' collective responsibility to monitor the effectiveness of the technology adoption and involve the teaching team in identifying ways to improve it where challenges exist.*

Similar to the two schools leading small scale initiatives, our findings show that technology leaders who led a school-wide adoption of the Navigo game also relied on their existing communication practices (Silver) and school culture (Yellow). However, these proved to be insufficient to monitor the material and time scheduling challenges that teachers faced in this early adoption phase. Since the technology leader and teaching staff had not jointly established a way to share these concerns, the technology leader's awareness of the challenges involved and consequently their ability to problem solve was impacted. These communication breakdowns remained an untapped opportunity to influence the school culture, as also suggested by De Jong [23]. Thus, school-wide initiatives involving educational technology pose an organisational challenge. *Schools whose culture does not foster collaboration must engage in additional organisational change to ensure that effective communication channels and norms are established.* Moreover, while the lack of monitoring in these schools was found to be problematic, as the case of Blue demonstrates, the technology leader's monitoring practice is effective only when it is followed by a solution-oriented approach highlighting the importance for *staff's commitment to problem solving. To this end, new data-driven tools that visualise school and class technology usage patterns could be particularly valuable to guide technology leaders in identifying teachers who could benefit from additional support.*

8 CONCLUSION

We embarked on a multiple case study of four primary schools who signed up to use a new adaptive literacy game called 'Navigo'. By adopting a situated lens, we looked at how whole schools used the technology and systematically analysed the actions and concerns of school technology leaders over a period of two school terms so that we could explore how this role impacted the adoption of new educational technology in the classroom. Through interviews with technology leaders and researcher fieldnotes from school visits we identified that in line with Johri [22], the introduction of new technology tools raised unexpected considerations relating to the materiality and uses of the technology itself. Our empirical research makes three main contributions to a growing body of HCI research that is examining how educational technologies are used in the school context. First, we describe in detail the concerns and actions of technology leaders based on empirical research involving four diverse school cases. Second, we present a systematic methodological approach for applying a situated-lens to study school-based technology adoption. Third, we propose considerations and identify recommendations for future work which we hope will be helpful for HCI researchers interested in supporting technology leaders tasked with leading technology adoption. Whilst we endeavoured to focus on different schools, one methodological limitation we faced was understanding how technology leader concerns and actions might vary based on geographically and culturally diverse contexts. Additional work is needed that considers how these concerns may change when access to resources is varied and different stakeholders take a prominent role in coordinating the technology adoption

process. By demonstrating what school technology leaders do during the early stages of technology adoption, it is hoped that our research helps to map out interrelated complexities when seeking to understand about and support school teams with adopting new educational technology.

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