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Making Creative Technology Workable in Under-Resourced Classrooms

Elaine Czech
University of Kent
Canterbury, United Kingdom
elaineczech@gmail.com

Luma Tabbaa
University of Kent
Canterbury, United Kingdom
L.A.Tabbaa@kent.ac.uk

Xiang Li
University of Kent
Canterbury, United Kingdom
xl273@kent.ac.uk

Sophia Ppali
CYENS Centre of Excellence
Nicosia, Cyprus
s.ppali@cyens.org.cy

Yvonne Cullen
University of Kent
Canterbury, United Kingdom
yvecullen@gmail.com

Chee Siang Ang
University of Kent
Canterbury, United Kingdom
Kent and Medway Medical School
Canterbury, United Kingdom
Imperial College London
London, United Kingdom
C.S.Ang@kent.ac.uk

Himanshu Verma
Delft University of Technology
Delft, Netherlands
H.Verma@tudelft.nl

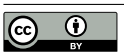
Alexandra Covaci
University of Kent
Canterbury, United Kingdom
A.Covaci@kent.ac.uk



Figure 1: (Left) Year 7 students in an under-resourced coastal school break from rigid seating plans to capture botanical forms using photogrammetry. (Centre & Right) Students iterate on these assets to create tessellated digital tiles inspired by Islamic art.

Abstract

In underserved coastal communities, the adoption of digital technology is deeply stratified. While schools with high socio-economic status (SES) leverage technology for creative agency, under-resourced schools often face a second-level digital divide, where hardware is treated as a disruption rather than a tool for inquiry. We investigate this dynamic through an exploratory study of a digital arts programme in low-SES UK secondary schools, in which Human-Computer Interaction (HCI) researchers served as advisors and observers of a co-created partnership between schools and a local digital arts charity. Our findings reveal a pedagogical chasm. Systemic constraints and assessment pressures force teachers into the role of risk-averse behavioural gatekeepers, while external facilitators manage the creative play. However, we identify how students bridge this gap by establishing peer infrastructures, shared talk and repair work that transform technical breakdowns into possibility spaces for learning. We argue that sustainable integration requires designing for school settings to empower the human relationships central to creative technology use.



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1 Introduction

In the United Kingdom (UK), secondary education is frequently organised around institutionally certified attainment, evidenced through time-bounded summative assessments [56]. While this system offers administrative consistency, it can also function as a mechanism of systemic exclusion in low-socioeconomic coastal communities, where pressure to perform on standardised metrics reduces the capacity to experiment with new tools or practices. Under these accountability pressures, schools' technology decisions tend to prioritise reliability and compliance over pedagogical exploration, reinforcing existing socio-economic divides.

In these contexts, technology adoption is deeply bifurcated by Socio-Economic Status (SES), affecting both material access and the pedagogical quality of student interactions [88]. High-SES environments more often adopt a *Literacy Model* that frames technology as a tool for individual agency, whereas low-SES contexts are frequently constrained to a *Telecommunications Model* focused on basic connectivity and standardised curriculum delivery [86]. As a consequence, while affluent students are more likely to engage in capital-enhancing activities such as inquiry and creative production, students in disadvantaged areas are often routed into passive, remedial uses of technology (e.g., drill-and-practice software) [28].

New digital interventions are frequently superimposed onto this stratified classroom and school setting without addressing these structural conditions. Often functioning as a solution looking for a problem [76], they follow a hardware-centric approach that prioritises physical access over the human infrastructure required to sustain meaningful use [82]. While high-SES schools may appoint specialised digital leads, under-resourced schools often lack this dedicated leadership; as a result, technology becomes another disruption to manage alongside funding and staffing pressures [49]. This can result in framing technology around safeguarding and administrative compliance rather than creative experimentation [83].

In this paper, we argue that reclaiming technology for empowerment requires shifting from top-down, productivity-based agendas to partnership-led technology adoption. While many implementations focus on individual device access or standardised delivery, our approach centres on expanding the school's human infrastructure by embedding external creative expertise directly into the classroom. Drawing on *Constructionism*, which prioritises play, curiosity, and emergent behaviours over rigid outcomes [60], we aim to move beyond the remediation model often imposed on low-SES students.

To study how such approaches unfold in practice, we deliberately sought a naturally occurring partnership already attempting this work. We identified a local digital arts charity with experience running school-based creative technology programmes and joined their schools programme as research partners. Working with two coastal secondary schools interested in immersive and tablet-based making with Year 7 students, particularly regarding Special Educational Needs and Disabilities (SEND) learners and those with below-average reading ages, we conducted an exploratory study of charity-led (facilitated and deployed through the charity), curriculum-aligned creative technology in everyday lessons.

Acting as advisors and observers, we supported the partnership to co-design and implement off-the-shelf immersive technologies into Year 7 Art and History lessons, and we documented the appropriation of technology within a school context rather than testing a predefined intervention or attainment outcome. We examine the value tensions that emerged between stakeholders (teachers, school leaders, and charity facilitators) and how students' peer infrastructures (e.g., micro-tutorials and repair work) helped sustain participation under real-world constraints. We add to the knowledge within Human-Computer Interaction (HCI) on supporting technology in classroom infrastructures [8, 29, 30, 63, 73] by providing lessons learned from our deployment. We build on our earlier work, which focused on process-based learning through technology-mediated art-making in low-socioeconomic schools [18].

In doing so, we address the following research questions:

RQ1 How do teachers and students negotiate the meaning of creative technology[1] within a curriculum dominated by high-stakes summative assessment?

RQ2 How does the appropriation of off-the-shelf immersive technologies happen in practice, and what workarounds and configurations are required to withstand real-world school constraints?

RQ3 What value tensions emerge between stakeholders (charity, school, teachers, students) during this co-creation process, and how can future HCI researchers implement technologies into similar low-resourced school infrastructures?

2 Related Work

Star and Ruhleder [79] identified three levels in contextual infrastructure that can create inequities of technology use or implementation into that context: first level issues result from limited access to resources and information, second level issues happen when access to one resource conflicts with access to another resource, and third level issues tend to be inherently political, going beyond that one context. In this section, we situate our work in UK secondary schools within these three infrastructural levels (i) accountability regimes that prioritise measurable attainment, which limit how students access and retain information, (ii) the practical constraints of technology adoption in under-resourced classrooms, and (iii) the specific challenges facing UK coastal communities.

2.1 Accountability and the squeezing of exploratory learning

Secondary schooling in the UK often operationalises learning through institutionally certified attainment, evidenced via time-bounded summative assessment [44, 56]. While this provides administrative clarity, it can produce strong washback effects: teaching and

[1]Technologies which are used to support creative outputs such as digital art or world-building.

feedback become oriented toward predictability, rehearsal, and optimisation for examinable outputs rather than experimentation and inquiry [11, 25]. These pressures can be particularly acute during the transition to secondary school, a period already associated with heightened stress [89].

Creative and interpretive subjects (e.g., arts, music, history) are especially vulnerable within this regime because they are harder to benchmark and inspect, and are often squeezed in favour of easily measured subjects [4, 32]. Yet disciplinary learning in these areas depends on iterative exploration, critique, and making reasoning visible through process [51]. Prior work shows that process-centred pedagogies can surface richer meaning-making than reproduction-oriented tasks [9, 52].

At the same time, accountability pressures influence not only what is taught but also how technology is used: rather than supporting experimentation, digital tools are often positioned as infrastructure for delivery and assessment. This is especially evident in low-SES schools, where technology adoption frequently remains constrained to a *Telecommunications Model* (connectivity and standardised curriculum delivery) rather than a *Literacy Model* that supports agency and creative production [86].

In direct contrast to traditional pedagogy, constructivists believe that learning comes about when a child actively 'constructs' through experience a means of understanding the world [1, 67]. Among those advocating for constructivist pedagogy, Seymour Papert promotes constructionism, that knowledge is formed and transformed in situ and that technology can serve as a means for developing tangible artefacts which evidence one's learning [1, 8, 61]. Two of the most well-known constructionist digital tools are Turtle Graphics and Scratch; both were built for learning and have proven to be successful. However, technologies, as constructionist objects, have rarely been used to help students grasp concepts beyond computational thinking. Even projects, like FUSE Studio[80], which aim to educate students in Science, Technology, Engineering, Arts, and Mathematics (STEAM) topics, do not necessarily seek to add to the students' knowledge of non-STEAM topics. Instead, for creative subjects, topics like history are presented as built environments for students to immerse themselves in [3], and the majority of these target higher education, not primary or secondary learners. Prior work on game-based and multisensory learning has shown how playful, embodied digital systems can support engagement and motivation in educational contexts [16, 46]; however, less is known about how such creative technologies are sustained within the everyday constraints of under-resourced classrooms.

2.2 A realist view: deployment challenges in under-resourced schools

HCI research has produced many learning technologies, yet even "innovative" systems often align with schooling's evaluative logics by supporting pre-specified tasks rather than sustained, open-ended inquiry [47, 72]. A persistent barrier to *deployability* is that many systems are bespoke and evaluated under controlled conditions, leaving the logistical constraints of everyday school routines under-examined [87]. Examples deploying commercial creative technologies (i.e., Virtual Reality (VR), Augmented Reality (AR)) in classrooms for collaborative learning of creative subjects, such as social sciences, are rarely done with secondary students [77].

Historical interventions illustrate why material access alone is insufficient. The "One Laptop per Child" movement assumed that individual device ownership would trigger pedagogical transformation, but in many low-SES contexts, it increased technical burden and fragmented classroom activity [88]. By contrast, "One Mouse per Child" approaches using Single Display Groupware showed how shared-device configurations can better support collaboration and social negotiation when resources are constrained [58].

Taken together, these lines of work point to the importance of the school's *human infrastructure*: teachers' capacity, technical confidence, and the practical support needed to keep tools working within the constraints of the school day. As Penuel found, teachers will oppose implementing new technologies that can potentially negatively impact their assessments as good educators [63]. By not working with existing school infrastructures, technology is frequently experienced as another disruption to manage alongside staffing pressures [49]. In such settings, technical failures can amplify risk-averse use, where technology is framed around compliance and control rather than the facilitative, student-centred pedagogies immersive tools often require [39]. Research initiatives, like the Connected Research Learning Network (CRLN), developed a series of projects across the United States, aimed to support peer-learning with technology [37] and even reframed failure as a sign of resilience [31]. And even though the CRLN has developed a Connect Arts Learning Framework [64], which incorporated insights from organisations that use digital technologies for art making, the framework is aimed more broadly at arts education and therefore does not focus on how different mediums, like technology, may factor into art learning.

2.3 Contextualising the research: UK coastal communities and the enrichment gap

UK coastal (sea-facing) communities are disproportionately affected by socio-economic disadvantage: two in every three coastal towns are classified as high-income deprivation areas [59]. Educational outcomes reflect these pressures; for example, 53% of disadvantaged pupils in these contexts fall below expected literacy attainment [21]. In response, schools often narrow the curriculum to prioritise benchmarked subjects such as English and Mathematics, reducing time and resourcing for creative and vocational learning [57].

This narrowing interacts with an *enrichment gap* or the disparity of access to extracurricular experiences and resources. In many coastal regions, geographical isolation can create *cultural deserts* in which access to cultural institutions like museums, galleries, and wider enrichment opportunities is uneven. While some families can provide enrichment through "*concerted cultivation*" [45] through adults purposefully fostering their children's skills and talents, low-SES households are more likely to experience *time poverty* due to multiple low-wage jobs and economic insecurity that constrain how much time they can put into ensuring their children accessing a variety of activities [59]. As a result, young people may have fewer opportunities to build cultural capital and socio-emotional capabilities (e.g., empathy, social negotiation) through sustained engagement with creative practices and cultural institutions [17].

These constraints can also shape digital participation: without access to supportive guidance and time for exploration, technology use is less likely to develop into creative, agentic practice [88].

At the same time, reductions in technical and creative pathways can further limit opportunities for technical agency and mobility; for instance, General Certificate of Secondary Education (GCSE) entries in Design and Technology have declined by around 50% since 2009 [22]. Taken together, these conditions motivate our focus on partnership-led approaches that extend a school's capacity. Our study examines how collaboration with a digital arts charity can act as a form of *enrichment infrastructure*, bringing creative expertise, cultural connection, and sustained support into the classroom in contexts where these resources are otherwise limited.

3 Methodology

We report an in-situ qualitative case study of a charity-led, immersive, tablet-based arts programme delivered in two UK coastal secondary schools. As such, we partnered with a local arts charity[2]; it was founded in 2015, within a low-socioeconomic area, by a digital composer and a visual artist and educator. The Charity aims to up-skill the next generation through creating projects that enable local people to access digital art-making tools and use digital technologies to create and share their stories. For this project, the Charity Partner co-designed curriculum-aligned, technology-enabled learning activities for Year 7 pupils (ages 11–12) with two secondary schools located in a low-socioeconomic coastal local authority in England. The delivery of the curriculum units was led by the Charity volunteers, who are local professional digital artists in close collaboration with Year 7 teachers. The artists are volunteers at the charity who are industry-based specialists in various creative industries such as theatre, film, and gaming. Noting that the artists were not specialists in adapting art-based activities for pupils with mixed abilities, the lesson plans were shaped and iteratively refined through teachers' expertise and feedback during the co-design process to support the full range of learners in mainstream classroom settings. The case study spans one academic year[3] and treats the charity–school partnership as the unit of analysis, with participation occurring through co-planning, co-teaching, and iterative adjustment between teachers and charity artists.

3.1 Researcher positionality and partnership

This study was conducted in partnership with a local digital arts charity running an already-planned year-long schools programme (October 2023–September 2024). The charity identified and secured the two participating schools and led delivery with teachers. Our HCI research team joined as the academic partner.

Our role was advisory and analytic rather than interventionist. We advised on technology integration and deployability (e.g., feasibility with shared devices, classroom workflow, sustainability with off-the-shelf tools), supported research documentation design, handled university ethics processes, and analysed how the programme unfolded in practice. We did not select students, run lessons, assess student work, or determine curriculum content; these decisions were made by the charity and schools within timetable, staffing, assessment, and equipment constraints.

Classroom observation was led by a community arts researcher employed by the university partner (15 years prior experience as a secondary teacher). They produced the primary observation corpus, which our HCI team then interpreted and analysed collaboratively.

3.2 Setting and participants

The study took place in two mixed-ability secondary schools in a coastal local authority in England (pseudonymised as School A and School B). Both schools serve communities with high proportions of students with SEND and below-average reading ages. The programme reached approximately 420 Year 7 students (11–12 years old) across the two schools. Twelve subject teachers (Art and History) participated. Because devices were shared, students typically worked in pairs or small groups, supported by class teachers and visiting digital artists from the charity.

3.3 Programme design and technologies used

The programme combined a planning/continuous professional development component with classroom delivery.

Planning and Continuous Professional Development (CPD) Teachers and charity artists took part in the equivalent of six CPD days across the year. CPD focused on: hands-on familiarity with tools; classroom routines for shared devices and VR; lesson prompts and resources aligned with existing schemes of work; and practicalities of safe, manageable classroom use (e.g., turn-taking, setup/sanitising, troubleshooting). CPD was episodic rather than continuous: capacity constraints meant that formal inset training was not always feasible, so teacher learning often occurred through team-teaching and in-situ coaching during delivery.

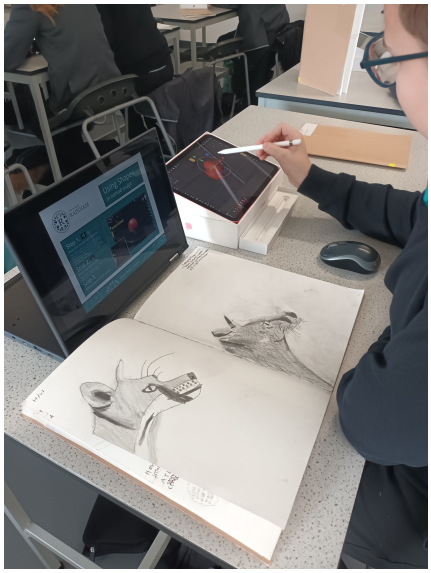
Classroom delivery. In each school, three curriculum-aligned units were delivered as part of timetabled lessons. Units ran over approximately two weeks each and comprised two to three one-hour lessons (around three hours per unit). School A embedded the programme in Year 7 Art; School B embedded it in Year 7 History classes (including one mixed-age SEND class).

Tools used. Across the units, students engaged in digital arts-based practices using off-the-shelf software on shared devices: tablet-based 3D modelling (e.g., *Nomad Sculpt*); digital drawing/collage (e.g., *Procreate*); photogrammetry/AR capture (e.g., *Scaniverse*); and VR creation/design (e.g., *OpenBrush*, *Arkio*). Activities were supported by familiar materials and routines (e.g., sketching on paper, group discussion, short demonstrations), and were introduced as making tasks rather than standalone technology lessons.

Curricular anchoring in Art and History. The programme was embedded in timetabled Year 7 lessons and designed to extend (rather than replace) each subject's existing scheme of work. In School A (Art), the units were anchored in (i) an *introduction to drawing* sequence (e.g., wildlife stimulus and the formal elements), where students translated 2D sketches into 3D form through digital sculpting; (ii) *Islamic art* as a context for pattern, abstraction,

[2]https://www.electricmedway.org

[3]Although the programme ran over one academic year, classroom delivery was not continuous. Time was required to establish the partnership, align units to schemes of work, prepare materials and device logistics, and support teachers' continuous professional development before delivery. Classroom units were then delivered in timetabled lesson blocks in each school, scheduled to fit term structures and the practicalities of sharing equipment across sites.



(a) Pupil translates a 2D sketch into a 3D model using Nomad Sculpt.



(b) The classroom environment at School A, with pupils listening to the charity facilitators and observing their demonstrations.

and tile-based composition, where students used photogrammetry outputs as visual material for digital collage-making; and (iii) *Renaissance art* as a prompt for exploring composition, scale, and light through painting in 3D space. In School B (History), the units were anchored in (i) *local history and museum practice*, where students created 3D representations of locally significant sites/objects as part of a virtual museum concept; (ii) *transportation and commemoration*, where students designed memorial forms informed by historical narratives and museum input; and (iii) *crime and punishment*, where the concepts of deterrence and rehabilitation structured students' design decisions in designing a *fair prison* task.

Across both schools, sessions typically followed a consistent classroom rhythm: a short teacher/artist demonstration; paired or small-group making with device rotation; informal peer troubleshooting; and a brief share-out/reflection. Shared access was a core feature of the classroom ecology, shaping how students learned through observation, narration, coaching, and repair.

3.4 Ethics, consent, and anonymisation

Our university ethics committee approved all methods and procedures. Consent and student participation processes were managed by the schools and charity in line with safeguarding and parental consent procedures. We did not collect identifiable student demographic data, attainment records, or behaviour records. All school, organisation, and location names are pseudonyms; survey responses were anonymous.

3.5 Data corpus and collection

We drew on three qualitative data sources. In the Findings, extracts are labelled as classroom observations **[O]**, charity reflections **[CR]**, and survey responses **[S]**.

Classroom observations [O]. A community arts researcher recorded fieldnotes during and immediately after lessons, capturing task flow, tool use, interactions around devices/materials, and classroom dynamics. From the observation log provided, we recorded 11 observed lesson slots at School A (approximately 12 hours) and 19 observed lesson slots at School B (approximately 18.5 hours), totalling 30 observed sessions (approximately 30.5 hours).

Charity reflections [CR]. We collected reflective artefacts produced through normal programme running (e.g., debrief notes after sessions, planning notes, CPD reflections) to capture the charity's perspective on delivery, friction points, and collaboration.

Student survey [S]. At the end of School A delivery, students completed a short paper-based survey in class. We collected 178 responses. Prompts were co-designed with teachers for accessibility (plain language; adults available to clarify questions without steering answers). A comparable survey was not administered at School B due to class sizes and time constraints within timetabled lessons. The survey was constructed in collaboration with the teachers and used simple language to make sure that the pupils understood the questions asked. The survey included a series of open-ended prompts about the activities carried out in the arts curriculum units. The questions asked pupils to describe and reflect on:

- Whether they enjoyed working with technologies and the apps they used;
- How they created their digital artworks from their initial form to the final output;
- What went well, the challenges they encountered, and how they overcame these challenges;
- In what ways they felt they had developed as artists;
- What kind of skills and techniques they gained through these classes;
- The perceived advantages and disadvantages of using technology to create digital art;
- Whether they preferred digital over traditional art-making techniques and why.

3.6 Data analysis

We analysed open-ended survey responses, observation notes, and partner reflections using Reflexive Thematic Analysis (RTA) [6, 7]. The HCI research team led an analysis in collaboration with the community arts researcher to ensure interpretations remained grounded in the classroom context. Analysis proceeded inductively: we familiarised ourselves with the corpus, wrote analytic memos, generated initial codes across [O]/[CR]/[S], and iteratively clustered codes into candidate themes. We refined themes through team discussion, attending to convergences and tensions across data sources and to negative/divergent cases. The final themes reported in the Findings reflect this iterative, reflexive process.

4 Findings

We report how creative technologies were appropriated in timetabled Year 7 Art and History lessons within the infrastructure of secondary schools in the UK. Across units, what the technology enabled was not a property of the tools alone; it emerged through classroom configurations (time, access, adult attention, peer support, and how tasks were framed and evidenced).

4.1 Opening, steering, and constraining creative exploration

Across units, the tools created *digital possibility spaces* where creativity unfolded through doing: trying an idea, undoing it, reshaping it, and following where it led. This process-oriented rhythm changed the classroom stance toward the task, from "getting it right first time" to learning by testing, adjusting, and discovering. Students themselves described this as being able to go further with ideas. One pupil wrote that the iPad "*assisted me to explore my creativity into greater depth*" [S, P142]. Another framed the experience as materially expansive: "*there is no limit, the imagination is your only limit*" [S, P140].

4.1.1 Immersion as permission to play (and to be less judged). Immersion was most pronounced in VR sessions (OpenBrush and Arkio), where the interaction itself became the lesson's engine. In OpenBrush, pupils oriented to environments, effects, and embodied movement in 3D space, expressing delight that was not reducible to an intended final image: "*Hey, I just touched the colours!*" [O]. The observer recorded a "joyous" atmosphere and pupils narrating explorations aloud (e.g., "*Hey, it's a chromatic wave!*", "*It's like your own little world*" [O]). Even fear and discomfort were folded into exploratory stretch: "*This is so scary, it's cool, but it's scary!*" [O]. Requests to continue (e.g., "*NOOOOOO just a bit longer please!*" [O]) suggest that the experience stretched pupils effectively as well as creatively.

This "permission to play" was not automatic. It was co-produced through facilitation (how adults framed the activity as exploratory, managed turn-taking, and set safety expectations) and through visibility configuration. When VR work remained largely illegible to others (i.e., what a pupil made was not immediately readable by the rest of the class), the observer noted pupils felt "less seen" and therefore "less judged" [O]. When VR output was made more publicly legible (e.g., through a shared view), moments of performance anxiety surfaced ("*You can all see my art!*"; "*This is actually so embarrassing!*" [O]), showing that "less judged" depends on how visibility is configured, not on VR per se.

Importantly, immersive permission was fragile under scarcity. In early Arkio sessions at School B, headset setup and changeovers absorbed adult attention, leaving some pupils waiting with little to do; time limits meant not all students accessed VR. In those moments, the room became noisier and more distractible, because access to the possibility space was unevenly distributed [O]. Later, when pupils had already developed confidence using Arkio on iPads and VR was introduced as "*just another interface*," exploration was freer and the atmosphere more playful [O]. A key pattern here is that immersion works best when pupils have *both* (i) time to explore and (ii) a stable classroom configuration that prevents waiting from becoming drift.

AR scanning also created a related (if different) immersive stretch. In the museum-trail activities, pupils described the experience as simultaneously enjoyable and unsettling ("*It's fun!*"; "*It's scary!*" [O]). Here, movement and embodied capture (walking around to scan, negotiating where to stand, what to capture) produced a kind of "*being in the task*" even without full VR.

4.1.2 Low-cost iteration and risk-taking through undoable making. Across non-immersive activities (Nomad Sculpt; Procreate), undoability functioned as a practical invitation to take risks. In Nomad Sculpt, the observer noted that "*the main advantage with digital clay was that it could be erased easily and started again*" and that "*deleting work on an app is less disturbing than ripping up work*" [O]. Students echoed this in the survey, contrasting limited physical materials with reworkable digital making: "*with clay you can only use it once, but with virtual art apps you can use it as often as you like*" [S, P8].

Undoability did not simply make pupils' "*less anxious*"; it changed how they acted. Rather than avoiding difficult moves, pupils attempted bolder edits because the cost of being wrong was lower. A student described this as embodied interaction with material-like feedback: "*we could interact with our pot as it would let us pinch and drag around different parts of the clay... Because of this, there wasn't really a limit, which made me feel as [if] I was playing with real clay!*" [S, P133] For some pupils, "risk" was personal as well as technical. One student reflected on entering the unit believing they could not do it, then leaving proud that they "*managed to take a risk*" and try [S, P139]. Another described how the digital context supported sustained attention and staying out of trouble: "*When id did it i did not mess around... i did not draw any thing that... would give me a detention*" [S, P84] In this sense, undoability and iteration widened participation by lowering the threshold for "having a go" and re-entering the task after setbacks—especially for SEND pupils, for whom the ability to undo reduced the visibility of "failure" and made peer scaffolding a viable substitute when one-to-one adult support was stretched [O].

4.1.3 Anchoring exploration to disciplinary aims (and what happens when it is misaligned). Possibility spaces supported subject learning most clearly when the affordances of the tool were made legible *as resources for disciplinary aims*. When alignment was weak, technical workflows and aesthetic play dominated, and the curriculum story faded.

This tension was most visible in the Islamic tile unit (Procreate + photogrammetry outputs). Here, the complexity of the technical pipeline (scanning/selection, colour changes, cropping/resizing, layering, copying/rotating into tiles) often consumed attention. The observer recorded that pupils could explain procedural steps (e.g., "making the background") but could not specify what it was for or how it related to Islamic art traditions [O]. Even where adults prompted historically "appropriate" colour palettes (blues/greens), many pupils chose reds and pinks because "I prefer" them [O]. The tool's "pull" was also visible in pupils reworking backgrounds into swirl patterns—tactile satisfaction and visual "pop" competed with the intended disciplinary anchor [O, fig. 1]. Adults were sometimes caught between encouraging creative flow and enforcing the art-historical rationale (a facilitation dilemma that recurs across creative subjects).

By contrast, in the History units, we more consistently observed moments where making became a bridge between evidence, interpretation, and explanation. In transportation and punishment lessons, archival images and narratives elicited strong reactions; pupils then translated these into visual metaphors and justifications. For instance, one pupil explained a colour choice as "*the blood from the lashes*" [O]. Another group reframed a fantastical design into a historically-inflected narrative object (e.g., a prison hulk / boat wreckage), prompting peer questions (*"Was it sabotage?"*) [O]. These moments show disciplinary anchoring not as "the teacher told them the right answer," but as pupils using making to externalise interpretation.

In the crime-and-punishment unit, anchoring was possible but not guaranteed. When discussion time was protected, pupils debated fairness and what punishment should involve (deterrence vs rehabilitation). When time was squeezed, conceptual discussion and design work competed, and the making component sometimes started too late for meaningful iteration [O]. In those cases, the tool became a rushed output device rather than a medium for exploring justice concepts.

4.1.4 When making becomes thinking. Across both subjects, we saw episodes where making prompted explanation and critical engagement rather than only production. In School B, pupils were asked (implicitly or explicitly) to account for what they were doing, whether it was "working," and why certain design choices were fair or meaningful. This pushed talk beyond procedure into reasoning about the topic (fairness, punishment, rehabilitation), even when pupils struggled to realise their intentions ("*I know what I want to do but I don't know how to do it*" [O]). The observer also noted that Year 7 pupils sometimes relied on inherited views rather than forming new opinions, which shaped the limits of empathetic design [O, fig. 3]. Even so, the task created a space where such assumptions could be surfaced and negotiated through discussion and design prompts.

In School A, critical engagement surfaced through pupils evaluating the medium and their own standards. Survey responses show pupils debating whether digital making counts as "real" art or lacks what they value about manual work. One pupil wrote: "*The disadvantages... are that it lacks the personal touch and emotional depth...*" [S, P142]. These tensions matter because they show that possibility spaces can simultaneously expand participation and generate new questions about authenticity, value, and what counts as achievement in creative work.

4.2 Peer infrastructures for exploration and classroom work

In shared-device lessons, pupils maintained workability through continuous peer-to-peer synchronisation: sharing screens, narrating steps, offering micro-tutorials, negotiating turns, and repairing breakdowns. This peer infrastructure became a primary mechanism through which pupils managed ambiguity and stabilised unfamiliar tools in real time.

4.2.1 Making the tool legible together. Observation notes repeatedly described a classroom atmosphere in which talk was continuous but often productive, a "buzz" that translated interface actions into shared know-how [O]. During VR sessions, navigation questions were frequently resolved peer-to-peer: "*How do you go into space?*" was met with concrete guidance: "*You can just scroll down until you find it*" [O]. Pupils also coached one another through tool settings in-the-moment (e.g., colour selection), such as "*I need to make mine more black! How do I make it more black!*" followed by "*Just scroll down and find the colour*" [O].

This talk made otherwise private headset experiences shareable and diagnosable. In the facilitation notes, a recurring challenge was that adults could not always tell what pupils were seeing or which tool-state they were in (e.g., when pupils had changed environments, lost orientation, or missed key controls) [CR]. Pupils' narration, therefore, became an informal monitoring layer: they described what they could see, asked for confirmation, and relayed fixes to nearby peers, reducing reliance on adult intervention [O]. This peer "translation layer" also surfaced around support needs. In one episode, an autistic pupil with selective mutism was put on the spot when asked if they needed help; a nearby pupil intervened to explain on their behalf, effectively translating need into an actionable response when adults lacked that context [O].

Peer narration also extended learning beyond direct device time. Because headsets and tablets were rotated, pupils waiting for a turn often learned vicariously by listening to partners describe effects, demonstrate steps, and recommend environments [O, CR]. Survey responses reinforce this distributed interface learning: pupils frequently framed success as coordinated progress rather than individual figuring out. One pupil described overcoming confusion through partner guidance: "*my partner helping me... guiding me how to do things when I didn't know how to*" [S, P140]. In short, peer talk operated as an on-the-fly interface literacy layer that helped stabilise participation under shared-device constraints.

4.2.2 Becoming the person who knows (distributed instructional labour). Peer infrastructures also redistributed classroom roles. In one exchange, a pupil reflected on supporting their partner and what that implied: "*I've never thought about [being a teacher] before!*" [O]. Another wrote: "*I have developed leadership by telling my partner how to do stuff...*" [S, P58]. We interpret this act as distributed instructional labour: in moments of overload (new tools, time pressure, device sharing), pupils created a parallel teaching channel that kept the activity moving.

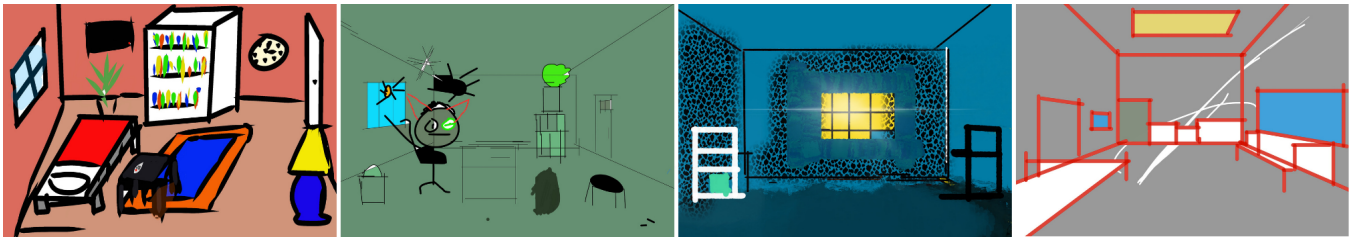


Figure 3: Four examples of Year 7 pupils' visualisations of *fair prisons*. Pupils developed designs through sketching and digital making, exploring how space, light, and everyday amenities could make punishment feel fair.

This role shift was partly infrastructural. During XR sessions, adults were often consumed by setup, boundaries, sanitising, and quick changeovers, leaving less capacity for step-by-step support while pupils were actively making [O]. In those moments, "the person who knows" emerged as a practical resource: pupils who had figured out a menu, a tool-state, or a workaround became the local reference point for others, translating demonstrations into actionable steps and helping peers recover when they got stuck or disoriented [O]. This also surfaced as a form of self-management: peer leaders reminded others about turn-taking and helped keep partners on task when attention drifted [O].

This redistribution was not frictionless. Device sharing made peer dynamics consequential: who held the iPad, who got the VR turn, and how long each pupil explored shaped competence and confidence. In some classes, partner talk was on-task and supportive; in others, it drifted or became uneven (*one pupil working while the other disengaged*) [O]. Where access was scarce, "knowing" could become a gatekeeping position: pupils who were quicker to learn sometimes dominated hands-on time, while quieter pupils waited longer or opted out [O]. These differences matter analytically because they show that "access" is not only about the number of devices, but about how social arrangements allocate meaningful hands-on time.

4.2.3 Co-regulation, humour, and keeping uncertainty tolerable. Open-ended making generates uncertainty (about 'what counts,' what the tool will do, and whether your attempt will look 'good'). Pupils used talk and humour to regulate that uncertainty and keep themselves on task. In the Procreate tile lesson, for example, self-deprecating jokes ("*Mine's crap!*" / "*Mine's even more crap!*") worked as a low-stakes way to stay present while struggling with a demanding, multi-step workflow [O]. In the same lesson, the observer noted pupils using humour to cover embarrassment about being 'creative' (e.g., "*inventing emojis*" to make a partner laugh), yet returning to complete the tile when nudged by adults and peers [O].

This co-regulation also showed up as 'thinking out loud' to stay calm. In the short pupil interview embedded in the observation notes, one child explicitly linked partner talk to emotional regulation: being allowed to talk and work with others "*helps my brain calm down*," [O] especially in lessons they usually find overwhelming. Here, talk functions as a coping strategy that makes ambiguity tolerable enough for persistence.

At the same time, the same conversational layer could tip into distraction when classroom conditions were unstable—late starts, rushed demonstrations, long changeovers, or uneven device access. In several sessions, the observer describes how, as adults became absorbed by setup/saving and transitions, off-task chatter increased, and some pupils drifted to other devices (e.g., Chromebooks), even when the overall room remained "*a buzz*" rather than overtly chaotic [O, CR]. This pattern matters: peer co-regulation is productive but fragile, and it depends on predictable routines, sufficiently 'bite-sized' tasks, and adult framing that keeps humour as glue rather than a route out of participation.

4.2.4 Care, repair, and shared responsibility when technology fails. Peer infrastructures also did 'repair' when systems or collaborations broke, often in ways that kept the lesson moving without escalating to adult intervention. When saving failed or work disappeared, pupils improvised: one student described losing their pot during the class saving process and using their partner's artefact to complete the accompanying writing task [S, P7]. Observation notes similarly capture moments where pupils collectively diagnosed glitches ("*Mine's just deleted… it just deleted itself!*") while nearby peers and adults tried to stabilise the workflow at the end of a noisy session [O].

Repair was also social and moral. Pupils described making amends after damaging a partner's work ("*I ruined his work once… I apologised and tried to make it better*" [S, P111]), and the observer notes multiple instances where partner structures helped re-absorb pupils who had drifted, returning them to the task through prompts, light teasing, or sharing "workarounds" (e.g., "*We've found a creative solution…*" by tracing from reference images and then passing that method to the next pair).

Immersive work added a further layer of care around bodies and boundaries. Early "*messing about*" around headsets was quickly shut down, after which the observer commented on being impressed by how pupils respected one another's physical space once norms were established [O]. In other words, pupils were not only learning tools, but they were also learning how to keep an XR classroom safe enough for play. For SEND pupils, this care work included protecting peers from unwanted attention and helping them participate without being singled out, especially when adult teams did not have full visibility of individual needs in the moment [O].

4.3 Boundary conditions and value tensions: what sustains (or collapses) creative technology in school

Finally, the possibility space and the peer infrastructure were continually bounded by material and organisational constraints, and by value tensions between stakeholders about what counts as a 'good lesson' under school accountability.

4.3.1 Deployability: time, access, and the labour of orchestration. Across both schools, breakdowns and bottlenecks were recurring features: connectivity problems, app crashes, complex saving workflows, and shortages of devices [O]. These shaped the pedagogical texture of lessons. In VR sessions, setup, sanitising, and changeovers absorbed adult attention, sometimes reducing support for pupils using the iPad interface in parallel [O]. In one Arkio lesson, time limits meant several pupils did not access VR at all. Those left waiting had little to do, and noise and distraction increased [O]. In other lessons, late arrivals, sanctions, or timetable disruptions compressed making time and intensified pressure near the end of sessions [O]. These episodes show that appropriation is partly an infrastructure problem: the more orchestration work required, the more fragile exploratory learning becomes.

Conversely, when configuration work was done well, it expanded what was possible. For example, support cameras and boundary-setting in VR reduced temptation to remove headsets and helped pupils feel secure [O]. Similarly, when pupils had prior practice with the iPad interface, VR could be introduced with less setup anxiety and more exploratory time [O]. In this sense, 'deployability' is not only about the tool working, but it is also about the classroom being configured so that working with the tool is pedagogically legible and socially safe.

4.3.2 CPD as human infrastructure: confidence, ownership, and inclusion. Teachers' engagement with creative technologies was developed through the programme's CPD and team-teaching arrangements. In partner reflections, one art teacher described an initial impulse to avoid digital tools (wanting to "*stick her head in the sand*") before recognising both their learning potential and their inevitability in schooling [CR]. This matters because teacher confidence shaped how pupils entered the work. In one set of parallel sessions, facilitators reported that a higher-attaining group appeared less confident and less assured, later attributing this to the class teacher being "*not confident with the tech*" [CR].

However, CPD was also constrained by school capacity. Notes from planning conversations suggest that while inset training was available, staff were unsure the academy could take it up, given workload pressures and wider institutional demands [CR]. In practice, joint delivery and in-the-moment coaching became a pragmatic substitute: teachers gained familiarity by observing, intervening, and gradually taking more ownership of routines and framing.

Finally, CPD emerged as an inclusion issue, not only a pedagogical one. An access case prompted the explicit recommendation that a student's assistant should also be taught the "*digital art methodology*" so they could support their learner effectively [CR]. This reinforces our wider argument: sustaining creative technology in under-resourced classrooms depends on building adult capacity across the whole classroom ecology, not simply providing devices.

4.3.3 Accountability, behaviour, and evidencing learning . A persistent tension across the partnership was the relationship between exploration and school logics of accountability. Teachers remained responsible for behaviour, safeguarding, pacing, and producing assessable outputs, while charity facilitators often prioritised creative engagement and process. This divergence surfaced explicitly in at least one lesson where the class teacher judged behaviour as unacceptable despite the charity being pleased with the learning outcome, prompting the observer to note: "*There are definitely different priorities here*" [O]. Such moments show that sustaining creative technology is not only a design or training problem, but it is also a values alignment problem.

Accountability also shaped pupils' own orientations. Even in process-oriented lessons, pupils frequently sought reassurance and monitored the quality of their outputs, sometimes deleting and restarting late into a session [O, CR]. In other words, the system of being judged does not disappear when tools enable undo. Rather, it reappears as questions of whether the artefact is 'good enough,' whether it counts, and how competence is made visible in a medium where mistakes can vanish.

4.3.4 When curricular difficulty meets technological novelty. Value tensions were intensified when lessons combined (i) conceptually demanding content and (ii) unfamiliar tools. In the crime-and-punishment unit, deterrence and rehabilitation required extended discussion and scaffolding; when this consumed most of the lesson, there was limited time to translate concepts into design and iteration [O]. In the Islamic tile unit, the charity notes make the mechanism visible: key steps such as resizing the canvas, flipping/rotating quadrants, and tessellating patterns required highly specific, step-by-step tutoring for most pairs, with adults *"rushing"* between groups to get work saved before the bell and little opportunity for plenary reflection. Under these conditions, pupils could often describe procedural actions (e.g., "*making the background*") but struggled to articulate how those steps served the disciplinary purpose of producing an Islamic-inspired tile [O]. These cases show why technology can appear to "*take over*" the lesson, not because pupils are shallow or adults are careless, but because attention and adult support are scarce resources. When setup/troubleshooting and step-by-step tool guidance dominate, the disciplinary anchor becomes easy to lose unless it is repeatedly made explicit through worked examples and prompts that tie technical moves back to the interpretive goal [O, CR].

5 Discussion

This research provides a case study examining how off-the-shelf immersive and creative tools are appropriated in the *messy* reality of under-resourced secondary schools in the UK. Echoing a broader shift in HCI toward in situ deployments, our results illustrate how the levels of school infrastructure in the UK (see 2) determine whether creative activity is *orchestrable*. Creativity is less a property of the tool than a property of the classroom ecology that forms around it.

While researchers have developed frameworks (e.g., [29, 30]) and toolkits (e.g., [73]) to facilitate the integration of technology into classroom ecologies, our findings provide further insights for researchers to consider if they wish to do infrastructuring work, i.e.,

redesign existing educational systems [63]. First, we foreground how *process* – iteration, play, undoing, and re-entry – is sustained (or collapses) under shared-device conditions. Second, we show how pupils build peer infrastructures that make tools legible and keep work moving when adult attention is absorbed by setup, rotation, and safeguarding - illustrating how even formal classroom can support a community of learners in which all members have an active role [70]. Third, we show that adoption is co-produced through the practical coupling of teachers and an external charity: a partnership that does not simply 'add technology,' but reallocates expertise, labour, and authority so that creative work can survive the school day.

Under-resourced schools, which have weaker collaborative staff structures, are under greater pressure to produce positive measurable outcomes that meet National and Local infrastructural requirements (e,g., covering National Curriculum constraints) [71]. Within such contexts, creative programmes can become one of the few spaces where students practice the dispositions that make development possible: curiosity, persistence, collaboration, and the courage to revise. For some pupils, particularly those who arrive already labelled as 'low' or 'behind', being permitted to explore is a counter-story [78]. Our findings, therefore, treat creative technology adoption as an equity question: how to build classroom conditions where more young people can access the experience of becoming a maker, not just a user.

5.1 Constraint as context: low-resource ecologies shape what creativity can become

Within the complexity of low-resourced secondary school infrastructure, 'constraint' is something that, while it permeates to cause the first and second level issues (as defined by Star and Ruhleder [79]), ultimately is something caused by the greater context in which a school sits. Ideally, through work on infrastructure, one would aim to eliminate these constraints; however, a core contribution of this paper is treating constraints caused by the larger classroom infrastructure or even the tools not as 'noise,' but as the medium through which creative technology can become educational. In our data, breakdowns and bottlenecks were recurring events that structured participation: waiting while headsets were sanitised, losing time to logins and saving workflows, working around distorted scans, or shifting from pupil-generated assets to preloaded materials when connectivity failed. These moments create what we might call an *attention economy*: every minute spent recovering a file is a minute not spent discussing Renaissance composition or debating deterrence versus rehabilitation.

This resonates with prior classroom deployments where connection/setup work becomes part of what the session *is* [48], and where richer materials broaden participation while increasing the reliability and troubleshooting load that must be absorbed in situ [24]. Under-resourcing intensifies this: orchestration labour rises as infrastructure degrades. For HCI, the implication is therefore more than 'make tools more robust,' but design for *recoverability within lesson time*: offline tolerance, using saving time for reflection work, seeing digital degradation as stylistic, and using 'handover' states to preserve context. Finally, policy-level infrastructure also matters to what becomes possible in classrooms; connectivity capacity shapes whether digital making can reliably occur in situ [15].

5.2 Partnership as capacity: making creative technology adoptable

Again, partnership can cause limitations across the school infrastructure levels; our research findings illustrate more of the workarounds for issues created due to a lack of access to resources or information. In both schools, the tools opened *possibility spaces* for iterative, process-based making, but what made those spaces usable in timetabled lessons was partnership capacity, not device access alone. While exposure to contemporary creative tools can counter forms of digital exclusion that shape later opportunities [34], under-resourced schools face intensified barriers to classroom technology use (time, budgets, and teacher confidence) [19]. As researchers, such as Scheepmaker et al. [73] have noted, redistributing expertise can expand pupils' access to diverse tools without imposing a parallel expectation that teachers keep pace with rapid technological change on top of existing pressures [40]. In this study, the charity partnership served this role: turning tool features into feasible lesson steps, preparing assets, modelling outcomes, troubleshooting breakdowns, and sustaining safe routines under shared-device conditions.

Partnership, between the tools' functions and the lesson, made visible a design tension: when tools require long, multi-step pipelines, procedure can dominate attention and weaken curricular anchoring (as in the Islamic art unit). Similar to how Karen Brennan [8] suggested negotiating tensions between direction and discovery with curating access to learning materials, our findings point toward *guided possibility spaces*: environments that preserve exploratory momentum while keeping disciplinary purpose close at hand. One design direction is to build lightweight "guidance handles" into tools and supporting materials: pullable micro-demonstrations, short exemplar galleries, and momentary prompts about what counts as progress, all configurable to classroom pace. These supports help move activity from manipulating effects toward constructive engagement cycles [12], and echo work on *productive constraint* that deliberately structures interaction to surface decisions and invite discussion rather than immediate consumption [38].

5.3 Teaching as orchestration: turning novelty into a lesson

However, looking at partnership naturally highlighted more visible infrastructural tensions in low-resourced schools [79]: the lack of structures and systems to facilitate collaboration, as well as some of the inherent distrust and cynicism that may persist in the long term [71]. In our study, creative technologies succeeded or failed less because of what the tools could do and more because of what teachers could keep *workable* in real lessons: shared devices, tight time windows, safeguarding routines, and uneven access. This aligns with prior HCI deployments in secondary education: StoryMakAR shows how creative ambition can outpace remaining time for technical integration [48], while e-textiles work illustrates that participatory making adds reliability and troubleshooting burdens that teachers must absorb [24]. Our data adds to Ramey and Stevens' [69] best practices for facilitating technology by providing a sharper account

of *teacher orchestration work* that protects student engagement from collapsing into waiting, distraction, or mere workflow completion.

Teachers working in collaboration with the Art Facilitators as an education team produced the conditions under which exploratory work could happen at all: setting tone, enforcing turn-taking, keeping the room safe, and making the disciplinary purpose legible while tools competed for attention. When all members of the education team were engaged, pupils more often treated exploration as purposeful (they could say what they were doing *for*); when teacher authority was absent or weakened (e.g., cover lessons) and the education team was not working collaboratively, exploratory spaces were more fragile and external facilitators had less leverage because school-specific routines were not being enacted. This sits comfortably alongside education research showing that technology integration is shaped by teacher characteristics, school environment, and system constraints [5, 35, 41, 65, 66, 81]. The will–skill–tool model captures this interaction [43], and even where tools are less determinative, teacher beliefs and instructional confidence remain strong predictors of integration [14, 66, 75].

As Karen Brennan also argued [8], CPD and supporting teachers for enabling conditions for orchestration rather than an end in itself. Teacher attitudes can strongly shape adoption [13, 33], sometimes outweighing tools and skills [23, 74]. Self-efficacy and perceived competence also relate to integration [2, 84]. In our setting, CPD worked as legitimacy and rehearsal: enough situated fluency for teachers to stand behind the activity under accountability pressure, anticipate predictable friction points, and remain an authoritative anchor while external facilitators led tool-specific modelling. This aligns with extensions to will–skill–tool that emphasise pedagogy – confidence in employing instructional strategies that make technology serve learning [42] – and it reframes Technological Pedagogical Content Knowledge (also known as TPACK/TPCK) as a question of *steering possibility spaces toward disciplinary aims* rather than frequency-of-use [27, 53, 54, 75, 81].

5.4 Peerwork as pedagogy: distributed learning, access, and repair

Under shared-device constraints, it can be even more critical to think of the classroom as a community of learners as this can help mitigate some of the infrastructural barriers limiting access to information absorption by promoting more active engagement of students [70]. In our research, we saw how pupils built peer infrastructures that made active participation possible: partner talk, micro-tutorials, screen-sharing, narrating headset experiences, and role-shifting into 'the person who knows.' This peerwork functioned as a distributed interface layer that translated opaque tool states into actionable steps, and it allowed learning to continue even when only one person had hands-on control [36]. In under-resourced, SEND-heavy classrooms, this mattered because one-to-one adult support is often scarce precisely when it is most needed [20]. When adults were absorbed by setup, boundaries, sanitising, and saving workflows, pupils used peers to bridge the gap: learning vicariously while waiting, staying oriented through talk, and re-entering the task without having to 'start again' socially [26].

Importantly, peer infrastructures were both cognitive and affective. Humour, narration, and companionship made uncertainty tolerable long enough to persist in open-ended work [55], buffering the emotional impact of mistakes and technical failure [62]. While Ramey and Stevens found that peerwork can result in boosting the confidence of students [68], we found that peerwork more often has an equity edge. Under scarcity, 'the person who knows' can become a gatekeeper: quicker or louder pupils can dominate device time while quieter pupils wait, opt out, or become passive assistants [10]. In other words, access goes beyond hardware quantity; it is a social allocation of meaningful hands-on time and decision-making power, a negotiation of who has the right to direct the work [50]. For pupils already positioned as lower-attaining, including many with SEND and below-average reading ages, this difference can determine whether the tool expands participation or concentrates competence in a few confident users [85].

For HCI designers, the implication is to treat peer infrastructure as something to *support and equalise*. Classroom creative tools should assume shared control and scaffold it: multi-role participation (so non-drivers have valued work to do), turn-taking supports that make time and control legible, system-state visibility that helps peers diagnose where they are without waiting for adult confirmation, and repair-forward workflows (non-destructive histories; survivable saving) so breakdown does not become public 'failure.' Designing for equity in low-resource classrooms means designing for the *social physics* of shared devices: vicarious learning, uneven confidence, and the constant risk of dropout under time pressure.

6 Limitations

This work is an in-situ qualitative case study of a single charity-led programme in two coastal secondary schools, and its contributions are primarily explanatory rather than generalisable. First, the partnership model (and the participating schools) was pre-existing and selected by the charity; different forms of external partnership – or no partner at all– may produce different orchestration dynamics. Second, our data are uneven across sites: the student survey was administered in School A but not School B, limiting symmetry in how pupil perspectives are captured across subjects and contexts. Third, the observation corpus was produced primarily by one community arts researcher with prior teaching experience; this strengthens classroom sensitivity but also shapes what was noticed, prioritised, and recorded. Fourth, our focus is on appropriation and classroom ecology, not on measured attainment or longitudinal retention; we cannot claim learning gains or sustained adoption beyond the programme window. Fifth, novelty likely contributed to early excitement around XR; while we interpret novelty as one way possibility spaces open, further work could test how these dynamics evolve under routine, longer-term use. Finally, our examples and discussion of teachers' experiences are limited as we were unable to interview them; this is an area for possible future study, as it could only help to improve these types of partnerships for all members.

This study is written from an academic vantage point and does not share the lived experience of the communities these schools serve. We risk misreading constraint as "lack," or celebrating resilience without naming the structural conditions that demand it. We mitigated this through close collaboration with teachers, charity facilitators, and an observer with extensive classroom experience, and by foregrounding pupil voice where available. Still, our account

reflects what is visible in lessons, not families' perspectives or longer place-based histories. Future work should deepen community-led interpretation (e.g., participatory analysis, local review of claims, and priorities defined with schools and communities).

7 Conclusion

In many of the low socio-economic coastal communities of the UK, opportunities to engage with technologies to support education are limited, and when they are available, these interventions often lack sustainability. Through this paper, we illustrated the importance of supporting the human infrastructure for creating resilient interventions. By acting as advisors and observers for a partnership between a charity organisation and two secondary schools, we documented the various value tensions that arose between the stakeholders (teachers, school leaders, and charity facilitators), as well as the peer infrastructures that emerged that helped sustain participation. We argue that successful adoption of technology into under-resourced schools requires additional considerations related to the secondary school infrastructure that go beyond just physically supporting the device, but also the relationships that make creativity possible.

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References

[1] Edith Ackermann. 2001. Piaget's constructivism, Papert's constructionism: What's the difference. *Future of learning group publication* 5, 3 (2001), 438.

[2] Susan E Anderson, Judith G Groulx, and Robert M Maninger. 2011. Relationships among preservice teachers' technology-related abilities, beliefs, and intentions to use technology in their future classrooms. *Journal of Educational Computing Research* 45, 3 (2011), 321–338.

[3] Muhammad Shahid Anwar, Jie Yang, Jaroslav Frnda, Ahyoung Choi, Nilufar Baghaei, and Miram Ali. 2025. Metaverse and XR for cultural heritage education: applications, standards, architecture, and technological insights for enhanced immersive experience. *Virtual Reality* 29, 2 (2025), 51. doi:10.1007/s10055-025-01126-z

[4] A. Bacon. 2023. *The Arts in Schools: Foundations for the Future.* Gulbenkian Foundation.

[5] Khalid Abdullah Bingimlas. 2009. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, science and technology education* 5, 3 (2009), 235–245.

[6] Virginia Braun and Victoria Clarke. 2019. Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health* 11, 4 (Aug. 2019), 589–597. doi:10.1080/2159676X.2019.1628806 Publisher: Routledge _eprint: https://doi.org/10.1080/2159676X.2019.1628806.

[7] Virginia Braun and Victoria Clarke. 2021. One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative research in psychology* 18, 3 (2021), 328–352.

[8] Karen Brennan. 2015. Beyond technocentrism. *Constructivist foundations* 10, 3 (2015), 289–296.

[9] Alyshia Bustos, Nanibah Chacon, Mia Shaw, Fiona Bell, and Leah Buechley. 2024. Interactive Murals: New Opportunities for Collaborative STEAM Learning. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 655, 19 pages. doi:10.1145/3613904.3641987

[10] Heloisa Candello, Claudio Pinhanez, Mauro Pichiliani, Paulo Cavalin, Flavio Figueiredo, Marisa Vasconcelos, and Haylla Do Carmo. 2019. The effect of audiences on the user experience with conversational interfaces in physical spaces. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–13.

[11] David Carless and David Boud. 2018. The development of student feedback literacy: enabling uptake of feedback. *Assessment & Evaluation in Higher Education* 43, 8 (2018), 1315–1325.

[12] Michelene T. H. Chi and Ruth Wylie. 2014. The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes. *Educational Psychologist* 49, 4 (2014), 219–243. doi:10.1080/00461520.2014.965823

[13] Vincent Cho and Joshua Littenberg-Tobias. 2016. Digital devices and teaching the whole student: Developing and validating an instrument to measure educators' attitudes and beliefs. *Educational Technology Research and Development* 64, 4 (2016), 643–659.

[14] Rhonda Christensen and Gerald Knezek. 2017. Validating a mobile learning readiness survey: Assessing teachers' dispositions toward adoption. *Journal of Digital Learning in Teacher Education* 33, 4 (2017), 148–159.

[15] Adam Clark and Carl Baker. 2024. *5G in the UK.* Research Briefing CBP-7883. House of Commons Library. https://commonslibrary.parliament.uk/research-briefings/cbp-7883/

[16] Alexandra Covaci, Gheorghita Ghinea, Chang-Hsin Lin, Shu-Hsien Huang, and Ju-Ling Shih. 2018. Multisensory Games-Based Learning: Lessons Learnt from Olfactory Enhancement of a Digital Board Game. *Multimedia Tools and Applications* 77, 16 (2018), 21245–21263. doi:10.1007/s11042-017-5459-2

[17] Carl Cullinane and Rebecca Montacute. 2023. *Life Lessons 2023: The enrichment gap.* Technical Report. The Sutton Trust. https://www.suttontrust.com/our-research/life-lessons-2023/

[18] Elaine Czech, Luma Tabbaa, Xiang Li, Sophia Ppali, Yvonne Cullen, Chee Siang Ang, Himanshu Verma, and Alexandra Covaci. 2026. Reclaiming Creative Exploration: An In Situ Study to Support Process-Based Learning via Technology-Mediated Art-Making in Low Socioeconomic Schools. In *Proceedings of the 25th Interaction Design and Children Conference (IDC '26)* (Brighton, United Kingdom, 2026-06-22/2026-06-25). Association for Computing Machinery, New York, NY, USA. doi:10.1145/3773077.3806129

[19] Lyn Dawes. 2012. What stops teachers using new technology? In *Issues in teaching using ICT*. Routledge, 61–79.

[20] Emma E de Wit, Saskia C van Veen, Marjolein BM Zweekhorst, and Barbara J Regeer. 2016. Vicarious learning as a strategy to improve inclusive education for children with disabilities: facilitating learning from experience among grassroot initiatives in Ethiopia. *Knowledge Management for Development Journal* 12, 1 (2016), 85–103.

[21] Department for Education. 2025. Key stage 2 attainment, Academic year 2024/25. https://explore-education-statistics.service.gov.uk/find-statistics/key-stage-2-attainment/2024-25 Explore education statistics (GOV.UK). Published 11 September 2025; last updated 16 September 2025. Release type: Accredited official statistics..

[22] Education Policy Institute. 2022. *Spotlight on Design and Technology: Enrolment and the teaching workforce.* Technical Report. EPI. https://epi.org.uk/wp-content/uploads/2022/03/Spotlight-on-DT-report_EPI-March-2022.pdf Detailed analysis of the decline of technical subjects in UK state schools.

[23] Daan Farjon, Anneke Smits, and Joke Voogt. 2019. Technology integration of pre-service teachers explained by attitudes and beliefs, competency, access, and experience. *Computers & Education* 130 (2019), 81–93.

[24] Yifan Feng, Alan Dix, Thomas Feltwell, Daniel Gooch, and Eva Hornecker. 2025. SewSimple: An E-textile Prototyping Kit Supporting Computing Education. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems (CHI '25)*. ACM. doi:10.1145/3706599.3720262

[25] Sarah French, Ashton Dickerson, and Raoul A Mulder. 2024. A review of the benefits and drawbacks of high-stakes final examinations in higher education. *Higher Education* 88, 3 (2024), 893–918.

[26] Susan Geertshuis, Qian Liu, Ngaire Rix, Odette Murdoch, and Mark McConnell. 2021. Learning by watching others learn: the use of videoed tutorials in undergraduate business education. *Higher Education Pedagogies* 6, 1 (2021), 156–174.

[27] Josef Guggemos and Sabine Seufert. 2021. Teaching with and teaching about technology–Evidence for professional development of in-service teachers. *Computers in Human Behavior* 115 (2021), 106613.

[28] Eszter Hargittai. 2001. Second-level digital divide: Mapping differences in people's online skills. *arXiv preprint cs/0109068* (2001).

[29] Ronni Hayden, Stephanie Hladik, and Ricarose Roque. 2023. Expanding and focusing infrastructuring analysis for informal STEM education. In *Proceedings of the 17th International Conference of the Learning Sciences-ICLS 2023, pp. 998-1001.* International Society of the Learning Sciences.

[30] Ronni Hayden and Ricarose Roque. 2024. Lines of Infrastructuring: Revealing and Tracing Educators' Infrastructuring Practices Across Design Implementations. In *Proceedings of the 18th International Conference of the Learning Sciences-ICLS*

2024, pp. 881-888. International Society of the Learning Sciences.
[31] Jaakko Hilppö and Reed Stevens. 2020. "Failure is just another try": Re-framing failure in school through the FUSE studio approach. *International Journal of Educational Research* 99 (2020), 101494.
[32] House of Lords. 2023. *Requires improvement: urgent change for 11–16 education.* Technical Report. Education for 11–16 Committee.
[33] Pi-Sui Hsu. 2016. Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends* 60, 1 (2016), 30–40.
[34] Jie Huang and Susan Russell. 2006. The digital divide and academic achievement. *The Electronic Library* 24, 2 (2006), 160–173.
[35] Fethi A Inan and Deborah L Lowther. 2010. Factors affecting technology integration in K-12 classrooms: A path model. *Educational technology research and development* 58, 2 (2010), 137–154.
[36] Cristián Infante, Juan Weitz, Tomás Reyes, Miguel Nussbaum, Florencia Gómez, and Darinka Radovic. 2010. Co-located collaborative learning video game with single display groupware. *Interactive Learning Environments* 18, 2 (2010), 177–195.
[37] Mizuko Ito, Kris Gutiérrez, Sonia Livingstone, Bill Penuel, Jean Rhodes, Katie Salen, Juliet Schor, Julian Sefton-Green, and S Craig Watkins. 2013. *Connected learning: An agenda for research and design.* Digital Media and Learning Research Hub.
[38] Rune Møberg Jacobsen, Martin Lindrup, Joel Wester, Niels van Berkel, Dimitrios Raptis, and Peter Axel Nielsen. 2025. Prompt Machine: Enabling Physical LLM-Interactions for Learning. In *Companion Publication of the 2025 ACM Designing Interactive Systems Conference*. 284–288.
[39] Haozhe Jiang, Deqi Zhu, Ritesh Chugh, Darren Turnbull, and Wu Jin. 2025. Virtual reality and augmented reality-supported K-12 STEM learning: trends, advantages and challenges. *Education and Information Technologies* (2025), 1–37.
[40] Amy M Johnson, Matthew E Jacovina, Devin G Russell, and Christian M Soto. 2016. Challenges and solutions when using technologies in the classroom. In *Adaptive educational technologies for literacy instruction*. Routledge, 13–30.
[41] Young Ju Joo, Kyu Yon Lim, and Nam Hee Kim. 2016. The effects of secondary teachers' technostress on the intention to use technology in South Korea. *Computers & Education* 95 (2016), 114–122.
[42] Gerald Knezek and Rhonda Christensen. 2016. Extending the will, skill, tool model of technology integration: Adding pedagogy as a new model construct. *Journal of Computing in Higher Education* 28, 3 (2016), 307–325.
[43] Gerald Knezek, Rhonda Christensen, and Ricky Fluke. 2003. Testing a Will, Skill, Tool Model of Technology Integration. (2003).
[44] Daniel Koretz. 2022. *The testing charade: Pretending to make schools better.* University of Chicago Press.
[45] Annette Lareau. 2011. *Unequal Childhoods: Class, Race, and Family Life.* University of California Press. Foundational for the 'Concerted Cultivation' vs 'Natural Growth' argument.
[46] Chang-Hsin Lin, Shu-Hsien Huang, Ju-Ling Shih, Alexandra Covaci, and Gheorghita Ghinea. 2017. Game-Based Learning Effectiveness and Motivation Study between Competitive and Cooperative Modes. In *Proceedings of the 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*. IEEE, Timisoara, Romania, Article 8001737, 123–127 pages. doi:10.1109/ICALT.2017.34
[47] Xiao Ping Lin, Bin Bin Li, Zhen Ning Yao, Zhi Yang, and Mingshu Zhang. 2024. The impact of virtual reality on student engagement in the classroom–a critical review of the literature. *Frontiers in Psychology* 15 (2024), 1360574.
[48] Yu Lin, Yiyu Chen, Jiahui Yu, Yutong Chen, and Chien Shen. 2020. StoryMakAR: Bringing Stories to Life with an Augmented Reality & Physical Prototyping Toolkit for Youth. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*. ACM. doi:10.1145/3313831.3376790
[49] Orla Lynskey. 2023. Automation in Education: the use of EdTech in England. CIVICA News & Blog. https://www.civica.eu/news-events/news-blog/detail/automation-in-education-the-use-of-edtech-in-england DigiPublicValues Project.
[50] Simon Magnusson. 2022. *Boosting young citizens' deontic status: Interactional allocation of rights-to-decide in participatory democracy meetings.* Ph. D. Dissertation. Södertörns högskola.
[51] Jason K McDonald and Esther Michela. 2019. The design critique and the moral goods of studio pedagogy. *Design Studies* 62 (2019), 1–35.
[52] Andrew M Mcnutt, Anton Outkine, and Ravi Chugh. 2023. A Study of Editor Features in a Creative Coding Classroom. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 121, 15 pages. doi:10.1145/3544548.3580683
[53] Punya Mishra and Matthew J Koehler. 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record* 108, 6 (2006), 1017–1054.
[54] Punya Mishra and Matthew J Koehler. 2008. Introducing technological pedagogical content knowledge. In *annual meeting of the American Educational Research Association*, Vol. 1. 1–16.
[55] Geoff Musick, Guo Freeman, and Nathan J McNeese. 2021. Gaming as family time: Digital game co-play in modern parent-child relationships. *Proceedings of the ACM on Human-Computer Interaction* 5, CHI PLAY (2021), 1–25.
[56] National Education Union. 2025. *Submission to the Curriculum and Assessment Review: A New Vision for Secondary Education.* Technical Report. National Education Union, London, UK. https://neu.org.uk/campaigns/curriculum-assessment Critique of high-stakes summative assessment and narrow curricula.
[57] Eszter Neumann, Emma Towers, Sharon Gewirtz, and Meg Maguire. 2016. *A Curriculum for All? The Effects of Recent Key Stage 4 Curriculum, Assessment and Accountability Reforms on English Secondary Education.* Technical Report. King's College London. https://www.kcl.ac.uk/archive/news/education/news/curriculum-for-all-final.pdf Report commissioned by the National Union of Teachers (NUT). Accessed: 2026-01-18.
[58] Miguel Nussbaum, Claudio Alvarez, Angela McFarlane, Felipe Gomez, Sherry Clancy, and Raul Iturra. 2009. Collaborative learning with software on individual handhelds. *Computers & Education* 53, 2 (2009), 397–407. Foundational for 'One Mouse' collaborative models vs OLPC.
[59] Office for National Statistics. 2020. *Coastal towns in England and Wales.* Technical Report. ONS. https://www.ons.gov.uk/peoplepopulationandcommunity/educationandchildcare/articles/coastaltownsinenglandandwales/2020-10-06
[60] Seymour Papert. 1980. *Mindstorms: children, computers, and powerful ideas.* Basic Books, Inc., USA.
[61] Seymour Papert and Idit Harel. 1991. Situating constructionism. *constructionism* 36, 2 (1991), 1–11.
[62] Qingfeng Peng, Jie Zhang, Gege Liu, and Hong Li. 2025. Positive emotions and inhibitory control enhance prosocial sharing behavior in children under unequal resource conditions: An fNIRS study. *NeuroImage* (2025), 121434.
[63] William R. Penuel. 2019. Infrastructuring as a Practice of Design-Based Research for Supporting and Studying Equitable Implementation and Sustainability of Innovations. *Journal of the Learning Sciences* 28, 4-5 (2019), 659–677. arXiv:https://doi.org/10.1080/10508406.2018.1552151 doi:10.1080/10508406.2018.1552151
[64] Kylie Peppler, Maggie Dahn, and Mizuko Ito. 2023. The Connected Arts Learning Framework: An Expanded View of the Purposes and Possibilities for Arts Learning. *Wallace Foundation* (2023).
[65] Dominik Petko, Andrea Cantieni, and Doreen Prasse. 2017. Perceived quality of educational technology matters: A secondary analysis of students' ICT use, ICT-related attitudes, and PISA 2012 test scores. *Journal of Educational Computing Research* 54, 8 (2017), 1070–1091.
[66] Dominik Petko, Doreen Prasse, and Andrea Cantieni. 2018. The interplay of school readiness and teacher readiness for educational technology integration: A structural equation model. *Computers in the Schools* 35, 1 (2018), 1–18.
[67] Mike Petrich, Karen Wilkinson, and Bronwyn Bevan. 2013. It looks like fun, but are they learning? In *Design, make, play*. Routledge, 50–70.
[68] Kay Ramey and Reed Stevens. 2019. Girls as Experts, Helpers, Organizers, and Leaders: Designing for Equitable Access and Participation in CSCL Environments. In *A Wide Lens: Combining Embodied, Enactive, Extended, and Embedded Learning in Collaborative Settings, 13th International Conference on Computer Supported Collaborative Learning (CSCL) 2019, Volume 1*, K. Lund, G. P. Niccolai, E. Lavoué, C. Hmelo-Silver, G. Gweon, and M. Baker (Eds.). International Society of the Learning Sciences (ISLS), Lyon, France, 368–375. doi:10.22318/cscl2019.368
[69] Kay Ramey and Reed Stevens. 2020. Best Practices for Facilitation in a Choice-based, Peer Learning Environment: Lessons From the Field. In *Proceedings of the 14th International Conference of the Learning Sciences: The Interdisciplinarity of the Learning Sciences*.
[70] Barbara Rogoff. 1994. Developing understanding of the idea of communities of learners. *Mind, culture, and activity* 1, 4 (1994), 209–229.
[71] Elle Rustique-Forrester. 2005. Accountability and the pressures to exclude: A cautionary tale from England. *Education Policy Analysis Archives/Archivos Analíticos de Políticas Educativas* 13 (2005), 1–39.
[72] Francisco Javier Sandoval-Henríquez, Fabiola Sáez-Delgado, and Maria Graciela Badilla-Quintana. 2025. Systematic review on the integration of immersive technologies to improve learning in primary education. *Journal of Computers in Education* 12, 2 (2025), 477–502.
[73] Laura Scheepmaker, Kay Kender, Christopher Frauenberger, and Geraldine Fitzpatrick. 2021. Leaving the Field: Designing a Socio-Material Toolkit for Teachers to Continue to Design Technology with Children. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 145, 14 pages. doi:10.1145/3411764.3445462
[74] Ronny Scherer, Fazilat Siddiq, and Jo Tondeur. 2019. The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & education* 128 (2019), 13–35.
[75] Maria-Luisa Schmitz, Tessa Consoli, Chiara Antonietti, Alberto Cattaneo, Philipp Gonon, and Dominik Petko. 2024. Why do some teachers teach media literacy while others do not? Exploring predictors along the "will, skill, tool, pedagogy" model. *Computers in Human Behavior* 151 (2024), 108004.
[76] Neil Selwyn. 2016. *Is Technology Good for Education?* Polity Press, Cambridge, UK.

[77] Joschua Thomas Simon-Liedtke and Rigmor C Baraas. 2022. The Need for Universal Design of eXtended Reality (XR) Technology in Primary and Secondary Education. In *Virtual, Augmented and Mixed Reality: Applications in Education, Aviation and Industry*, Jessie Y C Chen and Gino Fragomeni (Eds.). Springer International Publishing, Cham, 121–141.

[78] Gary S. Stager. 2013. Papert's prison fab lab: implications for the maker movement and education design. In *Proceedings of the 12th International Conference on Interaction Design and Children* (New York, New York, USA) *(IDC '13)*. Association for Computing Machinery, New York, NY, USA, 487–490. doi:10.1145/2485760.2485811

[79] Susan Leigh Star and Karen Ruhleder. 1994. Steps towards an ecology of infrastructure: complex problems in design and access for large-scale collaborative systems. In *Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work* (Chapel Hill, North Carolina, USA) *(CSCW '94)*. Association for Computing Machinery, New York, NY, USA, 253–264. doi:10.1145/192844.193021

[80] Reed Stevens, Kemi Jona, Lauren Penney, Dionne Champion, Kay E Ramey, Jaakko Hilppö, Ruben Echevarria, and William Penuel. 2016. FUSE: An alternative infrastructure for empowering learners in schools. Singapore: International Society of the Learning Sciences.

[81] Merle Taimalu and Piret Luik. 2019. The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis. *Teaching and teacher Education* 79 (2019), 101–110.

[82] techUK. 2025. Analysis and Proposals from the Digital Maturity Gap Workshop. techUK Insights. https://www.techuk.org/resource/digital-maturity-gap-in-education-event-roundup.html Event round-up.

[83] The Independent. 2026. The new reason state schools are falling behind private schools. (2026). Discusses the risk-averse culture and lack of AI strategy.

[84] Jo Tondeur, Koen Aesaert, Sarah Prestridge, and Els Consuegra. 2018. A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers & Education* 122 (2018), 32–42.

[85] Theo Toppe, Susanne Hardecker, Franca Zerres, and Daniel BM Haun. 2021. The influence of cooperation and competition on preschoolers' prosociality toward in-group and out-group members. *Royal Society open science* 8, 5 (2021), 202171.

[86] UOC Repositori. 2026. *Redefining the Digital Divide in Higher Education.* Technical Report. Open University of Catalonia. https://openaccess.uoc.edu

[87] Megan Venn-Wycherley, Ahmed Kharrufa, Susan Lechelt, Rebecca Nicholson, Kate Howland, Abrar Almjally, Anthony Trory, and Vidya Sarangapani. 2024. The Realities of Evaluating Educational Technology in School Settings. *ACM Trans. Comput.-Hum. Interact.* 31, 2, Article 26 (Feb. 2024), 33 pages. doi:10.1145/3635146

[88] Mark Warschauer. 2003. *Technology and Social Inclusion: Rethinking the Digital Divide.* MIT Press, Cambridge, MA. Often cited as 2004 due to paperback release.

[89] Elizabeth Joan Wenden. 2015. Rising to the challenge: Exploring the transition from primary to secondary education in a Western Australian school. (2015).