(Physical) computing in schools: The ongoing case for practitioner support

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Abstract

For decades, researchers have pondered the problems of computing education in UK schools, and there has been no shortage of proposals and initiatives for addressing these. More recently, *physical computing* has become a popular approach to embedding digital education, particularly in the context of the micro:bit, with over half a million of these devices being provided to schools throughout the UK over the past two years. Much research has gone in to how this approach encourages engagement by bringing computing to life for young people. However, the problems of ensuring a high-quality education experience – equitably in all schools throughout the country – persist. In this work, we assess the situation from a teacher perspective, and provide evidence that far more effort is needed to directly support practitioners and to systematically assess their evolving needs.

CCS Concepts

• **Social and professional topics → Computing education**.

Keywords

Computing education, physical computing, teacher professional development, micro:bit

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1 Introduction

By the turn of the millennium, it was becoming evident that interest in, knowledge of, and capacity for computing was not keeping pace with the transformational rise of the digital society and economy. The impact of this was especially acute in the school classroom. In 2017, the Royal Society's Computing Education report characterised UK computing education provision as *"patchy and fragile,"* [23] highlighting a fragmented approach to delivery and need for systematic support for schools [11]. Nearly a decade later, computing education in UK schools continues to face continued challenges, including inadequate teacher training[16, 22], limited resources [11, 17], impractical classroom space [23, 24] and a lack of teachers with a subject specific qualification [17].

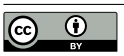
Physical computing is a popular approach to enhancing digital education, with the micro:bit, Arduino and Raspberry Pi successfully bringing this approach to life for young people [19]. However, despite numerous interventions, there remains a gap in understanding how physical computing education initiatives become sustainable implementation [9, 20, 23]. Most recently, the micro:bit *"next gen"* project is intended to address challenges of access and engagement with computing education in schools across the UK [2, 3], by providing small, programmable computers for use in the classroom [10] to support the delivery of computing and cross curricular activities [2]. Launched in 2023 as an extension of the original 2016 micro:bit programme, the project distributed 700,000 free micro:bit class sets to UK primary schools along with teacher training, English curriculum-aligned resources, and external technical and pedagogical support.

1.1 The challenge of physical computing

The use of such educational technologies in education has its challenges, which have been categorised as first-order (external) and second-order (internal) barriers to integration [8]. First-order barriers include factors such as limited access to resources, insufficient technical support, and institutional constraints, while second-order barriers include teacher beliefs, confidence, and attitudes toward technology [8]. Given existing concerns about computing education delivery in primary schools [16], the micro:bit project may address first-order resource barriers, but sustainable implementation requires professional development and support systems in order overcome second-order barriers such as confidence, competence and pedagogical knowledge [12]. Challenges to teacher educators' readiness to integrate educational technologies include insufficient techno-pedagogical knowledge, limited confidence in designing technology-enhanced learning environments, concerns about increased workload, low self-efficacy, and absence of structured peer collaboration and institutional support [1, 8].

1.2 Wales as a case study

Education policy in the UK's devolved nations - Wales, Scotland, and Northern Ireland - operates independently from Westminster, England, creating distinct educational landscapes with unique challenges and opportunities. This autonomy leads to substantial variation in national curricula and implementation strategies, with challenges particularly acute in rural areas where educational inequalities and hierarchies are intensified [21]. Wales exemplifies these



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challenges as a predominantly rural nation with an autonomous education system facing teacher isolation, poor workforce recruitment and retention, and limited computing-qualified teachers [6, 14]. The new Curriculum for Wales (implemented in primary schools in 2022) further complicates computing education by positioning digital competence as a cross-curricular capability alongside literacy and numeracy [25], creating additional curriculum targets for teachers to meet.

In Wales, Technocamps [15] has developed context-driven approaches addressing these challenges through professional development, curriculum resources, and in-school delivery tailored to the Welsh context. Their 2024 role in the "next gen" programme involved delivering training days, bespoke bilingual resources aligned with the Welsh Curriculum, and in-class delivery modelling, offering a valuable case study for examining micro:bit implementation and the specific impacts of a devolved educational context.

1.3 Research questions

It is within this context that our research investigates the following research questions: (1) What are the perceived benefits and challenges of using micro:bit technology in education from the teachers' perspective? (2) How does the availability of ongoing support affect teachers' long-term engagement with micro:bit technology? (3) What role do external support organisation play in supporting the effective implementation of micro:bits in schools?

Through addressing these questions, this study makes a contribution to the field by examining the experiences and challenges of integrating (physical) computing resource – specifically the micro:bit – into the delivery of computing education.

2 The Study

The initial survey was conducted between February and March 2024 with school teachers who participated in the "next gen" training workshops in Wales. Training was provided by Technocamps, and included a full-day covering: (1) basic micro:bit functionality and block-based programming; (2) pedagogical strategies for integrating micro:bits across the curriculum; (3) practical hands-on activities that teachers could implement in their classrooms; and (4) troubleshooting common technical issues.

The first survey comprised questions about teachers' roles, their experience with computing education, their use of digital resources, their prior experiences with Technocamps, and intentions regarding micro:bit implementation. The survey was completed by 152 participants from a total of 176 workshop attendees, representing an 86% response rate. A follow-up survey was conducted between May and June 2024 to assess progress since the initial training sessions, focusing on actual implementation rather than intentions. The follow-up survey yielded 53 responses (35% response rate from initial participants). Survey data were drawn from an independent review of the programme [13].

To deepen our understanding of these findings, we the undertook three semi-structured interviews in November 2024 with participating teachers. These teachers were selected to provide variation in geographic location, school language, teaching experience, and micro:bit familiarity. Following a sequential mixed-methods approach [7], combined with reflexive thematic analysis [4], we examined micro:bit implementation across participating Welsh schools, exploring teachers' experiences and perceived barriers. The research process adhered to ethical guidelines for educational research [5] and was approved by Swansea University's Research Ethics Committee.

3 The Findings

The initial survey captured responses from 152 teachers across Wales. Regarding prior engagement with Technocamps, 61% of respondents indicated they had benefited from their engagement in the past. Satisfaction with the training was high, with 76% rating the session delivery as "Excellent" and 22% rating it as "Good". When asked about the importance of the Training Day in preparing them to participate in the "next gen" programme, 69% rated it as "Essential" and 25% as "Important", indicating that 94% of participants perceived the training as valuable to implement.

Intentions to implement micro:bit technology post-training were also high, with 86% of respondents indicating they were "Very Likely" to use micro:bits in teaching and a further 13% reporting they were "Likely" to do so. However, intentions regarding specific activities were somewhat lower, with 58% indicating they were "Very Likely" to use provided activities and 25% reporting they were "Likely" to do so. Participants also placed high value on the ongoing support provided by Technocamps, with 72% rating it as "Essential" and 25% as "Important", underscoring the perceived need for continued support *beyond* initial training.

A significant finding was the limited availability of alternative support sources. When asked if there were other organisations besides Technocamps that had supported them in the past from which they would seek support for the micro:bits programme, 74% indicated they had no other organisation that would support them. Only 13% indicated they had external support, citing resources such as BBC Teach, the micro:bit website, and university partnerships. The remaining 14% were unsure where to find additional support.

The follow-up survey, conducted several months after the initial training, tracked the conversion from training enthusiasm to classroom implementation. Despite reminder communications, only 53 of the 152 initial participants (34%) responded. Given that teachers who successfully implemented micro:bits would naturally be more inclined to complete follow-up surveys, the 66% non-response rate suggests attrition between initial intentions and actual classroom adoption, alongside the time pressures of teachers responding to surveys during work [12, 18]. Indeed, 88% of those who did respond confirmed that they had already used the micro:bit when teaching, with a further 8% suggesting that they still had plans to do so; only 4% reported having no plans to use micro:bits in their teaching.

The interviews carried out with teachers confirmed that the use of the micro:bit increased student engagement (*"I could sit with them for a day and do micro bits"*) and their confidence (*"You're not kind of panicking or worrying about, 'oh, what if this doesn't work?"*).

However, teachers did note numerous challenges in the use of the micro:bit, such as time involved (*"We struggle to fit everything in, in a day, as it is"*), technology infrastructure (*"The older [Chromebooks] tend to not connect with the microbit all that well..."*) and resource management, with all teachers addressing how to distribute, collect, and maintain the micro:bits and accessories while preventing damage or loss.

Additionally, teachers expressed concern about educational inequity in Wales (*"[We] sometimes miss out on some of the great, lovely things that are out there"*), as resources and programmes are largely aligned with the English-curriculum. All participants highlighted how continuous support was crucial for developing their confidence and skills in using micro:bit technology, with particular appreciation for Technocamps' ongoing support after the Training Day (*"They've been out to my school. We had them in quite a lot to do micro:bit sessions. So, we've seen them using their resources as well."*), and Welsh curriculum-relevant structure (*"The biggest difference for me was... they've got different sections for all the areas of learning which we now have within schools"*).

4 Discussion

4.1 Perceived benefits and challenges

The "next gen" programme's distribution of free devices and Technocamps' training successfully removed primary resource barriers, with high initial satisfaction. However, technical infrastructure challenges emerged as a significant first-order barrier, particularly device compatibility issues with aging school technology. This suggests that while device provision is necessary, it is insufficient without addressing the broader technological challenges of infrastructure inequalities in schools (often demonstrated in practitioner-focused work, e.g. [19]), and indicate that Ertmer et al's et al. [8] first-order barriers extend beyond resource provision and into infrastructure, such as device compatibility. This finding aligns with the identification of inadequate classroom space and resource as systemic barriers [23, 24], indicating that physical computing initiatives need to account for schools' existing technological infrastructure alongside provision of new physical computing devices.

The gap between training participation and classroom implementation corresponds with Penuel et al's [18] observations of professional development outcomes demonstrating the persistence of second-order barriers, despite positive reactions to initial training. While most participants within the micro:bit "next gen" study rated their training as essential, their reported ongoing support from Technocamps demonstrates how one-off professional development interventions cannot address internal barriers of teacher beliefs and confidence [8]. The Welsh context adds further complexity, as teachers must integrate new technology and practices within the cross-curricular digital competence framework and the Curriculum for Wales [14, 25].

Teachers' observations that Welsh students *"miss out on some of the great, lovely things that are out there"* due to English-curriculum-aligned resources demonstrates how policy factors create barriers beyond Ertmer's framework [8] for integrating physical computing equitably throughout the UK. This challenge crosses the boundary of both first- and second-order barriers, as a resource limitation (absence of Welsh-language materials) and a confidence barrier (teachers adapting English resources for Welsh contexts). The value teachers placed on Technocamps' resources demonstrates that context-driven interventions [15] address both practical and pedagogical barriers more effectively than generic approaches, as physical computing initiatives designed for English urban settings risk reinforcing educational inequalities [11, 21] when applied to rural, or educationally distinct, regions.

4.2 Impact of ongoing support

The recognition among teachers that ongoing support (72% "essential", 25% "important") challenges traditional professional development approaches that prioritise initial training over sustained engagement. However, a marked discrepancy between intentions (58% very likely to use specific activities) and actual implementation (38%) reveals an "implementation dip": a phase where initial enthusiasm encounters the challenges of context. This implementation dip between intention and action exemplifies the limitations of transmission-focused professional development models [22], and highlights how decontextualised training approaches [16] fail to account for the complexities teachers face when translating theoretical knowledge into practice. In contrast, teachers who successfully implemented micro:bits consistently referenced ongoing support from Technocamps, including direct classroom modelling and continued resource provision. These successful implementations align with Falkner et al.'s findings that sustained communities of practice facilitate technology adoption more effectively than isolated training events [9].

The reliance on Technocamps (74% of teachers indicating no known alternative support sources) suggests a vulnerability in the educational ecosystem, and the evolution of contextualised support needs emerged as a critical dimension of sustained implementation. Teachers' requirements progressed from initial technical concerns about device connectivity to more complex challenges around curriculum integration. This progression indicates that effective support must be adaptive rather than static, with scaffolding strategies that respond to teachers' changing needs throughout their implementation journey, which can be provided through community-embedded models of practitioner support. Without support that adapts to these evolving needs, the initial investment in training and resources risks producing only temporary engagement rather than embedded pedagogical change [9].

4.3 Role of external organisations

This study demonstrates that external support organisations play an important role in the educational ecosystem [9], functioning as critical mediators between policy frameworks and classroom practice in the context of UK computing education's ongoing challenges. While initiatives like the micro:bit "next gen" programme attempt to address this through device distribution and training [2], this research demonstrates how sustainable implementation requires external organisations to translate broad policy ambitions into practical classroom realities. External organisations like Technocamps bridge the gap between the Curriculum for Wales's cross-curricular digital competence framework and teachers' day-to-day practice, providing structured, actionable resources that time-constrained teachers can implement without extensive preparation. Their role extends beyond supplementary support to become integral components of the educational infrastructure, compensating for systemic weaknesses through multiple support mechanisms tailored to teachers' evolving needs [16].

Teachers' concerns that Welsh students miss out on *"great, lovely things"* due to a typically English-focus on educational resource integration, contrasted with their appreciation for Technocamps' Welsh-context materials. This demonstrates how language, regional

and policy factors fundamentally shape technology adoption, integration and support. This finding stands to challenge universalist models of physical computing integration and associated professional development, which can assume that standardised national programmes are equally effective across diverse educational contexts, regardless of local infrastructure, teacher expertise, cultural factors, and institutional resources. This suggests that further work must explore how external organisations can develop and sustain culturally-responsive support models in other, educationally distinct regions beyond England.

5 Conclusion

We studied the experience of the micro:bit 'next gen' project and the subsequent experience of teachers implementing micro:bits in their classrooms, focusing on the role of external organisations in teachers' professional development. Our findings reveal that, whilst 86% of teachers expressed high intention to use micro:bits following training, adoption of micro:bits was impacted by technical difficulties, resource management, time constraints, language considerations and teacher confidence, preventing broader pedagogical transformation in the use of physical computing. External continued support was deemed key to success, with 72% of teachers rating such support as "essential" and a further 25% as "important", to their use of the micro:bit in the classroom. However, 74% indicated they felt a lack of organisations were available to support them in their practice.

We conclude from this that effective integration of educational technology requires a sustained support model that addresses technical, pedagogical and contextual needs - providing ready-to-use, curriculum-appropriate resources and continued external engagement beyond initial training activities, while being aware of technology infrastructure and educational policy. Local cultural contexts also shape teaching practices and learning expectations. These findings contribute to the wider computing education community by providing insights into the critical factors influencing the sustainable implementation of computing education technologies (particularly) outside of populated urban centres, where schools and teachers suffer from a lack of equitable resources and support [21].

Beyond initial training, teachers need ready-to-use resources, contextual implementation support, and continued external engagement that acknowledges (Wales') specific educational ecosystem, including: access to training, support organisations, teacher confidence and school languages. These findings have significant implications for educational stakeholders. For policymakers, our research suggests that investments in educational technology hardware must be matched with equivalent investments in sustained support infrastructures, addressing the lack of supporting organisations. For teacher educators and professional development providers, our findings highlight the need for training approaches that explicitly address the implementation gap between initial workshop enthusiasm and classroom reality, conceptualising professional development as an ongoing journey with differentiated support mechanisms available at various stages of technology adoption. For computing education researchers, this study demonstrates the importance of considering the context of language, culture and policy regarding educational technology implementation.

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